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**NEGOTIATING THE UNIFORMITY OF A COMMODITY:
THE RAPESEED COMMODITY CHAIN
IN THE PEOPLE'S REPUBLIC OF CHINA**

By

Keiko Tanaka

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ABSTRACT

NEGOTIATING THE UNIFORMITY OF A COMMODITY: THE RAPESEED COMMODITY CHAIN IN THE PEOPLE'S REPUBLIC OF CHINA

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Commodity chains are networks of labor and production processes including production, distribution and consumption of a given commodity. They are a type of vehicle for transforming a commodity, and social relations and nature surrounding that commodity. This dissertation research is designed to improve our understanding of how a given commodity chain creates and maintains uniformity in a commodity through technical change. It uses the case of the rapeseed chain in the People's Republic of China (PRC) since 1949 as an example. Uniformity is defined differently by each human actor in the chain. Thus, technical changes for creating uniformity in a commodity reveal negotiations among conflicting interests in and values for that commodity in a chain. The project follows rapeseed from production to consumption by using two complementary methods: (1) historical studies of the chain and (2) interviews with participants.

The study shows that each chain actor in China defines uniformity differently, and that the commodity chain extends its network from local to national and global by enrolling new actors, and integrating a new set of interests and values to shape the commodity. However,

in an effort to modernize science and technology, and the economy, the role of traditional actors (e.g., peasants, village processors) has become increasingly marginalized. Consequently, many research products are not valued or utilized by the villagers. This research suggests that the effectiveness of research products depends on the ability of a given research community to integrate the diverse interests and values of actors into technical change for the commodity.

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To Douglas Kevin Holbrook, who made this work possible.

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LIST OF ABBREVIATIONS

CAAM	Chinese Academy of Agricultural Mechanization
CAAS	Chinese Academy of Agricultural Sciences
CAFS	Chinese Academy of Fishery Sciences
CAPM	Chinese Academy of Preventive Medicine
CAS	Chinese Academy of Sciences
CCAAS	Central China Academy of Agricultural Sciences
CEROILS	China National Cereals, Oils and Foodstuffs Import and Export Corporation
COAC	Cereal and Oil Association of China
COFRC	Cereal, Oil, and Food Research Center
CPC	Communist Party of China
CRGB	Center of Rapeseed Genetics and Breeding
GOSs	grain and oil stations
HAU	Huazhong Agricultural University
HBA	Hubei Bureau of Agriculture
HBIT	Hubei Bureau of Internal Trade
HCHQR	Hubei Center for High Quality of Rapeseed R&D
HEAR	high erucic acid rapeseed
HOFC	Hubei Oils and Fats Company
HQVs	high quality varieties
HYVs	high yielding varieties
IAS	Institute of Animal Sciences
ICGR	Institute of Crop Germplasm Resources
IDRC	International Development Research Center
IFR	Institute of Feed Research
INFH	Institute of Nutrition and Food Hygiene
IOCR	Institute of Oil Crop Research
ISC	Input Supplying Company
MIT	Ministry of Internal Trade
MLT	Ministry of Light Industry
MOA	Ministry of Agriculture
MOC	Ministry of Commerce
MOE	Ministry of Education
MOMB	Ministry of Machine Building
MPH	Ministry of Public Health
MSC	Machine Supplying Company
NKTP	National Key Technology Program
NRVTP	National Rapeseed Variety Testing Program
NSFC	Natural Science Foundation of China
PRC	People's Republic of China
R&D	Research and development

S&T	science and technology
SC	Seed Company
SCAAS	South Central Academy of Agricultural Sciences
SCATC	South China Academy of Tropical Crops
SEZs	special economic zones
SPC	State Planning Commission
SSB	State Statistical Bureau
SSID	Social studies of international development
SSST	social studies of science and technology
SSTC	State Science and Technology Commission
TNCs	transnational corporations
XESS	Xishui Extension Service Station
XGOSC	Xishui Grain Oil Supply Company
XISC	Xishui Input Supplies Corporation
XOF	Xishui Office of Agriculture
XOFC	Xishui Oils and Fats Company
XOS	Xishui Office of Standards
XSC	Xishui Seed Company

LIST OF CHINESE WORDS

Chang Jiang (长江)
chaxugeju (差序格局)
danwei (单位)
gaoji youcai (高级油菜)
gaoji youzhi (高级油脂)
gongying gongshe (供应公社)
guojia paijia (国家牌价)
guojia biaoqun (国家标准)
heli (合理)
kaifa gongsi (开发公司)
kaijia xuanhuo (开架选货)
naoli laodong (脑力劳动)
nongye renkou (农业人口)
paijia (牌价)
putonghua (普通话)
routi laodong (肉体劳动)
shuijiao (水饺)
shuilu yaochong, edong menhu (水路要冲, 鄂东门户)
sige xiandaihua (四个现代化)
sirenbang (四人帮)
tuantigeju (团体格局)
xingzheng lishu guanxi (行政隶属关系)
xitong (系统)
yewu guanxi (业务关系)
you hong you zhuan (又红又专)
youpai (右派)

Rapeseed Cultivars and Classification:

baicaixing (白菜型)
Baiyou (白油)
Dongkoutian (洞口甜)
ganlanxing (甘蓝型)
Ganyou (甘油)
Huashuang (华双)
jiecaixing (芥菜型)
Menyuanxiao (门源小)

Ningbo (宁波)
Qinyou (秦油)
Qixingjian (七星剑)
Shengli Youcai (胜利油菜)
shuangdi youcai (双低油菜)
Xinghua (兴化)
Xishui Youcaibai (浍水油菜白)
Xishuibai (浍水白)
Zhongshuang (中双)
Zhongyou 821 (中油821)

Chapter 1

INTRODUCTION

Any technical change raises a basic set of social and ethical issues (Buttel 1990a): Who benefits? Who loses? What are the environmental consequences? Is this technology *good* or *bad* for us? This is largely because: (1) technology always involves disputes about conflicting values among different human actors who are affected by it, (2) technology (re)distributes wealth, power and status in society, and (3) technology transforms nature.

On the one hand, the development of modern science and technology (S&T), or more specifically *institutionalized technoscience*¹ in Western European countries from the seventeenth century, the U.S. from the eighteenth century and Japan from the nineteenth century onward, has contributed to successful economic development and the effective territorial expansion of these countries. On the other hand, the end of World War II, which marked the beginning of a new world order, also brought in a new era of understanding of the

¹ Science is often defined as a cognitive activity designed to resolve intellectual problems. Technology usually refers to: (1) physical objects or artifacts, (2) activities or processes to make these objects, and (3) know-how. These definitions imply that scientists are input suppliers for technologists who materialize scientific knowledge into technical products. However, the activities of making science and technology are so closely intertwined with each other that this separation between the two becomes problematic (Busch 1984; Latour 1987). As I will discuss later in this chapter, throughout this dissertation, *technoscience* is used to replace the term, *science and technology* (S&T).

role of technoscience in society. The dropping of two atomic bombs on Japan raised, not only within the scientific community and but also within society at large, numerous ethical and value issues surrounding the role of technoscience in society. This began to shake the notion that technoscience is inevitably always good for the public, and therefore, created more diverse images of and interests in technoscience. Today, we celebrate technological progress for improving a nation's productivity in economic activities and achieving superior military power, while we have become increasingly aware of and concerned about global warming, the loss of biological diversity, and environmental degradation. Therefore, understanding S&T helps us learn about our society, ourselves and social change, and allows us to ask what we do and what we value in a given time and space.

TECHNOSCIENCE AND SOCIETY

Social studies of science and technology (SSST) have emerged as an academic field to understand the role of technoscience in society. Early studies (e.g., Feyerabend 1975; 1978; Kuhn 1970; Merton 1973; Polanyi 1957) focused social accountability in knowledge construction. However, these early publications took an internalist view of scientific activities arguing that science is distinguished from other social institutions because of distinctive norms (Merton), scientific methods (Polanyi), and paradigms (Kuhn) shared by scientists. These internalists further argued that science is best left in the hands of experts. In their view, knowledge itself is not subject to any social critique since it merely describes the world. Therefore, the development and the continuity of science would require appropriate cultural conditions that value the autonomy of the scientific community in inquiry.

This internalist conception of science, that is, scientific activities have no connection to other social spheres, was challenged by Marxist critiques that pointed out how these activities are rooted in the *material structure* of a given historical time and space, and used as a tool to advance capitalist production relationships. For example, Veblen (1921) provided an evolutionary form of explanation of the emergence of modern science by focusing on the relationship between the mode of economic production and that of scientific production. Hessen (1968) showed how Newton's Principia was rooted in the technical demands of transportation, means of communication, mining and war industry imposed by emerging merchant capitalists during his lifetime. Nevertheless, this economic determinist position does not explain the diversity and complexity in the development of science across time and space where multiple conflicting demands for science exist.

More recent work in SSST (e.g., Bijker, Hughes and Pinch 1990; Callon 1986; Clarke and Fujimura 1992; Collins 1985; Cozzens and Gieryn 1990; Fuller 1988; Knorr-Cetina 1981; Latour 1987, 1988; Pickering 1992b) has maintained that the examination of practice is key to understanding how scientific knowledge and technological products are constructed in particular sociopolitical and economic contexts in a given historical time and space. In fact, their work has demonstrated that the existing division between science as a cognitive activity and technology as activities to produce physical objects is artificial. These authors examine research activities, whether basic or applied, as processes of network building among actors who share interests in a given research project. Moreover, they go even further to argue that the distinction between S&T and politics is misleading because the validity of research work, including scientific knowledge itself, is the outcome of social negotiations.

Agricultural Technoscience and Society

Across social sciences, numerous studies have examined the role of agricultural technoscience in social development. However, with the exception of a few recent studies (e.g., Busch and Lacy 1983; Busch et al. 1991; Giedion 1975; Goodman, Sorj and Wilkinson 1987; Kloppenburg 1988, 1991), many works tend to take the internalist view of technoscience and neglect analysis of technoscientific activities. On the other hand, the new SSST has a tendency to marginalize the examination of agricultural technoscience. Consequently, the effort to improve our understanding of the intersection between agricultural technoscience and society has been slow. However, the importance of such an understanding is twofold.

First, since the end of World War II, the issue of how to feed the rapidly growing population has been a main topic of discussion among various actors in the Third World development effort. Successful transfers of new technology from the U.S., European countries and Japan were assumed to increase food production, and therefore to improve the nutritional standards of the population in developing countries. Then, the surplus capital and labor from the improved agricultural sector were presumed to be invested in strengthening the industrial sector. Meanwhile, during the 1950s and 1960s, many countries formerly self-sufficient in food had come increasingly to depend on food imports and food aid largely from the U.S. As Friedmann (1982: S249) noted, the perception of a food crisis in the early 1970s led to food price inflation and legitimized “the international food order of the postwar era”. Today, the advancement of modern biotechnology in developed countries has already begun to threaten the viability of agricultural production in Third World countries as the new technology accelerates the replacement of agricultural processes with industrial processes

(Busch et al. 1991; Goodman, Sorj and Wilkinson 1987). Therefore, the analysis of the intersection between agricultural technoscience and society helps us enhance our ability to evaluate the rapidly growing imbalance between the developed and developing nations in income, wealth, power and status in the global political and economic order.

Second, products of agricultural technoscience have tremendous consequences to the welfare of the ecosystem. The Cold War led many nations, including developed countries, to tackle their diminishing self-sufficiency in certain food commodities by blindly accepting the U.S. model of capital-intensive agriculture (or the U.S. agro-industry model) (Goodman and Redclift 1991). This has accelerated the rate of environmental degradation in many countries. Recently, conventional approaches to agricultural research and development (R&D), based on intensive reliance on inorganic inputs, fossil-fuel-operated machinery, and a few genetically uniform varieties, have begun to receive a wide range of criticism for their negative consequences to the quality of human and nonhuman lives. Biological scientists (e.g., Carroll, Vandermeer and Rosset 1990a; Holden, Peacock and Williams 1993; Matson et al. 1997; Soule and Piper 1992) have warned us of a rapid degradation of agroecosystems,² such as soil erosion, water pollution and the loss of genetic diversity, induced by the blind application of technoscience to the modernization of agricultural production. Today, environmental groups often advocate alternative ways of producing and consuming our food at every level from farming to packaging. Consumer groups and food critics regularly voice their concerns over the quality of heavily engineered food products (both fresh produce and processed goods) and

² An agroecosystem is defined as an environment for agricultural activities, and an ecosystem modified by human activities (Carroll, Vandermeer and Rosset 1990b).

their long-term effect on our health.³ To date, the overwhelming majority of the world's population continues to rely on agriculture, animal husbandry, forestry, and fisheries as the main source of their income. The rapid population growth in the Third World will be likely to intensify such activities, and the rate of resource extraction from our ecosystem. In short, products of agricultural R&D will increasingly come to force us to answer the question -- "What kind of nature do we want?" (Busch 1991b).

Studies of Non-Western Technoscience

Within the current SSST literature, the application of actor-network approaches is limited with respect to understanding the interaction between market and technoscientific activities in non-Western countries.⁴ Many extant studies are concentrated in interdisciplinary fields of area studies (or country studies) and international development studies. Although they are informative on topics such as the history of technoscientific development, technoscientific policies, institutional characteristics of technoscientific communities, and R&D management in non-Western countries, they have three major weaknesses.

First, the literature on technoscience in the Third World tends to be concentrated on technology transfer and diffusion of innovations. For example, one-fourth of the works listed in Science, Technology, and Society in the Third World: An Annotated Bibliography (Shrum, Bankston and Voss 1995: 25) deal specifically with the subject of technology transfer. Until

³ Few publications have exclusively targeted a general audience. The only exceptions are the work of Doyle (1985) and of Mather (1995).

⁴ Some exceptions are recent work in the anthropology of science and technology. For example, see Chamarik (1994), Gaillard (1992), Gaillard, Krishna and Waast (1997), Goonatilake (1984, 1992), and Hess (1995).

recently, many such studies explicitly assumed that technology transfers and exchanges from developed nations were the best strategy for improving production techniques, and therefore production capability, in developing nations. At the theoretical and methodological levels, diffusion of innovations approaches (e.g., Hayami and Ruttan 1990; Rogers 1983) continue to dominate in such studies. Even among those critical of unequal supplier-recipient relations, the main concern is the fate of a final product from R&D, that is, a piece of new technology. They often neglect analysis of the processes by which technology is created, introduced, accepted or rejected, maintained and changed among various actors. Therefore, the literature tends to split into two extreme camps: those who celebrate technoscience as a means of modernization, and those who reject completely the value of technology transfer from the North to the South.

The second concern is closely related to the first. Many studies of technoscientific development in non-Western nations concentrate their analysis on the relationship between suppliers and recipients of new technology when examining the process of technical change. Government agents and policy makers are often portrayed as mediators between the two main actors. Therefore, the studies assume that effective and efficient technoscientific policies are necessary to ensure a successful technology transfer from one country to another, to allow the swift diffusion of an innovation from technoscientists to users, and to develop equitable relations between supplying and receiving countries. This assumption overemphasizes the role of nation-states in the process of technical change, and portrays the final users as passive with little effect on the process.

Finally, sociological studies of technoscientific development in the Third World have not been fully appreciated by academics, policy makers, aid agencies, non-governmental

organizations (NGOs), and others who are involved in the development effort. There appear to be two reasons for this. First, sociologists have relied heavily on theoretical frameworks used by development economists (e.g., the diffusion model, the induced innovation model). Second, at the same time, these researchers have played the critic of these economic studies, but failed to offer any new theoretical approaches. Consequently, within the discipline, the sociology of S&T and that of international development have remained completely separate fields with little communication between the two. Moreover, the sociology of international development has not been successful in overhauling the dominant paradigm for international development.

PARADIGMS FOR INTERNATIONAL DEVELOPMENT

Over the last five decades, goals, theoretical frameworks, and practices surrounding development projects have shifted constantly (see Table 1.1). The popular theme of development in the 1950s and 1960s was *modernization* (e.g., Lewis 1954; Ranis and Fei 1961). By this, it was meant that (ex-)colonies were to expand the modern capitalist exchange sector (e.g., industry, mining, plantations) and reduce the indigenous noncapitalist sector (e.g., small-scale agriculture, handicrafts). By the 1970s, more critical perspectives such as the dependency theory (e.g., Baran 1952; Frank 1972), world systems theory (e.g., Wallerstein 1974b), and community development theory (e.g., Chekki 1979) raised equity issues to be incorporated into development programs. In the 1980s, structural adjustment through macroeconomic policies (e.g., Timmer, Falcon and Pearson 1983) promised to smooth the path for the development of free-market economies in Third World countries. The effort for international development has been called in to question as a combined result

of various events including but not limited to: the failure of structural adjustment programs, rapid environmental degradation, and constant political upheavals in the Third World; growing disparity in the standard of living between the North and the South and among countries within the South; the end of Cold War; and economic downturns and the rise of conservatism in West.

Table 1.1 - Agendas and Theoretical Frameworks for International Development, 1950s - 2000s.

Period	Agendas	Theoretical Frameworks
1950s -1960s	Modernization	▸ Dual-sector model ▸ Diffusion model
1970s - 1980s	Growth with Equity	▸ Community development theory ▸ Dependency theory ▸ World systems theory ▸ Induced innovation model
1980s - 1990s	Macroeconomic Reform	▸ Structural adjustment
1990s - 2000s	Sustainability, Cooperation, and Democracy	▸ New institutional economics ▸ Social constructionism ▸ Post-Marxism/neo-Weberianism ▸ Actor-network model

Sources: Bauzon (1992), Booth (1992), Clague (1997), Staatz (1990).

In the international community, the pendulum has always swung over the question surrounding the appropriate role of the nation-state: How much should the state intervene in market activities? Whose interests and welfare should the state protect in the effort to establish a capitalist market economy? Modernization theorists supported state-directed and controlled development, while supporters of structural adjustment programs limited the role of the nation-state to merely an instrument for building the free-market economy. Moreover, critical theories of the 1970s and 1980s inspired various international development agencies

to pressure Third World nations to launch social welfare programs. Recently, the debate has been shifted to near the balancing point. That is, state interventions should not be too much or too little (World Bank 1997).

At a more fundamental level, however, the paradigm for international development has never changed. For nearly five decades, the notion of *development* has always meant the process of following certain necessary steps as described in Figure 1.1. The ultimate goal of Third World development has been defined as modernizing both the economic and political *structure* where exchange activities are relatively free from governmental interference. Moreover, *modernization* presupposes the establishment of a modern capitalist market system through effective use of modern S&T. Mellor (1990) argues that only by diversifying the economy away from agriculture will it eventually lead to meeting objectives of social wealth, equity and sustainability. However, this paradigm suggests five myths that are particularly problematic. Let me explain what they are:

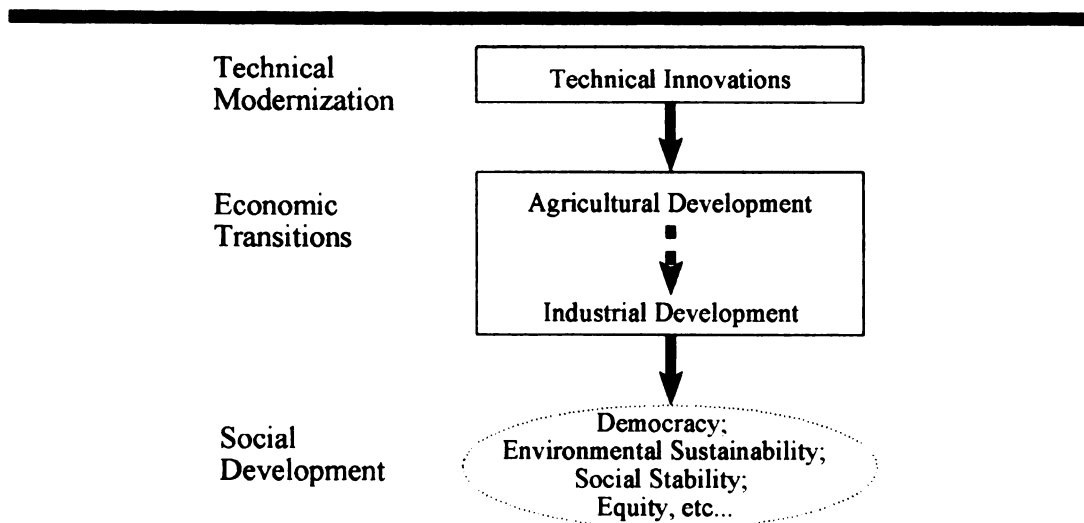


Figure 1.1 - Necessary Steps for Development.

Myth 1. Capitalist markets already exist in Third World countries. The term *developing* or *less developed* countries suggests that Third World countries have markets which need to be *developed* to function properly. However, the distinction between *developed* and *undeveloped* (or *underdeveloped*) markets is rarely explained. The demise of socialism starting in the late 1980s has given scholars of international development opportunities to observe the processes by which capitalist markets develop in the former socialist countries. Yet, no one seems to ask: What are capitalist markets? What are necessary building blocks of a capitalist economic system? Which capitalist system will be good for a particular nation? Or, is the market transition the right answer for every former socialist nation? Consequently, the international development community ends up merely collecting stories of successes and failures, but offers little practical advice as to how these nations can succeed in their transition from a planned to a market economy.

Myth 2. Technoscience is exogenous to economic development. Both scholars and practitioners of international development tend to treat R&D as a residual (i.e., an exogenous variable) of production, that is, something left over after land, labor and capital are accounted for. Moreover, these development specialists also view the relationship between technoscientific and economic activities as unidirectional. Technical innovations are always stressed as a necessary and the first step for socioeconomic development in Third World countries (see Figure 1.1). And, technoscience is assumed to be inevitably good for international development. Until very recently, therefore, students of international development paid little attention to actual processes of technoscience. Meanwhile, the SSST has come to largely ignore technoscientific processes in non-Western countries. Recent works that examine Third World technoscience (e.g., Chamarik and Goonatilake 1994;

Gaillard, Krishna and Waast 1997; Gaillard 1992; Goonatilake 1984) have received only marginal attention in the SSST.

Myth 3. The nation-state alone directs the transformations of economy, polity, and technical capacity in a given nation. The paradigm for international development overly focuses on the role of the nation-state in the so-called modernization effort. With appropriate macro policies, governance mechanisms and technical innovations, the state would allow its existing markets to behave in a proper fashion according to the Laws of Economics. In this picture, the state was the only actor that would transform the economic, political and technoscientific systems in a given nation.

Without a doubt, the state plays an important role in social change. However, the state does not have perfect information to make decisions about every political, economic, and technical activity in the nation. Moreover, neither does the state always know which decision would serve the best interests of the nation, nor act in a way to maximize social welfare. Indeed, other actors participate in the decision making processes for shaping institutions, activities, processes, and values and ethics in various domains of society. In addition, conflicts arise in every society among various actors who have distinctive interests, needs, values, perspectives, and motivations.

Myth 4. Social structure is “out there.” And, we all know what the structure is in each society. By assuming the preexistence of capitalist markets and blackboxing technoscience, the prevailing paradigm offers little explanation about how the *structure* is articulated in a society. In other words, the frame for the capitalist market structure has somehow always existed, even in a Third World society. Social studies of international development (SSID) have paid little attention in explaining how this frame emerged, and of

what it is consists of in a given society. Development projects were designed to tighten the nuts and bolts using a tool called modern S&T, and arrange people and things neatly into the correct space in the frame.

Myth 5. There are either macro or micro approaches to development. Consequent to the third myth, the development paradigm creates a macro/micro division in the development effort: the macro approach to fix the frame while the micro approach to arrange people and things. Moreover, the SSID community ends up being divided among disciplines. Each discipline addresses only a limited set of issues surrounding international development, and uses either one of the two approaches. Yet, the reliance on either one of the two approaches is shown to be inadequate by the failure in structural adjustment projects (the macro-approach) in Africa and community development projects (the micro-approach) in India.

In this study, I argue that *development* is a process of reorganizing social relations through new tools, values, knowledge and processes for monitoring and controlling the behaviors of humans and the role of nonhumans. In order to challenge the five myths of international development, I start with the question: What are key differences between so-called *developed* and *developing* countries in the mechanism to organize social relations surrounding sociopolitical and market activities?

Consider what are notable differences in the market practices between a street market in Wuhan, Hubei Province and at a grocery store in Grand Rapids, Michigan. At my favorite grocer in Grand Rapids, I notice a high degree of uniformity in the size, shape and price of things, the behaviors of people, and the process of labeling, measuring, wrapping and

exchanging . In contrast, at the market nearby my host institution, Huazhong Agricultural University, in Wuhan, I could hardly observe such uniformity in the quality of things, the behaviors of people and the process of commodity exchange.

In the West, uniformity has become very important in both our material and non-material lives. At school, we hope that our children at each grade will learn knowledge uniform throughout the nation. Many teenagers are terrified the idea of being different from their peers. Thus, those teens in a given clique usually look and talk alike. Moreover, the notion of *free-market* has become the most powerful ideology for justifying the economic, political and military actions of our government and corporations.

Indeed, the prevailing paradigm of international development is a product of this free-market ideology. In fact, we want people in developing countries to be like us -- living a house with lawn yard, driving a nice car to work, watching television as family entertainment while eating a TV dinner --, or at least accept uniformly our image what a *good life* is.

SCOPE OF THIS STUDY

This dissertation research aims to integrate three different fields within sociology including: the sociology of S&T, the sociology of agriculture, and the sociology of international development. In order to achieve this goal, the study examines the process in which the direction of technical change for an agricultural commodity in a non-Western country is shaped by negotiations, persuasion, and coercion among various actors surrounding the R&D program. This permits us to understand the social dynamics by which the values and ethical commitments of diverse human actors are incorporated into economic development through the process of technical change. In this study, I examine how the

concept of *uniformity* is treated as an integral value, or as something good and necessary in both capitalist markets and modern technoscience. The study uses the case of the rapeseed R&D program in the People's Republic of China (PRC) since 1949 as an example.

In this study, the fundamental questions repeatedly raised are: (1) How are various aspects of uniformity created in rapeseed through technical change, legal and policy measures and market procedures? (2) How are the values of each actor surrounding rapeseed negotiated in the process to create, maintain and change the uniformity of rapeseed? (3) How has this negotiation process changed over time, and how does it articulate with what we call the *social structure* of the PRC? In short, my main concern here is to understand how the value of uniformity is constructed among various actors in the process of sociopolitical and economic transformations.

The modern history of agriculture in the PRC is distinguished from that of the West in that the goals of agricultural production have been defined and pursued in the broad context of socialism. The maximization of production has not been necessarily tied to the profit motive evident in capitalist nations. The state has strong control over the distribution of resources, such as land, labor (currently to a lesser degree),⁵ and capital. Moreover, activities of agricultural R&D have been heavily incorporated into the central economic plans, and thus generally highly controlled by the state. Therefore, actors in the social network

⁵ Until recently, the state controlled the movement of the population by prohibiting the rural population from migrating from one locale to another, and particularly to urban areas. More recently, this restriction has been relaxed, not necessarily because the state changed its policy position on the matter, but because it lost the ability to enforce the restriction.

surrounding a given R&D project have not been allowed to interact autonomously and independently outside of the state interventions.

As discussed in the next chapter, the creation, maintenance and transformation of uniformity in commodities through technical change is a vital strategy for both public and non-public institutions to enter, survive, and succeed in capitalist markets. In the PRC, the recent reform measures have significantly changed the social dynamics by which values and ethical commitments of diverse human actors are incorporated into modern agricultural technoscience. This study aims to improve our ability to understand how the adoption of the capitalist value of creating and maintaining uniformity in commodities through technical change affects social relations in the agrofood system.

Objectives of the Study

In this dissertation research, there are three objectives. First, the study hopes to develop an empirically grounded theoretical approach to understanding value and ethical issues in the relationship between technoscience and economic development. Most studies of a given project or program of technical change examine either those technologies that were in an early stage of project conception, or those that have been completed a long time ago. One uniqueness of this dissertation study is that it analyzes the R&D program now in progress in a nation currently undergoing economic growth at a rapid rate. Moreover, the integration of actor network theory in current SSST and commodity chain analysis in sociology has helped me to focus on analyzing the processes of technical change beyond the sociopolitical context of laboratory and technoscience policy making. Recently, Latour and his colleagues (e.g., Bijker, Hughes and Pinch 1990; Callon 1986; Callon and Latour 1992) have insisted on

the symmetric treatment of both humans and nonhumans in the study of technoscientific processes (see Chapter 2). Yet, their empirical studies tend to privilege scientists in their ability to shape technoscientific products. In this study, this principle of symmetry is realized by following rapeseed rather than scientists, and identifying distinctive notions of uniformity, each of which is held by a given human actor in the rapeseed commodity chain. The importance and meaning of uniformity as a human value varies among actors. Therefore, this study uncovers how *uniformity* as a capitalist value has affected the ways in which rapeseed R&D projects are designed, conducted and evaluated, by comparing actual products of R&D and various notions of uniformity that exist in the social network of actors in the rapeseed commodity chain.

Second, the study aims to improve our understanding of how the creation of uniformity at each stage of transforming a commodity reflects ethical commitments and values of human actors in the commodity chain. In the PRC, the creation and maintenance of uniformity in rapeseed through technical change are currently key goals in both economic and R&D activities pertaining to rapeseed, as the achievement of such goals will allow the nation to participate in global rapeseed markets. However, in order to pursue uniformity as a legitimate goal and value in the technoscientific community, these linkages must simultaneously promote the development of capitalist markets in society, and the adoption of (a particular understanding of) uniformity as a key value in that society.

Third, this study attempts to determine the impact of negotiations among chain actors about technical changes on the transformation of society and nature. As Croll (1994) points out, the current reforms in the PRC are not simply a return to capitalism. They redefine social relations from family to nation-state, and thereby values and ethics within society. This

historical analysis of the social network of rapeseed research in the PRC hopes to reveal how modern technoscience is legitimated as the dominant knowledge system in society. Such an analysis will help us understand how non-Western societies incorporate the worldview created by technoscience into their traditional worldview. Differences in social networks surrounding a given technoscientific project among two or more countries may suggest the distinctive conception of S&T and nature/society in these societies.

Clarifications of Key Terms

Throughout this dissertation, instead of S&T I use the term *technoscience* in order to stress the interconnectedness of these two activities. As Pinch and Bijker (1987:19) point out, philosophers (and scientists) have overidealized distinctions between science and technology such that “science is about the *discovery* of truth whereas technology is about the *application* of truth” (my emphasis). However, the result of many empirical investigations demonstrate that the relationships⁶ between science and technology, pure and applied research, and basic and applied science are not unidirectional, and the distinctions are ambiguous. Layton (1977) points out that these divisions are socially constructed. Barnes (1982:166) argues that science and technology “are enmeshed in a symbolic relationship.” As discussed in the next chapter, scientists rely on technologies (e.g., equipment, tools, gadgets) to carry out their activities even when their research is purely theoretical. Moreover, when we compare various countries on organizational systems surrounding science and technology, we soon realize that distinctions such as pure and applied research, basic and

⁶ See Pinch and Bijker (1987) and Mulkay (1991) for brief reviews of empirical studies on these relationships.

applied science, and research and development require institutional mechanisms such as disciplinary boundaries, the division of labor between the public and private sectors, intellectual property laws and so on. Therefore, within the SSST, simplistic models and generalizations about the science-technology relationship have been largely abandoned though many researchers continue to use the terms science and technology.

It was Latour (1987: 174) who developed the term *technoscience* “to describe all the elements tied to the scientific contents” including scientists, their colleagues and helping hands, laboratories, equipment, tools, professional journals, clients, texts, and so on. He distinguishes technoscience from the expression “science and technology” in quotation marks “to designate what is kept of technoscience once all the trials of responsibility have been settled.” Thus, the term technoscience allows me to examine the process of setting boundaries between knowledge and products in making and those that have been already made, and between inside and outside of “science and technology.”

The term *commodity chain* comes from sociology, and is very similar to the concept *commodity subsector* used in agricultural economics and rural sociology. Both terms stress the processes in which a commodity is produced, distributed and consumed among various market participants. Hopkins and Wallerstein (1986: 159) define a commodity chain as “a network of labor and production processes whose end result is a finished commodity.” In this study, a commodity chain is defined as a social network of actors organized around a given commodity, and considered as a type of vehicle for negotiating conflicting notions of uniformity held by each human actor in order to transform that commodity through technical change. Thus, the term *chain* is used throughout this work as a synonym of the word *network*.

In this study, by *actor* I refer to those humans and nonhumans that take part in shaping rapeseed through production, legal and technoscientific activities. Therefore, human actors include technoscientists, government officials, farmers, input suppliers, food processors, marketers, transporters, wholesalers, retailers, consumers, international aid agents, overseas R&D collaborators, and foreign joint venturers. It is presumed that each human actor has his/her or its own interests, motivations, needs, perspectives, values and ethical commitments pertaining to technical change in rapeseed. Such differences are also assumed to be the direct result of particular relationships that he/she has with rapeseed.

Some examples of nonhuman actors are rapeseed, laboratory equipment, fertilizer, livestock, processing machinery, and so on. By treating things as *actors* rather than *resources/constraints*, I emphasize that they are not passive objects of human actions. Instead, these things act⁷ on humans and participate in settling technoscientific, political, economic and cultural disputes. Moreover, following Callon and Latour (1992), I argue that the dichotomy between humans (Society) and nonhumans (Nature) is artificial. Latour (1993) points out that such an understanding of Society/Nature is a product of what we call *modernity*, and that distinctions between humans and things hardly existed during the era of alchemy and astrology when people attributed human characteristics to nonhumans. When I was growing up in Japan, I often heard such expressions as “the mountains will get upset,” “the ocean shows her rage,” and “the trees warned me not to go into the forest.” Today, people in many cultures argue that Nature gets angry at human follies and punish humans by

⁷ Of course, things do not have intentions, wills or motives to physically act. For example, a chair does not move by itself to block our way. Someone has left it in the middle of a hallway. However, its existence does change the way in which we walk down the hallway.

causing disasters. In fact, those of us who live in *modern* society laugh at those who hold such animistic beliefs for their ignorance and primitiveness. Yet, the symmetrical treatment of humans and nonhumans allows me to analyze the development (or modernization) of a society as a process of redefining and setting the boundary between Society (humans) and Nature (nonhumans) by using technoscience.

Negotiation is a basic process of decision making and a means of getting something done (Strauss 1978). However, by *negotiation*, I do not necessarily mean that two or more human actors come together to confer face to face with each other in order to reach an agreement. Everyday in our life, negotiations appear in many forms. They are essential in maintaining and changing human relationships and social arrangements. In this study, the term negotiation is broadly used as an interaction process to which two or more actors bring their distinct interests, motivations, needs, perspectives, values, and ethical commitments in order to get something accomplished. And, the analytical focus is not placed on negotiation processes, but outcomes, or the resulting order in things and social arrangements, that implies that the differences between actors have been negotiated.

THE STUDY OF RAPESEED TECHNOSCIENCE IN THE PRC

For the last 40 years, technoscience like every other social institutions in the PRC has indeed experienced tremendous fluctuations as the nation underwent drastic political and economic transformations. Each of the major social events⁸ in the history of the PRC marks

⁸ Research on the technoscientific development in the PRC prior to the reforms of the 1980s is limited. See Wang (1993) for the technoscience policy changes between 1949-1989; Stavits (1978b) for the agricultural mechanization processes during the Land Reform (1950-52), the Great Leap Forward (1958-60), and the Great Proletarian Cultural Revolution (1966-

a distinctive phase of the development of technoscience. During the last three decades, major policy documents⁹ and the Five Year Plans¹⁰ reveal that top leaders in the PRC have begun to identify technoscience as a resource for achieving social change and national goals, and as a key tool for preserving legitimacy of the Communist Party of China (CPC). Moreover, these leaders stress the need for institutional reorganization in order to turn products of technoscience into commodities that are exchanged through the markets.

Existing Studies on Technoscience in the PRC

To date, however, very few studies have been conducted on technoscientific activities in China that allow an adequate assessment of their impact on the transformation of society and nature. Much of the existing work tends to be concentrated in the fields of history, economics and political science.

Without a doubt, Joseph Needham's mammoth work, Science and Civilization in China (Needham 1954-96), has made the most notable contribution to improving our understanding of the history of pre-modern Chinese technoscience. However, its major

76); and Bullock (1992), Orleans (1992) and Marshall (1993) for the impact of the Tiananmen Square incident (1989) on the technoscientific community.

⁹ Particularly important ones are (SSTC 1987, 1989): "Report Delivered at the National Science Conference" (1978); "Decisions of the Central Committee of the Communist Party of China on the Reform of the Science and Technology Management System" (1985); "Interim Regulations of the State Council for the Administration of Science and Technology Appropriation" (1986); and "Interim Regulations of the State Council on the Extension of Decision Making Power of Scientific and Technological Research Management."

¹⁰ Particularly, the 6th (1981-85), 7th (1985-90), and 8th (1991-95) Five-Year Plans show the strong emphasis on the development of technoscience (Beijing Review 1991a; SSTC 1987, 1989; Tang 1984)

weakness lies in his view that science has autonomy from the rest of society. He assumes that science consists of the cognitive activities of individual scientists as they attempt to reveal objective reality. For example, in his discussion of the history of Chinese thought, he points out that Chinese science was quasi-empirical during the ancient and Medieval periods, and that the visit of Jesuit missionaries in the 17th century marked a beginning of *the diffusion of universal science* (Ronan and Needham 1978). According to him, geographical isolation hampered the Chinese from linking their organic philosophy of nature with Western methods and ideas of science before the 17th century.

More recent studies of Chinese technoscience (e.g., Baark 1992; Conroy 1989; Miller 1996; Saich 1989; Simon 1992; Simon and Goldman 1989; Suttmeier 1989, 1992; Tang 1984) and agricultural technoscience (e.g., Conroy 1987; Delman 1988; Fan and Pardey 1993; Hussain 1989; Stavis 1978a, 1978b; Wiens 1978; Zhou 1987) tend to focus on the institutional characteristics (e.g., personnel, organizational arrangements, resources) of the technoscience communities and the policy issues surrounding technoscience. For example, the work by Suttmeier (1989) on R&D policy in the PRC since the 1970s has illuminated the interrelations between technoscientific development and political evolution during the reform period. Conroy (1989), Saich (1989), and Simon and Goldman (1989) are largely concerned with technoscience policy issues of the 1980s such as technology markets, technology transfer, industrial innovation, and the R&D environment. These studies employ a structural approach which regards the nation-state as the sole force behind policy formation and institutional changes in society.

This state-centered approach has been criticized by Baark (1992) who employs an actor network approach in political science¹¹ to reveal the existence of interest groups other than the state in making policy decisions pertaining to technoscientific activities. Moreover, he examines how fragmented and distorted authority and control within the interorganizational network create discrepancies between original policy goals and actual policy outcomes. Wang (1993: 8) combines this actor approach and the structural approach used in the earlier studies, in order to examine "the balance between scientific freedom/autonomy and government interventions/planning" in technoscience policy making processes.

All these works above recognize the importance of technoscience as a means of social change. However, these studies do not directly analyze technoscience in action. None of them actually examine a given R&D project in order to describe technoscientific practices and actual material settings for the technoscientists. By *negotiations* among network actors surrounding technoscience, they mean how technoscience policies, and institutional goals and resources are negotiated between technoscientific institutions and the state, not how a given product of technoscience is constructed through negotiations among corporate and individual actors surrounding it. Therefore, sociological works of technoscience in the PRC are needed to document how actual technoscientific processes affect the sociopolitical and economic system, agroecological systems, and the relationship between society and nature.

¹¹ For example, Lieberthal and Oksenberg (1988) use this approach to examine how policy goals are negotiated within the interorganizational network of actors in policy implementation processes in the PRC.

Why Rapeseed?

Rapeseed has played an important role in the Chinese agriculture for millennia (Wang 1987). Although Canada currently stands as the largest exporter of the crop, the PRC is the largest producer, followed by India and Canada. In the 1994-95 season, nine million metric tons, or 27% of the world's rapeseed was estimated to have been produced in the PRC (FAO 1996). Moreover, rapeseed remains the preferred crop for edible oil¹² in the PRC as it occupied 38% of the total production and 48% of the total sown area of edible oilseed crops in 1994 (Nongyebu 1995). It accounts for nearly a half of the edible oil supply in the PRC (US Embassy 1995). Rapeseed produced in the PRC has been largely consumed domestically as a source of edible oil, industrial products, organic fertilizer, and recently animal feed because: (1) the level of edible oil production does not meet domestic consumption needs, and (2) the quality of rapeseed and its products is not adequate for sale in global markets (various interviews, 1994, 1995, 1996).

The importance of examining rapeseed (an oilseed crop), rather than other crops or livestock, are as follows: First, oils and fats are an essential component of the human diet as a source of energy and as a carrier of fat soluble vitamins. Thus, increased consumption of edible oils is necessary to improve the nutritional standard of the PRC's population (US Embassy 1995; Whyte 1972). In many Western countries, soybeans dominate the edible

¹² According to the Chinese government, edible oilseed crops include peanuts, rapeseed, sesame seed, sunflower seed, huma, and miscellaneous oilseeds (i.e., castor bean, safflowerseed, and perillaseed), and exclude soybeans, cottonseed, and oil-bearing seeds and nuts from trees. I used the data on only what the Chinese government consider as edible oilseed crops in this study.

oilseed sector. In the PRC, however, soybeans¹³ are processed into various other products such as tofu and paste for both domestic consumption and exports, leaving little for processing as edible oil or animal feed. Moreover, rapeseed oil excels nutritionally as compared to peanut and sesame seed oils in that it has a lower level of unsaturated fat with a higher level of polyunsaturated fat.

Second, consumption of edible oils is highly elastic; there is a high positive correlation between standard of living and consumption of edible oil (Kueh 1988; World Bank 1985). For example, edible oil consumption in the PRC has the highest correlation with national income ($r^2=.90$) while grain has the lowest ($r^2=.79$) (see Table 1.2). By 1983, average income of the PRC's population had grown 2.3 times since 1952, and consumption of vegetable oil increased by 48% accordingly (see Appendix A).

Table 1.2 - Correlations between National Income and Selected Commodities in the PRC, per capita, 1952-1990.

Commodities	R ²
Edible Oil	0.90
Grain	0.79
Pork	0.89
Sugar	0.86

Sources: USDA (1992).

¹³ National average yield of soybeans in the PRC is less than that of many developing countries. Therefore, it lacks comparative advantage to rapeseed for processing into an edible oil or animal feed.

Third, an increase in rapeseed production is viewed as important for strengthening the livestock sector since rapeseed meal is a highly nutritious feed for animals (US Embassy 1995; World Bank 1985, 1987). Since the late 1970s, the growth in the PRC's livestock sector has been remarkable, with an average annual growth rate of 8% in output of all types of meat (Tuan 1993). However, the level of consumption of animal products among the PRC's population is far from adequate. Poor grain feeding systems and inadequate levels of protein supplementation contribute to current technical insufficiencies in the livestock sector. The increased use of rapeseed meals, derived from new varieties with low-glucosinolate content, has been recommended to alleviate this problem (Pigden 1983; Wang 1994; World Bank 1985, 1987).

Fourth, rapeseed can play a key role in crop rotation, thus contributing to the maintenance of soil fertility (Wang 1987) on the one hand and to providing viable economic opportunities on the other, particularly in regions with a short-growing season. Major advantages of rapeseed over other oilseed crops are its cold tolerance and that it can be adapted to more diverse climatic and soil conditions. Another advantage is that, unlike perennial oilseed crops, rapeseed does not require any equipment or farm inputs additional to those of wheat or other dry grain production.¹⁴

Fifth, rapeseed is a more manageable subject for the analysis of a national R&D program as a dissertation study than soybean or corn that have more diverse uses, and therefore involve more actors, than rapeseed. Between 1949 and 1993, a total of 5,865

¹⁴ This is particularly the case in most Asian countries since the area of rapeseed cultivation for each household is extremely small. However, in Canada where the scale of rapeseed production is large, farmers often use equipment specifically designed for rapeseed cultivation in order to improve labor productivity.

technical publications on rapeseed became available in the PRC. The numbers of publications and projects on, and actors involved in technical change on soybeans is likely to be two to three times more than those on rapeseed.

Finally, rapeseed has become a key global commodity only within the last two decades as a result of technical change made to the crop by Canadian technoscientists (Busch et al. 1994). The removal of erucic acid and glucosinolates from the crop through conventional plant breeding made it safe for both human and animal consumption (see Chapter 6 for details). At the same time, the availability of these low-erucic acid and low glucosinolate (or canola) varieties helped the crop to become a global commodity while it blackboxed the toxicity of erucic acid and glucosinolates in the global rapeseed R&D community. When the central government of the PRC began to gradually normalize foreign diplomacy in the early 1970s, Chinese rapeseed technoscientists immediately seized an opportunity to participate in the international effort to transform the crop into canola, a global commodity. Surrounded by the world's largest consumers of rapeseed oil, Japan and Korea, it is understandable that government officials in the PRC were enthusiastic about making the nation the world's largest exporter of the crop. Two decades later, however, although the PRC is still the world's largest producer of rapeseed, it has become a importer of the crop and its oil rather than an exporter.¹⁵

¹⁵ The PRC is the world's largest exporter of rapeseed meal. However, the total value of international trade of rapeseed meal is small.

ORGANIZATION OF THIS WORK

This dissertation consists of nine chapters. The second chapter deals with the theoretical framework used for this study. After reviews of the different theoretical approaches to technical change used in social science fields, I discuss why the value of creating and maintaining uniformity through technical change has become important in the capitalist economic system. I stress that the PRC's transition from a socialist to a more capitalist-oriented economy makes it ideal for examining how the value of uniformity plays a role in transforming a commodity. Moreover, the next chapter shows how the principle of symmetry is used in this study in order to argue that technical change requires simultaneous transformations in a given thing, and social behaviors of and social relations between humans surrounding the thing.

In the discussion of methods in Chapter 3, I elaborate how to bridge the gap between SSST and SSID in the understanding of technical change. The integration of actor network theory and commodity chain analysis allows me to trace simultaneously things (i.e., rapeseed and its byproducts) and people (i.e., human actors in the rapeseed chain) from laboratory to supermarket. Then, I point out how each of multiple methods used in this study has helped me delineate various dimensions of the rapeseed chain in the PRC.

In the following five analytic chapters, three topics are discussed including: (1) technical changes in rapeseed and its byproducts, (2) policy changes and standardization of production and distribution of rapeseed and its byproducts, and (3) the development of the rapeseed commodity chain. In Chapter 4, I examine the historical transformations of the technoscientific system for the last five decades. I show how this process has been strongly

influenced by the changing notion of what constitutes *good technoscience* and *good technoscientists*.

The analysis of the bibliographic data is followed in Chapter 5 in order to delineate the interaction between rapeseed R&D and production activities. I demonstrate on the one hand that the rapeseed R&D community in the PRC has been vulnerable to fluctuations in the political climate. Moreover, that the recent reform effort has tremendous impact on shifting the rapeseed R&D agenda in the nation. On the other hand, rapeseed R&D activities in the PRC have *affected* and have *been affected* simultaneously by both domestic and overseas activities pertaining to production, distribution, and consumption of rapeseed and its byproducts.

Then, the next three chapters focus how technoscience, grades and standards¹⁶, and values and ethics create, maintain, and change uniformity in both things and people. I argue that these three mechanisms together, though they appear unrelated, help to create modern capitalist markets. Successful technical change and formal standards are effective in: transforming things into commodities and people into market participants, strengthening linkages among actors in the commodity chain, and expanding the network.

The final chapter summarizes my findings pertaining to the interrelationship between economic development and the modernization of S&T. I sketch some lessons from this study for international development theories and practices, and suggest future studies needed on the subject.

¹⁶ Unless I specify otherwise, by grades and standards, I mean *formal* grades and standards.

Foreign words are italicized except those commonly used in English. All transliteration of Chinese terms is in the *pinyin* system of romanization of Mandarin (or *putonghua*), unless otherwise noted. Moreover, both Japanese and Chinese names are given in the customary order of the family name proceeding the given name, such as Mao Zedong, Zhou Enlai, and Tanaka Kakuei.

Chapter 2

THEORETICAL FRAMEWORK

INTRODUCTION

The twentieth century has supposedly been a period of technoscientific progress. Nearly every day a news report informs us about a revolutionary innovation in S&T. We are repeatedly told that the world is getting smaller and smaller because the rapid development of telecommunication and transportation technology has made it possible to link people around the world. For example, in 1995, 47.4 million Americans were projected to have traveled abroad (USDC 1996). The number of Americans who have regular access to Internet service is expected to increase from 31.3 million in 1997 to 45 million before the beginning of 1999 (Editor and Publisher 1997). In medical science, new AIDS drugs developed by Dr. David Ho, known as proteolytic enzyme inhibitors, have shown promising results in suppressing the replication of the HIV virus. This excited some to even predict mistakenly that the end of AIDS epidemic might be coming (Elmer-DeWitt 1996; Johnson 1997).

No wonder that many freshmen and sophomores in Introduction to Sociology classes in my university express openly and honestly their disbelief that a large portion of the world population today live with the average annual income of less than \$730 (World Bank 1997:

214-215).¹ Indeed, during the twentieth century, the great divide between the developed and developing/underdeveloped worlds has been solidified, and inequality between the two has increasingly grown. For those who live in so-called Third World (developing, underdeveloped, non-Western, or traditional) countries, it certainly does not seem that the world is becoming more accessible to them. Instead, the distance between their world and the rest seems to be increasing. Even with the constant development of new drugs and treatments, many infectious diseases, that have been nearly eradicated in developed countries, continue to be common in many Third World countries. Their infant mortality rates remain high and their life expectancy stays low because of lack of access to adequate health care, nutrition, and other basic needs. Moreover, many struggle to sustain means for supporting their family with bare minimum necessities. If it not has been directly responsible, technoscience seems to have contributed to this widening gap in the quality of lives between the developed and developing/underdeveloped countries.

Another great divide seems to be emerging within social sciences between those who study technoscience in developed countries, and those who study the lack of it in developing countries. On the one hand, scholars of SSST have been occupied with observing how technoscientists construct their product (e.g., claim, technology, method, equipment) by enrolling various actors in their labor process through such activities as grant seeking, experiments, report writing, publishing and lecturing. On the other hand, scholars of SSID continue to be occupied with the question of why some products of technoscience are adopted by the final user and others are not. In short, little attempt has been made by either

¹ The GNP per capita of 133 countries are used here, based on the 1995 dollars. Forty three countries below the GNP per capita of \$730 are classified as "Low-Income Economies."

the SSST or the SSID to understand what happens between the creation of a given technoscientific product in the laboratory, and the acceptance or rejection of it in the field.

In the next two chapters, I will discuss theoretical and methodological approaches that may be useful for linking these diverging fields of social science together and for developing a better understanding of the process of technical change from laboratory to farm field. This chapter compares various theoretical approaches used in SSST and SSID, and then, discusses theoretical issues addressed in this dissertation research. The next chapter presents how this study incorporates actor network theory into commodity chain analysis (CCA) as a methodological approach. This allows me to trace simultaneously things (i.e., rapeseed and its byproducts) and people (i.e., human actors in the rapeseed chain) from laboratory to farm field and supermarket. Moreover, by integrating strengths of both the SSST and the SSID, this methodological approach enables me to address issues relevant to the interaction between technoscience and development.

This chapter consists of four sections. The first section examines two dominant theoretical approaches to technical change in agriculture used in SSID including: the diffusion of innovations model and the induced innovation model. I argue that these approaches use an idealistic view of technoscience, and fail to recognize the existence of complex social interaction that affects the fate of technoscientific endeavor in a given social setting.

In order to debunk this naïve view of technoscience that dominates SSID, the next two sections discuss key issues in the history of SSST, particularly the transition from the older approaches, represented by Kuhn, Feyerabend and Merton to the newer approaches, including the social constructionist approach of Knorr-Cetina (1981), and Latour (1987, 1993) and his colleagues (e.g., Bijker, Hughes and Pinch 1990; Callon and Latour 1992).

First, I will summarize the former in order to delineate their contributions to the development of the latter, and show the major differences between the two. Second, I will evaluate theoretical strengths and weaknesses of the new approaches, including the principle of symmetry employed in the social constructionist approach.

The fourth section is used to discuss how value and ethical issues can be addressed in the study of agricultural technoscience, using the principle of symmetry. The section tries to integrate a wide range of literature concerning agricultural development, technoscience, and agroecology to show how the value of uniformity becomes important in the development of *both* modern S&T and the modern market economy.

THEORIES OF TECHNICAL CHANGE IN AGRICULTURE

In the last four decades, the importance of agriculture in economic development has been recognized in various social sciences. Many theoretical approaches in the development literature,² either implicitly or explicitly, stress the importance of building a nation's capacity for agricultural R&D as a major determinant for success in agricultural development. They have indicated that the development and utilization of appropriate technology and communication channels necessary in farming enables the improvement of agricultural capacity.

² Some of the major theoretical approaches include: dual-sector models (e.g., Johnston and Mellor 1961; Lele 1975; Lewis 1954; Ranis and Fei 1961), dependency theory (e.g., Frank 1972; Prebisch 1963; Singer 1950; Wallerstein 1974a), and agricultural sector models (e.g., the resource exploitation model, the conservation model, the location model, high payoff input model). See Hayami and Ruttan (1990) and Staatz and Eicher (1990) for the detailed reviews on various models in development economics. For more anthropological and sociological perspectives, see Cernea (1985b), Chambers (1983) and Norgaard (1994).

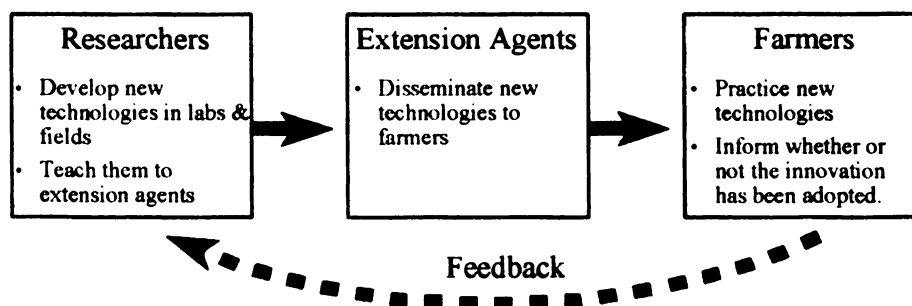
Below I examine two such approaches in SSID: the diffusion model and the induced innovation model. Despite many criticisms from those inside and outside of SSID over the last two decades, these models continue to dominate in development policies, programs, and research projects. The review of these models help us understand the two diverging directions in examining technical change in agriculture.

The Diffusion Model

In the last several decades, use of the diffusion model has accelerated the institutionalization and professionalization of agricultural technoscience. The model helped to define that there are three distinctive functions in agricultural development including education, research, and extension (Hayami and Ruttan 1990). According to this model (Rogers 1983), scientists develop new technologies in the laboratories and experimental fields, and teach them to extension agents who disseminate them to farmers (see Figure 2.1). Although the three functions of teaching, research, and extension are integrated in the ideal agricultural R&D system, the communication flow in this model is one way. Feedback in this model is limited to the rate of diffusion of particular innovations. In other words, farmers are asked to inform the researcher or extension agent whether or not the innovation has been adopted (Ruttan 1990). Moreover, the diffusion model assumes the superiority of researchers over farmers in answering technical problems in farming. Therefore, it is the direct result of farmers' ignorance if the innovation is not adopted.

On theoretical grounds, this model combines the neo-classical theory of firms and humans as rational economic beings with the Cartesian method of reductionism in technoscience. Thus, the model emphasizes individual behaviors (or the behaviors of

individual firms) for success/failure in producing (technoscientists), distributing (extension agents) and adopting (farmers, companies) a given technical innovation on a specific commodity. In this model, it is irrelevant how various production activities are organized around that commodity. Therefore, for example, a farmer's decision to reject a new rapeseed variety has no connection with his or her linkages with neighboring farmers who lost their money from that particular variety, or elevators who refuse to purchase grain of that variety. In short, the difference between production and research in their goals, tools, expertise, and organizations is of no importance in understanding the process of technical change.



Source: Busch et al. (1991)

Figure 2.1 - The Diffusion Model.

Moreover, since these linkages among actors surrounding a commodity are not a concern, the model pays little attention as to how a given technical innovation might affect the entire commodity production processes and the distribution of wealth, income, status, and power among human actors surrounding that commodity. Using the technological determinist view, new innovations are treated as always something good for society because they improve production activities and the quality of our lives. In this model, new innovations are also

silver bullets to solve problems of hunger, poverty, and inequality in the world. They are there to ensure the availability of, access to, and adequacy of food (or three A's of food security) for the world population. Therefore, *right* innovations can and should be diffused to any place in the world regardless of specific physical and social environments surrounding agricultural production. This is possible because there is "a single, objective social and physical world in which we all live" (Busch et al. 1991: 43).

However, critical studies of agricultural R&D in development (e.g., Altieri 1990; Biggelaar 1991; Bird 1987; Busch et al. 1991; Cashman 1991; Croll and Parkin 1992a, 1992b; Ingold 1992) show that the reality is socially constructed and that it is a product of negotiations among actors, both human and nonhuman, at a particular time and space. Using case studies, these authors demonstrate that new products of technoscience are not necessarily always good for society, or a symbol of social progress at all. These studies suggest that researchers ignore the existence of other actors surrounding a given technical innovation, and try to impose the world they construct on other actors.

Contrary to the ideal agricultural R&D system in Figure 2.1, in reality reports from extension agents and farmers' concerns for production activities are rarely incorporated into research decisions in the U.S. (Busch and Lacy 1983). This problem is even more profound in the Third World (Biggelaar 1991; Busch et al. 1991). There are countless stories about how the direct transfer of a given technical innovation from one location to another has failed. However, such failures are often dismissed as problems with society and nothing to do with the nature of that particular innovation. In short, the diffusion model fails to consider the institutional nature of knowledge production processes because the model views

technoscience as something separable from the rest of society. The model rejects the idea that technical issues in an innovation are also social issues.

To date, the diffusion model dominates in the international development effort. This model has provided development agencies and R&D institutions with a justification for neglecting to deal with distributive justice issues surrounding technical change. As Deo and Swanson (1991) note, the goals of agricultural R&D in Third World countries have increasingly moved away from protecting the well-being of humans by achieving three A's of food security. Instead, governments, aid agencies and private companies desire technical innovations to accumulate the wealth of nations. Indeed, agricultural R&D in many developing countries focuses on export (i.e., cash) crops rather than domestic food crops, and thereby limits its direct benefits to a small portion of the population in each country. Consequently, products of the modernized agricultural R&D system based on technoscience have removed farmers from their traditional role in developing technical innovations, and have increased their dependency on institutionalized research and extension services located outside of their villages as was the case in the Green Revolution (Bailey 1991; Juma 1989; Lipton and Longhurst 1989).

The Induced Innovation Model

In the induced innovation model (Hayami and Ruttan 1990; Ruttan 1982; Ruttan and Hayami 1990), technical change is viewed as endogenous to the development process based on historical evidence that different countries pursue different paths of technological change in the process of agricultural development (Ruttan 1990: 94). Ruttan (1982) shows that

technological innovations are developed not based entirely on scientific/technical merit but also in response to relative scarcity of factors of production.

Compared with the diffusion model, this model tries to address some of the important distributive issues surrounding the agrofood system. It emphasizes that institutions (both public and private) need to be transformed in ways that are compatible with cultural and resource endowments of a society in order to create sources of new knowledge and technology, and increase efficiency and effectiveness of a society (see Figure 2.2). Hayami and Ruttan (1990) particularly stress changes in such policies as land tenure, property rights and family planning, for ensuring both efficiency and equity in community development. In one sense, the induced innovation model represents a significant step forward in understanding strategic issues surrounding the development of an effective agricultural R&D system. Unlike the diffusion model, which disregards the institutional nature of technical changes, this model explicitly, though rather superficially, articulates the interrelationship between technoscientific development and institutional development.

On the other hand, the induced innovation model, like the diffusion model, assumes that only modern technoscience can foster economic development. It further maintains that these institutional adjustments are necessary *conditions* for the development of technoscience. Ruttan and Hayami (1990: 107, emphasis added) note: "the issue of how to organize and manage the development and allocation of *scientific and technical* resources becomes the single most critical factor in the agricultural development process." Moreover, this model does not concern the *consequences* of technical change for activities, social relations, and ecosystem surrounding agrofood production, distribution, and consumption.

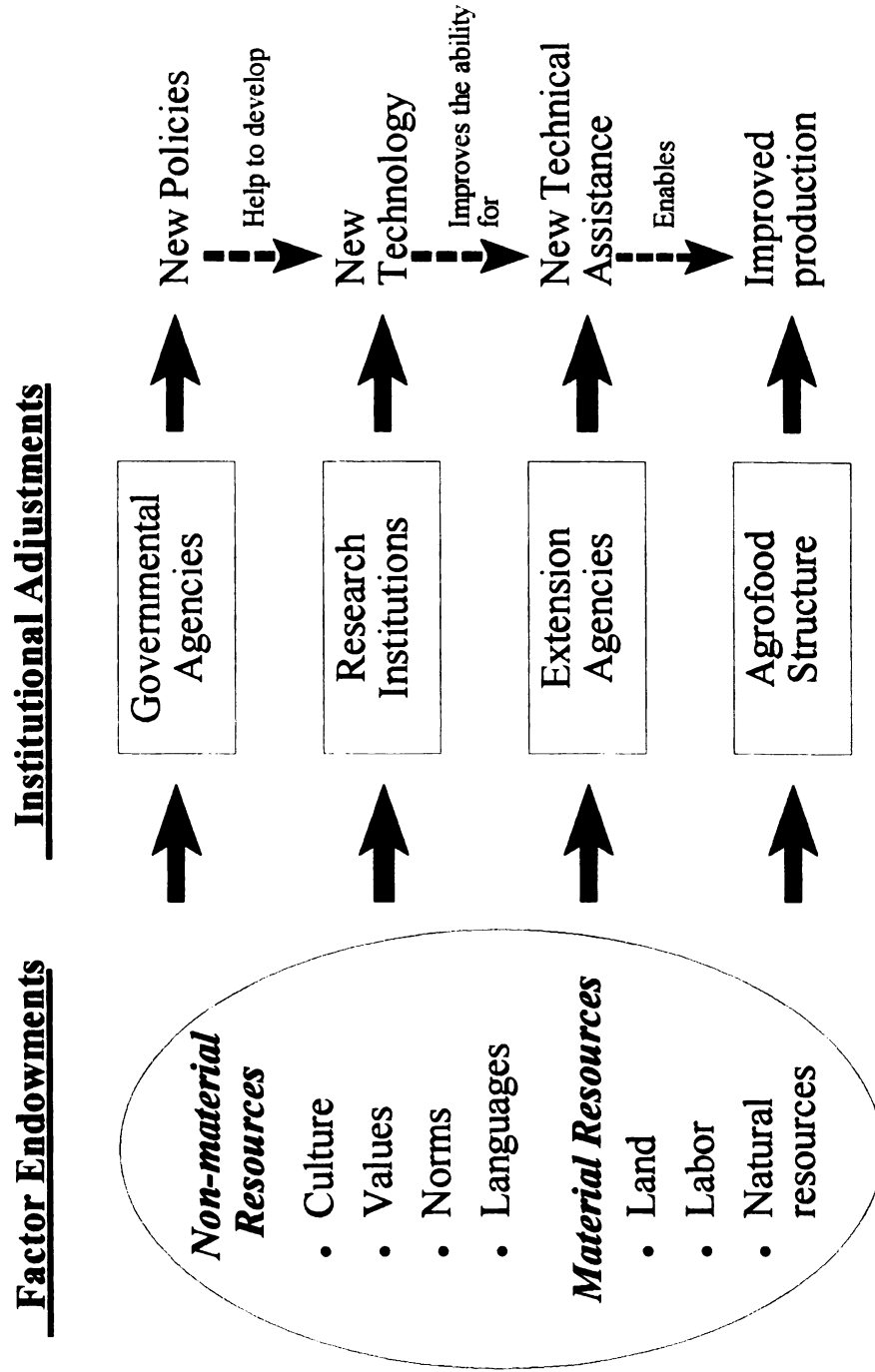


Figure 2.2 - The Induced Innovation Model.

Furthermore, the model assumes that the market determines what the relative factor scarcities are in a given society. Based on this information, the public supports R&D as the result of an democratic policy making process. Yet, such an open policy making process does not exist particularly in many Third World countries, mainly because of constant political instability, and legal and financial restrictions imposed on farmers, marketers, processors, retailers, and consumers. Moreover, interests of actors surrounding an agricultural R&D program often conflict with each other. For example, high protein wheat is desired by bread manufacturers while the protein content is inversely correlated with the yield of wheat (Busch et al. 1991). However, it is clearly not the market that determines whether the protein content of wheat should be high or low. Therefore, technical change involves negotiations, persuasion, and coercion among human actors with distinctive interests. And, the resulting decisions reflect the power relationships among these actors in a given society.

Consequently, various premises of this model do not correspond to the actual decision making process about resource and cultural endowments in society. It ignores the fact that the developed nations have a powerful influence on certain R&D projects to be pursued or not pursued in Third World countries through international aid (e.g., Perkins 1990). Moreover, institutional innovations (e.g., structural adjustment policies) in Third World countries are also often forced on them by the developed nations. For example, we can attribute success in Japanese land reform to the initiative of and pressure from the U.S. for social reforms during the post-war period (Hayami 1975; Ogura 1970). In fact, although the induced innovation model theorizes that there is a relationship between R&D policies and relative factor scarcities, the model does not empirically investigate it beyond statistical analysis of aggregated data. In short, this gap between the model and reality in the decision

making process never narrows because the proponents of the model never examine activities of participants in the process. Therefore, the model neglects to consider the importance of political empowerment among various social groups.

The main weakness in both of the above models stems from the notion that technoscience is inevitably a beneficial activity in society. Supporters of the first model do not even question that technoscience is an autonomous activity independent from other social spheres. Proponents of the second model argue that relative factor scarcities, determined in the market, drive the political process of funds allocation, or that if they do not, they should. Consequently, both models fail to recognize the existence of resource relationships (e.g., funding agencies, colleagues, governmental agencies, industrial companies, suppliers of instruments and materials, clientèles) surrounding the process of technoscience. Since the process by which a technoscientific product is created is completely blackboxed, whatever has survived the process is assumed as *good* for potential users, and therefore for society as a whole.

However, history does not support their claim that agricultural R&D ensures the well-being of people. For example, Giedion (1975) shows the social consequences of several technological changes that were made in the last century in the agrofood system (e.g., Swift's refrigerated rail cars, tractors and harvesters, mass production of bread). These and other innovations, developed by the application of modern technoscience, have encouraged increasing substitution of on-farm activities by off-farm and industrial processes (Goodman, Sorj and Wilkinson 1987). Busch et al. (1991) describe how technological changes affected the transformation of wheat and tomato commodity chains. All these cases disclose that

products of agricultural R&D do not necessarily benefit everyone. On the contrary, they produce undesirable and unanticipated impacts on society, such as the displacement of farmers and factory workers, the degradation of soil and water, and the creation of super-pests. Busch et al. (1989:127) make a forthright point that:

The conclusion that technical change does not benefit everyone in the same manner implies its dependence on societal arrangements. The genesis of technical change is part of the enterprise to satisfy human wants and needs which vary according to group membership.

Yet, the effort to refute the idea of autonomy of technoscience has not yet been successful, at least within the SSID community. Until recently, the process of knowledge production was not a concern for many students of international development. Those who have been dissatisfied with the diffusion model or the induced innovation model went outside of their field to seek alternative theoretical approaches to understand the process of technical change. They found some answers in the work of SSST. Now, let us review some key ideas raised in that literature.

OLDER SSST APPROACHES: KUHN, FEYERABEND AND MERTON

Today, we can find numerous examples where technoscience as a social institution comes under attack in news reports, magazine articles, science fiction, movies, television programs, or other media. Regardless of our educational background and professional training, we have come to question the validity and reliability of various technoscientific products more than ever before. In the flood of contradictory information, we also have to weigh various pieces of evidence and decide by ourselves which claims to believe and not to believe.

It has been a long and difficult voyage to establish the notion in our society that technoscience is socially constructed. As mentioned in the previous chapter, the emergence and development of SSST has been closely related to the history of contradictory roles played by technoscience in society. On the one hand, technoscience represented the answer to speedy recovery from devastation from the two world wars and a step forward to our glorious future. On the other hand, our blind faith in technoscience for solving every social problem from health to poverty justified rapid and ruthless mechanization of agriculture and industry in the 1950s and 1960s, and consequently, led to a future tainted by a new set of social problems (e.g., global warming, loss of biodiversity, environmental degradation, drug addiction, obesity).

In the section below, I will examine the works of three early figures in SSST who paved our way to a new conceptualization of science. Few in current SSST deny their contributions to establishing a new field of social science. These three scholars were distinctive from the previous generations of philosophers and historians of S&T in that they placed social processes, rather than *cognitive* and psychological processes, of constructing knowledge at the center of their analyses.

Kuhn's Paradigm Shifts

In The Structure of Scientific Revolutions, Kuhn (1970) asked: What is the nature of science? Why has the scientific enterprise been successful in our society? However, he was not interested in the cognitive process of science, but actual practices of scientists. Moreover, he brought to our attention that science is not the work of individual scientists, but that of the *community* of scientists.

By examining historical shifts in physical theories, he argues that science is not developed through the accumulation of individual discoveries and inventions, as science textbooks describe. He describes science as a process of solving puzzles and replacing one paradigm with another by *revolution*. According to Kuhn, *paradigms*³ provide scientists with a basis for further articulating and specifying replications in science. In other words, the quality of a given paradigm is determined by comparing predictions from the paradigm with the physical world as well as with those from the other paradigms. Therefore, according to Kuhn, scientific knowledge is constructed *collectively*, involving a social process.

However, Kuhn (1970: 94) argues that different paradigms within a given field of science are *incommensurable*:

[T]he choice between competing paradigms proves to be a choice between incompatible modes of community lives, ... [and therefore] the choice is not and cannot be determined merely by the evaluative procedures characteristic of normal science.

On the one hand, he sees different paradigms in science as representing different *beliefs* within the scientific community. On the other hand, he also considers normal science as a process of puzzle solving. He notes that to learn about a given field of science is to learn how to use instruments and tools of the field in order to put together pieces of a puzzle. Here, he takes a materialist view of science where scientists share practices. This suggests that different paradigms are incommensurable, not necessarily because of different beliefs among scientists, but because of different practices among them. However, he does not go further to articulate this relationship between ideas and materials in science. And, he fails to recognize that a

³ Kuhn (1970: 10) writes, “some accepted examples of scientific practice -- examples which include laws, theories, applications, and instrumentation together -- provide models from which spring particular coherent traditions of scientific research.”

group of scientists who share the same belief may reach different conclusions about a given phenomenon because of different instruments which produce a wide range of interpretations of the same data.

Another, and more important, problem with Kuhn's work is that he rests the selection of a scientific paradigm solely on debates among scientists, leaving non-scientists as outsiders to the scientific revolution, and thereby taking an internalist approach to the study of technoscience. Despite his insight that science is a social process, Kuhn treats the scientific community as something separable from the rest of society. Therefore, his work is still far from finding a link between science and society.

Feyerabend's Anything Goes

Feyerabend (1975,1978) agrees with Kuhn's criticism that the history of science should not be presented as the history of successful individuals which is separable from the rest of history. His major contributions to the SSST include his assertion that science is one tradition among many kinds of knowledge in our society, and his emphasis that language is a means of developing worldviews. In fact, these views reveal his position as a social constructionist. But, he goes so far as to say that all there is are social constructs.

For example, Feyerabend (1975: 21) rejects the linear notion of scientific progress, and proposes "anarchism in science," that is, "absolute freedom of speech, debate, and expression." He emphasizes an *open* society which accepts the maxim "anything goes." In his view, everyone should be allowed to make decisions as to what knowledge is to be accepted in our society regardless of its grounding in science. However, his anarchism leads us to question where the regularity of the world as we comprehend it comes from. For

Feyerabend, it is a matter of individuals constructing reality without any constraints imposed upon them by social institutions (e.g., schools, family, churches, politics, workplaces). In short, he totally disregards the institutional nature of the knowledge production process.

There is another version of social constructionism, that is, that there is a real world out there, but it can be known through numerous worldviews, each of which can selectively reveal certain aspects of it. Contrary to Feyerabend's assumption, human beings develop various methods to regularize the world so that it will become more comprehensible. For example, existing works in ethnomethodology (e.g., Cashman 1991; Croll and Parkin 1992a, 1992b; Ingold 1992; Norgaard 1981, 1994; Richards 1985, 1989) show that each ethnic group has its own set of norms to mutually interpret the world which its members share. And, different methods used by different groups to understand a given natural phenomenon often lead to diverse conceptions of the world.

Merton's Autonomy of Science

Merton (1973) recognizes the *reciprocal* relations between science and other social institutions in their social development. He argues that there are multiple worldviews, each of which challenges the validity and legitimacy of the others. According to Merton, a particular worldview is formulated by social bases (e.g., status, class, gender, race, ethnicity, institutional affiliations) and cultural bases (e.g., values, interests, ethics) in a given historic time and space. Moreover, he (1973: 175) argues that there is interdependence among different social institutional spheres because "[t]he same individuals play multiple social statuses and roles: scientific and religious and economic and political." Therefore, science, though seemingly distinct from other institutional spheres, is only partially autonomous in our

society. For example, he notes that major values and interests of the time can also influence scientists on the choice of investigative problems.

In Merton's view, appropriate cultural conditions are required for the autonomy, development and continuity of science as a social institution. He (1973: 185-186) explains that the fundamental difference between science and other social institutions is its valuing autonomy in scientific inquiry:

Science gradually acquired an increasing degree of autonomy, claiming legitimacy as something good in its own right ... as the quest for physical well-being or for personal salvation. Once science was established with a degree of functional autonomy, the doctrine of basic scientific knowledge as a value in its own right became an integral part of the creed of scientists.

Moreover, Merton (1973: 260) even goes further to argue that science *should* enjoy a high degree of autonomy when compared with other social institutions:

Science must not suffer itself to become the handmaiden of theology or economy or state. The function of this sentiment is to preserve the autonomy of science.

Neither Kuhn's internalist nor Feyerabend's anarchist approach deal in depth with the question of who and with what criteria certain knowledge is evaluated in society as good or bad in relation to particular political and economic contexts. Moreover, Merton's investigation does not go beyond describing institutional characteristics of the scientific community (e.g., reward system, evaluation system, age structure).

However, their contributions to the new generations of the SSST should not be underestimated. Kuhn's recognition of science as practice has provided impetus for laboratory studies (e.g., Latour 1988; Latour and Woolgar 1979) and controversy studies (e.g., Collins 1985) which directly examine how technoscientists actually engage in

technoscientific activities. The works of Feyerabend have inspired students of non-Western technoscience (e.g., Goonatilake 1984, 1992; Hess 1995; Richards 1989) and feminist studies of technoscience (e.g., Haraway 1989; Harding 1986, 1991; Keller 1983) to challenge the hegemony of Western technoscience and examine other ways of knowing. Finally, it was Merton who paved the way by treating technoscience like any other social institution.

THE PRINCIPLE OF SYMMETRY AND THE NEW SSST

In the last two decades, SSST have made significant departures from the previous approaches in that the principle of symmetry has been greatly extended. Woolgar (1992: 334) notes that "the concept of symmetry distinguishes different phases in the history of [the SSST]." Merton (1973) proposed a symmetric relationship between science and other social institutions. Bloor (1976) articulated the concept of symmetry as a methodological principle by treating both correct and false knowledge claims equally.

More recently, Latour (1987: 258) has extended this principle as seven rules of method in SSST. He presents six symmetrical relations including: (1) technoscience already being made vs. technoscience in the making, (2) creators vs. later users of technoscientific products, (3) Nature vs. Society, (4) inside vs. outside of a given social network of technoscience, (5) perspectives which arise when going away from vs. when coming back to the network, (6) materials vs. ideas. This greatly extended principle of symmetry has had an enormous impact on the SSST in their methodological approaches to studying technoscience in action. Moreover, this principle has helped to develop a theoretical understanding of the role of technoscience in the relationship between the natural and social worlds.

Technoscience as Building Networks

First, the new SSST have moved away from the notion that technoscience is an autonomous activity independent from other social spheres, and has shown that processes and products of technoscience are both affected by and affect social relations surrounding a particular technoscientific activity. This new SSST deconstructs idealized descriptions -- employed by Kuhn and Merton -- of technoscientific practices and of norms among technoscientists that prescribe their behaviors. And, it articulates the relationship between cognitive (paradigm as a belief) and material (puzzle solving by shared practices) aspects of science with an assertion that validity in technoscientific work is the outcome of social negotiations, and that "[t]ruth ... is a social phenomenon" (Clarke 1990: 17).

Second, from a methodological point of view, these recent works in SSST, unlike previous ones, obtain their claims from empirically-based and, what Pickering (1992a) calls, *naturalistic* studies of real technoscience in the making, past or present. For example, laboratory studies (e.g., Knorr-Cetina 1981; Latour 1988; Latour and Woolgar 1979) explain the socially constructed nature of technoscience by directly observing actions of researchers, and both material and cognitive environments in the laboratories for making technoscience. Controversy studies (e.g., Collins 1985) also use a microsocial approach to analyze production of consensual knowledge out of technoscientific disputes.

These empirically-based approaches allow the new SSST to make the third departure from the previous approaches, that is, their emphasis on the instrumental (Pickering 1992a: 4) or craft (Clarke and Fujimura 1992) aspect of scientific knowledge. Those laboratory studies mentioned above show how scientists attempt to simulate a natural phenomenon and make it work in their laboratories by *tinkering* (Knorr-Cetina 1981) with *inscription devices*

(Latour 1987). However, the phenomenon observed in the laboratory is locally specific, tightly controlled and managed by the scientists using instruments. Such inscription devices as texts, graphs/charts, instruments, measurements, etc., used at various stages of making technoscience, enable the construction of certain societies. O'Connell (1993: 130) calls such societies "material collectives -- communities of persons and institutions mutually exchanging the same representations and material representatives for abstract scientific entities." It is this instrumental aspect of science that allows a locally specific phenomenon in laboratories to become an *immutable mobile*, and enables these technoscientists to describe themselves as loyal to technoscientific truths and to present their research results as value-free.

Fourth, the new SSST applies the metaphor of system (Bijker, Hughes and Pinch 1990) to studies of technoscientific activities with an emphasis on the agency of technoscientific actors. Any technoscientist maintains a variety of relationships with colleagues, practitioners, funding agencies, governmental agencies, industrial companies, suppliers of instruments and materials, and their family members. For example, in the process of transferring the research question and outcome outside the laboratory, technoscientists use various political strategies to organize non-researchers (e.g., foundations, government agencies, farmers, consumers, university administrators, etc.). Moreover, Knorr-Cetina (1981: 7) shows that scientists constantly base their decisions on "the expected response of specific members of [the] community, or to the dictates of the journal in which they wish to publish."

This is the case because not only technoscientists in a given field but also non-technoscientists have a motivation to participate (e.g., funding) in a R&D project, and an interest in the outcome of the research. In a capitalist society, it has been suggested that these

networks are formed surrounding the profit motive -- not only economic but also political and social -- of actors involved in the process of knowledge production (Bijker, Hughes and Pinch 1990; Knorr-Cetina 1981; Latour 1987). These works have explicitly shown that the effectiveness of technoscientific products in society largely depends on the strength of networks that link these particular interests, motivations, and perspectives of human and nonhuman actors involved in a particular R&D program. As Hagendijk (1990: 48) notes, "[w]ithin this 'transepistemic' context scientists are required to handle both natural and social phenomena." In short, a technoscientific fact is socially constructed in a network of *transcientific fields* from a infinite number of potential ways of looking at the world. Moreover, this actor network approach to SSST has also extended our attention beyond laboratories and technoscientific communities, and has encouraged us to examine the construction of a given technoscientific product in society at a given time and space.

Finally, the symmetric treatment of human and nonhuman actors has removed humans from their previous central role in the creation of technoscientific products (e.g., Bijker, Hughes and Pinch 1990; Callon 1986; Callon and Latour 1992; Latour 1987, 1993; Latour, Mauguin and Teil 1992; Woolgar 1992). In this view, the direction of technoscience largely depends on the ability of technoscientists to enroll *both* human and nonhuman actors and to build strong associations between technoscientific arguments and the actors. According to the principle of symmetry, there are four reasons why nonhumans should be given a position equal to humans in networks of technoscience:

- (1) Technoscientists constantly try to bring natural objects to bear on their debates among colleagues and among other human actors.
- (2) Nonhumans participate in settling controversies in technoscience.

(3) Humans have no thinkable social life without the participation of nonhumans; by the same token, contrary to the assumption of Collins and Yearley (1992) things or nonhumans have a social life of their own (Appadurai 1986b).

(4) Changes in the social world simultaneously imply changes in the natural world, or vice versa.

This position is quite different from earlier social constructionist approaches taken by the Edinburgh School (e.g., Barnes 1974, 1977; Bloor 1976; Shapin 1979; Shapin and Schaffer 1985) and the Bath School (e.g., Collins 1985).⁴ As Latour (1993: 4, emphasis added) notes: "...science studies are talking *not* about the social contexts and the interests of power [as these two schools have insisted], but about their involvement with *collectives* and *objects*." By collectives, he means the associations of humans and nonhumans, of which society is only one part. Further, he argues that the proliferation and stabilization of hybrids or quasi-objects (i.e., products of technoscience) show this separation between nature and society problematic and ambiguous, because each hybrid varies in the degree of *social-ness* and *natural-ness*.

Collins and Yearley (1992: 108) criticize this principle of symmetry and argue that technoscientific activities can be only understood from a social realist position, that is, "experien[ing] the social world in a naive way, as the day-to-day foundation of reality." Callon and Latour (1992) respond by noting that this social realist position in SSST contributes to the view that natural scientists have hegemony in defining the distribution between what is natural and what is social since these scientists are given power and autonomy to "naively experience the natural world" (Collins and Yearley 1992: 108). They further argue that we can no longer explain society by nature, or explain nature by society;

⁴ See Pickering (1992a) for a summary of the history of the SSST.

both society and nature must be simultaneously explained by quasi-objects since "'natures' and 'societies' are secreted as by-products of [the] circulation of quasi-objects" (Callon and Latour 1992: 349).

Critical Evaluations of the Principle of Symmetry and the New SSST

The new SSST has provided a wide range of both theoretical and methodological entry points in studying technoscience by rejecting technoscience as a purely individual cognitive process designed to reveal an objective reality. Besides laboratories and technoscientific controversies, the growing literature in the new SSST has analyzed different elements of the technoscientific processes including: bibliographic references (e.g., Juska and Busch 1994), scientific texts (e.g., Latour 1987; Woolgar 1988), tools (e.g., Clarke and Fujimura 1992), measurements (e.g., O'Connell 1993), and testing (e.g., Pinch 1993). This has enriched the SSST as an academic field, allowing its students to promote technoscience as an important topic of inquiry in our society and, more importantly, to challenge existing disciplinary modes of scholarship.

Second, examination of technoscience as practice and culture in our society has contributed to our understanding of the relationships between ideas and materials, or the social/cultural world and the natural/physical world, in the construction of technoscientific knowledge. Although scholars vary significantly in their approaches within social constructionism, one thing is clear: both humans and nonhumans *do* play a role in collectively constructing technoscientific knowledge. Particularly, the actor network approach is useful in explaining how different conceptions of technoscience are the outcome of dissimilar types of networks surrounding the same type of R&D project.

Finally, the principle of symmetry has allowed us to shift our attention from the causes to the consequences of technoscientific endeavors. Such dichotomies as truth/falsity, subjectivity/objectivity, nature/society and so on can be no longer viewed as causes to explain why technoscience maintains such a dominant position in our society. Instead, we can begin to understand that the weaknesses of other knowledge systems comes not from the lack of validity of their knowledge *per se*, but from weak linkages among human and nonhuman actors within their networks. Moreover, by examining the emergence, maintenance and transformation of a social network among human and nonhuman actors surrounding a given R&D project, we can illuminate simultaneous changes in the social and natural worlds in a given society during a given time period.

However, the new SSST is not without weaknesses. First, as Fuller (1988) points out, the laboratory studies have concentrated their attention on decision making by technoscientists as producers of knowledge with the assumption that only technoscientists practice *technoscientific research* to advance social knowledge. Despite their emphasis on the symmetric treatment of humans and nonhumans, the major methodological threshold in the works by Knorr-Cetina (1981), and Latour (1987, 1993) and his colleagues (Bijker, Hughes and Pinch 1990; Callon 1986) has been to follow technoscientists, and to examine their interactions with other human and nonhuman actors rather than the other way around. Consequently, this principle of symmetry tends to privilege technoscientific communities. However, knowledge does not necessarily distribute power to those who create the knowledge, and technoscientists are often not entirely in control of their own activities (Fuller 1988; Rouse 1987). Nonhuman actors do affect activities of human actors in participating in the knowledge construction process. Thus, an explicit portrayal of the characteristics of

nonhuman actors over time and space is needed in order to illuminate the role of nonhuman actors in technoscientific processes.

The second criticism is closely related to the first. That is, because of the focus on technoscientific activities, SSST until very recently had a tendency to neglect the examination of various distributive issues of political economy in relation to technoscientific activities. Of particular interest is the interaction between technoscientific and market activities, and the role of technoscience in the economic growth of non-Western countries.⁵ However, any product of technoscience always (re)distributes wealth, income, status and power within society, and (re)socializes nature. Indeed, some scholars have already begun to address these issues on a more theoretical level. For example, Latour (1993) discusses the role of technoscience in creating and solidifying the hierarchy of knowledge systems, and the distribution of power. Murdoch (1994) suggests the actor network theory approach be applied when examining the rural economy. From a more empirical stance, Busch and Tanaka (1996) use quality standards to link technoscientific activities with market activities. Yet, more empirical studies are needed in this area.

Third, SSST has a tendency to concentrate on particular types of technoscience such as physics and the biomedical sciences. This tendency appears to come from the tradition of the philosophy and history of technoscience which has placed physics in the highest position in the hierarchy of knowledge, and the fact that the biomedical sciences often tend to raise

⁵ In this sense, the actor network theory approach in SSST is quite different from the interorganizational network theory (e.g., Benson 1975; Cook 1978; Galaskiewicz 1985) and the commodity chain analysis approach, which explicitly assume that power is embedded in exchange relations within the interorganizational networks, and stress the impact of negotiations among corporate actors.

more visible controversies in society than other fields of technoscience. As pointed out in the previous chapter, the number of studies on agricultural technoscience within the framework of SSST is extremely small.

Finally, until very recently, the application of the principle of symmetry to ethical and value issues surrounding technoscience has been limited to a few studies (e.g., Clarke and Fujimura 1992; Wise). Most studies in SSST in the 1970s and 1980s focused on various elements of the technoscientific processes without explicitly raising the questions of how and why the participants bring their values and ethical commitments to the process.

Students of the new SSST reject internal community views of technoscience by empirically examining how technoscience is actually made. And, they begin their analysis by redefining of what technoscientific process entails. These constructionists recognize that technoscience is more than just conducting experiments in a laboratory, trying to replicate a phenomenon using scientific methods. Instead, technoscience involves other activities such as preparing and writing grant proposals, allocating the total R&D fund to various activities, setting up a series of experiments, and writing research reports and journal articles. Therefore, they examine how non-scientists (e.g., funding agents, policy makers, industrialists) and nonhumans (e.g., tools, equipment, experimental animals, texts) are enrolled in shaping a given research project from its conception, to its execution and completion.

Although this constructionist SSST represents a significant departure from the older internalist approaches, as I pointed out above, there are four weaknesses including: (1) supply-oriented analysis of technoscience, (2) the tendency to ignore various distributive

issues of political economy, and (3) analysis of only selected technoscientific fields, and (4) limited application of the symmetry principle to ethical and values issues. As discussed in the previous chapter, this sociological research represents an effort to answer these four criticisms. Moreover, it is an attempt to find both theoretical and empirical common ground between SSST and SSID so as to understand the process of technical change. In the section below, let us discuss theoretical issues addressed in this study.

THE CREATION OF UNIFORMITY THROUGH TECHNICAL CHANGE

Agriculture is one of many domains through which humans experience nature. Existing studies in agricultural development implicitly suggest a number of critical value and ethical issues embedded in technical changes: *What* types of values should be addressed? *Whose* values should be incorporated? For example, the induced innovation model discussed above emphasizes that institutions be made compatible with cultural endowments of a society (Hayami and Ruttan 1990). From quite different perspectives, anthropologists and sociologists stress the integration of local (or indigenous) knowledge into development efforts (e.g., Biggelaar 1991; Cashman 1991; Cernea 1985a; Kloppenburg 1991; Richards 1989). Also, the growing literature on sustainable agriculture⁶ (e.g., Blatz 1992; Carroll, Vandermeer and Rosset 1990a; Edwards et al. 1990; Soule and Piper 1992) proposes that an ecological approach be adopted to farming practices and research activities. However, by focusing their attention on a given class of actors (i.e., governments for the first approach, and farmers for

⁶ See Blatz (1992) for numerous meanings attached to the term *sustainability*.

the latter two), they fail to provide an adequate explanation as to how values and ethical commitments of *different* human actors are negotiated.

Yet, interactions among various human actors surrounding agriculture reveal power relationships, and thereby key characteristics of society. As Strauss (1978: 5) argues: "Social order is a negotiated order." Similarly, but on a more philosophical level, Benjamin (1990) discusses how compromise is an essential but inadequately studied part of understanding human values and integrity. Both authors use an organization (e.g., a hospital) or debate (e.g., abortion) as the unit of analysis to show that diverse values come from our relationships with other humans, and that these values also shape these relationships. Nevertheless our social relationships are not limited to humans, but also include nonhumans.

Agriculture involves a chain of activities from the acquisition of farming inputs to the consumption of commodities. Human actors who are concerned with each activity of agricultural production participate in the process of shaping nonhuman (or natural) objects into socially desirable commodities through production and processing, market processes, legal and policy measures, and technical change. As discussed in detail in Chapter 7, not all things available in society are commodities, though all commodities are things. Commodities are things in a certain situation in which their exchangeability for other things is viewed at a given time and place as their social relevant features. In other words, we, humans, make things become commodities. However, at the same time, when a given thing we bring for exchange becomes recognized as a commodity, we become *market participants*. In the simultaneous transformations of things into commodities and humans into market participants, a commodity chain extends its linkages by enrolling more and more actors.

In this study, a network of actors surrounding a *thing* is used as the unit of analysis. By symmetrically examining the socialization of rapeseed into various commodities (e.g., seed, grain, oil, meal) and that of humans into market participants, I show how social order and the relationship between nature and society are negotiated in the network. Particularly, I focus my attention to the process of creating, maintaining and changing uniformity in things and human treatments of those things through technoscientific and market activities.

Uniformity and Capitalist Practices

Through technical innovation, modern capitalist agriculture has improved its ability to mass-produce and deliver highly uniform products throughout the world. Consider our grocery shopping experiences in the U.S.: When we pick tomatoes from a box with a price tag, we assume that their differences in size, taste, and shape are trivial. We don't drive around town to compare the quality of tomatoes between two or more stores. These tomatoes are available to us even when snow is on the ground in Michigan. In short, the development of uniformity has improved the certainty of American consumers (both of intermediate and final products) about the quality and the availability of these agricultural products.

Technical innovation is only one strategy to create uniformity in things. But, uniformity must be maintained by quality standards. What is unique in modern capitalist agriculture is that such standards as grain quality, weight, and kernel size are global (i.e., *immutable mobiles*) (Latour 1987) rather than local (i.e., *mutable immobiles*) (Kloppenborg 1991). The development of universal monetary exchange, measurements, arithmetic, and

machines and tools for measurement have made it possible to extend standards from local to global markets (Braudel 1992).

As Appadurai (1986a: 14) argues, "standards and criteria (symbolic, classificatory and moral) ... define the exchangeability of things in any particular social and historic context." Busch and Tanaka (1996) propose that these standards also make capitalist markets possible by objectifying criteria for exchange relationships, and by providing concrete goals for the transformation of a commodity. Moreover, standards also serve to establish more or less universal *practices* in capitalist markets.

For example, grain standards which specify the amount of inert materials and damage, color, moisture, etc. encourage farmers to perform relatively uniform practices in managing their crop, soil and water. In order to meet standards on rapeseed oil, food processing companies also use more or less similar types of equipment, procedures, and solvents to separate the oil from rapeseed. Furthermore, rapeseed which meets quality standards can be traded without the presence of buyers and sellers on international commodity exchanges. Therefore, these standards serve to increase certainty in transactions between the parties in the market, and thereby reduce transaction costs (Williamson 1975, 1985).

In short, standards transform things from singularities into commodities (Appadurai 1986b). At the same time, they also standardize human practices and exchange relationships surrounding a given commodity in order to establish and maintain the exchange value of a given commodity on the market (Buttel 1990b). In other words, humans also lose singularity in their practices and relationships, and become actors in the market.

Uniformity and Goodness

The above discussion suggests clearly that uniformity is something *good* and *necessary* for the establishment and maintenance of capitalist markets. However, different human actors surrounding a given agricultural commodity demand that different types of uniformity be created through technical changes. For example, rapeseed farmers are concerned more with agronomic characteristics of each rapeseed variety (e.g., growth rate, yield); food processors are interested in changes in the biochemical content of rapeseed (e.g., the levels of erucic acid and glucosinolates⁷). These differences in the notion of uniformity reflect conflicting values and ethical commitments each actor holds toward a given commodity and his/her role in that chain. More specifically, it involves different understandings about the quality of that commodity, and distinctive methods of demonstrating the quality of their contribution to the chain activities.

Consider MacIntyre's (1984: 58) example:

From such factual premises as 'He gets a better yield for this crop per acre than any farmer in the district,' 'He has the most effective programme of soil renewal yet known,' 'His dairy herd won all the first prizes at the agricultural shows,' the evaluative conclusion validly follows that 'He is a good farmer.'

The above text suggests that: (1) the concept of a farmer is defined in terms of the purpose or function which a farmer is expected to serve in a society, and (2) the concept of a farmer and the criteria for someone being a *good farmer* are not independent of each other. Using a case study in Emilia Romagna, Italy, however, Ploeg (1990) shows that different notions of what constitutes good farming exist from place to place, suggesting that the factual

⁷ Erucic acid and glucosinolates are allegedly toxic substances in rapeseed. Canola (or double-zero) refers to varieties of rapeseed with < 5% erucic acid and < 30 micromoles of glucosinolates.

premises and their interpretations may be contentious even within a given society and change over time and space.

In a different context, Latour (1987: 89, original emphasis) uses the concept of *trials* to argue that each *performance* by a given human (e.g., scientist, hero) or nonhuman actor (e.g., instruments) "presupposes a *competence* which retrospectively explains why [he/she or it] withstood all the ordeals." Busch and Tanaka (1996) even go further to argue that successful completion of each trial by a nonhuman actor is simultaneously a statement about both the nonhuman and the human actor. Therefore, if Farmer Mary's harvest fails to meet the minimum grade, it is discarded as a *poor crop*, while she is judged as a *poor farmer*. If good rapeseed farmers are viewed as those who achieve a high yield, then in order to demonstrate its goodness, *good rapeseed* has to germinate and mature about the same time with even density and height for maximum harvest.

Boltanski and Thévenot (1991) argue that there are multiple *domains* (e.g., of commerce, religion, politics) within a given society, each of which prescribes unique paths to achieving greatness through the accomplishment of a set of deeds and values. They note that "[d]ifferent methods for attaining greatness, correspond to different methods for testing reality" (p. 167). Waltzer (1983) uses the concept of *spheres of justice* to make a similar point that a set of distributive criteria in one sphere is not necessarily applicable to another. This multiplicity of our social world, and thus in the notions of greatness, gives individuals options for the attainment of different values and goals.

In short, the notion of uniformity is not universal, even within a given society, but is both temporal and spatial. This is because the goodness embedded in the notion of uniformity is not static, but constantly changing over time. And, the values and ethical commitments

each individual or corporate actor holds at a particular time and place contribute to the development of a particular notion of uniformity in a given commodity. However, technical changes that create uniformity in a commodity cannot, and do not have to, satisfy all the values of the commodity chain actors. In a given commodity research program, technoscientists try to estimate what kind of technical change other actors might desire. However, their values on and ethical commitment to that commodity are often not related to those held by other chain actors. The commodity chain works only because the human actors at different locations in the chain can hold different values but engage in coordinated actions.

Technoscience as a Creator of Uniformity

Since the late nineteenth century, agricultural R&D activities have increasingly become incorporated into national policies with clear goals to build capacity for S&T, and thereby to guide economic development. Within commodity chains, the government, universities and big corporations supported the replacement of local knowledge with institutionalized S&T as the main engine for technical change on commodities and production processes. The location of technical moved from farm fields and factories to laboratories; the main agents switched from farmers and factory workers to technoscientists. Moreover, technoscience provided R&D activities with more concrete standards and criteria by which researchers were: (1) to appraise their problems, procedures and results, and (2) to engage in negotiations with the other actors in the social network. This has increased the ability of researchers to enroll both human (e.g., policy makers, funding agents, farmers, industrialists) and nonhuman (e.g., equipment, tools, texts) actors necessary into R&D activities.

Empirical studies of technoscience in action discussed above have shown us that environments for technoscientific activities are regulated by either formal or informal specific standards in terms of materials (e.g., labs, tools, measurements), social relations (e.g., hierarchical relations), and cultural characteristics (e.g., norms, values, ethics). These standards also regularize the actions of scientists at each step of the technoscientific processes, by prescribing what these scientists can and cannot do. This is because these standards represent *trials* to scientists. They are motivated to make their behavior conform to the shared standards in the scientific community because their competence and greatness as scientists is measured by their performance in completing each trial. Moreover, with the compliance of scientists, these standards also regularize scientific problems, procedures and results.

O'Connell (1993: 151) shows how standards on measurement units and tools become "Nature's best representatives" that scientists can use indirectly to "tap into Nature." Rouse (1987: 113) further notes that:

[T]he 'standardization' of scientific problems, tools, procedures, and results...involves both transforming the things themselves to make them applicable outside their original setting and developing more exoteric [*sic*] interpretations that make them accessible to the nonspecialists.

Therefore, standards for scientific problems, tools, procedures, labs and results allow these scientists to become more efficient and effective in simulating a natural phenomenon in their lab, and transferring (translating) it outside the lab. By creating regularity and universality in the products of technoscientific activities, and making them become immutable mobiles, technoscience increases its power as a knowledge system (Rouse 1987).

Furthermore, these standards also provide opportunities for negotiations between scientists and the other actors within social networks surrounding a given research project. Pinch (1993) examines the activity of testing (e.g., of data, machines, skills) to argue that technical specifications are constantly appraised for their compatibility with other systems of the technology as well as with the society. Busch and Tanaka (1996) show that standards stipulate not only how a given commodity must be produced at each stage of the circulation process in the market, but also how it must be tested to meet the quality specified in them in order for that commodity to pass on from one stage to another. And, a set of standards at a given stage involves constant negotiations between buyers and sellers of the commodity as to how standards are created, maintained and changed through technical changes, market processes, and legal and regulatory mechanisms.

Standards, Technoscience, and the Agrofood System

Institutionalized technoscience has virtually transformed the agrofood sector in the West which is now characterized by: (1) specialization of production, (2) concentration of capital, land, income and power, (3) the industrial substitution of farming products, (4) the industrial appropriation of farming processes, and (5) mass-production and consumption of products (Goe and Kenney 1991; Goodman, Sorj and Wilkinson 1987). Today, for example, American farmers treat soil, and plant and harvest their crop, in a more uniform fashion within a shorter period of time than their predecessors. This has reduced labor time and increased productivity, while encouraging the expansion in farm size, reducing the number of farming households, and increasing the number of dual-income farm households (Browne et al. 1992). Technical changes in on-farm activities have also fragmented the agricultural process into

discrete segments (e.g., farming input production, seed production, processing, transportation, marketing), and therefore made it possible to appropriate each segment as a specific sector of industrial activity (Goodman, Sorj and Wilkinson 1987). Ploeg (1990: 20) points out that this externalization of farm tasks has gone so far that "few tasks remain on the farm," resulting in an increased dependency of farmers on markets. Moreover, farm products have been increasingly substituted by processed products by the industrial sector. This has reduced agriculture to a mere provider of industrial input, and separated rural communities⁸ from the farming and agrofood system by turning them into a simple source of laborers and consumers (Swanson 1990).

The nature of consumers of agrofood products in the developed countries has also changed within the last several decades. Increases in advertising affect day to day consumer behavior. We choose particular products to satisfy not only our physical needs, but also our social needs. Through our purchases, we also try to create a certain image about ourselves including our income, status, power, wealth, taste and beauty. Moreover, the growing diversity in family types⁹ has also affected our agrofood consumption patterns. For example, today we spend less time preparing food than previous generations, and thus demand more packaged and processed food (Levenstein 1988). At the same time, the improved health consciousness and environmental awareness has raised issues about what is in our food and how it is produced. In short, the mass market in the developed countries has been

⁸ Flora (1990: 169) points out rural retail trade has been restructured to "Wall-Marting and Seven-Elevening of rural America."

⁹ For example, the increase in single-person households, the increasing participation of women in the labor force, and the increase in multiple income families.

increasingly fragmented, demanding more and more differentiated products (Goe and Kenney 1991).

This and the increased globalization of capital and labor have promoted the vertical integration of agricultural activities in order to increase flexibility in agricultural production and distribution for differentiating products and to respond rapidly to changing market demand (Bonanno et al. 1994). Flexible specialization in agrofood production has become possible because standardization of farm products made it possible to industrialize each activity of agrofood production and distribution. Seasonal and regional differences in the availability of agricultural commodities have become less and less important in what kind of food consumed in the developed countries.

Consequently, the proportion of value-added created in a commodity by farmers has declined sharply, while that by food processors and retailers has increased dramatically (Busch et al. 1991). However, the last half of this century has also witnessed the increased concentration of capital not only in the farm sector, but also in the off-farm sectors. Within each sector of industrial activity, capital has become concentrated in a small number of large-scale enterprises (i.e., transnational corporations [TNCs]) (Bonanno et al. 1994).

Moreover, this standardization of agricultural commodities and market processes has fostered the establishment, maintenance and transformation of the international food order. Most agricultural commodities produced in developing countries lack the uniformity in shape, size, taste and color necessary to be traded in global markets. Therefore, the creation of uniformity of commodities through the development of capacity for modern agricultural technoscience has become a major goal for developing countries in order to participate in the global market. However, many lack the ability and resources to establish necessary

institutional mechanisms to achieve such a goal. In short, these technical innovations for standardization of commodities and farming practices altered the global agrofood system, by redistributing income, wealth, power and status within a given society, and among societies in the global market.

Uniformity and the Nature/Society Relationship

Finally, technical changes also create new realms of negotiation between human society and nature. Consider how modern agricultural technoscience in the last century achieved uniformity of commodities by transforming nature -- manipulation of genes, replacement of organic farming inputs (e.g., fertilizer, pesticide, herbicide) with inorganic ones, and mechanization of the labor process on the field. This modern uniform agriculture has improved the ability of plants and animals to reproduce, but also increased the dangers for ecological imbalance.

For example, Soule, Carre and Jackson (1990) point out that 80 to 90% of the world's calories are provided by only 10 to 20 crops, and less than 10 animal species. They further note that in the U.S. only six cultivars each occupied 42% of the soybean crop, 43% of the hybrid corn, and 38% of wheat acreage in 1980. And, the varieties of these crops have limited the genetic base. Pimentel et al. (1992) note that approximately 80% of deforestation (20 million ha/yr) is due to the conversion of forest to agricultural lands. One third of the world's harvest comes from 17% of farm land that is under irrigation; the agrofood sector consumes about 70% of the total world water supply (Soule, Carre and Jackson 1990). The

danger of crop failure due to outbreak of pests and weeds has also increased (Carroll 1990; Salick and Merrick 1990).¹⁰

This ecological damage has largely occurred simply because each actor carried out his or her duties based on his or her notion of goodness -- *good scientists* develop high yielding varieties, *good extension agents* diffuse them, and *good farmers* adopt them in order to achieve high yield. Yet, outbreaks of super pests and virulent weeds, soil erosion, water pollution and the loss of biodiversity have demanded that these actors alter their practices, and revise their concept of *goodness*.

Moreover, in this highly engineered system of society/nature, both humans (e.g., farmers) and nonhumans (e.g., soil, seed, water) rely on R&D institutions to provide new instruments and means for maintenance of the vitality of the agroecosystem and agrofood system, rather than relying solely on each actor's own ability to do so. In short, the externalization of farm tasks and natural resources, and the specialization of agricultural activities are linked closely to how technical changes affect the standardization of commodities, labor processes and institutional relations on the one hand, and the relationship between nature and society on the other. This enables humans to identify nature and society as distinctive entities and to pursue the goal of making nature submit to society, by objectifying nature and turning society into its protector, and at the same time, its destroyer (Latour 1993; Norgaard 1994). For example, the U.S. Endangered Species Act of 1973 specified criteria and standards for choosing which species are to be or not to be protected.

¹⁰ For example, the late-blight fungus (*Phytophthora infestans*) in Ireland in 1846 (Ainsworth 1981; Platt 1992), corn leaf blight in the U.S. in 1970 (Moore 1970; Wallin 1970), and *Chromolaena* infestation of pastures and plantations in the Philippines (Pancho 1983).

In fact, this selection of species became a political process. In short, the relationship between nature and society becomes the domination and control of nature by society, reducing nature to a passive respondent to human activities.

However, nature not only reacts to society, but also acts on society (Busch 1991a). The recent earthquake in Japan not only terminated and ruined thousands of human lives in Kobe, but also impaired the political and economic functions nationally as well as globally (Newsweek 1995; Time 1995). The extent of damage from this *natural* disaster was intensified by the dense population, the inadequate planning for urbanization, and the lack of preparation. In short, it was also a *human-made* disaster. And, this experience forces humans to adjust their behavior to meet the needs of nature, as volcanic and tectonic movements do not alter their behavior to meet the needs of society. Any outbreak of pests and weeds, flood, or frost similarly causes crop failures, starvation, and even worse death, and often forces farmers to migrate or change farming practices. As Latour (1993) argues, society is no longer social as nature is no longer natural. In short, nature and society participate in simultaneously shaping each other.

SUMMARY

In the first three sections of this chapter, I reviewed theoretical approaches from the development literature, the old SSST, and the constructionist SSST. I argue that a major gap between the first and third approach lies in the locus of analysis for understanding technical change. The first concentrates its effort in examining the fate of a given new technology when it reaches potential final users (e.g., farmers, factory owners). The last exclusively deals with the processes before the technology departs the hands of technoscientists.

Neither approach is adequate to understand the interaction between technoscience and development. On the one hand, the development literature treats technoscience as an exogenous variable to production, and therefore neglects to examine actual the process in which a given technical innovation is created. By blackboxing technoscience, this literature is often unable to explain why technical innovations often fail to achieve intended effects on production activities. On the other hand, although the constructionist SSST literature treats technoscience as an endogenous variable to production, little attention has been paid to technoscientific processes in the Third World. Therefore, the interaction between technoscience and development has not been adequately addressed at all in that literature either.

In the final section, I argued that an analysis of how uniformity is created in a commodity through technical change allows us to strengthen weaknesses in the current SSST literature, and address theoretical issues common to both SSST and SSID. An empirical study of the creation of uniformity offers numerous insights that help us to understand the complex interaction between: (1) technoscience and economic development, (2) society and nature, and (3) values and facts. The use of actor network theory as a theoretical framework allows me to conceptualize these three sets of symmetries in the process of creating, maintaining, and changing the network of actors surrounding rapeseed.

In the next chapter, I will introduce commodity chain analysis as a methodological approach that allows us to analyze a missing link between the creator and the user of technical change.

Chapter 3

METHODS

INTRODUCTION

In the last two chapters, I pointed out that there have been two distinct fields emerging within social sciences in the analysis of technical change. On the one hand, SSST are concerned with the process in which various actors are enrolled into a network that shapes the products of technoscience. The analytical focus of these studies tends to be placed on a group of technoscientists and their interaction with other actors in order to create a particular product. Because the studies tend to select a highly controversial, renowned or advanced product of technoscience, they rarely discuss technoscientific activities in developing countries or the impact of a given technoscientific development in the First World on the lives of those in the Third World. Few individual or corporate actors from developing countries are likely to be enrolled in such a network. And, if they are, their associations are weak, and therefore have little effect on the process by which a technoscientific product is constructed.

On the other hand, SSID stress that a developing country must devise an effective and efficient approach to accelerate technical change in order to realize growth in its economy. Most extant works concentrate their analyses on the process by which a given product of technoscience from advanced countries is adopted or rejected by potential end users (e.g.,

farmers, factories, governmental agencies) in a developing country. As a result, they take technoscientific processes for granted and rarely examine the process by which the product has been constructed together. Despite a philosophical disagreement with conventional SSID researchers about the validity of indigenous knowledge, many sociologists and anthropologists of Third World knowledge continue to share the methodological approach of limiting their inquiry to one corporate actor (usually villagers).

In the last chapter, I argued that the concept of uniformity has become an integral value in both the capitalist economic system, and institutionalized science and technology (i.e., technoscience) that determines *what* and *who* can be part of a given network of market and/or technoscientific activities. In order to develop a strategic understanding of the value of uniformity in establishing and transforming a specific pattern of social relations and interaction, we need to examine how this value affects those who have not yet fully become part of these networks. For this reason, I chose to examine the effort of rapeseed chain actors in the PRC to create and maintain uniformity in rapeseed and its byproducts through technical change. Such an analysis can address issues relevant to both SSST and SSID, and therefore may contribute to bringing the two divergent fields closer together.

In the late 1970s, the central government of the PRC initiated a series of new programs to turn rapeseed into an export crop largely in order to earn foreign currency. During the Seventh Five Year Plan, the first national program for rapeseed R&D began (see Chapter 5). Between the mid 1980s and the early 1990s, most national standards on rapeseed and its byproducts were issued (see Chapter 6). The central government encouraged provincial governments in the rapeseed producing area to establish similar programs. Two decades later, the PRC has become the world's largest producer of rapeseed. However,

instead of becoming an exporter, it has become an importer of both rapeseed and its oil. Chinese products are not yet accepted in the international rapeseed market because most rapeseed produced in the PRC fails to meet the international standards.

Why have rapeseed chain actors in the PRC been unsuccessful so far in making the quality of rapeseed uniform for the international market? How does each actor in the chain shape rapeseed and its products through technical change, legal and policy measures, and/or market procedures? In this process, how are different values of uniformity brought in and negotiated among various actors?

In order to answer these questions in the next five chapters, this dissertation study uses the commodity chain (or subsector) analysis approach with two complementary methods -- historical studies of the rapeseed commodity chain and interviews with the chain participants -- thereby tracing various transformations of rapeseed at each stage from production to consumption (see Figure 3.1). The use of multiple methods allowed me to integrate various dimensions of the rapeseed commodity chain which are delineated by each method (Strauss 1990). In order to examine how different values and ethical commitments for the creation of uniformity in rapeseed through technical changes are negotiated in the commodity chain, I focus on the role of such human actors as scientists, government officials, extension agents, farmers, input suppliers, marketers, food processors, retailers and consumers. At the same time, I treat nonhuman actors such as rapeseed, tools, fertilizer, laws as equally important participants in building networks to shape rapeseed.

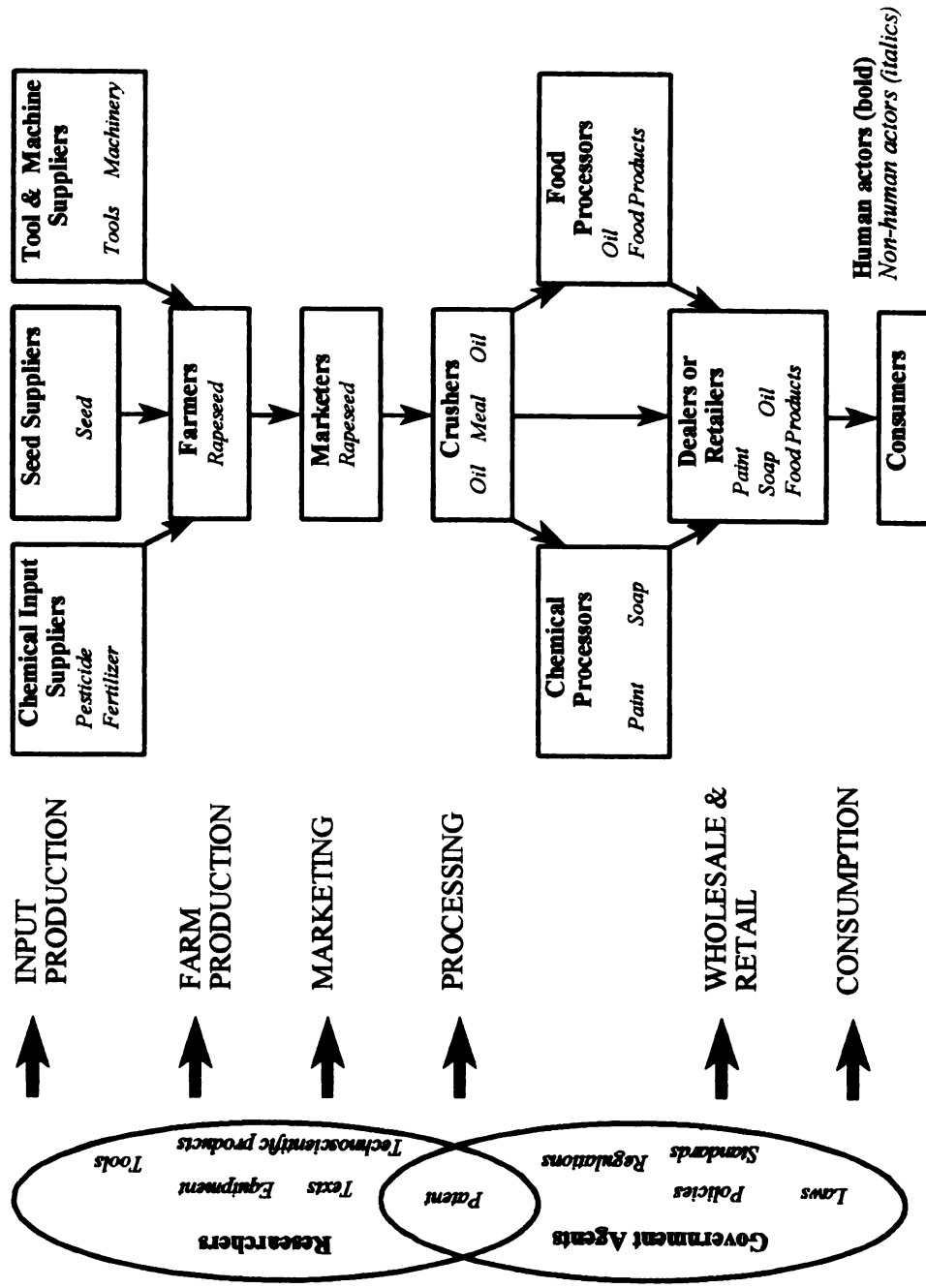


Figure 3.1 - The Rapeseed Commodity Chain in the PRC.

In the first section of this chapter, I first try to compare commodity chain analysis and actor network theory, and incorporate the theoretical framework of the latter into the former. Then, I argue that this exercise allows us to develop a methodological approach useful for integrating the divergent fields of social sciences, SSST and SSID, thereby reaching a better understanding of the process of technical change from laboratory to farm field. In the following two sections, the details of the research methods are delineated. General information about the county used in this research is provided in the fourth section. Finally, I reflect on strengths and weaknesses of the methods used in this study.

ANALYSIS OF A COMMODITY CHAIN

For decades agricultural economists have studied agricultural commodities. Economic statistics have long been collected and analyzed commodity by commodity. Hirschman (1958) introduced the concept of *forward and backward linkages* as a tool for investigating the effect of investment in one type of economic activity on others in a given product line. He argued that economic growth would come from maximizing investment in *linked* industries and strengthening input-output relations of product lines. However, the explicit conceptualization of commodity systems did not emerge until the work of Goldberg (1968) and Shaffer (1968) who developed the agricultural commodity subsector approach. These and later agricultural economists (e.g., Marion 1986) showed that the agricultural sector may be further divided into subsectors, each of which is distinctive for its concern for a given commodity at each stage from production to consumption.

During the last decade, a largely unrelated, although similar this approach has become a useful tool for sociological studies of commodities. It has come to be known as commodity

chain (or subsector) analysis. Some examples include the studies on tomatoes (Busch et al. 1991; Friedland and Barton 1975), lettuce (Friedland, Barton and Thomas 1981), wheat (Busch et al. 1991; Friedmann 1982), rapeseed (Busch et al. 1994; Busch and Tanaka 1996; Juska and Busch 1994), poultry (Heffernan 1984), beef (Heffernan, Constance and Gronski 1993), pork (Heffernan, Constance and Gronski 1993), apparel (Appelbaum, Smith and Christerson 1994; Korzeniewicz 1994; Taplin 1994), automobiles (Kim and Lee 1994; Lee and Cason 1994) and cocaine (Wilson and Zambrano 1994). These studies assume that, with increased specialization in market activities, there is “a social reality that can be [easily] delineated as a discrete commodity system” (Friedland 1984: 223). That is, we can observe a network of human actors who are linked together by a given commodity. Moreover, these studies demonstrate that such networks often emerge and extend far beyond the boundaries of nation states on the one hand, and at the same time, that each network *affects* and *is affected by* political and cultural strategies of nation-states for directing economic activities both domestically and internationally. Therefore, commodity chain analysis is a useful tool to investigate how economic and political activities, as well as our culture, have become increasingly globalized.

Although there are differences in their approaches, the existent commodity chain studies share a central methodological characteristic: they follow a given commodity through a chain from production to consumption, and examine how it and its meanings are transformed from one actor to another “within and by a network of relations” (Law 1994: 18). Moreover, this approach emphasizes the organizational linkages that emerge as a commodity is exchanged among human actors within the network for further transformation.

In this light, technoscience, government regulations, market rules, and patents are seen as strategies by which individuals and organizations seek to transform a given commodity.

On the one hand, commodity chain analysis is similar to the methodological approach of actor network theory delineated by Bruno Latour (1987) and discussed in the previous chapter. They both are designed to link the macro and micro dimensions of social transformation processes that have been long analyzed within sociology as discrete units such as household, locality, nation-state, and global political or market system (Gereffi, Korzeniewicz and Korzeniewicz 1994: 2). At the same time, there are significant differences in their theoretical assumptions as summarized in Table 3.1. Below, I contrast the two approaches on three core assumptions about actors, networks, and relationships among actors in the network. Then, I meld the two by describing my own methodological approach to the study of a commodity chain with the perspective of actor network theory.

Assumption 1. A network is made of humans and things. Both commodity chain analysis and actor network theory focus on a network of human and nonhuman actors, and analyze how activities of a given actor are shaped by others in the network. By following a given actor (i.e., *commodity* in the commodity chain analysis, *technoscientific product* or *technoscientist* in actor network analysis), the analysis focuses on transformation processes of social groups, things, interactions between human and nonhuman actors, and interorganizational relationships. Often, each actor is assumed to bring into the network a distinctive set of interests, motivations, goals, perspectives, values and ethical commitments that are negotiated with those of other actors. Therefore, a given product (i.e., a *technoscientific product* in actor network analysis, a *commodity* in commodity chain analysis) represents an outcome of such negotiations.

Table 3.1 - Commodity Chain Analysis vs. Actor Network Theory: Three Major Assumptions.

Three Major Assumptions	Commodity Chain Analysis	Actor Network Theory
1. <i>A network consists of humans & things.</i>	• Human & nonhuman actors are treated asymmetrically. • A commodity preexists.	• Human & nonhuman actors are treated symmetrically. • A thing becomes a commodity.
2. <i>A network changes over time & space.</i>	• A network exists in the market.	• A network creates a market.
3. <i>All actors are not equal; there are power relations in the network.</i>	• Social structure creates inequality. • Power derives from the intrinsic nature of individual or corporate actors.	• The differential abilities & strategies of actors for bringing in resources for negotiations creates inequalities. • Power derives from the acts of individual or corporate actors.

On the other hand, the two approaches differ significantly in their treatment of humans and nonhumans. In actor network theory (see Chapter 2), humans and nonhumans are explicitly treated symmetrically as actors in a network. In another word, things such as equipment, tools, and experimental animals actively participate in settling technoscientific controversies and ordering the social world.

Although commodity chain analysts recognize that nonhumans (e.g., commodities, machinery, raw materials) play an important role in shaping social relations among human actors, they are often treated as exogenous to the network. Rather than active participants, commodities are regarded as merely catalysts for interaction between humans or molds for human activities. Therefore, most commodity chain studies pay little attention to commodities themselves. Indeed, they rarely discuss how a given thing becomes a commodity, and instead assume a commodity exists prior to the formation of a chain surrounding it.

However, the history of human beings is also the history of nature socialized by humans. Breeders have transformed wild plants, animals and insects to work for us. The shape of many mountains and rivers has been changed in order to farm, build dams, expand residential space, and meet other needs. We create laws and regulations to protect rare species, rain forests, and the quality of water and air. In short, all those things have their social lives; they have *become* what we know them as today. They are part of so-called Nature as much as cultural artifacts such as machines, equipment and tools used in laboratories by technoscientists or on farms by farmers. Since they are the material aspects of our social lives, nonhuman actors such as seed, fertilizer, pesticides, microscopes, beakers, and computers shape the activities and organizational linkages of a given network as much as human actors do.

Out of many things available in a society, only a handful of them can be marketed as commodities. Moreover, the status of a given thing as a commodity changes over time, space and persons. Kopytoff (1986: 64) argues that “[s]uch shifts and differences in whether and when a thing is a commodity reveal a moral economy that stands behind the objective economy of visible transactions.” Therefore, in order to understand the development of the rapeseed commodity chain in the PRC, I focus in this study on the shift of rapeseed from a traditional plant to be produced and consumed within rural households to a commodity to be exchanged in provincial, national and global markets. Moreover, I examine both human and nonhuman actors enrolled in the process by which rapeseed *became* a commodity.

Assumption 2. A network changes over time and space. Both commodity chains and technoscientific networks change over time and space reflecting the differences in the activities and relative power of those who are part of the network. The analysis of historical

changes is essential to understanding the current social arrangements within a given network. Moreover, regional variations in a particular activity (e.g., crop cultivation, crushing, technoscience), the organizational arrangement of a network, and the meaning of a product often hold important clues to answer why some actors from particular geographical locations have been (un)successful in extending their network links rapidly beyond their locale.

For example, until the twentieth century rapeseed was hardly a world market commodity. It would have been impossible to talk about a single rapeseed chain. Instead, there were several local chains in rapeseed producing countries that varied in length and strength, the membership of actors, and the activities that each actor performed. Within the last several decades, some actors have turned themselves into be part of the global rapeseed commodity chain by transforming their production methods, technology, institutional strategy, organizational arrangements, and so on. However, others have failed or are still trying to enroll themselves in the new network. Over time, new actors have also emerged in regions in which rapeseed chains did not historically exist.

Technical change, legal and policy measures, and market procedures are among some tools that shape a given commodity chain at a certain time and space. For commodity chain analysis, such a network of social relations only exists in the market. Indeed, a commodity chain is defined as a system of *labor processes* in which a commodity is produced, processed, distributed and consumed (e.g., Friedland 1984; Heffernan and Constance 1994). Thus, commodity chain studies rarely look at the process by which a given commodity market emerges. In short, various mechanisms that turn things into commodities are not of importance to these studies.

There are two problems with blackboxing the process of commoditization. First, it leads to understanding every social process and activity as the outcome of the social relations of production, or so-called *structural factors*. And, in this structuralist perspective, such activities as R&D and policy making are viewed as *exogenous* to the economic processes, or as shaping the social structure. Therefore, these social activities become irrelevant to sociological analysis.

The second problem is closely related to the first. Many commodity chain studies in the world systems literature (e.g., Korzeniewicz and Martin 1994) tend to give rather a static picture of commodity chains. Therefore, they do not offer any explanations as to why some corporate actors (usually nation-states, or transnational corporations [TNCs]) have become and remain part of the core and others remain peripheral in the global division of labor. Consequently, they tend to *describe* but often do not *explain* the transformation of commodity chains over time and space. This weakness largely comes from the assumption that macro-structural conditions preexist before the global commodity chains have formed. Therefore, these studies fail to recognize that actors create, maintain and change particular structural conditions in order to advance their role in a given commodity chain.

On the other hand, actor network theory does not take for granted such common sociological concepts as social structure, institutions, agencies or agents. Instead, actor network studies are concerned about recursive processes that are continuously driving, (re)ordering and transforming our social world. Thus, their analytical focus lies in *processes* of changing relations among actors not only in the domain of the market, but also in multiple and interrelated domains of our social lives. For example, studies of canola (Busch et al. 1994; Busch and Tanaka 1996; Juska and Busch 1994) show that the creation of the global

rapeseed market was possible for various reasons including, but not limited to, the Cold War, the elimination of erucic acid and glucosinolates by Canadian scientists, changes in quality standards for rapeseed and its products, the removal of trade barriers for oilseeds, and changes in nutritional consciousness among consumers.

Moreover, actor network studies argue that in the processes of network building so-called *structural characteristics* of society are negotiated for (re)production and transformation. Such starting points are powerful in understanding remarkable social transitions in the PRC where sociological categories such as *structure*, *nation-state*, *public* and *private* are increasingly in flux. They allow me to bring the question of what is entailed in the transition from a socialist to more market-oriented economy to the center of the analysis. In short, I hope to illustrate institutional reorganization processes that are allowing the establishment of a more capitalist society in the PRC.

Assumption 3. All actors are not equal; there are power relations in networks. The third similarity between actor network theory and commodity chain analysis lies in their assumption that all actors are not equal. Instead, that there are power relations among actors in networks. They both stress the strength of associations as an indicator of how powerful a given actor is in the network. On the other hand, they attribute such inequality among actors to different sources.

Because of the analytical focus on labor processes, commodity chain studies often presume that power disparities among human actors, for example between TNCs and local contractors, are already built into the structure of a market economy. They assume that power derives from the intrinsic nature of individual or corporate actors. And, economic efficiency in the pursuit of profit determines who are included and excluded from a given

chain, and how power is distributed among the members. Therefore, commodity chain analyses are rarely used to demonstrate the processes by which such structural forces as concentration of production and globalization of market activities become possible. However, changes in technology, policy or market rules, that often affect the membership of actors and the distribution of power among them in a given chain, may have nothing to do with economic efficiency *per se* (Busch 1990). For example, Friedland and Barton (1975) showed that the restructuring of the tomato chain in California through the introduction of a new harvesting machine had little to do with economies of scale or labor costs.

On the other hand, actor network studies stress that some actors are successful in bringing in more human and nonhuman actors to a given network in order to modify a thing or influence a decision, thereby enhancing their position in the network. The source of their power lies in their *actions* or what they do, rather than their characteristics or who they are. As Latour points out, a person becomes a hero or heroine from his or her deeds in overcoming difficulties; it is not some intrinsic characteristic but actions that speak of his or her greatness. In short, successful changes that a given actor makes in things, humans and the network demonstrate the power of action.

For example, seed companies are likely to be in a better position than farmers in the global rapeseed chain. This is because these companies are more successful than farmers in changing the biological features of rapeseed, planting practices of rapeseed farmers, and the relationships among seed producers, sellers and buyers. In order to pursue their interests in rapeseed, these companies often invest in research projects, lobby for policy changes, and make financial deals with competitors and subsidiaries. They also seek out new actors outside the chain, and more importantly, turn these new actors into their resources, for example,

rapeseed germplasm in the PRC, new research findings in molecular biology, and new customers in traditionally non-rapeseed producing countries. However, all those resources do not guarantee that seed companies become a powerful actor in the global rapeseed chain. Instead, their power as a rapeseed chain actor is only realized when they succeed through their actions in making changes in rapeseed, other chain actors, or the entire chain.

This is why power relations in a given network are not always stable at all, but change “when an actor in the chain attempts to modify it” (Busch 1990: 18). The attempt of one actor to change the network may be blocked by other actors in order to preserve their position. They may ally with each other to support their position against that of an opponent in the network. For example, in the late 1950s the Canadian government tried to ban the use of rapeseed as a source of edible oil out of the concern with the potential harmful effect of erucic acid on human health. However, leaders of producers, marketers, crushers and oil processors together successfully lobbied against the proposed change in the food and drug regulations. Instead, they convinced the government to develop the necessary research program so as to eliminate the apparently undesirable compound from rapeseed.

In short, the analysis of a commodity chain must focus on the actions of both human and nonhuman actors in transforming a commodity in the process of network building. Thus, in this dissertation study, I examine various actions that each human actor has performed on rapeseed by enrolling nonhuman actors to create, maintain and transform the uniformity of the seed, grain, oil and meal. I explicitly assume that these actions in turn reflect a specific concept of uniformity that each human actor holds as meaningful in order to enhance its position in the process of building or resisting the commodity chain. Moreover, I hope to demonstrate that shifts in the membership, power relations and activities within the

commodity chain are a result of negotiations over various aspects of rapeseed among actors (humans and nonhumans alike).

HISTORICAL STUDIES OF THE RAPESEED COMMODITY CHAIN

In this study, both primary and secondary documents were reviewed to trace over time the role of each human and nonhuman actor in creating, changing and maintaining the rapeseed commodity chain in the PRC. The following historical changes were examined at the national, provincial and county levels: (a) economic statistics of rapeseed and its products, (b) quality standards applied to rapeseed at each stage of the commodity chain (e.g., standards for registered seed, edible oils and meals), (c) methods used by each human actor for producing, transporting, marketing, processing, or retailing rapeseed and its products (e.g., types and amounts of inputs and machinery used), (d) research activities for rapeseed and related crops (e.g., new rapeseed varieties, new machines), and (e) state policy, economic plans and mass campaigns (e.g., collectivization vs. the household responsibility system, the Great Leap Forward, the Cultural Revolution).

These documentary data helped me identify various points of inquiry about changes in activities, institutions and organizational linkages within the rapeseed commodity chain at specific times and locations, and thus outcomes of the negotiations among these actors. These data describe the general trends of commodity chain activities and outcomes of the negotiations among these actors. Therefore, they allowed me to determine how the rapeseed chain has changed over time and to define how commodity chain organization has affected technical change in rapeseed.

When reviewing both quantitative and qualitative data, I constantly raised three questions to determine the strength of linkages between chain actors: (a) How have changes in the activities of one individual or corporate actor (e.g., the development of a low erucic acid rapeseed variety) been followed by adjustments in the activities of other actors (e.g., a new rapeseed oil standard that prohibits high erucic acid content)? (b) How has a technical innovation (e.g., a new rapeseed variety) affected the activities of actors in the rapeseed commodity chain (e.g., the adoption rate of this new variety, the price advantage of this variety)? (c) How has the behavior of other actors in the commodity chain (e.g., a low adoption rate of low erucic acid varieties) affected the direction of rapeseed research (e.g., shifting the research focus from developing low erucic acid varieties to high yielding varieties)? Interviews with individual or corporate actors were further used to confirm and modify results from the historical analysis.

A case study was used because: (1) the governmental agencies at the national level lack the detailed data on agricultural activities at the provincial and local levels (the same can be said for provincial agencies about data at local levels) and (2) actors and activities in the agricultural sector in the PRC are organized based on specific locations. Xishui county, Hubei was chosen because: (1) Hubei is one of the five major rapeseed producing provinces in the PRC; (2) rapeseed researchers at the Institute of Oil Crop Research (IOCR) of the Chinese Academy of Agricultural Sciences (CAAS) and the Center of Rapeseed Genetics and Breeding (CRGB) of the Huazhong Agricultural University (HAU) -- the two leading rapeseed R&D institutions in the PRC -- believe that this county is representative of counties which produce rapeseed in the PRC; and (3) the location allowed access to the IOCR and the

HAU in Wuhan, which respectively coordinate research on oil crops and education on the hybridization of rapeseed in the PRC.

Analysis of Activities and Relationship of Commodity Chain Actors

Using both English and Chinese language sources, I first collected both quantitative and qualitative data on domestic production, distribution and consumption as well as import and export of rapeseed seed, oil and meal. Furthermore, I gathered data on technoscientific activities related to these commodities.

During the Cultural Revolution (1966-76), little effort was made to collect and publish official statistics or qualitative data on economic activities in the nation. Since the publication of the first statistical yearbook by the State Statistical Bureau (SSB) in 1979, a wide range of statistical and encyclopedic communiqués have been released. In the last decade, the number of yearbooks, statistical annuals, and technical and trade journals published by ministries, bureaus, research institutions and industrial associations has rapidly increased.

Although recent publications have added statistical data not available in earlier years, gaps remain in some series. Where there were inconsistencies among the data from different sources, I relied primarily on Agricultural Statistics of the People's Republic of China, 1949-90 (USDA 1992) for historical data and Zhongguo Nongye Tongji Ziliao [Agricultural Statistical Materials in China] (Nongyebu, 1992-95) for recent data on production and procurement prices of rapeseed. In addition, Zhongguo Shangye Nianjian [Commercial Yearbook of China] (Shangyebu 1988, 1990, 1992) and Zhongguo Sipingongye Nianjian [Food Industry Yearbook of China] (Qingongyebu 1987, 1989, 1990, 1991, 1992) are used for recent data on the domestic distribution and consumption of edible oil and oilseed meal

including rapeseed oil and meal. For provincial and county statistics, I used Hubei Tongji Nianjian [Statistical Yearbook of Hubei] (Hubeisheng Tongjiju, 1985-95).

Besides the bibliography described below, I collected recent data on patent and innovation awards given for technical changes related to rapeseed and its byproducts. Various yearbooks published by ministries are particularly useful for this purpose. I also reviewed the annual report on R&D achievements published by the CAAS between 1966 and 1995. Moreover, I found publications by the SSB useful in understanding general trends of technoscientific activities, particularly the distribution of R&D resources among different economic sectors.

To examine historical changes in rapeseed commodity chain activities at the national level, correlational techniques were used among the annual data on the number of technoscientific publications on rapeseed, the quantity of rapeseed produced, the yield of rapeseed, the mixed-average of procurement prices among edible oil crops, the mixed-average of retail prices among edible oils, and the average per-capita consumption of edible oil. I used the data on edible oil and oilseed meal instead of those on rapeseed oil and meal for this purpose because the availability of the latter are limited only to recent years. Moreover, the frequency of publication varies from yearbook to yearbook. As of April 1995, few yearbooks had become available for the post-1992 years at the Beijing National Library and various publishing houses. Moreover, the availability of statistical data during the early PRC period is limited. Therefore, the correlational analysis is limited to the period between 1952 and 1992.

Finally, the strength of linkages among actors within the chain and the ability of each actor to affect technical change were determined by qualitatively comparing the above data.

This method was particularly useful in understanding activities of chain actors (e.g., extension agents, transporters, input suppliers) that were not adequately delineated in qualitative data.

Analysis of Quality Standards

Quality standards are defined in various laws and regulations that usually apply to rapeseed at each stage of its transformation from plant cultivation to consumption as edible oil or animal meal. I examined historical changes in national standards (*guojia biaozhun*) concerning quality of seed, grain, oil and meal, and marketing, processing, packaging and retailing the products. These standards determine the types of tests (e.g., yield tests, field tests, grading, inspection of fatty acid composition) that are performed on rapeseed at each stage of production to judge its desirability in the market. On the one hand, such tests imply the desire for uniformity in rapeseed and the behavior of those human actors who handle it at a particular stage. On the other hand, transformations in the social relations among various commodity chain actors are implied by historical changes in the type and procedure of these tests.

Prior to the late 1970s, there were few national standards on rapeseed and its byproducts. For example, no standards concerning the quality of seed of rapeseed were issued until the 1980s, including Rules for Agricultural Seed Testing (GB 3543) in 1983, Seed of Oil Crops (GB 4407) in 1984, Seed Packing of Main Agricultural Crops (GB 7414), and Seed Storage of Main Agricultural Crops (GB 7415). Therefore, when examining official standards (see Chapter 7), I focused on analyzing why standardization has become important during the post-Maoist period.

Moreover, interviews with commodity chain actors at the provincial and county levels were used to investigate what types of standards they generally use to determine the quality of their product and labor process. As discussed in Chapter 7, many national standards are not followed by chain actors at the subnational level. Instead, these actors use their own rules, instruments and criteria to test and judge the desirability of rapeseed at each stage of production. Differences in quality standards between formal and informal, and between national and local reflect different forms of rapeseed network organization that foster different types of actions by humans on the crop.

Analysis of the Rapeseed Bibliography

Since very few entries were made to computerized indexes such as AGRICOLA and CABDATA, the citations for rapeseed research in the PRC during the period between 1949 and 1993 were searched by hand in the Index of Chinese Science and Technology -- Agriculture Section [Zhongwen Keji Mulu -- Nongye] (CAAS 1981-95), and the Bibliography of Chinese Agriculture -- Rapeseed Section [Zhongwen Nongye Wenxian Mulu -- Youliao Fence] (CAAS 1983). A total of 5,865 citations were identified.

However, because these indexes are published by the CAAS, most publications are from research and academic institutions under the supervision of the Ministry of Agriculture (MOA) and not those under other ministries. This may have consequently limited the number of citations in the areas of food processing research frequently undertaken by the Cereal and Oil Chemistry Institute of the Ministry of Internal Trade (MIT), research institutions under the former Ministry of Light Industry (MLI), nutrition research undertaken by the Chinese Academy of Preventive Medicine (CAPM), or basic research (e.g., genetics, oil chemistry)

undertaken by the Chinese Academy of Sciences (CAS). However, the data appear to approximate rapeseed research activities during the 1949-93 period undertaken within the national agricultural research system as officially defined in the PRC.

When all the references were collected, content analysis began with the development of a list of publication topics on rapeseed. All titles, and if available, abstracts and keywords were used as cues for determining the content of the articles. The list was then grouped into 13 not mutually exclusive topics (cf. Juska and Busch 1994). Then, the citations were tallied by year and major topic area.

To examine how modes of rapeseed transformation have changed over time during the 1949-90 period, these research topics were further divided into seven research themes including: (1) plant breeding (including genetics and variety testing), (2) plant physiology, (3) diseases and pests, (4) farm inputs (i.e., soil, water, fertilizer, herbicide, and pesticide), (5) post-harvest treatments (i.e., rapeseed processing, and oil and meal chemistry and nutrition), (6) cultural practices (i.e., the specific practices engaged in by farmers in the field), and (7) other (i.e., economic statistics, translations, general news). Finally, the data were divided into four groups using the three modes of rapeseed manipulation in the study of Juska and Busch (1994), including manipulation of the plant, manipulation of the (both physical and social) environment, and manipulation of post-harvest technologies. In this study, publications not relevant to the transformation of rapeseed (e.g., statistics, local news) are included as the fourth category, "other," since the collection of such information is considered a legitimate technoscientific activity in the agricultural research community in the PRC.

Following the study of Juska and Busch (1994), these four modes of rapeseed transformation were assumed to represent different forms of rapeseed network organization.

In short, farmers dominate the commodity chain if rapeseed is primarily transformed through manipulation of the environment for growing the crop (e.g., use of inputs, timing of sowing). Food processors and consumers control rapeseed transformations when post-harvest treatment is the primary research topic. Moreover, the growth in relative importance of the research community is suggested by an increase in the portion of research focusing on manipulation of the plants. Finally, the decreasing significance of the fourth category shows the growing importance of technical research, and therefore, the increased level of institutionalization of agricultural technoscience.

INTERVIEWS WITH PARTICIPANTS IN THE COMMODITY CHAIN

In order to understand the compromises among diverse values about technical change in the rapeseed commodity chain, semi-structured interviews were conducted on-site with scientists, government agents, extension agents, farmers, input suppliers, marketers, food processors, retailers, and consumers in Beijing, Wuhan (capital of Hubei Province), and Xishui county. A total of 46 interviews were completed. Each interview lasted about 30-45 minutes. The distribution of actors and their extent of chain network involvement is shown in Table 3.2.

These interviewees were seen as key informants who represent specific corporate actors (e.g., research institutions, government agencies, input supply companies). However, there is no clear-cut division of labor among actors in the rapeseed commodity chain at the county level. For example, no corporate actors specialize in one of four post-harvest activities including procurement of rapeseed from farmers, processing of rapeseed into oil and meal, retailing of edible oil, and transportation of rapeseed and its byproducts within the

county and province. Among the four post-harvest actors being interviewed, two carry out all four, and the rest perform all except oil processing. Similarly, some peasants indicated that they often market their own crop, process it into rapeseed oil and meal, and supply their own farming inputs such as seed, fertilizer and tools.

Table 3.2 - Distribution of Interviewees among Rapeseed Chain Actors in the PRC.

Actor / Administrative Level	National	Provincial	County
Researchers	21	(10) ¹	
Extension Agents	1		2
Farmers			8
Input Suppliers	1		2
Post-Harvest Processors			4
Consumers			3
Government Agents	1	1	1

Notes: 1. Out of 21 interviewees, 10 have conducted or are currently conducting research projects for Hubei Province.

Also, among 21 researchers, nine were breeders, technicians or graduate students in breeding or genetics projects to transform different characteristics (e.g., yield, fatty acid composition) of rapeseed. Two were concerned with oil processing techniques, and one with oil nutrition. Two researchers studied the use of rapeseed as animal feed. The research areas of seven interviewees can be categorized as “other” because their work are not directly concerned with technical change in rapeseed or its byproducts. However, five of them were helpful for me in understanding the historical transformations and the current sociopolitical and economic environment of rapeseed chain activities. Finally, two interviews at the

Biotechnology Research Center of the CAAS were informative for me to understand a possible future direction of crop breeding including rapeseed in the PRC.

The interview questions (see examples in Appendix B) were constructed so as to uncover the negotiation processes for technical change in the commodity chain by identifying (1) distinct interests, values and ethical commitments of each chain actor in rapeseed research, (2) modes of interaction among the actors, and (3) the impact of technical change on the activities and organizations of each actor. For example, peasants were asked how, when, and why they use (or don't use) a new variety of rapeseed; input suppliers, transporters, marketers, food processors, and retailers were asked how the introduction of this variety has changed their activities (e.g., methods of processing, amount of fertilizer sold to peasants); and scientists, extension agents, and government agents were asked why this variety has been developed and introduced. Although some actors at the county level play multiple roles in the rapeseed commodity chain, there is little evidence that they have experienced a conflict of interests, values and/or ethical commitments. Rather they always answered my interview questions from the standpoint of their dominant role.

Interview responses were analyzed to develop an understanding of how different values and ethical commitments of each actor converge on a set of complementary practices for transforming or maintaining the commodity chain. Moreover, they helped me determine how technical innovations for rapeseed have been shaped by negotiations, and often by the lack of them, among the actors in the chain.

CASE STUDY: XISHUI COUNTY, HUBEI PROVINCE

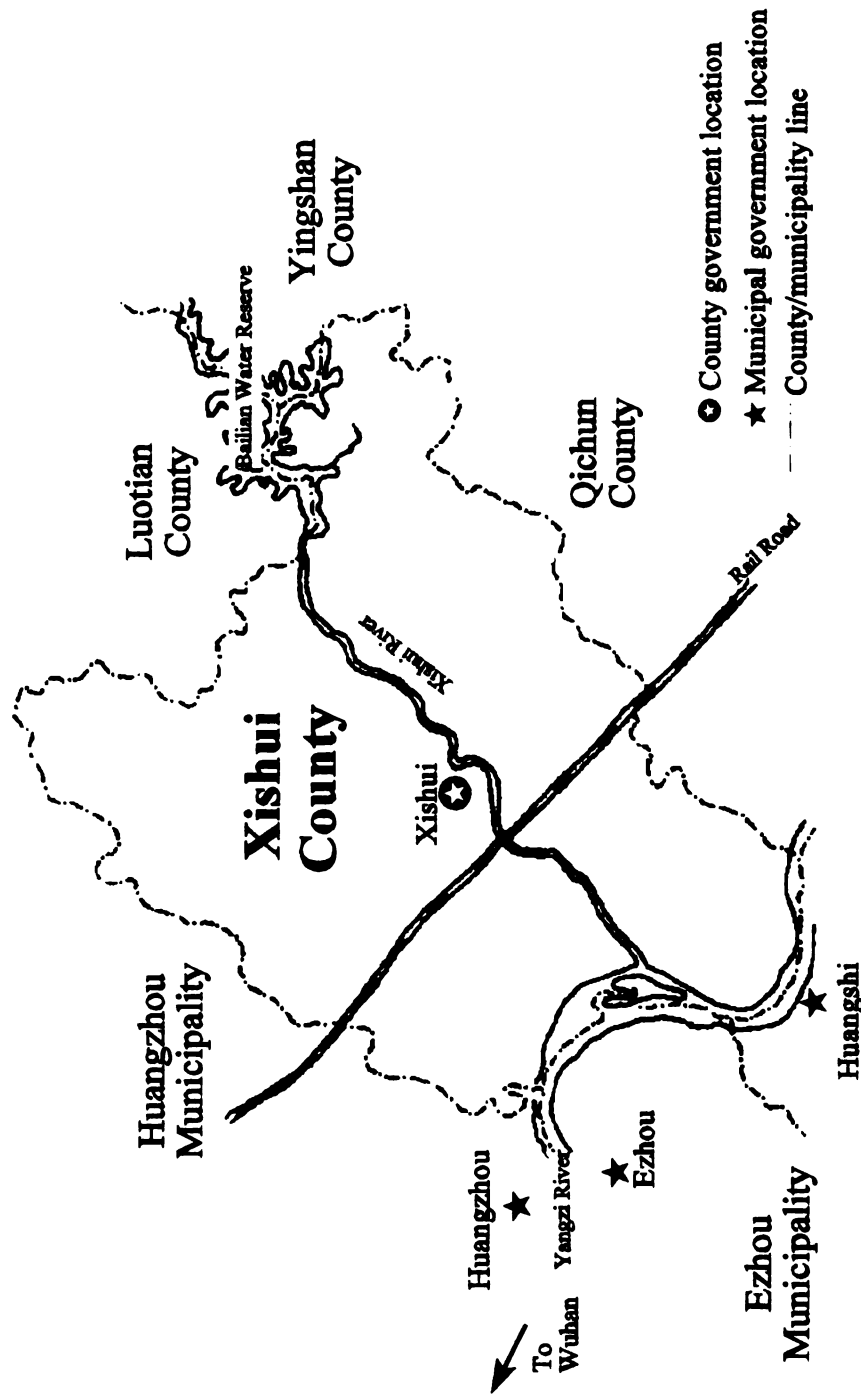
As the site of the industrial city and river port of Wuhan, Hubei Province has been one of China's most important provinces. Moreover, the province has historically been a major rapeseed producer in China. In 1994, Hubei produced approximately 1 million metric tons of rapeseed, and was the third largest producer following Sichuan and Anhui Provinces with the second highest yield (1,600 kg/ha) following Jiangsu Province (Nongyebu 1995). Rapeseed is the third most important crop in the province, following rice and wheat. As a raw material, the importance of rapeseed in Hubei Province goes beyond the agricultural sector. In 1990, the food industry was the third largest industrial sector, following machinery and textiles (Qingongyebu 1992). Edible oil processing has been a steadily rising industrial activity in the province. Furthermore, the feed industry has been rapidly growing in Hubei Province for the last few decades. By 1990, more than 850 factories had been built with a total annual production capacity of 3.4 million metric tons of feed (Hubeisheng Sipin Siliao Bangongshi 1992). These factories, small in scale, have become important economic backbone in many rural villages and townships.

With a population of over 4 million, Wuhan is one of the PRC's largest metropolises. Easy access to ground, water and air transportation attract many domestic and foreign investors to the city. Within the last decades, several large-scale food, chemical and feed processing factories have been built in Wuhan by joint ventures between foreign investors and provincial agencies. These factories are equipped with highly advanced oil crushing and refining machinery, and aim to produce high quality rapeseed products for the urban population and foreign customers. Moreover, multi-floor department stores draw together a large crowd of consumers all over the province every weekend. These consumers are eager

to benefit from the freedom to purchase daily necessities including edible oil and processed food products.

At the same time, the city is the nation's center for rapeseed research with the two leading institutions, the IOCR and HAU, located within 20 kilometers of each other. Several researchers at these institutions are renowned not only throughout the rapeseed research community in the PRC but also in the world. Although both institutions are mainly responsible for conducting research to advance knowledge on rapeseed for the entire nation, they also carry out locally-specific projects to enhance rapeseed production in Hubei Province.

In short, Hubei Province is important for not only rapeseed production, but also for oil and meal processing, wholesaling and retailing, as well as rapeseed R&D. Also, unlike Shanghai, Guangdong and other provinces with numerous special economic zones (SEZs), Hubei Province represents one of many non-coastal provinces that has initiated and implemented its own economic development and political reform programs with little financial assistance from the central government (Solinger 1996). A total of two months fieldwork in Wuhan, Hubei Province provided me with many insights about the current social transitions in the PRC that would have been easily overlooked if I had stayed in Beijing or any coastal metropolis for the entire period. Moreover, my three visits to Xishui County (see Figure 3.2) helped me observe why certain technical and policy changes enable and constrain some actors from participating in network building processes surrounding a commodity.



Note: In Hubei Province, there are 14 municipalities, 2 districts, 1 prefecture, and 1 forest area that have equivalent jurisdictional power. Xishui, Luotian, Yingshan and Qichun Counties are part of Huanggan District.

Figure 3.2 - Map of Xishui County.

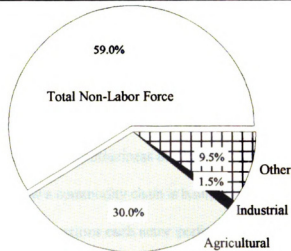
Xishui County

Xishui County is located approximately 100 kilometers east of Wuhan and 124 kilometers downstream on the *Chang Jiang* (or Yangzi River) which links the county with major cities such as Wuhan, Nanjing and Shanghai. The Xishui River, which runs through the center of the county, is a tributary of the Yangzi River, and has been an important water route for trade and communication (see Figure 3.2). Moreover, a railroad runs through the county to link it with Henan, Hubei and Jiangsu Provinces. Therefore, it is not surprising that Xishui has been called “a hub of water and ground routes, a gateway of eastern Hubei” (*shuili yaochong, edong menhu*), and that the county has developed as an important point of interprovincial trade among Henan, Anhui, Jiangxi and Hubei.

In 1994, the county had a total population of nearly 1 million who are spread among 14 townships, 12 villages, and two collective farms. Of the population, 89% live in areas in which the dominant economic activity is agriculture including animal husbandry, fisheries and forestry (*nongye renkou*). As Figure 3.3 shows, the majority of the labor force is engaged in agricultural occupations. In 1994, 55% of the county's gross domestic production value came from the primary sector, while 24% and 21% came from the secondary and tertiary sectors respectively (Hubeisheng Tongjiju 1995).

Like many rural counties in the Yangzi River Basin, peasants in Xishui usually enjoy triple cropping of grain, oilseed or cotton, and grain. Moreover, fresh water fisheries are an important economic activity for many peasants. In the last decade, rural enterprises also began to develop all over the county in the areas of metallurgy, machinery, chemicals, medicine, pharmaceuticals, construction materials, electronics, food, and textiles. The total value produced by rural industry increased from 524 million yuan in 1989 to 1.3 billion yuan

in 1995¹ (Hubeisheng Tongjiju 1995). However, there is nothing remarkable or unusual about Xishui's experience in rural development. Instead, Xishui is representative of many rural counties in the province.



Source: Hubeisheng Tongjiju (1995).

Figure 3.3 - Distribution of the Labor Force in Xishui County, Hubei Province.

Xishui is also a unit of Huanggang Prefecture, the second largest rapeseed producing district in Hubei Province. Among nine counties and cities within the prefecture, it ranks fourth in rapeseed production. Throughout the PRC, under the household responsibility system, arable land was divided equally in size among people in a county. This resulted in extremely small landholdings by each household. In Xishui, the average landholding is 0.04 ha per person (Hubeisheng Tongjiju 1995), and somewhere between 0.1 - 0.5 ha per household depending on the number of dependents (various interviews, 1995, 1996). Rather than specializing in one or two crops, peasants usually divide their land into three patches

¹ The 1989 figure was adjusted to the 1995 value of the yuan.

including a dry field, a paddy field and a vegetable field. In Xishui county, peasants each year grow wheat and cotton in their dry fields, and two crops of rice and rapeseed in their paddy fields. Among those I interviewed, the average size per household for rapeseed production was about 0.1 ha. As in most neighboring counties, rapeseed is generally planted in September or October, and harvested between mid-April and early May in Xishui.

On the one hand, Xishui seems an unimportant and undistinguished rural county for understanding the formation of commodity chains in the PRC. On the other hand, as discussed in detail in Chapter 8, this ordinariness helped me to understand the importance of networking, and explained how a commodity chain is built, maintained and transformed over time and space through specific actions each actor performs in relation to the commodity. Moreover, my experience there allowed me to observe various dimensions of the transition to a more market-oriented economy and the decentralized political system that are often hidden in the codified and aggregated data.

CONCLUSION: REFLECTIONS ON METHODS

In this chapter, I discussed the methods used for this dissertation project. In order to understand the historical processes of negotiating the concept of uniformity through technical change, I applied commodity chain analysis as a methodological approach, that is, to follow a commodity: rapeseed. However, I integrated the theoretical premises of actor network theory developed by Latour and Callon into the research methods. This marriage between commodity chain analysis and actor network theory provided me with five methodological strengths.

First, the symmetrical treatments of human and nonhuman actors allowed me to delineate how a given technical change (or quasi-object) (Latour 1993) simultaneously transforms and (re)produces society and nature. More importantly, the notion of symmetry helped me to understand how the distinction between the two becomes blurred in the negotiation process for creating, maintaining and transforming uniformity in rapeseed through technical change.

Second, the historical analysis of rapeseed technoscience over 40 years enabled me to examine both technoscience in the making and technoscience already being made. As pointed out in the previous chapter, until very recently, many empirical studies on laboratories and controversies in the SSST have not adequately articulated the symmetrical treatment of the creators and the later users of a given technoscientific product. However, using commodity chain analysis, this study followed a commodity (i.e., rapeseed) instead of technoscientists. Both documents and interviews revealed how the later users would adopt, modify and reject many of the products of technoscience.

Third, the use of multiple methods permitted me to examine the transformations of the rapeseed chain in the PRC over time and space in the multifaceted domains of the social world including markets, the polity, laws, technoscience, ethics and values. Fourth, the case study helped me to trace specific deeds of each actor that affected the activities and memberships of as well as relationships among actors in the rapeseed chain. Finally, by revealing both the multidimensionality and specificity of the network building processes, I was able to illuminate certain aspects of the current social transformations in the PRC.

Nevertheless, my research methods are not free from some weaknesses. First, the analysis of a commodity chain was not easy in the PRC where various stages of production

activities are controlled by distinctive *xitong*, each of which consists of bureaucracies responsible for administrative, R&D, educational and market activities. The *xitong* under the MOA, including the CAAS, the IOCR and HAU, supervises only pre-harvest production activities of rapeseed and manufacturing of animal feed. Most personnel from the MOA *xitong* had little or no contact with those from other *xitong*. Therefore, in order to investigate post-harvest activities such as marketing, processing, retailing and consumption of rapeseed and its products, I needed to seek new sets of contacts and bureaucratic procedures to access data. My lack of contacts with those actors from non-MOA *xitong* consequently skewed my analysis of the rapeseed commodity chain in the PRC to weigh more on the pre-harvest aspects of the chain. On the other hand, my own frustrating experience with networking in the PRC helped me to recognize the main barriers for successful development of commodity chains with strong linkages between actors.

Second, the use of a county as the unit of case study may not have been ideal for a dissertation study for three reasons. First, very little documentary data on counties are available for the public. Usually, provincial statistical yearbooks list most data by prefectures rather than counties. Second, I sensed that the government of a rural county was not well prepared to work with a graduate student from a foreign country. Although the number of foreign professionals who visit rural counties has increased rapidly within the last decade, my status as a merely a Ph.D. candidate disadvantaged me from gaining permission for various research activities. Finally, I underestimated the diversity of sociocultural and agroecological conditions within a given county in the PRC. My visits to two townships showed noticeable variations in rapeseed production activities within Xishui County. From these three difficulties of fieldwork in Xishui, I recognized the need for a systematic study that involves

multiple-administrative levels from provinces to townships in order to develop a comprehensive understanding of network building processes surrounding a commodity.

However, this research certainly benefitted from the use of a county as an analytical unit because the lower the administrative level, the weaker community barriers between *xitong* become. For example, I discovered that it was easier to contact human actors at different stages of rapeseed production in Xishui County than when I dealt with government officials in Beijing or Wuhan. It was not until my first visit to the county that I began to develop a clear picture of how the rapeseed commodity chain functions in the PRC.

Finally, closely related to the point about the need for a study that involves multiple-administrative units, a survey may have benefitted this study. A survey of various human actors, particularly extension agents, researchers, marketers, processors and retailers, at different administrative units may have improved my understanding of such questions as what similarities and differences exist in the activity at a specific stage of rapeseed transformation among human actors from different administrative levels, what kind of relationships human actors form with those from different administrative levels, and how various reform policies have affected the institutional environment for both pre- and post-harvest activities of rapeseed production. Of course, the major problem with conducting a survey in the PRC has to do with the amount of time, resources and effort necessary to receive a permit and actually carry it out.

The complexity of the bureaucratic system in the PRC has been a major stumbling block for many social scientists in conducting research. To date, access to many data are limited for foreign scholars, and many social science research activities are prohibited. Thus, the development of effective and practical research methods has become important for social

scientists in successfully completing research projects in the PRC. Although the methodology used for this dissertation study is far from perfect, the seven months of fieldwork over a two year period in the PRC allowed me to gain data unavailable in the U.S., and helped me develop research skills hard to acquire without hands-on fieldwork.

Chapter 4

GOOD TECHNOSCIENCE, GOOD TECHNOSCIENTISTS

...What has brought about the tremendous advances
in the productive forces and the vast increase in labour productivity?
Mainly the power of science, the power of technology.

----Deng Xiaoping (March 18, 1978).

INTRODUCTION

A decade ago, James O'Connor (1984) argued that conditions of economic and social reproduction (and crisis tendencies) in a given country need to be examined in the context of the dominant national ideologies. He further stressed the interplay of two motives, namely *capital accumulation* (or economic modernization) and *legitimation of the state*, in policy making. Although his studies mainly concerned the capitalist system, O'Connor's arguments can be applied to examine the history of technoscience policies in the PRC.

As an institution of the state and a social productive force, technoscience does not necessarily contribute to modernizing the economy, nor does it always help to legitimate state power. In a socialist system, by over-politicizing legitimation of state control over society, nation-states are often required to find new criteria for capital accumulation and social distributions. Indeed, technoscience policies in the PRC show that the national government

and the CPC constantly shifted their view on the legitimacy of the existing technoscientific establishment based on the debate over the dialectic relationship between *redness* or *hong* (i.e., embrace of correct revolutionary ideology) and *expertness* or *zhuan* (i.e., mastery of technical and scientific expertise). For nearly the last five decades, this debate has revealed critical values embedded in the institutionalization of technoscience in the PRC. It is an attempt of the CPC to define the official view of what constitutes *good technoscientists* and *good technoscience*. And, this notion of goodness has become the basis for institutionalizing the technoscience system.

As already pointed out in Chapter 1, the sociopolitical environment for the technoscientific system over the last five decades has changed dramatically. Following the Marxist interpretation of the role of technoscience, the CPC has continuously advocated that technoscience is an essential force to advance the mode of production, and therefore that the development of technoscience allows the achievement of revolutionary goals to eventually emancipate the working class from oppressive labor processes (Liang, Wen and Liu 1992b).

However, the historical transformations of the nation's agricultural research system suggest that what constitutes *legitimate* technoscientific activities has fluctuated significantly over the years. How should technoscientific activities be pursued? Who should control the process of technoscience? How should technoscientific products be distributed in society? Who should benefit from them? These are questions that have been raised over and over in Chinese society for the last five decades. During each of the events discussed below, the answers became the basis for the distinctive experience that the agricultural system underwent. Mao and other party leaders used such Marxist dialectic rhetoric as ideological purity (*redness*) versus technical competence (*expertness*), self-reliance versus reliance on

foreign technology, science for the masses versus science for the bourgeoisie to define the answers to the above questions.

This chapter examines the historical transformations of the notion of goodness in the institutionalization of agricultural technoscience in the PRC during the last 47 years. Based on the different forms of interplay between the roles of technoscience in capital accumulation and legitimation of state power, the analysis in this research is broken down into seven time periods (see Table 4.1). Major historical events, such as the First Five Year Plan (1953-57), the Great Leap Forward (1958-60), the Great Famine (1959-61), the adjustment policy (1961-66), the Great Proletarian Cultural Revolution (1966-76), the decollectivization and political/economic reforms (1977-85), the introduction of the household responsibility system (1985), and the reform of the technoscience system (1985-90) provided points of inquiry in determining the shifts in national ideologies and economic and social policies. The goal of this chapter is not to provide a detailed analysis of these events which can in any case be found elsewhere (e.g., MacFarquhar 1960, 1983). Instead, I try to illustrate that each of these periods marks a distinctive phase in agricultural as well as technoscientific development.¹

¹ Research on technoscience development in the PRC prior to the reforms of the 1980s is limited. See Wang (1993) for the technoscience policy changes between 1949 and 1989; Stavis (1978a) for the agricultural mechanization processes during the Land Reform (1950-52), the Great Leap Forward (1958-60), and the Great Proletarian Cultural Revolution (1966-76); and Bullock (1992) and *Science* (1993) for the impact of the Tiananmen Square Incident (1989) on the technoscientific community.

Table 4.1 - Good Technoscience and Good Technoscientists, by Period.

Values	Good Technoscience		Good Technoscientists	
	Role of Technoscience	Main Ideologies	Main Agent	Red vs. Expert
I 1949-57	Economic modernization	Marxist-Leninism-Maoism	Technoscientists	Red/Expert → Red
II 1958-61	Legitimation of state	Marxist-Leninism-Maoism	Mass	Red
III 1962-65	Economic recovery	Marxist-Leninism-Maoism; Technoscientific theories	Technoscientists	Red/Expert
IV 1966-71	Legitimation of state	Marxist-Leninism-Maoism	Mass	Red
V 1972-77	Economic recovery	Marxist-Leninism-Maoism; Technoscientific theories	Technoscientists	Red → Red/Expert
VI 1978-84	Economic modernization; Legitimation of state	Technoscientific theories	Technoscientists	Expert
VII 1985-97	Economic modernization; Legitimation of state	Technoscientific theories	Technoscientists	Expert

By focusing on the major sociopolitical and economic events that shaped the direction of technoscientific activities in the PRC, I raise two questions for each of the seven periods: (1) What is the notion of good technoscience and technoscientists? (2) How has it been defined? Then, I discuss how the legitimacy and value of technoscience as an institution in socialist polity was shaped by power struggles within the CPC and China's relationship with the USSR and Western nations. By doing so, I hope to show that the constant shift in the notion of good technoscience and technoscientists did not allow technoscience to be fully institutionalized, and thereby weakened the role of technoscience in economic development.

PERIOD I (1949-57): POST-REVOLUTION & FIRST FIVE YEAR PLAN

After the Communist Revolution, the construction of the technoscientific system was carried out immediately, by establishing the CAS. Moreover, the current system of agricultural research, education and extension under the MOA *xitong* began to gradually take shape during this period under the tenet that the application of scientific theories would benefit production (CAAS 1992). By 1952, seven regional institutes of agricultural research were established, namely the North Eastern, Northern, Eastern, Central, Southern, South Western, and North Western Institutes of Agricultural Research. Under the 1951-55 Agricultural R&D Plan, these institutes were instructed to focus on developing solutions to specific technical problems commonly seen in their own rural areas, such as sparse sowing, extensive cultivation, inadequate fertilizer, and severe disease and pest problems (CAAS 1992).

Emergence of the Basic Institutional Framework

Until the First Five Year Plan period, a clear institutional framework for the technoscientific system did not emerge in the PRC. The goal of the First Five Year Plan was to build a country-wide industrial infrastructure with an emphasis on heavy industry. During this period, 42.5% of the nation's capital investment was poured into the industrial sector (of which 85% was used for heavy industry) while the agricultural sector received only 7.1% (Wang 1993: 42).

The establishment of a more centralized research institute was viewed as necessary in order to unite the leadership for agricultural R&D in the nation, coordinate the movement to collectivize agricultural production, and encourage agricultural development (CAAS 1992). Therefore, in the mid-1950s, China adopted the Soviet model of the centrally controlled and mission-oriented R&D system, and sought technical assistance nearly exclusively from the USSR and East European countries to build the system. The PRC dispatched many promising young scientists, engineers and students to the USSR while employing foreign technical advisors and experts in both administrative offices and research institutes within the R&D system. The government also relied on the direct transfer of technical innovations from countries in the Soviet Bloc. In 1955, the Coordinating Committee for Agricultural Research was organized in order to formulate a blueprint for the CAAS that took over the responsibilities of supervising the seven regional institutes in 1957.

Each province, autonomous region and city also established its own regional research system. According to the incomplete statistics (CAAS 1992), the number of agricultural experiment stations at the provincial level increased from 35 in 1949 to 93 in 1956. Furthermore, the number of provinces, autonomous regions and cities with their own research

system increased from five provinces, and ten autonomous regions and cities in 1949 to 14 provinces, and 76 autonomous regions and cities in 1956.

Moreover, agricultural universities, colleges and vocational schools were organized at the national, provincial, district and county levels. Although the primary objective of higher educational institutions was defined as providing students with scientific and technical training in agriculture, research activities were also carried out in these institutions with a specific emphasis on meeting regional or local needs for new technology.

Nevertheless, the application of the Soviet model in the technoscientific system and economic development, which disproportionately stressed the development of heavy industry and sacrifice of agriculture, had a negative impact on agricultural production, eventually leading Mao and the CPC to launch the ambitious Great Leap Forward program. “The Twelve-Year Plan for Science and Technology Development from 1956 to 1967” was finalized in 1957 as China’s first long-term science plan; it identified twelve priorities areas. This list suggests that the primary consideration of the plan was strengthening defense and heavy industry. Only two out of twelve priorities were directly applicable to agriculture including: technical problems related to harnessing of the Yellow and Yangzi Rivers, and mechanization of agriculture and chemical fertilizer. Wang (1993: 45) points out that the Twelve-Year Plan not only “began the tradition of mission-oriented science and technology planning,” but also solidified “a top-down ‘science/technology-push’ approach to innovation.” Moreover, the plan confirmed that both administrative and scientific personnel involved in science planning found little value in agricultural technoscience for political and economic development of the nation.

The Hundred Flowers Campaign (1957) and the Role of Intellectuals

The CPC expected intellectuals to play a key role in instituting an R&D system which would help the nation to build an industrial society. However, following the tradition of the May Fourth Movement in the 1920s and 1930s, many elderly intellectuals continued to advocate intellectual autonomy from any political parties. Moreover, those who were highly trained in technoscience had received their graduate training overseas, and therefore were strongly influenced by Western thought.

The party used mass thought-reform campaigns to indoctrinate the intellectuals in Marxism-Leninism and Mao's thought, and to force them to follow the party's shifting political lines. In winter of 1951-52, university students were mobilized to criticize their teachers and demand changes in the curriculum from the American and European to the Soviet model.

During the Hundred Flowers Campaign (1957), intellectuals were encouraged to speak out their criticisms of the CPC. However, after they spoke out, they found themselves being labeled as *rightist* (or *youpai*), and ordered to engage in self-criticism and repent for their errors. By the winter of 1956/57, more than 550,000 university students, professors, administrators, technicians and scientists were labeled as *rightist*, attacked, purged and sent to labor camps (Wang and Li 1986, cited in Wang 1993: 50).

Regardless of the pervasiveness of such mass campaigns, they alone would have not been adequate to change intellectuals into productive members of Communist China, and ensure that technoscientific activities became a driving force for the nation's modernization. In the process of establishing a centrally planned economic system and a communist polity, institutions for technoscientific activities also needed to be centralized, and fitted into the

framework of communist ideologies. Each Five Year Plan began to provide R&D institutes with specific guidelines for every technoscientific activity in the nation as to what projects should be funded, why these projects should be pursued, and who should engage in the projects. Decisions for job assignment, promotion, housing, and food rationing were handed down by the CPC hierarchy. Moreover, the CPC brought party personnel into R&D organizations to set up dual control of technoscientists -- administrative and political. In short, the institutional environment for intellectuals needed to be such that the CPC would be able to regulate their technoscientific and personal activities.

Moreover, any theoretical approaches in technoscience which contradicted Marxism-Leninism and Mao's thought were censured fiercely. For example, Darwinism and Mendel's or Morgan's genetics were forbidden to be taught at agricultural universities and colleges. Agricultural researchers were not allowed to use biometrics (Li 1950; Li 1989; Schneider 1989). Many distinguished breeders and genetic scientists were attacked as *idealists*, *metaphysicians*, and *capitalists*. The fundamental goal of agricultural technoscientific activities was defined not necessarily as strengthening scientific knowledge of agriculture for the sake of science, but developing specific technologies for which effectiveness would be measured by actual production activities with agricultural crops. In short, agricultural technoscientific activities could become legitimate only if they would serve peasants in meeting production goals specified by each Five Year Plan.

PERIOD II (1958-61): THE GREAT LEAP FORWARD AND THE GREAT FAMINE

During the course of the First Five Year Plan, gross agricultural output increased by about 3 percent (USDA 1992). By 1957, the increase in grain output declined to merely 1

percent, and the industrial growth rate was the second lowest since 1949. The agricultural sector was losing its ability to satisfy all the demands of the nation including providing adequate food for the increasing population and providing a surplus to support industrialization in the urban areas.

Mao called for the *walking-on-two-legs* approach that aimed at accelerating the growth of both agriculture and industry through the use of a *technological dualism*. Both modern and traditional production technologies were to develop simultaneously, by maximizing the advantages of capital-intensive and large-scale production units as well as labor-intensive, small-scale ones. The ideological foundation of the Great Leap Forward relied on the notion that the masses possess great latent power and could, with the strength of their effort and under the right organizational environment, produce real capital. Therefore, a new technological revolution was to begin in the countryside by the hands of peasants. Under Mao's slogan of "Take grain as the key link," the Great Leap Forward further pushed the grain-first policy, and instituted an agricultural system, the effectiveness of which was measured by the annual production of grain crops. Moreover, peasants were mobilized to produce all inputs necessary for the countryside, and a surplus for urban areas.

The Great Leap Forward and *Red and Expert*

At the same time, the purge of intellectuals under the Hundred Flowers Campaign continued and even intensified in some areas, although natural scientists were relatively more protected from criticism than social and human scientists. The legitimacy of intellectuals as the main agents of technoscience came to be questioned particularly in applied scientific fields such as agricultural sciences. A series of thought reforms during the early 1950s and the

Anti-Rightist Campaign during the Great Leap Forward aimed at transforming intellectuals as both *red* and *expert* (*you hong you zhuan*). Wang (1993) points out that the uniqueness of the Great Leap Forward lies in attempting to indoctrinate professionals to equate ideological *redness* with technical and scientific expertise.

The CPC declared that the agricultural technoscience would be returned to the hands of the masses (i.e., peasants), and that the existing institutional system of agricultural R&D institutes was tainted by the wind of the bourgeoisie because it separated technoscientists from peasants. Beginning in March 1958, the agricultural research system was decentralized, and many research activities were either transferred to the rural areas or totally abandoned. During 1960 and 1961, one third of the research personnel at the CAAS was transferred to rural villages (CAAS 1992). Reliance on local resources and locally-based research and extension was emphasized in order to promote a link between research and production (Delman 1988; Fan and Pardey 1993; Stavis 1978b).

However, this ideological debate over *red* and *expert* had another dimension for the elite group within the technoscientific community. The CPC leaders ordered that the core of the nation's scientific personnel (i.e., those engaged in R&D related to national security) be protected from the disturbance brought about by the mass campaign. Indeed, those scientists made significant progress in semiconductors, electronics, computer technology, automation and atomic energy (Wang 1993). In short, the Great Leap Forward solidified the tradition of China's scientific policy in which defense-related fields of technoscience were strongly centrally controlled and regulated while other fields experienced constant shifts in their role in society depending on the general development strategy and ideological climate of the time.

The Great Famine and Economic Downturn

However, rapid industrialization and reorganization of rural institutions without proper planning created enormous pressure for village cadres to carry out economic decisions and to implement technical innovations (e.g., seed varieties, double cropping, irrigation, farm tools) without adequate management skills and proper local adaptation (Oi 1989; Stavis 1978b). The reliance on one or two grain crops of specified cultivars as well as adverse climatic conditions in consecutive years from 1959 to 1961 exacerbated the food shortage, and turned it into the worst famine in modern history. The Great Famine of 1959-61 resulted in the death of somewhere between 11 and 30 million people in 1960 alone (Kane 1988; MacFarquhar 1983).

Moreover, by the 1950s, the relationship between the USSR and China deteriorated over their differences in development means and goals. The uprisings in Poland and Hungary forced the USSR to limit the amount of economic aid available to China. In 1960, the USSR suspended all bilateral educational and technical cooperation programs, and recalled their experts, blueprints, plans and technical resources that had remained in China. The PRC was left to manage projects modeled after the USSR without adequate expertise or resources.

PERIOD III (1962-65): THE READJUSTMENT POLICY

By 1961, the nation began to gradually return to more pragmatic policies which would foster more stable patterns of social development. At the Ninth Plenum of the Eighth CPC Central Committee in January 1961, three major agreements were reached for inclusion in the adjustment policy: (1) a balance growth approach, (2) agriculture as the foundation of the nation's economy, and (3) an increase in the production of consumer goods by balancing light

and heavy industry. In agriculture, administrative control was relaxed. Peasants were encouraged to return to small plots and abandon small shops for manufacturing steel and other production inputs. Even market forces were introduced to restore farm incentives.

Readjustment Policy for the Technoscience Community

Both Mao Zedong and the party leaders were willing to create a more favorable atmosphere for scientific, technological and economic development. To fill the technical gap left by the USSR, China began to selectively import technology from Japan and Western Europe, and to send a limited number of students to non-communist nations for professional training. The political pressure on intellectuals was briefly relaxed in order to restore the national agricultural research system and strengthen its ability to increase agricultural production.

By 1962, many research institutions and personnel returned from the countryside to their original locations. The Bureau of Science and Technology was established within the MOA to foster the development of agricultural technoscience and to promote a recovery in agricultural production. The extension system was particularly strengthened during this period. In 1963, the MOA also organized the Science and Technology Committee which provided advisory services to the ministry regarding agricultural technoscientific issues. During this period, the “Twelve Year Agricultural S&T Development Plan for the 1963-72 period” was developed with a special emphasis on the improvement of crop yield.

In contrast to the concentration on applied science during the Great Leap Forward, the CPC now emphasized scientific theory and abandoned the mass-oriented research projects that had been promoted earlier. Scientists were even given material incentives (e.g., extra

rations of edible oil) in order to fully develop their potential in *high intellectual labor* (or *gaoji naoli laodong*) (CAAS 1992). Moreover, the party at all levels was instructed to follow the advice of scientific personnel for technical matters, to let scientists and technicians take responsibility and direction in their own work, and to replace section chiefs who knew nothing about technical matters with university graduates.

The Intellectuals as the Working Class

The failure of the Great Leap Forward directly resulted in the decline of Mao's prestige as party leader, and the emergence of new figures in the political center including Liu Shaoqi (president of the PRC), Zhou Enlai (premier of the State Council), and Deng Xiaoping (Secretary-General of the CPC). Both Liu and Zhou attenuated the significance of *redness* as they believed in the need for greater separation between the professions and politics. They also supported the technoscientific community by developing a more open and tolerant political atmosphere for research. At the National Conference of Science and Technology in February 1962, Zhou declared that the majority of the intellectuals belong to the working class (Zhang 1989)². This was a significant step forward to re-legitimizing the intellectuals as the main agents for technoscientific activities and the role of the technoscientific system in modernizing the nation's economy.

By 1964, however, Mao began to criticize the continuing influence of bourgeois ideology on university science departments. The issue of *red* and *expert* created a division within the party leadership. As the intra-elite power struggle intensified during 1964 and

² For example, see Zhou's (1992 [1963]) speech at the Working Meeting for Science and Technology in Shanghai on January 29, 1963.

1965, the intellectuals were drawn into further political chaos. The technoscientific system began to crumble to dust in the following years.

PERIOD IV (1966-71): THE RED GUARDS

At the time when the national agricultural R&D system was regaining its ability to productively carry out the “Twelve Year Plan,” and agricultural production returned to the pre-Great Leap Forward level, another mass campaign began. The Great Proletarian Cultural Revolution began as a rather spontaneous effort to revive ideological class struggle in order to rectify the deterioration of ideological discipline within the party and cultural bureaucracies. When the effort was met with outright opposition from party members and political bureaucrats, the Cultural Revolution “exploded into a full-scale campaign of unprecedented ferocity and unexpected dimensions” (Goldman 1981: 117). Mao and his allies used student activists (or the Red Guards) to attack party members and intellectuals who possessed ideas contradictory to Marxism-Leninism and Mao’s thought.

Crisis in the Technoscientific Community

In the beginning, the Cultural Revolution managed not to interfere with industrial and agricultural production or with science and technology. Scientists were exempted from the Cultural Revolution, and instructed to continue their work as long as they did not engage in anti-party and anti-socialist activities or illicit relations with foreign countries. The Red Guards were instructed to refrain from attacking scientists and scientific institutions. Goldman (1981: 136) quotes an editorial of People’s Daily on July 23, 1966 to illustrate that high academic standards continued to be fostered in technoscience, and that technoscientists

remained in charge of nation's technoscientific activities regardless of their Western characteristics:

To learn with modesty from the advanced experience in science and technology of other countries is an important task for Chinese scientific workers.

The purges of Liu Shaoqi and Deng Xiaoping in the winter of 1966-67 removed the official advocates for protecting the technoscientific community from the mass campaign. The dichotomy between *red* and *expert* emerged to a greater degree as the central ideological polemic for justifying technoscientific policy. During the early years of the Cultural Revolution, the former finally took precedence over the latter.

Under the slogan, "Learning from the masses," agricultural researchers and technicians were once again forced to abandon their research and return to rural areas to learn from peasants. It was argued that experience gained from day to day physical labor (as opposed to intellectual labor) was a major contributor to technical innovations. Therefore, workers and peasants replaced the intellectuals at the center of China's technoscientific development. According to Goldman (1981: 137), the China News Agency made an announcement on October 17, 1966 that a new era had begun in China's technoscientific development. Like other intellectuals, technoscientists were to repent their Western and bourgeois thought:

China's scientific development could no longer rely on advanced Western technologies, and a handful of Western-trained scientists cooped up in laboratories, unaware of the needs of the masses. Instead, it would rely on Mao's thought to inspire the Chinese masses to create their own innovations.

Once the institutional framework of technoscience was redefined where the working/peasant class was to create technological innovations through their own daily labor processes, the existing institutional system became expendable. Therefore, many research and

even administrative activities were completely abandoned. Large amounts of library materials, equipment and facilities were damaged, and much precious germplasm was lost. Prior to the Cultural Revolution, Mao's thought was merely an ideological guide for technoscientists. Now it became the direct source for research activities and technological change, providing epistemological categories and ideological perspectives for every *good* (or *red*) technoscientist to adopt.

The Turning Point

By 1967, the Cultural Revolution moved to the urban area of most provinces, and the scale and scope of the violence escalated. China was nearly in a state of civil war when the Red Guards rampaged to violently attack not only intellectuals and party bureaucrats but also army leaders. As the nation moved closer to anarchy, Mao decided to curb the movement by purging the leaders of the Cultural Revolution Group and disbanding the Red Guards. By 1969, many crucial elements of the Cultural Revolution movement (e.g., the youth rebellion and violence, the attack on the party) ended, although intellectuals continued to suffer from attacks. The CPC leaders began gradually to return to their original position before demotion during the 1966-68 period and to restore order in the communist polity.

PERIOD V (1972-77): RETRENCHMENT

After the removal of the Red Guards from the mass movement, the second phase of the Cultural Revolution became less violent and brought back more pragmatic leaders to the Party. Between 1971 and 1975, over half of the economic planners purged in the previous phase were rehabilitated. Zhou Enlai and his supporters -- proponents of a more moderate

and balanced political line -- began to lead the effort to return the control of technoscience from the masses to intellectuals and technical experts.

Retrenchment

In fall of 1970, the North China Agricultural Conference opened. It restored agricultural modernization policies³ under the leadership of Zhou Enlai. In August 1972, the National Science and Technology Working Conference was held to revitalize technoscientific activities, based on intellectual and technical expertise in modern technoscientific disciplines and by restoring the institutional environment which was destroyed a few years earlier. Consequently, research activities began gradually to return to normal as the CPC recognized the importance of building the nation's technoscientific capacity for economic development. However, the damage caused by the Cultural Revolution was so profound as to haunt the entire technoscientific community to this date.

In 1970, the CAAS was officially abandoned, and renewed as the Chinese Academy of Agriculture and Forestry. Because of many staff were still in the rural areas, the number of staff was merely 620 in contrast to 13,963 before the Cultural Revolution (CAAS 1992). The number of research units declined from 62 to 35. After the National Symposium of Agricultural and Forestry Science and Technology in April 1972, agricultural R&D work began to gradually recover from the damage and regain strength to carry out research activities. At the meeting, it was decided to organize cooperative research projects based on twenty-two important objectives for agricultural R&D (CAAS 1992). However, the emphasis

³ The author thanks Dr. Mark Selden for pointing out these events.

in agricultural R&D continued to remain on the improvement of cotton and grain crops through varietal changes.

New Values in the Institutionalization of Technoscience

A more dramatic shift in the formation of technoscience policy during this time was a shift in emphasis among technoscientific fields. The gradual normalization of diplomatic relations with Western countries, particularly with the U.S., permitted greater opportunities for disclosing to the world, and more importantly to its own citizens, the nation's failure in realizing the *Four Modernizations Project* (or *sige xiandaihua*) that had been pursued for the last three decades. This brought a new set of interests, motivations, values and ethical commitments to top leaders in both the CPC and the technoscientific community. The CPC found the importance of effectively utilizing foreign relations to shape domestic political and economic policies. Technoscientists in the PRC were eager to participate in the international technoscientific community. In short, the greater exposure to the world helped the views of these historically antagonistic groups to converge their view on the guiding ideological principles for modernizing the technoscientific system.

Under the leadership of Premier Zhou, and later Deng Xiaoping, technology imports were encouraged to increase the efficiency of the industrial sector. According to Wang (1993: 74), China contracted with Japan and Western Europe for the purchase of over \$2 billion worth of equipment, machinery and complete plants. This open-door policy completely ended China's self-reliance for technological innovations, and substantially reduced the burden of applied research that would bring direct and immediate benefits to agricultural and industrial production. Instead, the technoscience system was encouraged to

move toward research fields that had the potential to attract foreign attention and increase China's prestige in the world. Basic science, which had been neglected for years, came to be recognized as important for modernizing the technoscientific system in the nation.

PERIOD VI (1978-84): FOUR MODERNIZATIONS

After the death of Mao Zedong and the arrest of *Gang of Four* (*sirenbang*), the CPC, under the full leadership of Deng Xiaoping, launched radical reforms of sociopolitical and economic organizations through (1) the decollectivization of agricultural and industrial production units, (2) the decentralization of political authority to provincial and local governments, (3) opening the door to the world, and (4) greater reliance on modern technoscience for economic development. The *Four Modernizations* became a renewed slogan for sociopolitical and economic development and the symbol for the Party's legitimacy, but its meaning changed. In other words, degrees of growth in agriculture, industry, defense and technoscience (i.e., the four productive forces, or *structure*) replaced the transformation of *superstructure* (i.e., communist vs. bourgeois ideology and culture) as the measurements for the CPC's leadership in the nation.

Reorganization of the Technoscience System

In 1978, both at the National Conference on Science and Technology, and the Third Plenum of the Eleventh CPC Central Committee, significant steps were made to consolidate different factions within the Party so as to reach official rectification of the ideological principles of the technoscience system. Under the slogan of *Four Modernizations*, the CPC issued a series of reform measures to reorganize the entire technoscience system.

Starting in October 1977, a new system of college entrance examinations began to be implemented that stressed students' performance in Chinese, mathematics and basic sciences. Moreover, graduate degrees began to be offered at selected universities, colleges and research institutes. In 1978, the State Council ordered the reinstatement of the CAAS. Professional ranks and titles were restored, and promotions were made for those who lost the opportunity in the previous ten years. Professional journals were renewed and revised as the main vehicle for technoscientists to communicate with their peers in the nation and even overseas.

At the same time, the leadership structure of universities and research institutes was reorganized by shifting control over technoscientists from the hands of the CPC to those of administrators in each organization. In June 1979, the National People's Congress passed new laws that allowed each institute to be run by one director and several deputy directors under the general leadership of the Party committee.

Moreover, at the same Conference in 1978 the "Outline of the National Plan for the Development of Science and Technology for the 1978-85 Period (Draft)" provided technoscientists with concrete, though broad and ambitious, targets for their activities for the first time in nearly two decades. The emphasis was placed on basic research in order to catch up with international developments in numerous fields in technoscience.

The objectives of the plan included: (1) reaching advanced nations' technical level of the 1970s by the mid-1980s in a number of technoscientific fields, (2) increasing the number of professional researchers to 800,000, (3) building a number of up-to-date research centers, and (4) completing the institutionalization of a nationwide system of technoscientific research (Wang 1993: 83). The plan also defined eight priority areas for modernizing technoscientific research: agriculture, energy resources, materials, electronic computers, lasers, space science

and technology, high energy physics, and genetics. Among the list of 108 priority programs, however, only 17 concerned agriculture. In short, the plan gave a clear justification to the reorganization of the technoscientific system by shifting the nation's focus from applied to basic research in terms of financial and personnel allocations.

Redefining the Goodness of Technoscience and Technoscientists

At the National Conference on Science and Technology, Deng Xiaoping announced that technoscience is one of four productive forces, and the most important one for a nation's social development (Liang, Wen and Liu 1992b). A remarkable aspect of the new policy measures discussed above is the change in criteria used to define and measure the goodness of technoscience.

In the previous two decades, Chinese technoscience relied exclusively on internal measures such as direct contributions to the nation's agricultural and industrial production and ideological correctness for evaluating how good its own technoscience system and technoscientists was. The nation's economic growth was calculated by the amount of a few major commodities (e.g., grain, steel, coal) produced in a given period of time without much consideration as to productivity or efficiency in the production process or quality of products. Therefore, the notion of *good technoscience* was based on short-term achievements with little consideration to more abstract and long-term contributions to producing knowledge. During the second and fourth periods, ideological correctness of technoscientists predominated as the sole criteria for defining *good technoscience*.

The opening of doors to the world brought not only opportunities for financial and technical assistance to improve nation's economy, but a new set of tools and criteria to

measure China's economic and technoscientific performance by situating the nation in a global context. Efficiency and productivity became indicators of economic growth. The improvement of product quality became an important goal in modernizing agricultural and industrial production.

However, the 10-year plan for technoscientific development clearly shows that many research priorities had little relevance to China's actual resource capabilities and did not correspond to China's actual situation and needs. As Wang (1993: 84) points out, "[r]esearch priorities were noteworthy more for their state-of-the-art scientific glamor and prestige than for their techno-economic feasibility." In short, *good technoscience* came to mean the potential to enhance the nation's prestige, status, wealth and power in the global political and economic system in the long-run.

Moreover, there was a strong tendency to mystify technoscience as the answer to all social problems in the PRC. Having become disillusioned with the formerly dominant ideology of Marxism-Leninism-Maoism, political leaders and intellectuals sought to fill an ideological vacuum with the idealization of technoscience (Simon and Goldman 1989; Wang 1993). Consequently, the role of technoscientists and experts increased in decision-making for economic planning and policy analysis. In short, technoscience came to signify the key to maintaining the legitimacy of the CPC in the nation.

However, the CPC was faced with the dilemma of maintaining central control over technoscientific activities on the one hand, and creating a more autonomous environment for technoscientists to maximize their abilities to engage in research on the other. The decentralization of agricultural and industrial management and the introduction of market mechanisms also helped the emergence of new actors such as local governments, industrial

enterprises, entrepreneurs and international organizations who now shaped technoscientific policies and R&D activities. Moreover, the continuation of the centralized institutional mechanism of technoscience with weak horizontal linkages among R&D institutions (see Chapter 6) created many redundancies in R&D projects and competition for funding. Although the central government always stressed the need for technoscience to serve production, the Chinese technoscience system never had addressed the issue of managing the products of R&D. For example, the State Science and Technology Commission (SSTC), the planning agency for technoscience, had never played a significant role in disseminating R&D results into the production process. It had always assumed that the products of technoscience would somehow spread across farms and factories without much intervention from the government or research institutions.

PERIOD VII (1985-93): REFORM OF THE TECHNOSCIENCE SYSTEM

Starting in the mid-1980s, a series of policy reform measures were issued to improve the effectiveness and efficiency of the technoscience system, particularly to increase the accountability of technoscience to economic production. After the decision was made to further modify the economic system in October 1984, the CPC released the formal reform document -- the "Resolution on the Reform of the Science and Technology System" -- in March 1984. This document illustrates an explicit attempt of the Party to create a linkage between economic reform and reform of the technoscientific system.

Reform of the Technoscience System

A series of reform measures for funding were introduced to make research institutions financially independent, to link them with production, to foster initiative among technoscientific personnel by encouraging collaboration among various research institutions, and to overcome the uneven and unequal distribution of research institutions within China by encouraging cooperation among provinces. Moreover, they aimed to reduce the central government's control over the allocation of research budgets, and to increase the role of external contractual funding mechanisms (e.g., the contract system, technological markets). Although the central government maintains its control over key projects defined in each Five Year Plan, research institutes are encouraged to engage in contracts with enterprises or other research units and to seek funding from research foundations.

The contract-system⁴ aimed to enhance the ability of research institutes to be cost-effective in their activities and to encourage them to evaluate the quantity and quality of their projects. The goals of the introduction of technological markets, where products of technoscience are marketed directly to enterprises, included speeding up the diffusion of technoscience to production processes by creating material (i.e., profit) incentives, promoting production-oriented R&D, encouraging labor mobility among technoscientists, and breaking down administrative barriers (Simon and Goldman 1989).

Various new organizations (governmental and semi- non-governmental) were also formed to facilitate planning and setting technoscientific priorities, such as the National Research Center for Science and Technology Development, exchanging information and

⁴ See Baark (1986) for the detailed discussion of the contract system and technology markets.

coordinating activities of professional societies including the Chinese Association for Science and Technology. Furthermore, a set of new laws and regulations were enacted to provide incentives for innovations by Chinese scientists and engineers, to protect national interests in the international communities, and to attract foreign investments to enterprises in China including: the Trademark Law (1982), the Patent Law (1985), the Civil Law of China (1986), the Contract Law on Technology (1987), the Law on State Secrets (1987) and the Copyright Law (1991) (Beijing Review 1991b). Moreover, regulations on standards, grading and safety were also issued to promote the improvement of quality in economic production through technical change (Nongyebu 1989c). This reliance on the legal system to improve the economy and the technoscientific system is something new to the people in the PRC.

In February 1986, the SSTC established the Natural Science Foundation of China (NSFC), which helped to increase funding opportunities for some researchers, particularly those who (a) were middle-aged, (b) had received a graduate degree, (c) had completed some training overseas, and (d) engaged in research in one of the priority areas. Similar to the NSF in the U.S., each scientist competes for a project-based grant provided by the NSFC and proposals are peer-reviewed. Such open competitions for research funds are designed to improve the quality of R&D in the PRC. In fact, only one or two out of ten proposals actually get funded (Meng 1995). This was the first time that the concept of *peer review* was introduced in the China's technoscience system.

Products of Technoscience: From Free Goods to Commodities

Suttmeier (1986) points out that strong ideological constraints to full development of the technoscientific system in the PRC during the Maoist period derived from the view of

Marxism-Leninism-Maoism that technoscientific knowledge and products are *free goods* and belong to the whole people. Therefore, there were no *material* incentives for technological innovations. As shown above, in the post-Mao period, technoscientific knowledge and products are no longer treated as a free good, but are treated as commodities that can be exchanged through market processes. In fact, the technoscientific reform program during Period VII was based on the premise that commercialization of technoscience would speed up the processes of technological innovation, thereby strengthening economic development.

However, this commercialization of technoscience involves redefining central power and the balance between state and market control over the technoscientific system. On the one hand, it reduces the financial dependency of the technoscientific system on the central government. Research institutes and universities are forced to become more financially independent by seeking contacts with enterprises, foundations, governmental agencies and other units, and/or developing their own companies that directly market the products of research. Moreover, this financial independence also allows the technoscientific system more autonomy in administering technoscientific activities. Instead of propaganda and mass-campaigns, formal measures such as laws, regulations and market processes have come to guide decision making processes among research institutes and universities.

On the other hand, the commercialization of technoscience also has the objective of increasing effective central power, or enabling the central authorities to do more effectively what they want to do. As decentralization of decision making power has expanded to rural households, enterprises, local governments, research institutes and universities, the roles of the central coordinating bodies such as the State Planning Commission (SPC) and the SSTC have clearly become more important. The logic behind this simultaneous decentralization and

centralization lies in the fact that the legitimacy of the nation-state (and therefore the Party) rests on its ability to deliver the promise of the *Four Modernizations*.

More importantly, the recent commercialization of technoscience fundamentally altered both criteria for and the process of defining the goodness of technoscience and that of technoscientists. When research projects were exclusively determined by a centrally planned process, the technoscientific system needed only to be responsive to the perspectives, interests, motives, values and ethical commitments of the central government, regardless of negotiations among other actors prior to developing a given central plan or policy. Therefore, the notion of the goodness of technoscience and technoscientists was also handed down from the top with little room for negotiation.

Today, a series of new actors such as enterprises, foundations, rural households, local governments and other research units -- both domestic and foreign -- participate in negotiations to shape research projects with their distinctive ideas of what, when, how and for what purposes a given research project should be carried out. Therefore, the notion of *good technoscience* and *good technoscientists* also must be negotiated among them. As is the case in the rest of the world, such a notion has come to depend greatly on concrete improvements in production processes (e.g., productivity, quality improvement), patents, profits, publications, acceptance from peers in the world and research funds. And, fundability of a given research project is determined by potential applicability to actual production processes, and/or potential contribution to global technoscientific knowledge.

Standardization: From Quantity to Quality

Both the commercialization of technoscience and the increasing participation in the global market have made policy makers, enterprise managers and researchers in the PRC realize the importance of standardization on a national scale. For the last three decades, the legacy of self-reliance in socioeconomic development and centralized control of political power created an institutional environment in both technoscientific and economic production that exclusively focused on the quantity of products without any consideration of the processes of production, distribution and consumption. An enormous imbalance in resource endowments among enterprises, farms and research institutes led to a serious lack of nationwide standards on quality, safety and technology. Moreover, the Great Leap Forward and Cultural Revolution programs completely disrupted various programs to establish national standards on, for example, measurements, seed, livestock breeds, industrial products, arms, etc. (Zhao and Huang 1993).

As discussed in Chapter 7 in detail, the revitalization of a centralized effort to standardize since the late 1970s was based on the view that standardization is a means to speed up both technoscientific and economic development by strengthening management and order in the production processes. On the one hand, formal standards appear to have replaced ideological doctrines of the CPC for disciplining social relations and processes of production. Certainly, grand party slogans such as those used in the Great Leap Forward or the Cultural Revolution are very powerful as described above. However, formal standards are also ideological, but represent a different type of strategy to infuse dominant values, ethics and ideas. In fact, propaganda and standards represent two notions of power that Foucault (1979) describes in the development of the modern penal system. The power of standards

comes from the ability to discipline minute aspects of things by controlling human activities. In this sense, they are a very powerful tool for the nation-state to direct socioeconomic and political activities.

The introduction of the household responsibility system has encouraged competition among rural households, enterprises, and technoscientific and administrative institutions for financial and technical resources both in domestic and global markets. Many enterprises in the late 1970s and the early 1980s realized the importance of meeting international standards in order to successfully participate in the global market. Chinese products were rejected by overseas markets owing to a lack of quality. Disparity among enterprises, rural households and research institutes began to emerge partly because of the differences in producing quality products. This has increasingly changed the emphasis of production processes from quantity to quality. In short, the criteria for determining the effectiveness of production processes changed from “How many products does a given unit produce?” to “How good are the products produced by that unit?” This fundamental shift in values of economic activities has allowed the national, provincial and local governments to accelerate the effort at standardization. At the same time, the role of technoscience in economic activities has been strengthened as technoscience became the driving force for realizing the standardization of production processes.

CONCLUSION

Despite popular presentation of technoscience as a value-free institution, the case of Chinese technoscience shows that the institutional framework of technoscience reflects the ideology and values dominant in a given society at a given time. Not only do they affect what

kind of research projects should be supported, but also how these projects should be theorized, methodized and reported. In short, every aspect of technoscience (e.g., material, cognitive, ideological) are shaped by the dominant ideology and values in society. Moreover, stability in these ideology and values affects how successfully technoscience is institutionalized in that society.

However, this is not to argue that the relationship between ideology and technoscience is unidirectional, e.g., that the dominant ideology inevitably determines the technoscientific system in a given society. Moreover, I reject the argument that everything there is to know in this world is reducible to our ideological constructs, or that facts are nothing but representations of our values. Instead, I argue that the relationship between ideology and technoscience, or values and facts, is far more complex, and that it is symmetrical. This is because both technoscience and ideology (or facts and values) are the outcome of negotiations, persuasion and coercion among actors. Although technoscience and ideology exist in the same network, each of these two domains involves a different set of actors, expertise, practices, tools, methods, organizational forms, goals and purposes. The relationship between these two domains is symmetrical because each influences the other by redefining necessary elements to be included in the network and changing the strength of linkages between actors. The seven periods described above indeed represent a distinctive form of the relationship between technoscience and ideology in the PRC.

The historical transformation of the technoscientific system in the PRC is linked to the changing notion of what constitutes *good technoscientists* and *good technoscience*. During the first five periods, technoscience was highly politicized in the debate over the dialectical relationship between *red* and *expert*. Moreover, the institutionalization of technoscience was

hampered by a constant shift in the notion of what constitutes a legitimate technoscientific system. However, note that each period differ in actors, tools, practices and organizational forms involved in shaping both the dominant ideology and the technoscientific system. For example, after the deterioration of the Sino-Soviet relationship, the USSR disappeared as a vital actor in the technoscientific process in the PRC. Nevertheless, the nation's propaganda continued to be formed in response to the USSR's political, military and economic platforms. On the one hand, certain top leaders in the CPC dominated the process deciding who should be involved in the debate and how this debate should progress. On the other hand, their power relationships were not always stable. Thus, the impact of the red-expert debate on the technoscientific community varies considerably over the five periods. As I will show in the next two chapters, the examination of actual technoscientific activities reveal the limitations of the CPC's dominance in (re)defining the legitimacy of technoscience in the PRC.

The reform programs since the late 1970s increasingly changed the sphere of the debate to the balance between state and market. The role of technoscience is no longer isolated from economic production, but deeply intertwined with both domestic and international market activities. Moreover, the reform program brought new actors with distinctive values and interests into the process of redefining what constitutes a legitimate technoscientific system in the PRC. In addition, the opening of doors to the world changed domains in and criteria by which the nation's excellence is evaluated. No longer is the CPC's legitimacy to lead the nation measured only by its ability to feed, clothe and shelter the Chinese population. Instead, more emphasis has begun to be placed on the party's capacity to make the nation a participant in global politics, markets, and technoscientific communities. In order to achieve this goal, the CPC needed a new tool for disciplining political, economic

and technoscientific activities so that resulting products of these processes would adhere to international standards.

Inclusion of new actors, practices, expertise, tools and goals into the network has certainly changed the interaction between ideology and technoscience in the PRC. In fact, in the last two periods, these two domains appear to exist independently. Thus, some may treat the diminution of party ideology in technoscientific activities as evidence that the PRC's technoscientific system has been successfully institutionalized. Nevertheless, it is important to recognize that new measures such as laws, regulations, grades and standards, market procedures, competitive grants, the contract-system, technological markets, professional organizations and peer review also reflect the ideology and values dominant in the PRC. They are tools to propagandize for the CPC's control of the nation and the superiority of Chinese-style socialism. However, unlike demonstrations, mass movements, public meetings and purges during the Great Leap Forward and the Cultural Revolution eras, new tools do not rely on infliction on physical and psychological pain as a means to control social relations and restore the power of the CPC. Instead, these new tools define what is socially acceptable human behavior and what things are at the minute level. Therefore, the power of the CPC can be realized by its success to use these tools in order to reorganize social relations by disciplining minute aspects of humans and things.

In the next four chapters, by examining activities and products of technoscience, I will show how three domains of our activities -- ideology (or values), technoscience and production -- are intertwined with each other in the network that consists of humans, things, ideas, tools, practices, values, texts, policies, etc. In the next chapter, I will examine the interaction of production and research activities for the last five decades by using the case of

rapeseed research publications. Then, in the following three chapters, I will illustrate how the value of uniformity has come to play a role reorganizing networks surrounding rapeseed by focusing on three domains including technoscience (Chapter 6), standardization (Chapter 7) and commodity exchange (Chapter 8).

Chapter 5

RAPESEED AND TECHNOSCIENCE IN THE PRC

INTRODUCTION

In the last chapter, I focused on the interaction between ideology and technoscience by showing how the technoscientific system in the PRC has been shaped by the changing notion of what constitutes *good technoscientists* and *good technoscience*. Just as recent studies of Chinese S&T policies (e.g., Saich 1989; Simon and Goldman 1989; Wang 1993) and dissident intellectuals (e.g., Goldman 1981; Miller 1996), I too emphasized the vulnerability of the technoscientific community to political and ideological struggles under the communist regime. However, although many extant works treat science¹ as a social institution interdependent with political and economic realms, they do not subject scientific knowledge itself to any social analysis.

For example, Miller (1996) describes science as if it were a unique institution made up of individuals with distinct socio-cultural biographies who are united by their shared norms and values. According to his Mertonian conception of science, the analytical focal point lies in understanding what socio-cultural and political conditions inhibit or foster “the norms of

¹ Most existing studies in this area tend to use dichotomies between science and technology, basic and applied science, theoretical and empirical science, and external- and internal-orientation of science.

healthy science into politics” (Miller 1996: 4). He argues that the driving force of intellectual dissidents such as Fang Lizhi, Dong Guanbi and Jin Wulun comes from their internal value for establishing and protecting the autonomy of science from state interventions. Moreover, he asserts that the orientation of science, that is the balance between basic and applied science, is determined by the tension between this anti-authoritarian ethics of science and the authoritarian ethics of the government. Miller (1996: 26) argues:

[S]cience lives by an internal, antiauthoritarian ethic and ultimately humanistic mission that sees value in understanding nature for its own sake. Maintaining that ethic is, in the minds of some scientists, essential to their calling. China’s experience in the 1980s is one clear example of this dynamic tension.

Yet, he never explains the process by which the so-called “scientific ethos” (p. 188) is internalized by Chinese dissidents. Instead, he describes them as heroes with a strong faith in science and a noble sense of mission to protect the community. Their heroism originates from their social role as scientists, and is expressed in their political activities and philosophical writings. But, Miller pays no attention at all to the relationship between their heroism and their practices in making scientific knowledge.

Similarly, extant work on S&T policies (e.g., Baark 1992; Conroy 1989; Saich 1989; Simon and Goldman 1989; Wang 1993) often describes minute details of technoscience policy making processes within the CPC leadership, but pay no attention to science in the making. These authors treat research activities as exogenous to the policy making process. Thus, discrepancies between policy goals and actual policy outcomes in S&T come from problems in the policy making process, particularly the relationship between the government and the S&T community, not in the technoscientific process. According to this view, therefore,

appropriate policies would foster the development of *good technoscience* and *good technoscientists*, thereby creating *good technoscientific products*.

In contrast, while focusing on technoscience in action, the SSST literature (e.g., Bijker, Hughes and Pinch 1990; Cozzens and Gieryn 1990; Knorr-Cetina 1981; Latour 1987; Pickering 1992b) tends to neglect to examine the interaction between technoscientific and production activities. As a result, the fate of new technoscientific products or processes beyond the laboratory is rarely discussed. Therefore, we are left in the dark as to whether what technoscientists produce are in fact *good technoscientific products*.

In the next four chapters, I will shift my attention to practices, values and processes pertaining technoscience in the PRC. By examining R&D, production and legal activities pertaining rapeseed, I will ask: What did technoscientists do to demonstrate that they practice *good technoscience* and are *good technoscientists*? What products and knowledge did they produce as *good technoscientific products*? What did other actors do to create, maintain and change these products and knowledge? Were these products in fact *good technoscientific products*? Using the actor network theory of the SSST (see Chapter 2), I will show that technoscience concerning rapeseed in the PRC has been developed and transformed in the context of building a network among various human (e.g., government officials, peasants, entrepreneurs, consumers, etc.) and nonhuman (e.g., rapeseed, oil, pigs, fertilizer, etc.) actors. And, I argue that products of rapeseed R&D are the outcome of negotiations among these actors who have an interest in technical change in the crop and the reflection of their power relations in the network. Moreover, I discuss why *good technoscientists* with *good technoscience* do not necessarily produce *good technoscientific products* in a society.

In this chapter, I examine the technoscientific literature on rapeseed published in the PRC between 1949 and 1993. Particularly, I am interested in demonstrating the interaction between production and technoscientific activities pertaining to rapeseed. For this reason, I discuss the shift in rapeseed R&D in the context of the commodity chain development by breaking down the analysis into three eras and seven periods.² As summarized in Table 5.1, these eras and periods³ mark a distinctive phase of rapeseed technoscience and commodity chain development.

The first section briefly discusses the role of rapeseed in the PRC. In the following section, the chronology of major events concerning rapeseed is summarized. Then, the third section analyzes rapeseed publication patterns in the context of the transformation of the agricultural sector and the rapeseed commodity chain. In the conclusion, I argue that rapeseed R&D simultaneously affect and are being affected by activities involving production, distribution and consumption of rapeseed and its byproducts. In short, technoscience not a exogenous variable of production induced by the political process. Although they appear to be separate domains in society, the processes of technoscience, politics and economy are intertwined in the same network.

² The same seven periods used in Chapter 4 are regrouped into three eras.

³ Note that they are not the only possible groupings.

Table 5.1 - Changes in the Organization of Agriculture, the Role of Technoscience, and the Goal of Rapeseed Production, 1949-93.

Era	1		2		3	
Period	I 1949-57	II 1958-61	III 1962-65	IV 1966-71	V 1972-77	VI 1978-84 VII 1985-93
Organization of Agriculture	Transformation to socialist agriculture			Establishment of stability in the rural sector		Transformation to more market-oriented agriculture
Role of Technoscience	Economic modernization	Legitimation of state	Economic recovery	Legitimation of state	Economic recovery	Economic modernization; Legitimation of state
Goal for Rapeseed Production	Self-sufficiency in oil crops	Not specified	Self-sufficiency in oil crops	Not specified	Self-sufficiency in edible oil	Self-sufficiency in edible oil and animal feed; Entry into the world market

ROLE OF RAPESEED IN CHINA

The production of edible oil crops in the PRC varies regionally (see Figure 5.1). Rapeseed is largely produced in central China, around the Yangzi River Valley (i.e., Anhui, Hubei, Hunan, Jiangxi, Shanghai, Zhejiang) and the Sichuan Valley while peanut production is concentrated in the coastal provinces, particularly in Shandong, Henan, Hebei, Guangdong and Jiangsu, and soybean production in the northern provinces. At present, three species of rapeseed are cultivated in the PRC: *Brassica campestris* L., *B. juncea* L., and *B. napus* L. As the PRC has vast territory with diverse agroecological conditions, the rapeseed production region is divided into winter rape zone with six areas and spring rape zones with three areas (Liu 1991).

Winter rape varieties dominate China's rapeseed cultivation, providing 90% of total rapeseed production (Wang 1987). They are concentrated in the rapeseed production areas: (1) north central China, (2) Yunnan-Guizhou Plateau, (3) Sichuan Valley, (4) middle reach of the Yangzi River, (5) lower reach of the Yangzi River, and (6) southern coast. Moreover, the Yangzi River areas and Sichuan Valley are the high-yielding regions, with an average yield of 1,360 kilogram per hectare (Nongyebu 1995). Currently, the five largest rape-producing provinces are Sichuan, Anhui, Hubei, and Hunan, making up about 64% of the total production and 57% of the total area (Nongyebu 1995). In the winter rape region, rapeseed is mainly cultivated in wet fields after one or two seasons of rice.

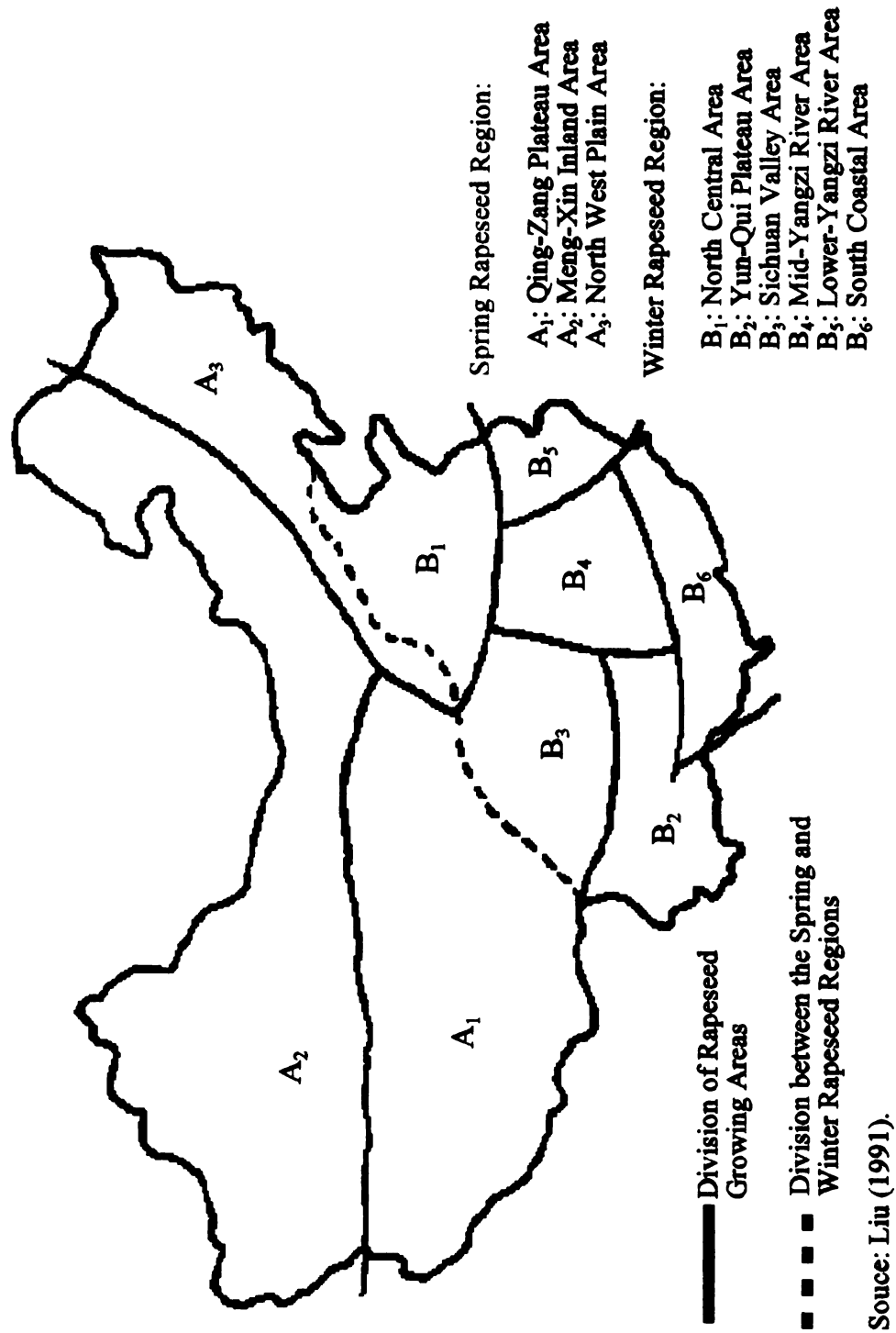


Figure 5.1 - Rapeseed Cultivation Regions in the PRC.

On the other hand, spring rape varieties are used on (1) the Qinghai-Tibetan Plateau, (2) the Mongolian-Xinjiang Plateau, and (3) the Northeastern plateau. The spring rape zone is characterized by severe cold winters with a short growing season -- very much similar to the Canadian and Scandinavian rapeseed production regions (Liu 1991). Rapeseed is usually rotated in the dry field with wheat, oats, or corn. More recently, canola varieties imported from Canada and Sweden are cultivated in the region.

Between 1949 and 1994, rapeseed production increased from 0.7 to 7.5 million metric tons, and yield increased by 2.7 times (see Appendix C). A dramatic expansion of rapeseed area occurred starting in the late 1970s. However, Table 5.2 shows that the growth in rapeseed production has not been linear. Fluctuations in area, production and yield of rapeseed among seven periods suggest that the network surrounding the crop may not have been stable, and therefore that careful analysis of rapeseed production activities during each period is necessary.

Table 5.2 - Average Area, Production and Yield of Rapeseed in the PRC, 1949-94 (by period).

Period	Area 1,000 ha	Production 1,000 tons	Yield kg/ha
I	1,839	852	470
II	2,050	765	366
III	1,604	759	460
IV	1,522	982	635
V	2,167	1,364	632
VI	3,316	3,552	1,038
VII	5,330	6,505	1,217

Sources: USDA (1992); Nongyebu (1992, 1993, 1994, 1995)

Historically, rapeseed has played an important role in China as a source of edible oil, organic fertilizer, animal feeds, and raw materials for soap and paints. As the standard of living in the nation began to improve rapidly since the 1970s, the demand for oilseed crops such as rapeseed also started to rise. Although production of rapeseed has rapidly increased within the last two decades and China leads the world in rapeseed production, domestic production of the crop does not yet fully meet the domestic demands for edible oil and animal feed products. Moreover, the role of rapeseed as an oil crop has come to depend greatly on the price advantage in the world oilseed market, and the ability of the domestic light industrial sector to substitute rapeseed for other oil crops (e.g., soybeans, peanuts, tropical oil crops).

Edible Oil

Rapeseed is the dominant edible oil crop in the PRC. In 1994, rapeseed accounted for 38% of total production and 47% of the total area sown to edible oil crops⁴ (Nongyebu 1995). One advantage of rapeseed as an edible oil crop compared with soybeans and peanuts is its high rate of oil extraction. Although soybeans and peanuts exceed rapeseed in the total quantity of production, only 14% of peanuts and 8% of soybeans harvested in 1995 were used as edible oil while 30% of the rapeseed harvest was consumed as edible oil as shown in Table 5.2 (US Embassy 1995). Nearly 40% of both soybeans and peanuts are consumed as food (often in processed form). And, soybeans are one of the major sources of animal feed in the PRC.

⁴ According to the Chinese government, edible oil crops include peanuts, rapeseed, sesame seed, sunflower seed, huma, and miscellaneous oilseeds (i.e., castor bean, safflowerseed, and perillaseed). Soybeans, cottonseed, and oil-bearing seeds and nuts from trees are excluded.

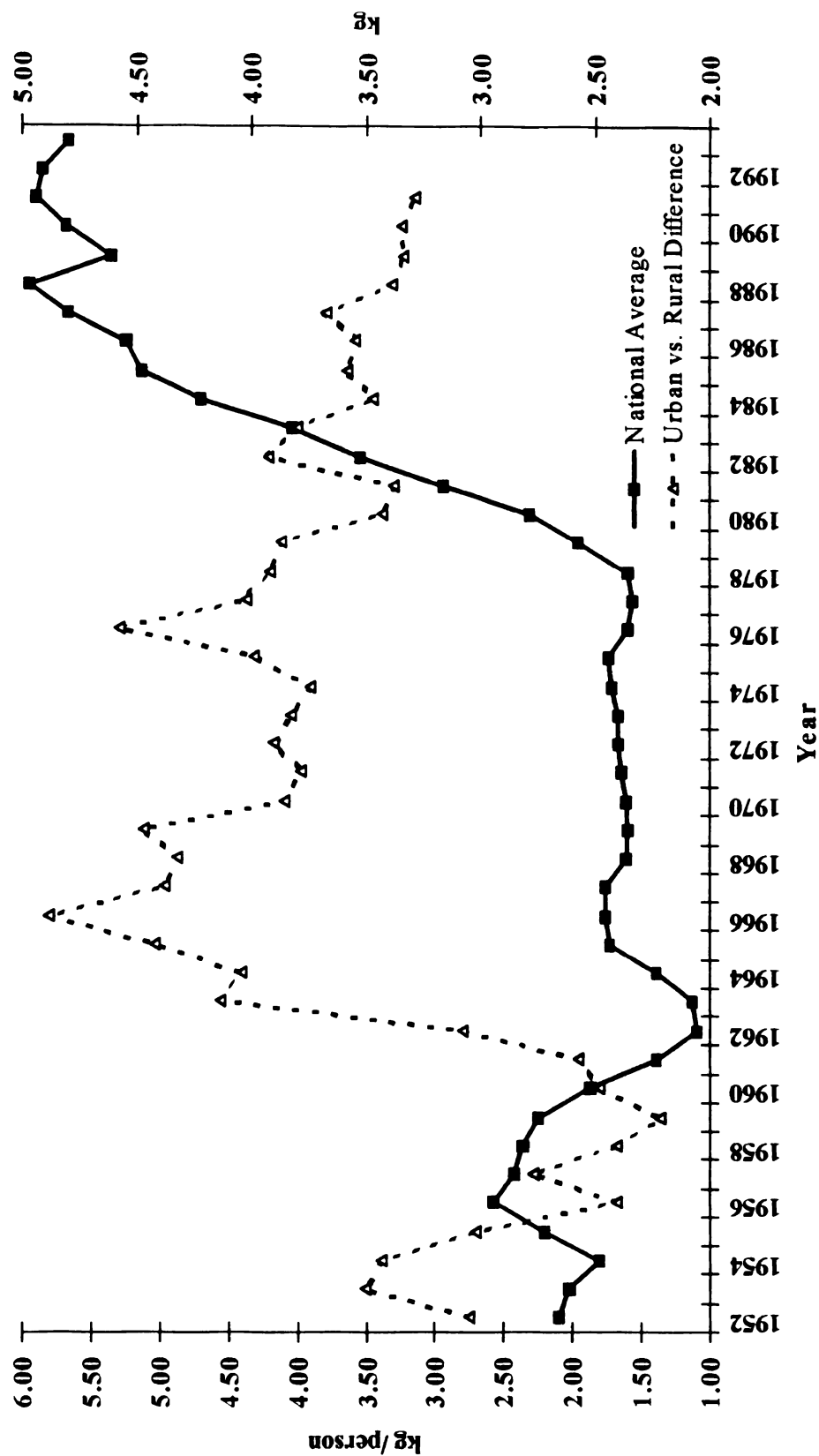
Table 5.3 - Utilization of Oil Crops in the PRC, 1995.

	Crushed				Food	Feed, Seed, Waste
	Oil	Meal (Feed, Waste)	Meal (Industrial)	Loss		
Rapeseed	30%	4%	51%	5%	0%	10%
Soybeans	8%	40%	0%	3%	39%	10%
Peanut	14%	22%	0%	20%	36%	8%

Source: US Embassy (1995).

Between 1952 and 1978, the annual level of edible oil (including vegetable and animal oils) consumption was fairly stable (see Figure 5.2)⁵, with a national average of 1.8 kg per person (USDA 1992). Starting in the 1978, the average per capita consumption level rose sharply. On the one hand, this seems closely related to the improved standard of living among the population -- both in rural and urban areas. On the other hand, the link between the standard of living and the level of oil consumption cannot explain the widening gap between the urban and rural population of the PRC in edible oil consumption since 1978. This is largely because unlike most capitalist countries edible oil was rationed by the government until recently. In fact, the data suggest that between 1952 and 1978 each urban dweller received three times more ration of edible oil from the government than his or her rural counterpart did. However, while the majority of the rural population began to supply their own edible oil after the breakup of the communes, the rationing of edible oil for the urban population continued until 1985.

⁵ See Appendix D for the raw data.



Source: Shangyebeu (1992, 1993); USDA (1992).

Note: *The 1991 and 1992 data are for the national average only.

Figure 5.2 - Annual Per Capita Consumption of Edible Oils, the National Average and the Difference between the Urban and Rural Population, the PRC, 1952-92.*

However, the consumption pattern of edible oil products is also closely linked to the geographical distribution of oil crop production. According to my recent interviews (various interviews, 1995, 1996), sesame oil is favored by most consumers in the PRC for overall quality, followed by peanut oil. However, the price of these oils, particularly sesame, is prohibitive for daily use. Generally, consumers north of the Huang River use soybean oil, while those south of the river use rapeseed oil. Although rapeseed oil is best suited for frying foods⁶ among all the edible oils, it is least favored by even regular rapeseed oil users for its unpleasant smell, dark color, and distinctive taste. However, more recently, with the introduction of oil refining techniques, these undesirable physical characteristics have begun to be removed from rapeseed oil products, particularly those which are available to the urban population.

Meal

In the last three decades, the demand for animal products has increased dramatically in the PRC. The average annual consumption of meats nearly tripled between 1952 and 1990. For example, during the period, annual per capita consumption of pork⁷ increased from 9 kg to 25 kg for the urban population, and from 6 kg to 15 kg for the rural population (USDA 1992). However, historically the majority of peasants in the PRC have conducted animal

⁶ Rapeseed oil has less moisture, and a high smoke point. This makes the oil ideal for frying food at a high temperature.

⁷ See Appendix D for the national, urban and rural average in the annual per capita consumption of pork.

husbandry merely as a sideline to crop farming.⁸ Therefore, until recently large-scale animal production was nearly non-existent. In order to improve the nutritional standards of the PRC's population, the government and aid agencies (e.g., World Bank, FAO) began to support projects to expand the scale of animal husbandry (World Bank 1987). Yet, the lack of a domestic supply of high quality animal feeds has been an obstacle to achieving this goal.

The use of rapeseed as a source of animal feeds has been limited because of the high content of glucosinolates, which are goitrogenic when fed in large quantity to farm animals, especially pigs and chickens. Therefore, rapeseed meal is largely used as organic fertilizer, and occasionally turned into fish feed or mixed with other feed materials. The PRC exports surplus rapeseed meal to Japan, Korea and Russia where it is also processed into fertilizer and fish feeds.

RAPESEED R&D DEVELOPMENT

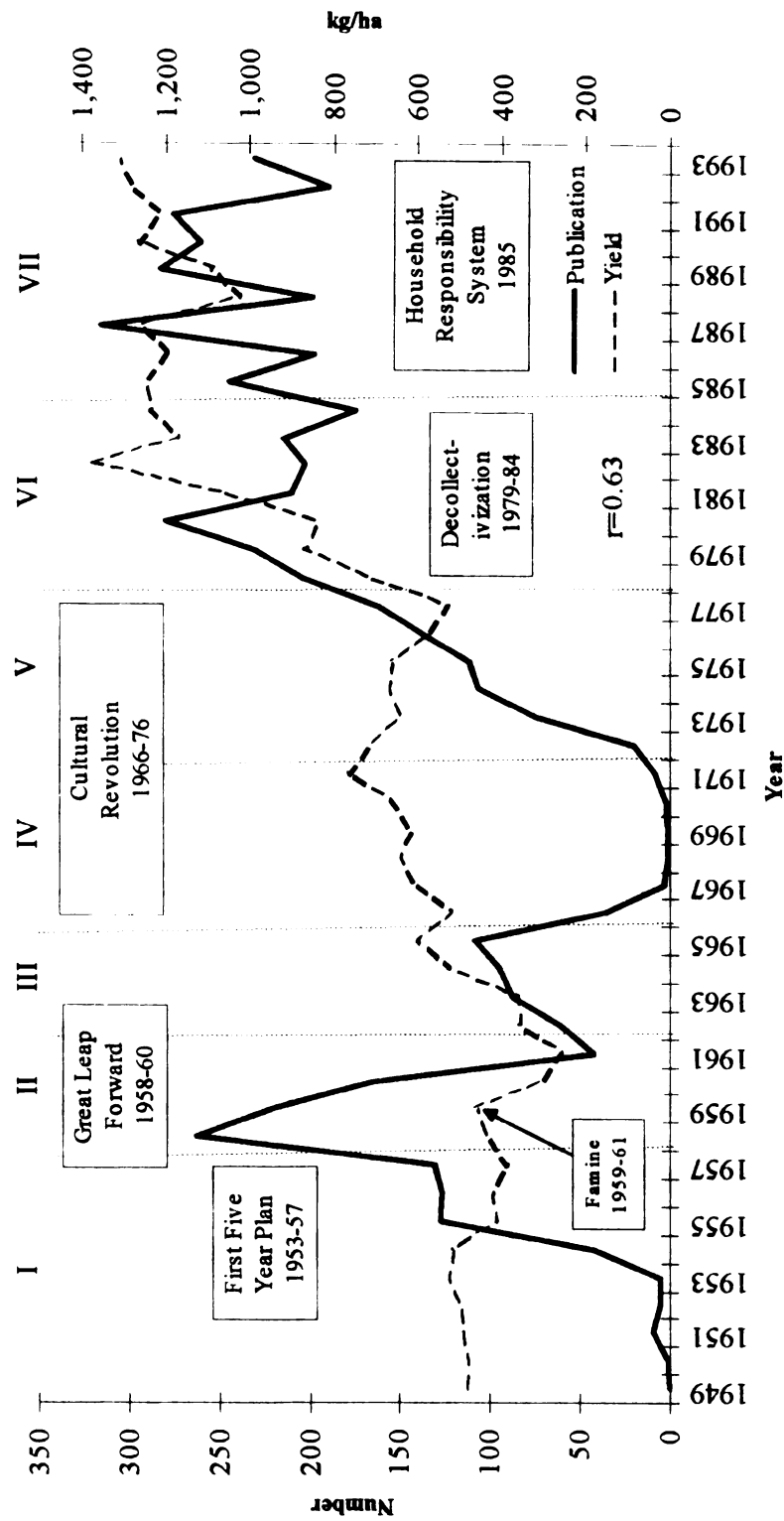
In the last chapter, I divided the history of technoscience into seven periods based on the interplay between two motives (O'Connor 1984) in policy making: *capital accumulation* and *legitimation of the state*. In this chapter, I examine how technoscientists actually pursue their activities in the context of changing organizational forms and goals for rapeseed production. Thus, I regrouped these seven periods into three eras (see Table 5.1) in order to discuss the history of rapeseed R&D in the PRC by analyzing the technical literature on rapeseed.

⁸ Nomads in Inner Mongolia, the Tibetan Plateau, and Xinjiang have been exceptions to this. However, they have repeatedly been forced to abandon their nomadic way of life, and switch to sedentary farming.

The first era consists of three periods that are characterized by the establishment of a centrally planned agricultural system and the reorganization of the national agricultural research system, both using the Soviet model. The goal of rapeseed production was defined in the First Five Year Plan (1953-57) as realizing self-sufficiency in edible oil. The second era includes the fourth and fifth periods. This era is distinguished in that the Great Proletarian Cultural Revolution completely destroyed the network of rapeseed technoscience. The last two periods comprise the third era. It is characterized by the transformation of agriculture to a more market-orientation, and a dramatic shift in the role of rapeseed in Chinese agriculture and technoscience.

Figure 5.3 shows striking fluctuations in the trend of rapeseed publications⁹ over the last forty years. Curiously, these fluctuations correspond to the changing political climate for technoscientists, particularly shifts in the notions of *good technoscience* and *good technoscientists* as discussed in the previous chapter. In other words, when technoscientists were viewed as the main agent of technoscience and their technical expertise became an important criterion for their work, the number of publications was in an upward trend. In contrast, when masses became the main agent and *redness* became a necessary credential, the number of publications began to decline.

⁹ See Appendix E for the raw data on the number of rapeseed publications and the distribution of research topics.



Source: Nongyebu (1992, 1993, 1994); USDA (1992).

Figure 5.3 - Publications on and Yield of Rapeseed, the PRC, 1949-93.

This interplay between the political ideology surrounding technoscience and the actual trend in rapeseed publications suggest several important aspects of Chinese technoscience ignored in S&T policy studies. First, the publication data empirically illustrate the vulnerability of agricultural technoscience to the political environment. The sudden declines in the number of publications during the Great Leap Forward and the Cultural Revolution show the pervasiveness of disruptions of the technoscientific system --“basic” (or pure, theoretical) and “applied” science alike.

Second, the data also illuminate something about “science by masses” during these two periods. For one thing, in “science by masses,” publication activities did not play an important role. As I will show in the next chapter, many important achievements in rapeseed research were indeed made during these periods. Although most agricultural technoscientists were relocated to rural areas, R&D activities never stopped even during the height of the Leap and Cultural Revolution movements. Therefore, we must keep in mind that the publication trend in Figure 5.3 tells us only about certain activities by certain actors. Nevertheless, the analysis of technical literature on rapeseed is a starting point to examine how technoscientific products/knowledge pertaining to the crop were constructed in the PRC.

During Period I (1949-1957), a rapid increase in the number of rapeseed publications from 1953 to 1958 indicates the emergence of a functioning rapeseed research system (see Figure 5.3). The predecessor of the IOCR of the CAAS, the Central China Academy of Agricultural Sciences (CCAAS),¹⁰ was located in Hubei Province. In the first half of the 1950s, however, there was no mention of rapeseed in its annual reports (CCAAS 1954a,

¹⁰ The name of South Central Academy of Agricultural Sciences (SCAAS) was changed to the CCAAS in 1955.

1954b; SCAAS 1951, 1952). By 1955, laboratories for rapeseed research opened at both the national and provincial academies, and the First National Symposium of Rapeseed Research was hosted by the MOA in 1956 (Liu 1994). The rapid growth in the total number of rapeseed publications from Period I to Period II corresponds to the emergence of a rapeseed research program at the CCAAS.

However, during the very early stage, the rapeseed research community lacked scientifically trained personnel. Those scholars who went overseas for a graduate degree¹¹ before the Communist Revolution were asked to return to the PRC in order to lead the improvement of the agricultural R&D system. However, many rapeseed scholars including Dr. Liu Houli at HAU, the PRC's authority in rapeseed breeding, did not return until the end of the 1950s. They later played an important role in training many currently active researchers.

During Period II (1958-1961), however, the rapeseed research system was decentralized. Many rapeseed researchers were removed from their labs and sent to rural areas in order to strengthen the linkage between production and research. However, the policy of regional self-reliance and self-sufficiency in grain led to a deterioration of research projects for the improvement of non-grain crops including rapeseed even in the rural areas. Some rapeseed researchers were forced to completely abandon their projects, and switch to

¹¹ Opportunities for overseas training (i.e., graduate degrees) for rapeseed researchers disappeared completely starting from the mid 1950s until the late 1970s and early 1980s. A Ph.D. degree in agricultural technoscientific fields was not conferred in the PRC until the early 1980s. Therefore, currently, those scholars between of age 40 and 60 are likely to lack any graduate training.

studying grain crops (Liu 1995). Indeed, the decline in the number of rapeseed publications from 1958 to 1961 is striking.

By Period III (1962-1965), the disastrous results of the Leap forced the Communist Party to return to more realistic policies that would help to achieve self-sufficiency in rapeseed production. By 1962, many research institutions and personnel returned to their original locations. The number of rapeseed publications began to increase again for a brief period before the Cultural Revolution. In 1964, the first comprehensive technical book on rapeseed cultivation was published in the PRC (Liu 1994).

During Period IV (1966-1971), the number of publications on rapeseed research fell dramatically as scientists became a target for political criticism and physical retaliation. It is striking that only 51 citations were recorded during the entire period including only 15 citations between 1967 and 1971. This lack of citations might also be attributed to the fact that many public records were destroyed during the height of the Cultural Revolution. It was not only laboratory research activities which halted during this period, but also regulatory and legislative activities important to production, processing, and distribution of rapeseed and its byproducts. Nevertheless, although rapeseed remained unimportant to the PRC's agriculture, the Cultural Revolution was also a decade of relative stability in rapeseed production compared to the previous three periods.

By Period V (1972-1977), many crucial elements of the Cultural Revolution movement (e.g., youth rebellion and violence, the attack of the party) had ended, and rapeseed research activities gradually returned to normal. In July 1973, the National Conference on Cooperation in Rapeseed Science and Technology was held to develop a rapeseed research agenda for the 1973-80 period. According to the report, rapeseed was

considered to possess the highest growth potential among the four major oilseed crops in the PRC. This was the first time that China's rapeseed production was evaluated in comparison to the technical level of other rapeseed producing countries. In this conference, China's need to develop its own double-low rapeseed varieties was stressed in order to reach and surpass the world level in rapeseed R&D.

Coincidentally, this was also the period when the Canadian research community succeeded in the development of new varieties free of two allegedly toxic compounds (i.e., erucic acid and glucosinolates) and began to transform the crop into a key player in the world oilseed market. By the early 1970s, major rapeseed research institutions began research projects to breed their own double-low varieties and investigate the possible use of rapeseed meal as animal feed (Liu 1995). By 1974, the number of rapeseed publications returned to the 1965 level. Furthermore, the normalization of foreign relations allowed some rapeseed research institutions to start seeking opportunities for research collaborations with, technical assistance and transfers from, and personnel exchange with overseas institutions, particularly from Canada, Sweden and the UK.

During Period VI (1978-1984), rapeseed was officially recognized as a key crop in the PRC for improving nutritional standards and strengthening the livestock sector (Tuan 1993; World Bank 1985, 1987). Under the sixth five year plan (1981-85), the SSTC established for the first time a national research program under the leadership of the SSTC, allowing each institute to seek multiple funding sources. As a result, the Sixth Five Year Plan (1980-85) for the first time included in the agricultural research agenda the development of high quality rapeseed varieties, turning rapeseed meal into animal feed (Liu 1995; Nongyebu 1989c). The National Key Technology Program (NKTP), which started in 1982, also

included several projects for the improvement of rapeseed. According to a report published in 1983, exports of rapeseed were expected to reach 2.3 million metric tons by 1990, and 15 million metric tons by 2000. Therefore, the national rapeseed research program which took shape during this period developed three goals: (1) to increase domestic production in order to meet the need for edible oils and animal feeds, (2) to turn rapeseed into an export crop, and (3) to improve R&D capabilities so as to reach the international level.

By the seventh period (1985-1994), the rapeseed research community began to enjoy a more relaxed environment than during any previous periods. The Seventh Five Year Plan included the development of protein sources for feeding animals, particularly from rapeseed and cotton seed, and the improvement of food processing techniques as priority areas. This increased support from the central government and the availability of funds from international organizations (e.g., World Bank, FAO), foreign universities and agencies contributed to the improvement of rapeseed research capacity in the PRC (various interviews, 1995). Meanwhile, rapeseed researchers began to actively participate and play an important role in the activities of the global rapeseed research community. This contributed to the shift in the goal of rapeseed production and research from achieving self-sufficiency to turning the PRC a key player in the global rapeseed market.

RAPESEED PUBLICATIONS PATTERNS, 1949-93

Many technical change in an agricultural crop involves in three modes of transformation: the crop itself, the environment where the crop is handled (e.g., cultivation, processing, retailing), and post-harvest treatment of the crop. As Juska and Busch (1994: 594) point out, each of the three modes presumes “the existence of specific, self-contained

networks in which each mode [can be] realized.” Any of these transformations requires changes in the behavior of one or more actors and in the interaction between actors surrounding the commodity. Therefore, the focus of research topics not only reflects the strategy for manipulating the crop, environment, and post-harvest treatment, but also implies whose interests, values, ethics and perspectives are integrated into technical change.

In a centrally planned economy the government and the dominant party tend to hold strong control over the emergence, maintenance and transformation of commodity chains. In the PRC before the late 1970s (Period I-V), the development of the rapeseed commodity chain was indeed distinguished by centrally planned policies that strictly defined economic activities of the participants through production quotas, procurement prices, and food and farm input rations. Human actors surrounding a given research project (e.g., scientists, government agents, peasants, input suppliers, extension agents, food processors, retailers/wholesalers, consumers) were not allowed to interact autonomously and independently outside of the state interventions. However, the analysis of rapeseed transformations into technoscientific knowledge and a commodity reveals that the case of the rapeseed commodity chain in the PRC is no exception in that rapeseed research activities are carried out in the context of developing the rapeseed chain.

As shown in Table 5.4, the number of rapeseed publications has a high correlation with various economic indicators¹² that describe general trends in the activities of the rapeseed commodity chain between 1952 and 1991 (Shangyebu 1992; USDA 1992). However, a qualitative comparison of these data at each period suggests that organizational linkages

¹² See Appendix F for the raw data on the economic indicators used in Table 5.4.

among various actors within the chain have not always been strong. In other words, changes in the activities of one corporate actor (e.g., an increase in the procurement price) have not necessarily been followed by adjustments in the activities of other actors (e.g., growth in rapeseed yield or area planted). Similarly, a new technical innovation (e.g., a low erucic and low glucosinolate variety) sometimes has little effect on the activities of other actors in the rapeseed chain (e.g., a high adoption rate and price advantage for this new variety).

Table 5.4 - Correlations between Publications on Rapeseed and Economic Indicators concerning Rapeseed Production, the PRC, 1952-91.

	<i>Publications on Rapeseed</i>	<i>Rapeseed Production</i>	<i>Rapeseed Yield</i>	<i>Purchase Price of Oil Crops^{1,2}</i>	<i>Retail Price of Edible Oils^{1,2}</i>	<i>Consumption of Edible Oils²</i>
Publications	1.00					
Production	0.72	1.00				
Yield	0.60	0.93	1.00			
Purchase Price	0.68	0.91	0.86	1.00		
Retail Price	0.56	0.85	0.76	0.95	1.0	
Consumption	0.70	0.97	0.87	0.90	0.86	1.00

Notes: ¹ Mixed average price is used here. It is an average of fixed, negotiated and open market prices, as well as an average of various standards, grades and qualities. ² The data for 1949-51 are not available.

Source: SSB (1992); USDA (1992).

Toward Socialist Rapeseed Agriculture (1949-65)

Before the Communist Revolution, most peasants in Central and Southern China raised rapeseed largely as a subsistence crop; they crushed their harvest to extract oil for edible and non-edible purposes, used meal as organic fertilizer, and fed leftover leaves and

stems to their pigs. Very little rapeseed and its products were traded in markets. Thus, during the pre-PRC period, rapeseed's significance as a commodity was limited.

Socialist transitions of agricultural production involved radical changes in the organizational forms for distributing land, capital, labor, commodities, and knowledge within society. They were accompanied by instability and uncertainty in agricultural production and research activities. The First Five Year Plan (1953-57) indicated the amount of rapeseed to be produced in order for the nation to achieve self-sufficiency in edible oil. For peasants, the first priority in rapeseed cultivation shifted from securing enough household supplies to making a delivery to the government.

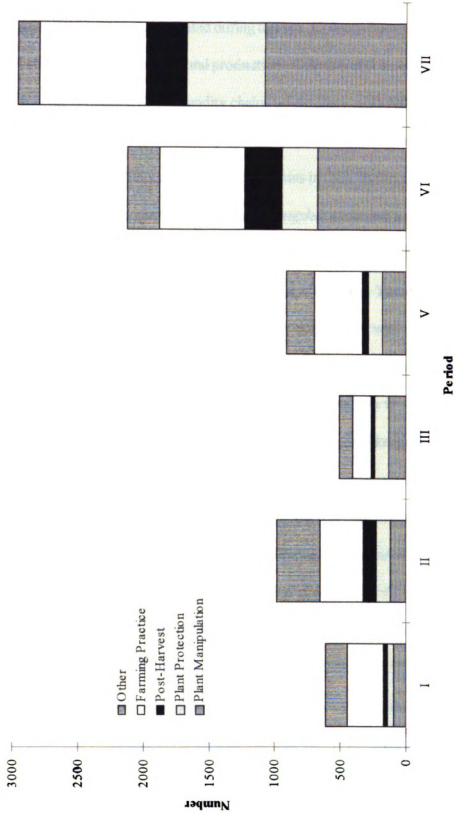
During Period I although the sown area increased, rapeseed yield continued to decline at an average annual rate of 2.5%, reaching 20% below the 1949 level by 1952 (USDA 1992). By the late 1950s, the failure to meet the production goals of edible oil crops during the First Five Year Plan led the central government to establish separate laboratories for rapeseed research at both the national and provincial academies. In 1956, the Ministry of Agriculture held the First National Symposium of Rapeseed Research to develop research projects that would realize China's goal of achieving self-sufficiency in edible oil (Liu 1994). The main strategy was to increase rapeseed yield through the application of technoscience, particularly the Soviet model of agricultural technoscience.¹³ In short, rapeseed was for the first time recognized as an object to be studied and manipulated outside of farm fields. On

¹³ Prior to the deterioration of the relationship with the USSR, China's agricultural research institutions relied on the Soviets for not only technical assistance and personnel exchange to improve the technical capacity, but also theoretical frameworks and methodological approaches to design and conduct research projects.

the other hand, little attention was paid to the improvement of storage and oil processing techniques.

According to various reports from the early rapeseed R&D programs published following that symposium, the primary goal for technical change in rapeseed was to increase yield through (1) the breeding of high yielding varieties, (2) the improvement of cultivation techniques (e.g., planting, the use of fertilizer), and (3) plant protection (e.g., against diseases, pests, drought). This research strategy would have required substantial transformation in the crop itself. Thus, we expect that during the first era manipulation of the plant was would have dominated rapeseed research. As shown in Figure 5.4, however, manipulation of the environment -- cultural practices of peasants growing rapeseed (e.g., when and how to plant, care, and harvest) -- overwhelmingly dominated rapeseed research. And, it is important to understand this discrepancy between the policy goal for and actual practices in rapeseed R&D.

The rapeseed research community faced three major stumbling blocks in order to successfully execute technical change in rapeseed. First, because the plant spread across the country with diverse ecological conditions over a long period, there seemed an enormous number of distinct varieties within the species. Moreover, cultivation practices for rapeseed differed tremendously geographically and culturally even within a given province. In order to breed high yielding varieties and recommend effective cultivation techniques, researchers first needed to record and evaluate characteristics of local varieties and cultivation practices within their own region. This required the development of uniform methods for variety testing and classification among research institutions across the nation.



Sources: CAAS (1981-95, 1983).

Note: Period IV is excluded from the analysis as the total number of citation ($n=51$) is too small for meaningful comparison.

Figure 5.4 - The Distribution of Rapeseed Topics, the PRC, 1949-93.

The second set of problems concerned the institutional environment where the rapeseed commodity chain was created during this era. Collectivization replaced the previous forms of social relations in agricultural production. Collectives (i.e., communes) became the basic unit in the formation of commodity chains where there were little division of labor for commodity production. For example, peasants not only cultivated rapeseed, but also made their own farm inputs and operated crushing facilities in their commune. In each commune, a Supply and Market Cooperative (*gongying gongshe*) procured a portion of the harvest quota, submitted it to a higher administrative organ, and distributed rations of farm inputs, food and other products among the members in the commune. Therefore, in this localized network, the expected technical change for each commodity was also extremely locally specific. Since the rapeseed research community was still at its infancy, peasants continued to be the dominant player in technical innovations, particularly in selecting high yielding varieties. Researchers largely remained the observers and record keepers of local knowledge on rapeseed.

Finally, since most actors within each collective handled more crops than just rapeseed, their limited resources were primarily directed to rice and wheat production under the grain-first policy, leaving very little to rapeseed production. As the role of rapeseed in Chinese agriculture remained marginal, the links among actors in the rapeseed commodity chain continued to be weak. For example, during the famine of 1958-61, the damage to rapeseed production was more profound than for grain crops. Even in 1961, when the production level of every crop fell to all-time low, the level of rice production remained above the 1949 level, while that of rapeseed was half of the 1949 level though the average procurement price of oil crops increased by 18.2% from the previous year (USDA 1992). It

was not until the end of the Cultural Revolution that the total area of rapeseed cultivation exceeded the level prior to the famine.

The above three elements helped to explain why during the first era rapeseed research was dominated by research topics relating to manipulation of the production environment (e.g., "Farming Practice," "Plant Protection," and "Others") instead of manipulation of the plant overwhelmingly dominate rapeseed research. Specifically, the number of publications on "Farming Practice" (i.e., when and how peasants plant, care and harvest) and "Others" (i.e., economic statistics, local production news, general study of the crop) predominate the mode of rapeseed research during the first and second periods. Between the first two periods, it is notable that these two non-technical categories declined from a total of 72% to 67% while technical categories (i.e., "Plant Manipulation," "Plant Protection," and "Post-Harvest") increased from a total of 28% to 33%. Considering the time gap between actual research and publication, these shifts may suggest the increased institutionalization of agricultural research activities in the PRC. Moreover, rapid increases in research on "Plant Protection" from Period I to Periods II and III appear to have some links with the famine of 1959-61, which was largely caused by adverse climate, and outbreak of pests and diseases. Furthermore, during Period III, a brief period between the two mass anti-intellectual and anti-science campaigns, the number of publications under technical categories increased dramatically to 51%. This may be attributed to the effort to institutionalize the agricultural R&D system briefly before it was completely abandoned.

Nevertheless, content analysis suggests that the rapeseed literature during the entire first era lacks the technical specialization observed in industrialized nations such as Canada, the U.S. and the U.K. during the same period. Thus, a large portion of citations were coded

under more than two categories, often farming practice and one or more other technical categories. The total number of highly specialized technical articles in such areas as genetics, oil chemistry, and plant physiology during these periods seems extremely small compared with the last two periods. Finally, the proportion of citations originating from research institutions is smaller than in the latter periods. In other words, local governmental and party organizations published as many, if not more, articles about technical innovations by peasants as research institutions did about their innovations.

Stability in Rapeseed Production (1966-71)

The rise of the Cultural Revolution movement again hampered the process of making rapeseed technoscientists vital in the network around rapeseed. First, the rapeseed research community was completely destroyed at the time when researchers began improving their ability to recommend appropriate varieties and cultivation techniques to peasants, and started new projects on rapeseed hybridization. Researchers were stripped of their jobs as technoscientists and sent to rural factories and farms. Their laboratories, tools, equipment, data and records were destroyed. Second, the effort to standardize the quality of seed, grain, oil and meal of rapeseed through technical change and policy measures was also halted. Third, the grain-first policy was pushed forward, and therefore the effort to strengthen rapeseed production was again abandoned.

During Period IV (1966-71), the average area of rapeseed cultivation is lowest of the entire 1949-93 period. Moreover, the procurement price of rapeseed appears¹⁴ to have

¹⁴ Here, I use the mixed average procurement price of edible oil crops. No separate data is available for rapeseed.

declined between 1965 and 1970 while the retail price of rapeseed oil seems to have remained constant (USDA 1992). However, during this period, the level of yield stayed constantly higher than the previous periods, thereby keeping the production level stable. This phenomenon may be attributed to various reasons. First, unlike the Great Leap Forward, the Cultural Revolution campaigns strictly remained within urban areas, leaving the rural production system unharmed from them. Thus, for the first time since 1949, the rural sector experienced relative stability in the environment for agricultural production. In a sense, socialist organizational forms of rapeseed production seem to have finally taken root in the soil of rural China. Second, the restriction on the size of rapeseed cultivation area encouraged each commune to adopt the highest yielding varieties in order to deliver the quota while leaving enough surplus for its own consumption. The collective form of production organizations helped to popularize a given technical change in a large area at a rapid pace. For example, just prior to the Cultural Revolution, in the winter rapeseed zone researchers and extension agents recommended the switch from landraces, or locally adopted varieties (mainly *B. campestris* or *B. juncea*), to *B. napus* varieties bred at research institutes from imported cultivars based on research results that showed the yield superiority of the latter. By the end of the Cultural Revolution, *B. napus* varieties were cultivated in somewhere between 80% and 90% of the winter rapeseed region (see Chapter 6).

Until the beginning of the second era, rapeseed as knowledge had been varied among extremely localized networks of actors, largely peasants. Moreover, there had been little specialized knowledge about the plant. Every rapeseed producer knew the physiological characteristics of their local varieties, proper cultivation techniques for each variety, and efficient processing techniques for and uses of the plant. The switch from *B. campestris* to

B. napus varieties was the first major technical change originated at formal research institutions, and carried out at a regional scale covering most rapeseed producing provinces. In short, despite the abandonment of the rapeseed research community, technoscientists within the commodity chain remained as players in rapeseed technical change. Interviews with prominent rapeseed researchers indicated that they unofficially continued their research work (largely breeding) at the farm to which they were sent.

After the National Symposium of Agricultural and Forestry Science and Technology in April 1972, rapeseed research work began to gradually recover from the damage of the Cultural Revolution and regain strength. Moreover, the National Conference on Cooperation in Rapeseed Science and Technology in July 1973 helped to transform the processes of network building around rapeseed. First, rapeseed for the first time became the link among research institutions who studied the crop. Before this conference, constant shifts in the political environment for technoscience prevented the effective implementation of national research agendas set at various professional conferences.¹⁵ Instead, rapeseed research was conducted to meet local needs with little collaboration among research institutions across provinces and even within a given province. At the 1973 National Conference, participants evaluated potential roles of rapeseed in the national economy. They emphasized the need for individual and organizational cooperation in rapeseed research in order to turn rapeseed into the nation's key crop for rising national income and improving living standards.

¹⁵ They include the First National Symposium on Rapeseed Variety Test in 1956, the National Working Meeting among Oil Crop Research Institutions in 1961 and the National Symposium of Rapeseed Science and Technology in 1963.

Second, under the unified goal to enhance the position of rapeseed in the national economy, technoscientists also began to appraise the nation's level of rapeseed research in a global context. China's rapeseed research projects had always been driven by production needs of specific locations. As these researchers became increasingly aware of rapeseed research outside the PRC, however, they also became conscious of potential contributions of their studies to the improvement in the nation's capacity for basic research, particularly in the areas of genetics and plant physiology, as well as to that of the nation's reputation in agricultural research in the world. At the same time, the central government gradually reversed its negative position toward engaging in research collaboration and personnel exchange with, and receiving financial and technical assistance from overseas institutions. Therefore, rapeseed researchers realized that their technoscientific achievements (as opposed to their ideological correctness) in the PRC would determine their reputation in the global rapeseed research community, and their ability to enroll additional human and nonhuman actors from overseas as their allies in the network surrounding their projects. In turn, their performance in these domestic projects also would help win a favorable position in the nation. In other words, rapeseed also became their vehicle to simultaneously enroll themselves in both the national and global networks of rapeseed technoscience.

In 1974, six low-erucic acid varieties were imported from Canada in order to carry out the goal of developing low-erucic acid varieties adapted to the agroecological conditions of the PRC. Around the same time, many rapeseed breeding programs in Sichuan and Hubei began to make significant progress toward the development of hybrids (see Chapter 6) including the discovery of a naturally male sterile variety, named *Polima* in 1972 (Liu 1994).

These may explain the graduate increase in the number of citations on “Plant Manipulation” starting in Period V (see Figure 5.4).

Toward More Market-Oriented Rapeseed Agriculture

During the last two periods, a series of policy reforms (e.g., the relaxation of the centrally planned economy, decollectivization, decentralization of political authority, the entry into global markets) contributed to a dramatic growth in rapeseed agriculture in the PRC. Between 1978 and 1984, the rapeseed area expanded at a rate of 5.6%; the area is currently almost four times larger than the 1949 level (Nongyebu 1995). In 1992, rapeseed production reached a record high of 7.7 million metric tons (Nongyebu 1993). Moreover, its yield almost doubled from 719 kg/ha in 1978 to 1,309 kg/ha in 1993 (Nongyebu 1994; USDA 1992). Finally, as discussed in the detail below, various actors in the PRC has begun to play key roles in the global rapeseed commodity chain.

These remarkable shifts can be attributed to three simultaneous processes of transformation. The first process involves changes in the role of rapeseed as a commodity in Chinese economy. Since the late 1970s, the central government shifted emphasis away from regional self-sufficiency and self-reliance on grain to diversity and regional specialization in agriculture. This encouraged peasants for the first time to cultivate non-grain crops. By 1980, the central government officially recognized rapeseed as a key crop in the PRC as its oil would contribute to improving nutritional standards and provide raw materials to industries, and its meal would help to strengthen the livestock sector (Tuan 1993; World Bank 1985, 1987). For the last three decades, rapeseed agriculture was only evaluated by the level of oilseed production -- whether or not it reached the quota set by the central economic

plan. Therefore, the central or provincial governments were not concerned with the ways in which rapeseed was consumed. Now, for the first time, rapeseed was looked upon as a raw material for various specific commodities including edible oil, animal feed, paint, soap, cosmetics, and etc. And, rapeseed agriculture began to be evaluated on its ability to meet the domestic demand for each commodity derived from the plant. However, in the mid-1980s, based on the optimistic and unrealistic projection that the rate of increase in rapeseed production would continue or even accelerate in the next decade, both the government and research community developed an ambitious plan to turn rapeseed into an export crop in order to earn foreign currencies. As the importance of rapeseed as a commodity increased in the Chinese economy, the central government began to gradually loosen its control over the crop. By the late 1980s, rapeseed was removed from the list of commodities in the central production plan, and edible oil was dropped from the food rationing program.

The above changes in the role of rapeseed as a commodity were accompanied by transformations in the rapeseed commodity chain. Since the late 1970s, the entire agrofood system has been decollectivized, and new organizational forms, norms and conventions have been introduced to shape the rapeseed commodity chain. First, the role of the CPC and government organizations declined, allowing many actors to become more autonomous. For example, individual farming households determine how much rapeseed to plant and how it is raised, harvested and sold. Various public enterprises (e.g., seed companies, input supply companies, oil processing companies) also make their own operational decisions. Today, many rapeseed oil products for the urban consumers are sold at privately-owned retail stores. Second, new legal measures (e.g., patent laws, grading regulations, quality standards, commerce and trade laws) were issued to replace interpersonal relations (e.g., peasants'

relationships with party cadres) in defining what constitute legitimate market activities and expected behaviors of each actor in the commodity chain. The central government learned the need for such formal measures through bitter lessons from participation in the global economy. For example, up till recently, most actors in the rapeseed chain paid little attention to the quality of the commodities. When foreign companies repeatedly rejected China's rapeseed and deemed their market practices unacceptable by, the chain members recognized the importance of ensuring that the commodity met international standards and their practices followed market convention (see Chapter 7). Third, in order to effectively carry out their responsibilities in the market, these actors were encouraged to develop more specialized knowledge and skills about the commodity as well as specific relationships with it. In short, the specialization in rapeseed chain activities began to emerge as each actor became free from the central plan and turned into a market agent. Consequently, these three adjustments in social relations within the communist polity and economy altered the mechanism for creating, maintaining and transforming the network of actors surrounding a given commodity.

Today, the rapeseed commodity chain is no longer imposed by the central government or controlled by the central production plan, the unified procurement system and the national rationing system. As I will repeatedly stress, instead the rapeseed commodity chain develops as autonomous and independent actors enroll and leave the network. Legal measures, market procedures, grades and standards, values, interests and ethical commitments serve as devices to monitor the behavior of actors and the activities of the chain as a whole. In short, they are what Foucault (1979) describes as surveillance mechanisms, and therefore, what allows the commodity chain to be a self-organized network.

The final process deals with rapeseed transformations as knowledge. In 1978, both at the National Conference on Science and Technology, and the Third Plenum of the Eleventh CPC Central Committee, significant steps were made to elevate the role of technoscience to one of the four means to modernize the nation. Both the central and provincial governments and party organs called for technical change in rapeseed through technoscience in order to achieve self-sufficiency in edible oil and meal. As a result, rapeseed research projects were for the first time included in the agricultural research agenda of a five-year plan. This helped technoscientists to replace villagers (largely peasants) as the dominant players in technical change on rapeseed. However, as the role of rapeseed as a commodity shifted, so did the goal of rapeseed research. For example, the Sixth Five Year Plan (1980-85) included the development of high quality rapeseed varieties, and of rapeseed meal as animal feed (Liu 1995; Nongyebu 1989c). Both the Seventh and Eighth Five Year Plans increased support for various rapeseed research projects in order to develop and disseminate double-zero (i.e., low erucic acid and low glucosinolates, or canola) varieties (various interviews, 1995). In short, Chinese criteria for *high quality* (*gaoji*) in rapeseed varieties shifted from their yield potential to their fatty acid composition. More precisely, high quality varieties must meet international standards for rapeseed, and produce oil and meal acceptable in the international market.

As shown in Figure 5.4, the foci of rapeseed research noticeably shifted from the previous two eras during the third era. The transition from local-knowledge-based to technoscience-based research is demonstrated by the increased significance of manipulation of the plant in rapeseed research during this era. Particularly, changes in the distribution of research topics from Period V to Period VI are striking: the proportion of citations on “Plant Manipulation” and “Post-Harvest” increased from 20% to 32% and from 5% to 13%

respectively, while that on “Farming Practice” and “Other” declined from 40% to 31% and from 23% to 12% respectively. By Period VII, “Plant Manipulation” (36%) and “Plant Protection” (20%) overwhelmingly dominated rapeseed research in the PRC. These shifts in the research foci suggest substantial changes in the role of rapeseed as commodity/knowledge in the commodity chain. At the same time, they also imply the reorganization of social relations among actors within the chain. As I will show in the case study in Xishui County, the third era saw a significant increase in the role of input suppliers, food processors and consumers concomitant with a decline in the role of peasants in shaping technical change on rapeseed.

Careful content analysis of the publications in this era also show the increased technical specialization both in terms of research topics and the location of research. The literature since the late 1970s is significantly easier to codify into one or two scientific topics. Unlike the previous five periods, much of rapeseed research during these two periods was conducted in provincial and national research institutions or agricultural universities. Local experiment stations are confined to conducting adaptation research and extension work.

Moreover, increased technical sophistication in research topics can be observed particularly in the areas of genetics and breeding, soil chemistry, and agronomy. Currently, the PRC is on an equal footing with Canada and Japan in the effort to develop new rapeseed varieties (Imamura 1994). China became the first country to succeed in developing hybrid rapeseed varieties. *Polima*, a male sterile line developed at HAU, is used by plant breeders in Canada, Japan and Europe. Finally, contributions to the international rapeseed research community can be observed through the increased number of titles including foreign collaborators, and research materials of foreign origin (e.g., varieties, equipment, methods).

These changes in the rapeseed literature strongly suggest that rapeseed research has been increasingly institutionalized, and particularly specialized, to meet the political and economic goals of the nation and to ensure its entrance into and survival in the international food order.

CONCLUSION

Technical publications are indeed products of technoscientific activities. In one sense, they are what a given technoscientific community consider as *good technoscientific products* at a given time. They are part of the shared knowledge within that community. At the same time, publications also tell us about people, things, practices, ideas, values, organizational forms, expertise, etc. that make up that community. In this sense, technical citations are inscriptions of networks surrounding the technoscientific community that can be analyzed. Therefore, the analysis of technical literature in a given society illuminates the process of institutionalizing technoscience in a given society at a given time. However, these data alone are not sufficient to understand technoscience as a social institution. This is largely because they do not tell us anything about what happened technoscientific products *before* they were created and *after* they left the hand of technoscientists.

In the case of rapeseed research in the PRC, the analysis of the rapeseed literature suggests that rapeseed technoscience involves production of new knowledge and modifications of the plant. These publications show us what were legitimate *practices* and who actually participated in the process of constructing knowledge about the plant in the PRC. During the first two eras, the main strategy for rapeseed research was to utilize and improve local knowledge about the plant and cultivation techniques for it. Consequently, many rapeseed publications were written by those with limited *formal* training in modern

science, and circulated in non-professional media such as newspapers and magazines. During the third era, however, the authors, publication types and institutional affiliations of rapeseed publications were completely different from those in the previous two eras. They indicate the increased professionalization and specialization in rapeseed research. The type of knowledge produced from research moved away from non-technical to more technical knowledge (see Figure 5.5).

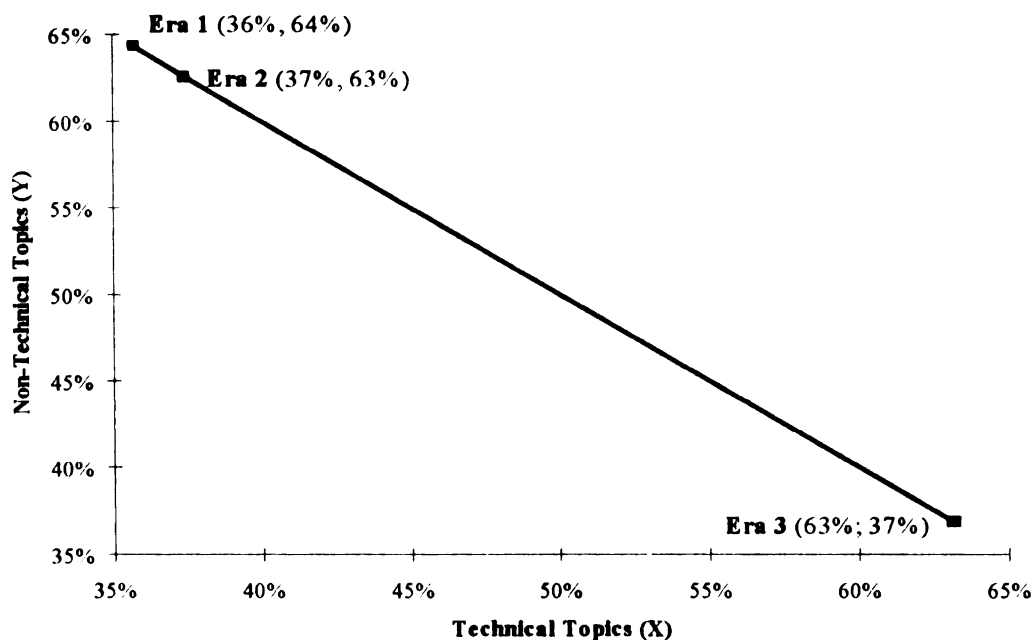


Figure 5.5 - The Distribution of Rapeseed Publications between Technical and Non-Technical Topics, by Three Eras.

Nevertheless, rapeseed is also an agricultural crop to be cultivated, processed and consumed. It is a *commodity* to be exchanged between human actors. Thus, when combined with economic indicators related to rapeseed, the analysis of rapeseed publications reveals that rapeseed technoscience also involves extension of the networks surrounding the crop as both knowledge/commodities. While constructing knowledge about the plant, rapeseed research also reshaped the role of rapeseed as a commodity and reorganized the network of

actors involved in production, distribution and consumption of the crop. Thus, shifts in research topics and publication practices also reflect changes in social relations among actors involved in technoscientific, legal, political and economic activities concerning rapeseed and its byproducts.

For the first two eras, centrally planned policies with strict control of urban migration among peasants allowed the state to monopolize market activities concerning rapeseed both at the domestic and international levels including the purchase and distribution of farm products. These policies resulted in the lack of integration between pre-harvest and post-harvest activities of rapeseed production. Moreover, the policy of self-sufficiency and self-reliance in both agricultural and industrial production discouraged interregional trade within the nation without approval and instruction from the central government. Consequently, the organizational form of the rapeseed chain remained a myriad of small local networks, not necessarily extending beyond local boundaries (e.g., county, village). In other words, a strong rapeseed commodity network never developed at the national level as there were no rules or guides for economic transactions beyond the locality. Rapeseed production activities were locally specific, the knowledge about the plant/commodity was also grounded in specific localities.

During the third era, the transition from local-knowledge-based to technoscientific-knowledge-based research (see Figure 5.5) corresponds with the increasing differentiation of actors in the rapeseed commodity chain, the diversification of rapeseed commodity production, and the emerging need to meet specific demands of a wider range of intermediate and final consumers. In other words, with the opening the doors to the world and the introduction of market mechanisms, new elements entered into the rapeseed commodity chain.

Each actor now has an option to extend market activities beyond a small locality which was once strictly defined by the administrative hierarchy. The availability of canola varieties from foreign research communities has allowed marketers to export their products. Moreover, the adoption of advanced storage, transportation, and oil refinement technologies at factories (often large-scale factories located in the special economic zones) has permitted oil processors to market their products over greater distances. In short, the incorporation of new elements into the rapeseed commodity chain became possible by providing the crop with new qualities that allowed it to establish linkages between and among elements of the chain.

Nevertheless, many actors in the rapeseed chain in the PRC, particularly those located in the rural areas, have lagged behind technoscientists in extending their networks. The decollectivization and the introduction of market economy have not automatically made these actors into market participants. Or, put another way, the conversion from a centrally planned to a more market oriented economy in itself has not been enough to successfully develop the rapeseed commodity chain. Moreover, the development of so called “high quality” varieties (e.g., canola varieties, hybrids) specified in the national rapeseed R&D program in itself has not been sufficient to achieve the goal of turning rapeseed into an export crop. In fact, within the last two decades, the PRC became an importer of rapeseed from Canada and rapeseed oil from Europe and North America.

In the next three chapters, I will attempt to explain why rapeseed chain actors in the PRC have not been successful in reorganizing their linkages with other actors. I will discuss the importance of technical (Chapter 6), legal (Chapter 7), and institutional (Chapter 8) changes, and changes in values of actors (Chapter 8) that will be needed to allow the

extension of the networks. In each chapter, I will focus on the effort to create, maintain and change uniformity in rapeseed and its products through these processes. By doing so, I hope to show that what researchers view as *good technoscience* does not necessarily produce *good technoscientific products*.

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Chapter 6

NEGOTIATING FOR THE CREATION OF UNIFORMITY: RAPESEED RESEARCH

INTRODUCTION

During our freshman year of college, we learn that scientific knowledge is different from other types of knowledge such as arts and humanities. Most introductory textbooks of natural or social sciences define the former as an *organized* and *systematic* body of knowledge. Moreover, these textbooks explain that the use of scientific method allows scientists to *evaluate*, *understand*, and *predict* a phenomenon that they study. Furthermore, in order for a piece of information to be recognized as scientific knowledge, research results must be replicated. And, it is this predictability and repeatability of a phenomenon that supposedly makes science more reliable than other types of knowledge. As a freshman, I did not question what I learned from these textbooks about science. Over a decade later, as a student of the SSST, I became fascinated by the dichotomy that exists in our society between scientific and non-scientific knowledge. I have come to realize that the meaning of *organized*, as opposed to *unorganized* and *disorganized*, knowledge holds the key to understanding not only what makes technoscientific knowledge unique but also powerful in modern society.

By the above definition, then, technoscience is a human endeavor to organize knowledge about natural and social phenomena. However, as Law (1994) demonstrates from

his case study, actually doing technoscience involves more than organizing knowledge, but also ordering the modern world itself through (re)structuring a network of heterogeneous materials including, but not limited to, scientists, talk, texts, lab animals, machine, tools, architectures, lab technicians, and research funds. In other words, technoscientists are agents for both technical and social change, that is, agents for what Law (1994: 2) calls “sociotechnical ordering.”

Success in such an endeavor depends on precision in controlling activities for sociotechnical ordering. In order for a set of research results to be replicated, every experiment on the same research topic must be conducted in an environment uniformly controlled in a precise manner for room temperature and moisture, the number and time of tests performed, the amount of chemical compounds used, to the qualifications of lab technicians and the breed of lab animals. Moreover, research findings from these experiments must be reported in a uniform fashion as specified by a journal or a professional organization, using language that can be understood uniformly by the members of a particular technoscientific community. As Wise (1995: 9) emphasizes, “[p]recision thus requires ... an extensive set of agreements about materials, instruments, methods, and values that reach out into the larger culture.” Therefore, predictability and repeatability of a phenomenon in technoscience depend on precision accomplished by an extended network of people and things.

Furthermore, precision through instruments and measurements makes it possible “to extend uniform order” in many domains of our experience “and control over larger territories” (Wise 1995: 5). Thus, if sociotechnical ordering is one of the most important goals in technoscience, then creating uniformity must be seen as its greatest virtue.

The next three chapters examine how various chain actors are enrolled in the effort of creating and maintaining uniformity in rapeseed through technical change, legal and policy measures, and market procedures. Particular emphasis is placed on the impact of economic and political reforms since the late 1970s in making uniformity a dominant value in the transformation of rapeseed as both commodity and knowledge. Moreover, these reforms have changed the environment for negotiations of goals, interests, motives and values among various chain actors. I will show that rapeseed researchers in the PRC, despite their high competency in generating technical change, have not yet been successful in reorganizing a network of heterogeneous materials outside their laboratories. In other words, new technology and official standards for rapeseed and its products have been ineffective in meeting their goals. In Chapter 8, using a case study of Xishui County, I will demonstrate that the commodity chain surrounding rapeseed as a commodity is still in the process of being reordered, and that diverse values of uniformity in rapeseed held by other actors are hardly incorporated into technical change.

In this chapter, I examine specific products of technoscience developed over the last four decades to create uniformity. The first section briefly describes the institutional environment for the rapeseed technoscience community. Then, in the next section, I examine three types of technoscientific products that represent different meanings of uniformity. Although these products were developed chronologically in sequence, there were considerable overlaps in the time periods. I demonstrate that changes in the concept of uniformity embedded in each type of technoscientific product reflect on the simultaneous transformations of rapeseed as commodities and as knowledge. Moreover, these changes suggest that rapeseed technoscience in the PRC has become increasingly institutionalized and

integrated into the global network of rapeseed technoscience. Today, understanding of rapeseed in society largely comes from abstract (or technoscientific) knowledge rather than from local (or indigenous) knowledge, while the use of the plant is differentiated into specific commodities such as edible oils, feeds, fertilizers, and industrial products. However, the increased abstraction as knowledge and differentiation as a commodity requires more precise control over human and nonhuman actors in the network. Therefore, technoscientists must be able to establish uniformity at every step in the process of generating technical change in order to successfully create a particular type of uniformity in rapeseed. In conclusion, I point out that the rapeseed research community is technically competent to develop products beneficial to China's rapeseed production. However, I argue that technoscience products alone are not sufficient to induce technical change because the behaviors of other chain actors must change in order to create and maintain the benefits of these products.

INSTITUTIONAL ENVIRONMENTS OF NEGOTIATIONS

The basic structure of the rapeseed technoscientific system has not changed much since its emergence during the 1950s (CAAS 1992; Nongyebu 1989c). According to policy goals specified in a five year plan with funds allocated by the State Planning Commission through the SSTC and respective ministries under the State Council, various institutions linked horizontally and vertically carry out research, extension, training, and education projects related to rapeseed. Usually, these projects are conducted by four horizontally-linked sectors (see Figure 6.1): (1) Academies, institutes and universities/colleges (e.g., Huazhong

Agricultural University) under the jurisdiction of the MOA¹ carry out both basic and applied research in pre-harvest activities of rapeseed production. (2) Institutions under the CAS perform basic research related to agrofood sciences (e.g., biology, botany, genetics, physiology, entomology, chemistry, etc.). (3) Universities and colleges under the Ministry of Education (MOE) engage in basic and applied research for training and educational purposes. (4) Academies, institutes, universities, and colleges of other ministries conduct basic and applied research in post-harvest issues such as oil processing (e.g., the MIT; the MLI) and human nutrition² (e.g., the Ministry of Public Health [MPH]). However, as observers of the Chinese agricultural research system (e.g., CAAS 1992; Fan and Pardey 1993; Niu and Chen 1994; Nongyebu 1989) have repeatedly pointed out, very little communication takes place among the horizontally-linked institutions. Consequently, it is extremely difficult to develop multidisciplinary collaborative research projects. Moreover, the weak horizontal linkages often foster competition between institutions over limited funding, thereby creating unnecessary duplication (Conroy 1989; Fan and Pardey 1993; Simon and Goldman 1989; Stavits 1978a).

¹ Besides the CAAS, the MOA supervises the South China Academy of Tropical Crops (SCATC), the Chinese Academy of Fishery Sciences (CAFS), the Institute of Agricultural Engineering and Design, the Agricultural Environment Protection Institute, and the Biogas Institute. The Chinese Academy of Agricultural Mechanization (CAAM) is jointly controlled by the MOA and the Ministry of Machine Building (MOMB).

² Animal nutrition is conducted by institutes under the CAAS and the MOA.

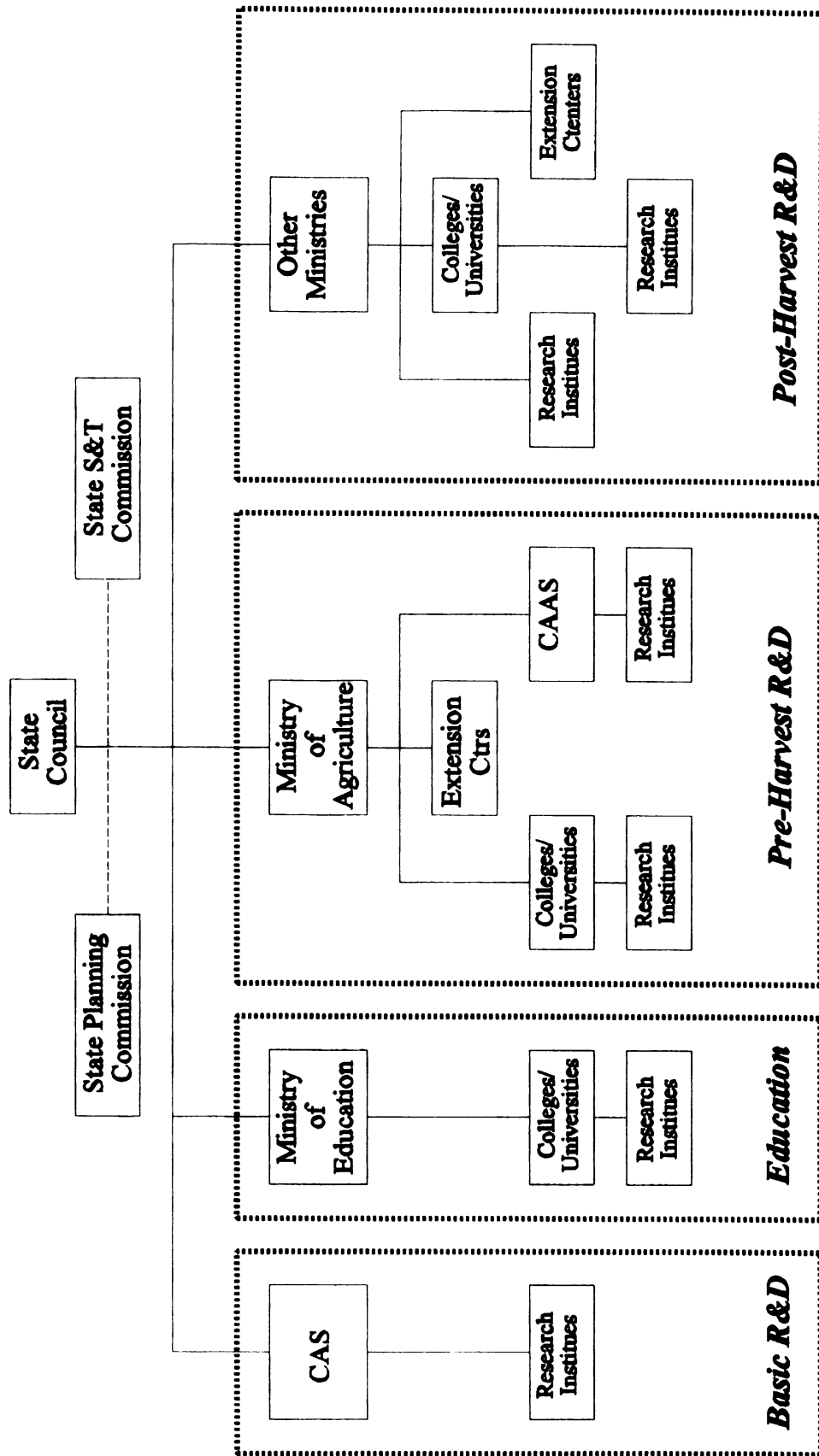


Figure 6.1 - Horizontal Linkages of Rapeseed R&D Institutions at the National Level in the PRC.

Moreover, R&D institutes, extension agencies and universities are vertically linked under a *xitong* of a given ministry among different levels of administration (see Figure 6.2). While national institutions develop programs applicable to the entire nation (e.g., basic research, pilot research), provincial and local institutions carry out programs specific to their local circumstances (e.g., adaptive R&D³, extension). These institutions from different levels maintain “professional relationships” (*yewu guanxi*), but not “administrative relationships” (*xingzheng lishu guanxi*). In other words, although they often engage in a series of collaborative programs and exchange policy and technical information, they are administratively independent and autonomous from each other. At each level, research, extension and education institutions under a ministerial *xitong* are administratively controlled by and responsive to their immediate government. Therefore, each local branch of a ministerial *xitong* develops its own research, educational and extension plans, finalized by its own Science and Technology Commission, and receives funding from its own Planning Commission and Economic Commission. Because administrative authority tends to dominate making decisions about research activities through its funding and personnel management mechanisms, research institutions are usually prone to respond only to the demands of immediate administrative authority, not to those of the production sector (Zhou 1987). Therefore, few financial resources or policy guidelines are directly funneled through the ministerial *xitong* from the center to local levels.

³ For example, much of plant breeding for local varieties takes place at the prefectural level.

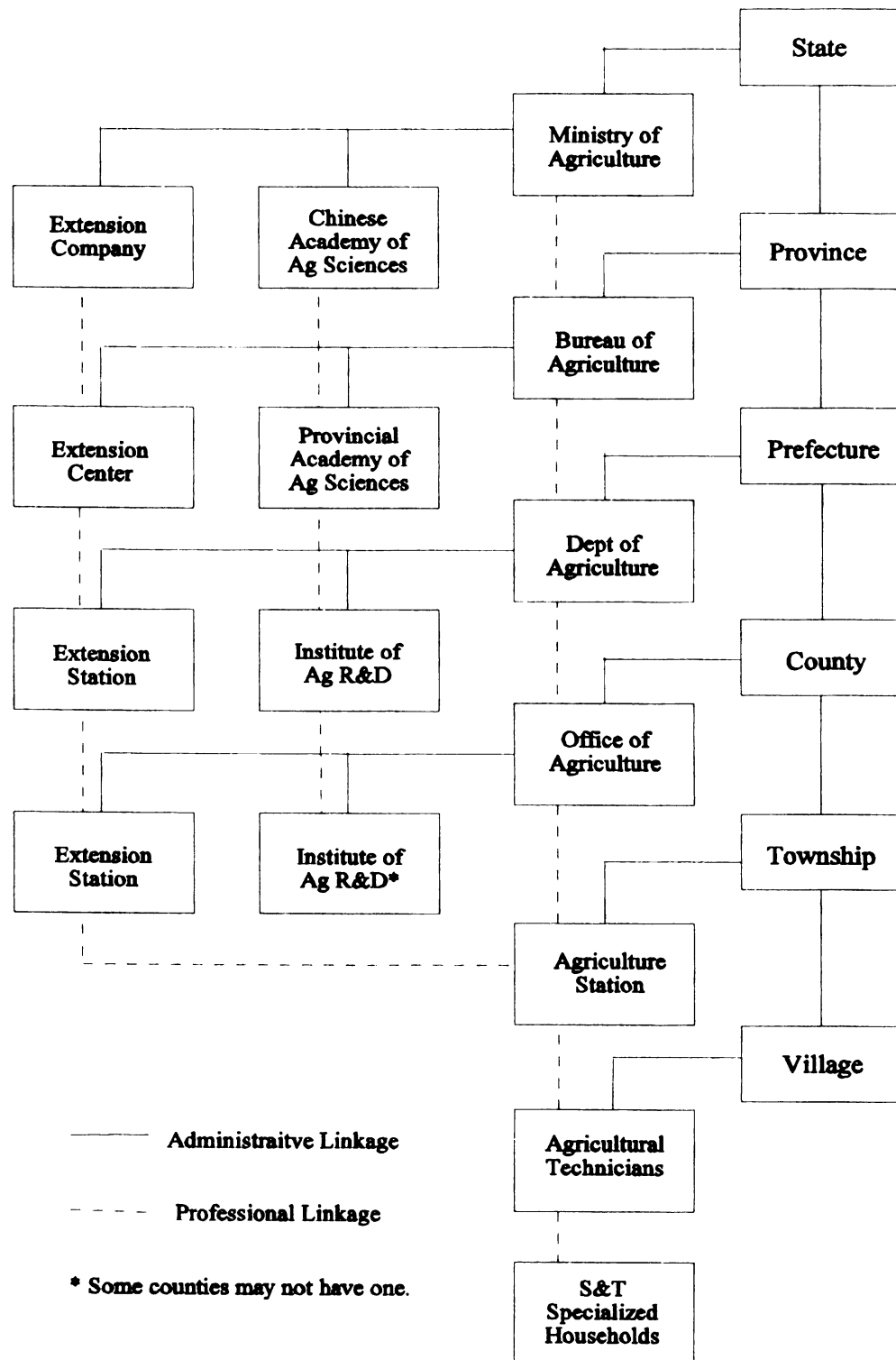


Figure 6.2 - Vertical Linkages of Research and Extension Units under the MOA *xitong*.

The weak horizontal linkages and ineffective vertical linkages among governmental, research, educational, and extension organizations make it very difficult to develop a comprehensive program for rapeseed research that encompasses every stage of commodity production from developing adequate farm inputs to solving consumption needs of rapeseed oil, meal and other byproducts. Compared with the one in Canada, the rapeseed research community in the PRC has weak ties to actors in the rapeseed network, though individual researchers may have strong ties with particular actors (Figure 6.3). This makes the rapeseed research program ineffective in adjusting to changes in the agroecological and socioeconomic environments surrounding production, distribution and consumption of rapeseed and its byproducts. Moreover, the policy goals for research, education and extension at a given stage of the rapeseed production process (e.g., a new rapeseed variety) often cannot be achieved because of the lack of coordination to induce necessary changes in production technologies and activities at another stage (e.g., edible oil processing).

As discussed in the next three chapters, the past and present rapeseed research programs at both the national and subnational levels are hardly satisfactory for the regional need of economic development despite impressive improvements in technical sophistication and competence at each research institution.

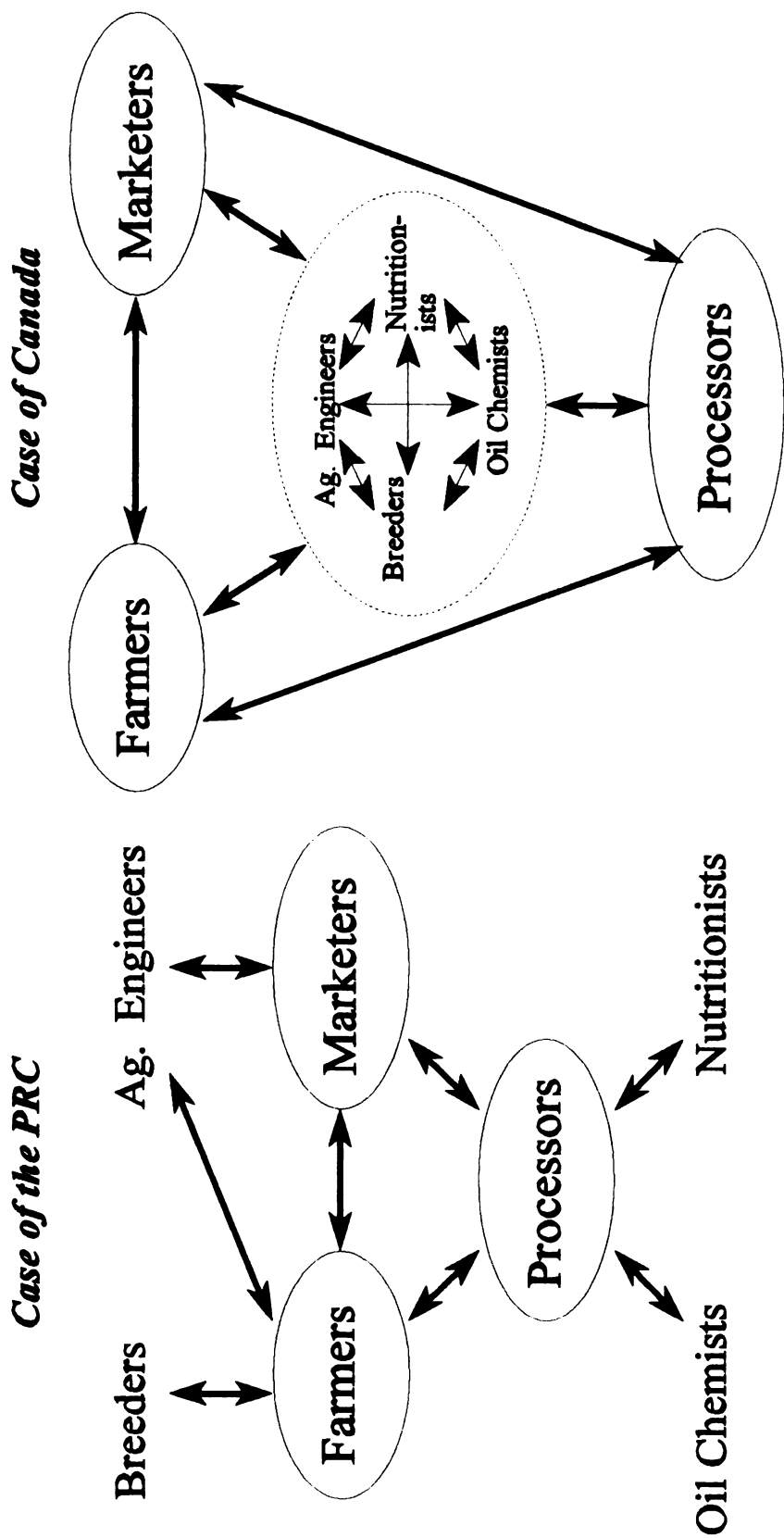


Figure 6.3 - Links between Technoscientists and Selected Rapeseed Chain Actors.

TECHNOSCIENCE FOR CREATING UNIFORMITY

As pointed out in Chapter 5, rapeseed cultivation in the PRC is unequalled by any other nation in the world in that (1) the history of rapeseed cultivation goes back a few millennia, (2) the geographical area of rapeseed cultivation is large, and (3) rapeseed cultivation conditions are diverse. Before the Communist Revolution, little attempt had been made by the government and the agricultural research community to develop a national program to improve rapeseed production (SAAS 1964).

In a planned economy, the precision of the data collected by the state determines success in an economic plan for a given commodity. Under the broad goal of establishing self-sufficiency in food, the PRC collectivized agriculture in order to improve the state's ability to manage production, distribution, and consumption activities of key crops including rapeseed by setting their annual quota at each stage. In a given administrative unit (e.g., commune, brigade, team), the cultivation area was consolidated in order to maximize the economies of scale. By the late 1950s, the rapeseed research program began to take a shape with a goal of creating uniformity in rapeseed production. Over the next four decades, three related strategies were developed to achieve this goal (see Figure 6.4), each of which focused on specific aspects of rapeseed and represented a distinctive notion of uniformity in it.

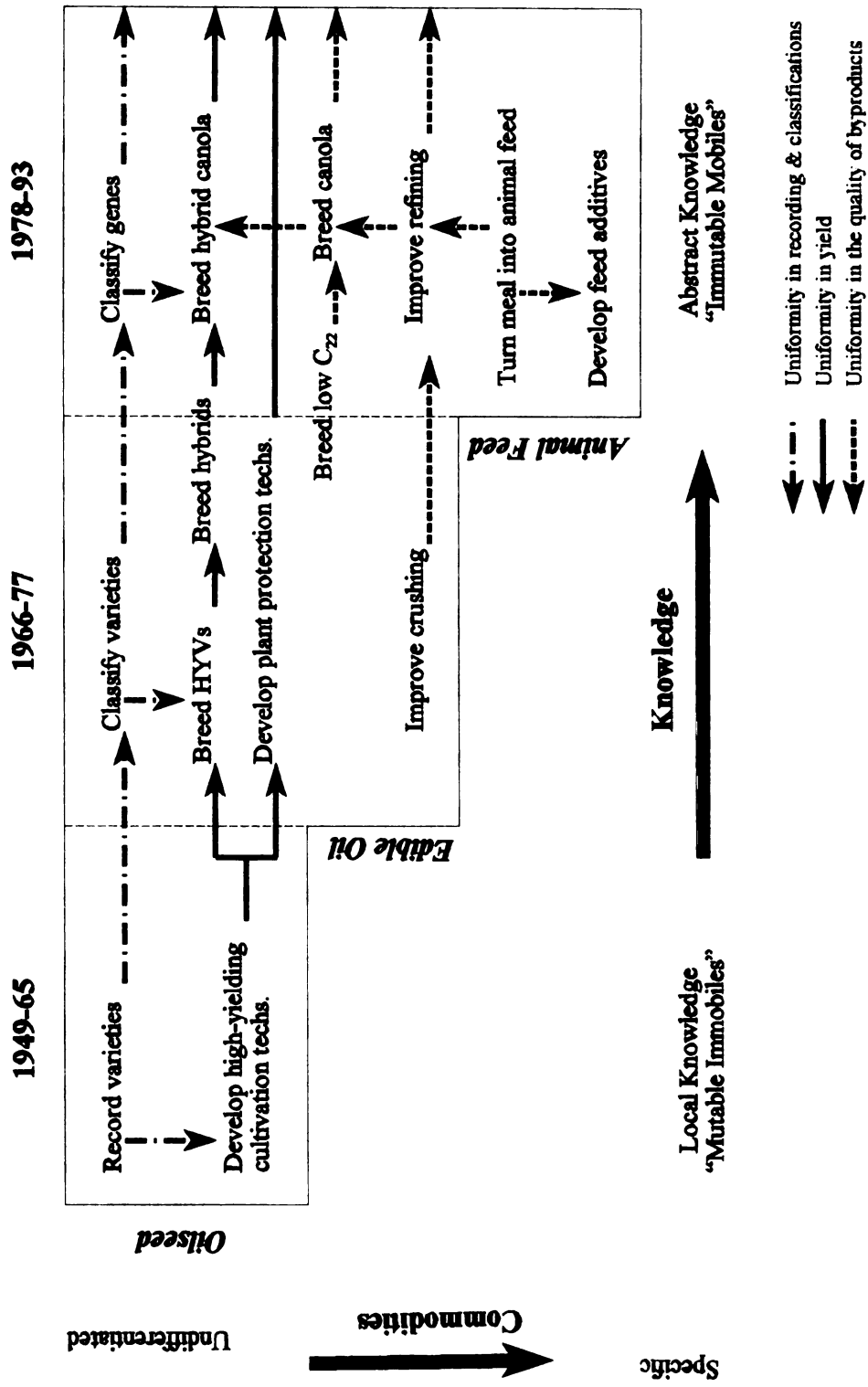


Figure 6.4 - Transformations of Rapeseed into Commodities/Knowledge, the PRC, 1949-93.

Uniformity in Recording and Classification

Prior to the establishment of the national agricultural research system in the 1950s, very limited botanical and agronomic work on rapeseed had been carried out (SAAS 1964). Consequently, rapeseed cultivation techniques and harvesting practices remained highly specific to small localities. This regional diversity in rapeseed cultivation techniques presented a number of problems in the new system of agriculture.

First, there were enormous regional gaps in the ability to fulfil production quotas for the crop. Thus, it was difficult for the central government to project an annual increase in rapeseed production. Second, provincial and local research institutes established their own programs for rapeseed based on the situation of oil crop production in the area. However, the newly established system of agricultural research lacked resources and personnel to engage in sophisticated or large-scale research projects on non-grain crops. Third, researchers and extension agents could not advise their provincial and local governments effectively as to which cultivation techniques should be recommended because they simply did not know which varieties, inputs, and pest management and other cultivation techniques would yield most in a given region. Therefore, the first strategy in the establishment of order in rapeseed research involved creating uniformity in methods, language, and materials used by technoscientists.

Taxonomy. In August 1956, the National Symposium for Rapeseed Experiment and Research was held in Sichuan Province. This meeting was significant in the history of rapeseed research in the PRC for two reasons. First, it was probably the first technoscientific meeting ever held in China at a national-scale among rapeseed researchers. At this meeting,

the basic strategy for rapeseed research in the nation was laid down in order to help provincial academies and local institutes to design their own projects (CAAS-IOCR 1988).

Second, three classifications of domesticated rapeseed were approved at this meeting, including: (1) *baicaixing* (*Brassica campestris* L.), (2) *jiecaixing* (*Brassica juncea* L.), and (3) *ganlanxing* (*Brassica napus* L.). According to Rapeseed Cultivation in China (*Zhongguo Youcai Zaipei*) (SAAS 1964: 14), these classifications “are in accord with the long history of rapeseed cultivation in our country, current demands for developing rapeseed production, and scientific classifications based on plant morphological and agronomic traits.” At the meeting, participants created a list of morphological and agronomic characteristics of each rapeseed type. This list became the basis for surveying, collecting and indexing local varieties and cultivation techniques.

The taxonomic scheme approved at this meeting became the first tool for rapeseed researchers to create uniformity in rapeseed research. These researchers came from diverse backgrounds in technical training and experience as well as cultural understandings about the crop. As pointed out in Chapter 4, the qualifications for technoscientists changed constantly between the early 1950s and the late 1970s. Therefore, technical training of researchers ranged from those with a Ph.D. degree from a Western or Soviet university to those who had only completed primary education. Moreover, prior to the standardization of the Chinese language, researchers from different locations even within the same province often could not verbally communicate with each other because of tremendous variations in dialects. The word for rapeseed even varied among regions. Therefore, the three-classification-scheme became a measuring stick. The language uniformly shared by these researchers allowed them

to exchange information, collaborate on research projects, and improve rapeseed research in the nation.

Variety Tests. Prior to the establishment of the IOCR under the CAAS in 1960, each research institute relied on its own methods and criteria for testing varieties and cultivation techniques. This resulted in an enormous gap among localities in the ability to increase yield as instructed by the central and provincial governments. A dramatic decline in rapeseed production during and immediately after the Great Leap Forward (see Chapter 5) led the IOCR to set an initial research goal for rapeseed as collection and recording of regional variations in the characteristics of rapeseed varieties, cultivation methods, major disease and pest problems, and agroecological conditions (CAAS-IOCR 1961a). Soon, measuring oil content was added as a key research area. However, in order to prepare for a national catalogue of rapeseed varieties, standards for indexing and organizing each variety had to be established.

In 1961, the First National Oilseed Crop Research Meeting was held among fifty six representatives from 33 research units in 22 provinces, autonomous regions and cities to discuss the current and future status of oilseed crop research in the nation (CAAS-IOCR 1961c). Participants pointed out that according to their incomplete statistics there were 102 research units and 472 researchers (including 97 rapeseed, 92 peanut and 169 soybean specialists) specialized in oilseed crop research nationwide (CAAS-IOCR 1961d). However, they agreed that a major concern with oil crop research was the lack of uniformity in experimental procedures (CAAS-IOCR 1961b).

Therefore, the participants developed a proposal for the first national rapeseed research program that emphasized the use of standardized methods to collect data on regional

diversity in cropping systems, cultivation practices and techniques, and varieties (CAAS-IOCR 1961d). For example, the proposal designated three types of plots to be used for variety tests, and then defined the size and purpose of each type.⁴ The amount and type of fertilizer used in each test was specified. Moreover, timing of data collection during the plant's growth cycle, measurements, and the types of data to be collected were specified in the proposal. Each experiment period was designated as three years. This proposal later became the basis for the National Rapeseed Variety Testing Program (NRVTP).

In 1963, at the National Symposium of Rapeseed Science and Technology, 25 representatives from seven provincial research organizations developed a detailed plan to make rapeseed variety tests for the 1963-64 season uniform throughout the nation (CAAS-IOCR 1963). Standardized research methods were emphasized as a means to raise the quality of rapeseed research in the nation. Moreover, in this plan, research institutes within the same rapeseed production area were encouraged to cooperate by sharing test varieties. Finally, the NRVTP officially began among the participating institutions.

By 1965, the results of the first experiment period (1963-65) became available. According to the report from the National Symposium of Winter Rapeseed Varietal Trials, 51 research units and seed stations from 13 provinces and cities participated in the First NRVTP, including 64.7% of units participating for the entire three-year period (CAAS-IOCR 1965a). At this meeting, modifications were also made for the second experiment period (1963-68) in order to further standardize the variety testing procedure (CAAS-IOCR 1965b).

⁴ The exact definitions of experiment plot, control plots and standard plot is not important here.

Publication of The Annals of Rapeseed Varieties in China (*Zhongguo Youcai Pinzhongzhi*) (CAAS-IOCR 1988) in 1988 was one of important achievements that resulted from the NRVTP. The catalogue lists 416 distinct varieties that had been actually cultivated in twenty provinces, cities, and autonomous districts in the PRC, including 181 *B. campestris* varieties, 86 *B. juncea* varieties, 133 *B. napus* varieties, 11 other types of varieties, and six imported varieties (CAAS-IOCR 1988). Besides the publication of the national and provincial catalogues of rapeseed varieties, the NRVTP was significant for the direction of rapeseed research in four ways.

First, it helped to strengthen linkages in a nationwide network of rapeseed (pre-harvest) research institutions under a uniform chain of command from the center to the local level. Many provinces were successful in breeding high yielding varieties (HYVs) of rapeseed during the 1960s and the early 1970s because breeding materials and reliable information about them became available through the network. Furthermore, using this network, superior varieties were popularized over a large area as a cultivation input and a research material.

Second, the program accelerated an improvement in the technical capability for rapeseed breeding in the PRC. During the three-year period, 46 distinctive varieties were certified including those which later became dominant varieties in rapeseed cultivating provinces. From the 1960s onward, the number of new varieties introduced in the PRC escalated. More importantly, breeding materials for hybrid varieties were discovered in the mid 1960s that later helped the PRC's rapeseed breeding research to receive international acclaim.

Third, this program later became the basis for designing national standards, laws, and regulations in seed management and distribution (see Chapter 7). Variety licensing and seed certification go through rigorous tests similar to those described in the NRVTP.

Finally, by using uniform research design, the program specified what constituted good practices in testing rapeseed varieties. The report of the NRVTP for the first test period stressed that the quality of variety testing could not be improved without uniformity in cultivation techniques by researchers during the test period. Thus, the quality of researchers depends on not only their ability to perform individual tests precisely specified by the NRVTP guidelines, but also on their ability to ensure uniformity in the growth of the test varieties throughout the test period. This suggests that a good researcher must be also a good cultivator of the crop.

Gene Banks. The development of germplasm banks (or gene banks) during the 1980s also owes much to the effort to standardize variety tests and recording in order to create uniformity in breeding materials stored at each research institution. The opening of the doors to the world also helped rapeseed researchers in the PRC to improve their technical capacity to collect, store, and utilize germplasm for breeding and other research purposes. By 1986, the rapeseed research community in the PRC had collected 3,535 accessions of rapeseed breeding materials in total, including 1,557 accessions of *B. napus*, 932 accessions of *B. juncea*, 616 accessions of *B. campestris*, 13 accessions of other, and 417 accessions of imported varieties (Gao 1991b: 745). The Institute of Crop Germplasm Resources (ICGR) of the CAAS maintains the nation's designated facility for long-term storage. However, some provincial academies, institutes of the CAAS (e.g., IOCR), and university research centers also maintain their own germplasm banks.

The maintenance of such facilities has become increasingly important for rapeseed researchers in the PRC for three reasons. First, recently breeding projects began to focus on the development of superior hybrid varieties in terms of both agronomic and quality characteristics. These projects are usually very specific as to what are desired yield, maturity length, minimum oil and protein content, and minimum erucic acid and glucosinolate content. Therefore, researchers need techniques, tools, methods, and inputs that allow them to manipulate the plant to create uniformity at the genetic level (e.g., male sterility).

Second, the genetic diversity of rapeseed in the PRC attracted wide interest from overseas researchers at academies, universities, and seed companies. Both the IOCR and HAU have received research funding from research institutions in Canada, England, Sweden, the U.S., and Japan in exchange for access to China's germplasm resources. Control of access to unique genetic materials, thus, makes it possible for rapeseed researchers in the PRC to extend their links to the international rapeseed research network. In turn, this further improves their technical capacity for rapeseed research and management of genetic resources, thereby enhancing their ties with overseas actors.

The recent shift in rapeseed research from traditional breeding to genetic engineering also transformed the rapeseed research network in the PRC. Until the late 1970s, a national rapeseed research program simply meant that each province would develop its own research program under a broad policy guideline, and report results and progress of the program at a national meeting. For example, although the aim of the NRVTP was to allow provincial researchers to breed HYVs, the program never specified how much yield increase should be made by these varieties, or what yield was desired in order to be considered as a superior variety. It was up to each province to decide specific criteria for the desired characteristics

of a new variety. In short, the linkages among research institutions were merely for exchanging information and research materials, not for research collaborations.

However, the costliness and technical complexity of genetic engineering compared with traditional breeding prohibit many research institutes at the provincial level and below from independently pursuing breeding projects. Consequently, their relationship with the IOCR, the ICGR, and national agricultural universities (e.g., HAU) is no longer limited to exchanging information and research materials. Under a national rapeseed research project, today the IOCR (or the HAU) often collaborates with several provincial academies, local research institutes, and county extension centers. The project encompasses everything from the development of a new variety through genetic engineering to extension of the variety to rapeseed growers in the participating provinces. In short, the centralization of technoscientific activities has become possible.

Success of such a collaborative project depends on the ability of each participant to preserve the advantage of this new technology at each stage. In other words, all participants at a given stage of the project must maintain uniformity in research methods, techniques, the skills of personnel, tools, equipment, criteria, texts, and values. Often, this entails inducing necessary behavioral changes in non-participants (e.g., seed producers, farmers, input suppliers). In short, the manipulation of rapeseed at a microscopic level requires the control of researchers' behavior at a minute level. Moreover, stronger links not only between researchers from different institutions but also between researchers and other actors become imperative.

Uniformity in Yield

Between late 1953 and September 1954, the State Council issued two decrees to increase edible oil crop production. In order to achieve this goal, an increase in rapeseed yield through the popularization of HYVs and superior cultivation techniques immediately became the dominant approach in the newly established agricultural research system from the center to local level. Until the late 1970s, the goal of rapeseed research in the PRC focused exclusively on yield increases. Not much work had been done on research on post-harvest issues such as oil chemistry, processing, and nutrition.

Moreover, projects concerning the development of new varieties and cultivation techniques remained largely province-based because of enormous diversity in climatic and ecological conditions in the PRC's rapeseed area. Thus, research collaborations between provinces were usually limited to exchanging cultivars and technical information. Indeed, most rapeseed cultivars and techniques were diffused county by county in a given province. Therefore, only a few varieties and cultivation techniques were known throughout the nation's rapeseed area. In this section, I focus my discussion on varieties and cultivation techniques that have been popularized in Hubei Province.

Socialist modernization of rapeseed production meant that the crop was produced with techniques tested and recommended by technoscientists. Thus, cadres at each administrative level would be able to project the amount of rapeseed to be seeded and harvested in order to meet the annual production plan, thereby ensuring the state's ability to control rapeseed production, distribution, and consumption in society. This also required that peasants in a given commune would behave in a uniform fashion so that the effectiveness of the new techniques (including HYVs) would be maximized in the field.

High Yielding Varieties. In the early 1950s, much of the effort in rapeseed research consisted of identifying and popularizing local varieties with high yield, rather than breeding HYVs at a research institution. For example, *Xishui Youcaibai* (hereafter *Xishuibai*) was originally a local variety commonly used by peasants in Xishui County, Hubei Province. The strengths of *Xishuibai* were its high yield potential (average of 670-890 kg/ha), early maturity (180-185 days), and high resistance to cold. By the late 1950s, like *Qixingjian* from Sichuan, *Dongkoutian* from Hunan, *Xinghua* from Jiangsu, *Ningbo* from Zhejiang, and *Menyuanxiao* from Qinghua, *Xishuibai* became a popular HYV cultivated throughout Hubei Province. Later all these local varieties also became important parent materials for breeders to develop new hybrid varieties at provincial research institutions. For example, between the late 1960s and the mid 1970s, HAU used *Xishuibai* as a parent material to crossbreed several varieties including Huayou Nos. 6 and 12, and self-sterile varieties such as 74-211 and 75-271 (CAAS-IOCR 1988).

Historically, China's rapeseed cultivation had been dominated by *B. juncea* and *B. campestris* cultivars including those mentioned above. However, soon researchers learned that *Shengli Youcai* (hereafter *Shengli*), a *B. napus* variety originally imported from England in 1942, would usually yield 20-30% higher (maximum yield could reach 2,240-2,600 kg/ha) than local cultivars (CAAS-IOCR 1990). In the 1950s, a massive nationwide campaign began to replace local varieties with *Shengli* in the winter rapeseed area. In the fall of 1953, the variety was first introduced widely in Sichuan Province; then provinces in the middle and lower reaches of the Yangzi River region began to plant it after 1954. Within five years, the area cultivated with this variety reached over 300,000 hectares, or roughly 25% of the

nation's rapeseed area (CAAS-IOCR 1990). In 1958, in Sichuan Province 70% of the total rapeseed area was cultivated with *Shengli* (CAAS-IOCR 1988: 246).

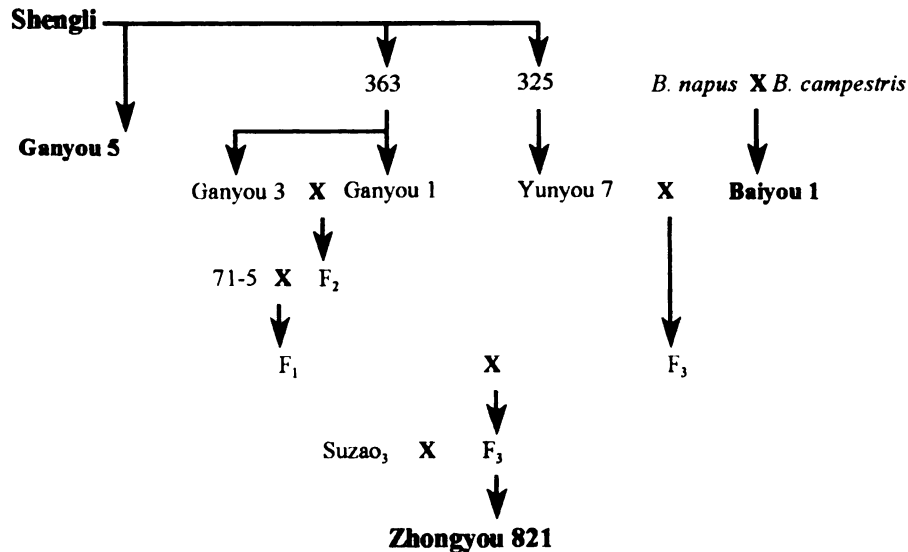
Many peasants in the winter rapeseed area have always practiced multiple cropping. By the Great Leap Forward (1958-1960), however, the pressure to intensify grain production reached to its peak. Moreover, the campaign to popularize *Shengli* came at the same time as the expansion of triple cropping in the middle and lower reaches of the Yangzi River area, demanding that peasants squeeze one crop of rapeseed into the schedule of two rice crops (CAAS-IOCR 1990). Despite the superiority in yield, *Shengli* had several fatal weaknesses in the triple-cropping district. First, the variety took too long (roughly 230-250 days) to mature, two and half months more than *Xishuibai*. This adversely affected rice production by disrupting the planting and harvesting timings. The labor burden of peasants increased in the fall as they needed to harvest rice and prepare the field for rapeseed within an extremely short period of time. Second, the variety required more fertilizer than *Xishuibai*. However, communes were annually allotted with a limited amount of chemical fertilizer. Many communes could not spare any fertilizer away from grain crops for growing this new rapeseed variety. Finally, *Shengli* did not have strong resistance to drought and several common diseases.

Despite these weaknesses, rapeseed researchers were convinced from the experience with *Shengli* that *B. napus* cultivars would yield higher than traditionally popular *B. campestris* and *B. juncea* cultivars with shorter growth cycles. And, this variety became the basis for breeders to define agronomic characteristics desired uniformly from rapeseed cultivars. Thus, starting in the late 1950s, breeding projects throughout the nation uniformly focused on improving *Shengli* for higher yield, earlier maturity, and stronger resistance to

cold, drought, pests, and diseases. Throughout the 1960s and 1970s, peasants in the winter rapeseed area were encouraged to switch from their local *B. campestris* variety (e.g., *Xishuibai*) to a *B. napus* variety developed from *Shengli* at a research institution. By 1982, 219 out of 225 *B. napus* cultivars developed in the PRC had *Shengli* as a parent. Among them, 128 were direct selections from it, 91 were crosses derived from it, and 6 were selected using other breeding methods such as cell-fusion (CAAS-IOCR 1990). Indeed, all these cultivars had similar agronomic characteristics, including an average yield of 2,200-2,600 kg per hectare, a maximum maturity length of 210 days, an average oil content of 43%, and good resistance to cold. The collective agricultural system made the extension of these offspring or kin of *Shengli* easy for researchers and extension agents. Within a given collective unit, peasants usually planted a single cultivar. Thus, often the diffusion rate of a new variety reached 60-70% within a given county. This suggests that, until the mid and late 1970s when hybrids of *Shengli* were introduced, genetic materials of rapeseed in the field were highly uniform throughout the nation.

The breakup of collective agriculture did not diminish the value of uniformity in yield, but instead has helped peasants to become obsessed with it. The current champion *Zhongyou 821* was developed by the CAAS and introduced in Hubei Province in 1984. Unlike other relatives, *Zhongyou 821* is a hybrid of *Shengli* that has been nationally popularized for its superior yield (up to 4,100 kg/ha), high resistance to pests, diseases and adverse climatic conditions, and early maturity (214 days). By 1989, nearly 3 million hectares, or one fifth of the nation's rapeseed area, was cultivated with this variety alone; in Hubei Province, it covered 70% of the province's total rapeseed area (CAAS 1991). As shown in Figure 6.5, however, a large portion of genetic materials of this variety indeed come from *Shengli*. And,

the variety is genetically similar to other currently popular varieties in Hubei such as *Ganyou* Nos. 3 and 5, and *Baiyou* No. 1.



Note: F₁ offspring obtained by crossing the parental generation (P₁); F₂ is offspring of the cross between members of the F₁ generation; F₃ is that between members of the F₂ generation.
Source: CAAS-IOCR (1988, 1990).

Figure 6.5 - Breeding Pedigree of Widely Used Rapeseed Varieties in the PRC, 1990-96.

Nevertheless, peasants' continuous demand for HYVs became increasingly problematic to rapeseed researchers as their concerns with uniformity in rapeseed characteristics began to change. As I discuss below, in the late 1970s the dominant goal for rapeseed research started to shift away from meeting domestic needs to transforming the crop into an export commodity. The IOCR, HAU and other dominant rapeseed research institutions all began to engage in projects to develop low erucic acid, and later low erucic acid and low glucosinolate (or canola) varieties. Yet, peasants and other potential users will not easily accept technoscientific products developed with such a goal in mind. Consequently, researchers found a compromise in projects that aim at the development of canola hybrids.

Between the late 1960s and early 1970s, with the goal of developing HYVs, rapeseed researchers in the PRC made remarkable advancements in knowledge about and techniques of plant breeding, particularly in research on mutation and heterosis, with little or no direct assistance from foreign researchers. By the time the nation's doors were opened to the world, these researchers were ready to contribute to rapeseed genetics, breeding, agronomy, and plant physiology at the international level. For example, the PRC was the first nation to discover cytoplasmic male sterility in rapeseed (named *Polima*) and popularize a hybrid (*Qinyou No. 2*) developed from it on a large scale. Moreover, over the last two decades, the nation institutionalized a comprehensive study of rapeseed hybrids that covers everything from basic genetics to hybridization techniques (Fu 1995b). Yet, the PRC was behind in research on the elimination of erucic acid and glucosinolates from rapeseed oil and meal. By the mid 1980s, the major strategy in rapeseed research became the selection and popularization of canola hybrids in order to increase yield while turning the crop into viable commodities in the international market at the same time. The chief evidence both researchers and government officials used to support the economic advantage of hybrids over traditional varieties was that yields of corn and rice increased in the countries that adopted hybrids. Breeders assumed that hybrid breeding would equally benefit rapeseed production in the PRC, providing growers with a higher economic return and consumers with cheaper products derived from the crop.

However, using the case of hybrid corn, Lewontin and Berlan (1990: 622) dispute the social benefit of hybrids. They argue that the contribution of hybrid breeding to the historical increase in corn yield diminishes when major changes in husbandry methods are taken into account. Moreover, they point out that a hybrid "is a copy-protection device" for seed

companies because “[f]armers cannot reproduce hybrids by holding out seed from their crops.” In fact, hybrid rapeseed did allow seeds of rape to become a commodity, thereby encouraging research institutes to start up their own seed companies. On the other hand, it increased the cost of rapeseed cultivation for peasants who adopted them. As shown in Chapter 8, peasants pointed out that hybrid varieties required more chemical inputs, particularly fertilizer and pesticide, than the existing varieties such as *Zhongyou 821*. In short, despite enthusiasm by researchers and government officials, the economic return of hybrid rapeseed is marginal at best, and often negative when compared with those varieties bred from conventional breeding.

Cultivation Techniques. Starting in the late 1950s, rapeseed cultivation methods in the PRC were transformed in order to increase yield. The main strategy for achieving this goal was to intensify production by introducing more “rational” (*heli*) techniques at sowing and multiple cropping systems. Based on the results from field experiments by local research institutions, extension agents made recommendations for new techniques (including varieties) to communes.

The first major changes in rapeseed cultivation techniques included the use of deep plowing and a shift from broadcasting to sowing seed in a strip. These changes occurred simultaneously with national campaigns to expand the multiple cropping area and popularize high yielding *B. napus* varieties, including *Shengli* and its offspring. Each of these four techniques alone was proved to be beneficial in increasing rapeseed yield. However, both growers and observers of the crop soon realized a serious dilemma when these techniques were used together in the triple cropping area (rice → rice → rapeseed) (CAAS-IOCR 1990: 320). For example, in Hubei Province, rapeseed would need to be seeded between late

September and early October, and would take about 200-220 days before harvest even with an early maturity HYV selected directly from *Shengli*. However, the season for two rice crops would last about 160-180 days, and the second rice crop would not be ready for harvest until late October or early November. In short, it required a minimum of 380-400 days just to cultivate three crops together in the same field! This does not even take the time for preparation and harvest of each crop into consideration. Therefore, both deep plowing and strip sowing required peasants to delay the rapeseed season even further, thus resulting in failure to achieve yield increases.⁵

In the 1960s, in order to solve this dilemma, transplanting techniques were introduced widely in the middle and lower reaches of the Yangzi River region. For example, in Hubei Province it was recommended to communes that rapeseed be seeded in the seedling bed in early October, and that seedlings be transplanted in early November. According to the Huanggan District Research Center in Hubei, this would increase yield by 42.6% as compared to direct sowing (CAAS-IOCR 1990: 321). Moreover, transplanting of rapeseed has made triple cropping possible in the nation's rapeseedbelt. When transplanting, peasants were encouraged to space seedlings as closely as possible to maximize yield. Based on the results of field tests by local researchers, extension agents recommended that an appropriate space would be realized by planting 150,000 - 600,000 seedlings per hectare in the winter rapeseed area and 300,000 - 750,000 seedlings per hectare in the spring rapeseed area.

⁵ Despite the effort to increase yield, the nation's rapeseed yield declined dramatically in 1960 and 1961 (USDA 1992). In Hubei, until 1965 rapeseed yield never exceeded the 1952 level of 521 kg/ha (Hubeisheng Tongjiju 1985). The introduction of inappropriate techniques for managing the multiple cropping system in this area may have contributed to the agricultural collapse of 1959-1961.

Uniformity in the Quality of Rapeseed Byproducts

Under the planned agricultural system, the creation of uniformity in rapeseed was to be achieved by transformations in the crop at the pre-harvest stages and in the behavior of cultivators. There was one and only one goal in rapeseed research -- to allow communes to deliver the required quantity of rapeseed without sacrificing grain production. Thus, year after year, researchers selected varieties that would yield higher than the previous ones, while extension agents convinced peasants to switch to new techniques that would contribute to higher yields than the previous season.

Departure from this obsession with yield as the dominant value in rapeseed research began in the late 1970s as technoscientists gradually established links with those outside their country after nearly two decades of absence. Just as in the rest of the world, Chinese rapeseed technoscientists were drawn into the international effort to qualitatively transform rapeseed as a source of edible oil, industrial oil, animal feed, and processed food. For example, the report of the National Conference of Rapeseed Research in 1977 (HAAS 1977) pointed out that rapeseed would have the highest prospect among four major oilseed crops to become an export crop, but needed qualitative transformations to meet international standards as a source of edible oil and animal feed. Based on that information, the government established a national rapeseed R&D program to develop canola varieties so that rapeseed would become an export crop, and so that China's rapeseed R&D capability would reach international levels.

Now rapeseed was no longer merely an oil crop, but also a raw material for manufactured products. This radical shift in conceptualizing the role of rapeseed as a commodity altered rapeseed research in the nation. The 6th Five-Year Plan (1981-1985)

included several projects which aimed at the improvement of rapeseed production and processing. The total amount of R&D investment on rapeseed increased substantially during the 7th (1986-1990) and 8th (1991-1995) Five-Year Plan periods. At the same time, the concern with uniformity in rapeseed shifted from yield to the quality of products derived from the crop.

The Debate over the Role of Erucic Acid. Starting in the mid 1950s with the Canadian research program, erucic acid and glucosinolates became recognized in the international rapeseed research community as undesirable compounds for both human and animal consumption, and therefore were removed from rapeseed.⁶ It was well documented that rapeseed meal was goitrogenic when fed in large quantities to farm animals. Thus, the need to remove glucosinolates from the plant was never questioned. However, to date the alleged toxicity of erucic acid has never been conclusively proved, and it is still debated in the technoscientific community. Starting in the 1980s, Chinese technoscientists also found themselves caught in this technoscientific controversy.

Unlike consumers in Europe and North America, the Chinese have been consuming high erucic acid rapeseed (HEAR) oil for millennia. However, a high rate of heart problems has not been observed in the rapeseed producing area. Two 7-week studies using a total of 140 human subjects by the Institute of Nutrition and Food Hygiene (INFH) of the CAPM (Wen et al. 1995) confirmed no significant negative effect of HEAR oil on human health (Wen et al., 1995). In the 1990s, the Cereal and Oil Association of China (COAC), which is made up of researchers, government officials and entrepreneurs, decided that erucic acid was not

⁶ See Busch et al. (1994) for the details.

an issue in the PRC as there was a lack of sufficient data to support a negative impact of rapeseed oil on human health. Therefore, the COAC recommended that there was no need to specify the maximum erucic acid content in the national standards for rapeseed and its oil products.

Despite the official position by several professional societies in human nutrition, medical sciences, and oil chemistry, individual scientists express uncertainty in this debate. Despite her own findings, Dr. Wen Zimei (Wen 1995), a main investigator in the nutritional studies above, strongly believes that erucic acid should be removed from rapeseed, and moreover, that the use of rapeseed oil should be restricted. During the interview, Dr. Fan Tie (Fan 1995) at the Cereal, Oil, and Food Research Center (COFRC), a leading figure in shaping the current position of the Oils and Fats Society of the PRC, displayed consciously or unconsciously his ambivalence:

Oil chemists abroad say that the 20th century has been the era of C₁₈ and predict that the 21st century will be the era of C₂₂ because it makes a good raw material for industry... The content of C₂₂ in our county is currently around 20-40%, *not good for any use. Lower than 5% or higher than 50% is the best.*

Contrary to post-harvest rapeseed researchers, breeders, agronomists, plant scientists, geneticists, entomologists, soil chemists, and other pre-harvest rapeseed scientists tend to uniformly support the elimination of erucic acid from rapeseed. Moreover, the central government has maintained its disproportionate favoring of pre-harvest over post-harvest technoscience in the last four national rapeseed research programs. From their perspective, re-debating the role of erucic acid is opening a can of worms for which Chinese technoscientists have little time (various interviews, 1996). Nevertheless, this disparity between pre- and post-harvest researchers in their view about an acceptable level of erucic

acid, along with the imbalance in research funding by the central government, appears to have been a main weakness in the nation's recent efforts to induce technical change in rapeseed.

Varieties with High Quality Characteristics. In 1974, the PRC sent a delegation of rapeseed researchers to Canada. The group brought back five cultivars including *Oro* (the world's first variety low in erucic acid) and *Midas*. In 1976, the world's first canola variety *Tower*⁷ became available to breeders in the PRC. By 1978, leading rapeseed research institutions began projects to develop "high quality rapeseed" (*gaoji youcai*). By this definition, new cultivars must have the following *specific* characteristics including: (1) low erucic acid content (< 1%), (2) low glucosinolate content (< 40 $\mu\text{mol/g}$), (3) high oil content (> 45%), (4) strong resistance to diseases, pests, weed, etc., and (5) yield comparable or higher than the existing varieties (Gao 1991a). Moreover, starting in the early 1980s, the MOA facilitated the establishment of collaborative research programs between the nation's key institutions and overseas institutions.⁸

Between 1976 and 1982, Canadian varieties were introduced with only minor adjustments in provinces that grow spring rapeseed including Xinjiang, Gansu, Qinghai, Xizang, Neimenggu, and Heilongjiang. However, the winter rapeseed area in the PRC required canola varieties that would adapt to agroecological conditions quite dissimilar to those in Canada. Therefore, breeding materials were imported from various countries,

⁷ Note that *Tower* was imported to the PRC only two years after its development in Canada by Baldur Stefansson of the University of Manitoba (Busch et al. 1994).

⁸ One example was the Sino-Canada Rapeseed Breeding Program for 1983-1991 directed by the SSTC and the MOA (MOA 1992). The International Development Research Center (IDRC) of Canada provided financial and technical support for the program. Besides the IOCR, the Shanghai, Qinghai, and Xinjiang Academies of Agricultural Sciences each had their own collaborative project.

including Australia (e.g., *Marnoo*, *PB 52*, *Ru 3*), the former West Germany (e.g., *QVZ*, *DSV-SR-37*, *DSV-SR-57*), France (e.g., *Primal*, *Jet-Neuf*), Sweden (e.g., *Topas*, *Hanna*), Poland (e.g., *Start*, *Bronowski*), and Denmark (e.g., *Dan*). Then, these foreign materials were crossed with Chinese cultivars. By the late 1980s, so-called “high-quality rapeseed” varieties were introduced to peasants in the winter rapeseed area.

This switch in the goal of rapeseed breeding between the pre- and the post-reform periods marked a turning point in the history of rapeseed research in the PRC. First, research institutes, universities, extension agencies, and state enterprises from different provinces but within the same *xitong* began to collaborate on research projects. Previously, researchers at the provincial level or below were concerned about selecting varieties that yielded highly only within their province, and did not care at all about how these varieties performed in other provinces. Moreover, each province and locality defined an adequate level of yield, and therefore specific characteristics desired in a variety and cultivation techniques necessary to achieve that yield level. As noted above, in the current breeding program, the desired features in a new variety are very explicit and uniform among research institutions throughout the nation. Moreover, the ultimate purposes for selecting these varieties are also agreed on by technoscientists and governmental bureaucrats. They are to transform China’s rapeseed into export commodities, and to improve the nation’s rapeseed research to a level comparable to the international level. In short, national research collaborations have become possible because research goals and purposes as well as the concept of desired characteristics in rapeseed have become uniform among research institutions.

Second, today rapeseed researchers in the PRC, on pre- and post-harvest topics alike, develop their understanding of rapeseed and design their research projects in response to

various domains, including domestic needs in production and technoscientific progress, the PRC's foreign diplomacy, the position of rapeseed oil and meal in the international market, and technoscientific achievements in other countries. Particularly, during the Great Leap Forward and the Great Proletarian Cultural Revolution, the CPC used its coercive power against these researchers to accept whatever the state defined as appropriate goals, methods, instruments, materials, texts, knowledge, behaviors, and values in research projects (see Chapter 3). The coercive power of the state has now been replaced by self-organized networks of human and nonhuman actors that often extend beyond the PRC. At the least, most universities and research academies at the national and provincial levels have links to research institutions, private enterprises, and governmental agencies abroad that provide them with financial, technical, and personnel assistance. These overseas actors indeed bring in their own interests, values, perspectives, needs, and ethical commitments to shape research projects in the PRC. Both Drs. Wen and Fan, mentioned above, cannot dismiss completely the alleged toxicity of erucic acid, despite the result of their own investigations, because their knowledge about the compound is equally affected by research results and technoscientific claims of their colleagues around the world.

Oil Refining. The development of technical change in oil processing⁹ has been considerably slower than that in rapeseed cultivation. According to Dr. Fan Tie at the COFRC (Fan 1995), in the 1950s rapeseed was crushed largely in small mills by homemade extractors. Thus, in the 1960s the goal in oil processing research became building (or

⁹ Oil crushing is the process of extracting oil from oilseeds. Refining involves the removal of undesirable constituents (e.g., phospholipids, chlorophyll, sulphur) from crude oils in order to improve oil quality.

importing) and introducing crushing machines such as the screw press and mechanical pressure press in order to improve the efficiency in meeting the nation's demand for edible oil. Moreover, refining technology gradually began to become available in large cities. However, the Great Leap Forward and the Cultural Revolution disrupted the process of improving oil crushing technology. In order to push forward with Maoist idealism, these national campaigns encouraged the achievement of self-sufficiency and self-reliance in key commodities, including edible oil products. Just as in the case with the crop, quantity rather than quality mattered in the production and distribution of rapeseed oil. Therefore, the goal of technical change in oil processing was also an increase in the quantity of rapeseed oil crushed in the nation. However, rural communes had limited financial capacity to improve their equipment. Thus, they relied on themselves to devise crushing machinery. Hence, the scale of oil processing operations in rural China remained small, and most local mills continued to use indigenous oil crushing equipment. Meanwhile, production activities at large-scale factories in urban areas were upset by demonstrations and meetings during the Cultural Revolution. It became impossible to make decisions about technical change in oil processing. As a result, oil refining technology did not develop fully in the PRC until the late 1970s.

Within the last two decades, major advancements in rapeseed processing technology have been made as the goal in technical change shifted to the improvement of oil quality. First, soaking was introduced to medium- and large-scale factories as an additional procedure in extracting oil from rapeseed. This improved the efficiency of oil extraction. Second, the number of factories with oil refining technology has increased dramatically. Consequently, edible oil products such as salad oil and dressing, and high-grade cooking oil began to be

manufactured in the PRC. On the one hand, these new technologies have helped to improve the quality of rapeseed oil produced in the nation. On the other hand, they also allowed product differentiation in rapeseed oil according to its quality characteristics. Today, post-harvest rapeseed researchers agree that future technical change must allow Chinese processors to manufacture “high-quality oil” (*gaoji youzhi*) that uniformly meets the national standards (see Chapter 7). Moreover, these researchers hope to use rapeseed for manufacturing more diverse industrial oil products than soap and lamp oil.

At the same time, however, the total R&D budget for food research allocated by the SSTC has dwindled within the last decade. Therefore, both researchers and oil processors have begun to seek alternatives to the government for financial support to realize improvements in rapeseed oil processing (Fan 1995). For example, at the time of my fieldwork in 1995, the COFRC was building a new research facility with financial support from a German research institution.¹⁰ Large-scale factories with state of art oil refining equipment have been built in major cities such as Beijing, Shanghai, Tianjing, and Wuhan, using investment from foreign enterprises (various interviews, 1995, 1996). Participation of these foreign actors has influenced the rapeseed research community in the PRC to conceptualize what constitutes high quality rapeseed and good edible oil research. Consider that until the late 1970s research under the current MIT *xitong* was largely limited to oil processing technology, particularly identifying machines and techniques that improve oil extraction and refining procedures. Rapeseed research projects were designed to provide very specific knowledge (i.e., how to process) and products (i.e., processing equipment) to

¹⁰ The new facility is located in the Changping Xiaotangshang District, 15 kilometers from the current location in Beijing.

particular human actors (i.e., processors). The new COFRC facility houses 20 laboratories under five departments including: (1) grain processing, (2) food engineering, (3) oil chemistry and engineering, (4) biotechnology, and (5) chemistry and electronic engineering. The range of research topics has expanded. Outcomes of its research projects include abstract knowledge and products for technoscientific activities. In short, the shift in the goal of post-harvest technical change since the late 1970s has allowed product differentiation both in rapeseed oil and rapeseed oil research.

Animal Feed. Before the 1970s, very little attention was given to diversification in the use of rapeseed meal beyond organic fertilizer. The toxicity of rapeseed meal to farm animals, particularly pigs, was well understood by researchers. According to peasants, “pigs never like to eat rapeseed meal” (Interview, 1996). However, its high protein content (25-30%) was hard to ignore in a country with limited sources for nutritional animal feed, particularly pig feed. In the early 1970s, the first research project on rapeseed meal began. Its goal was not to remove toxic compounds from the meal, but instead, to directly use a small quantity of it without changing the quality characteristics. According to Dr. Li Jianfan at the Institute of Animal Sciences (IAS) of the CAAS (Li 1995), unfortunately very little was accomplished from this project because of lack of enthusiasm from the government, peasants, oil processors, and other human actors. The scale of both rapeseed production and animal husbandry was too small to recognize the benefit in such a research project.

During the 7th Five-Year Plan (1986-1990), the State Planning Commission finally turned the use of rapeseed as a protein source for animals into an important task in rapeseed research (National Importance Item No. 7501) and allocated 30 million yuan for feed research, which was divided among different projects (Li 1995). This national R&D program

for rapeseed meal took two paths including: (1) removing glucosinolates from rapeseed meal, and (2) directly using it without removing glucosinolates by controlling the amount of rapeseed meal and adding other chemicals. According to Dr. Li, the first strategy was not successful, and was therefore, canceled for the 8th Five-Year Plan period (1991-1995). The latter strategy showed positive outcomes, by providing peasants with various types of feed additives to be used at different growing stages of their animals. Consequently, research teams under the second project received further financial support from the SSTC for the 8th Five-Year Plan period.

Nevertheless, animal feed researchers soon came to realize that the use of rapeseed meal as an animal feed requires qualitative improvements in the seed of rapeseed and oil processing equipment, and modifications in the behavior of both peasants and oil processors. The need for low-glucosinolate varieties is rather self-explanatory. In addition to the use of new varieties mentioned above, peasants also need to treat rapeseed, particularly the amount and type of chemical inputs, in a such manner that the content of other chemical compounds in seed is more or less uniform. For example, soil in Gansu Province tends to produce rapeseed which contains high sulfur (Yang 1995).

The second major problem deals with oil processing procedures. In the PRC, rapeseed is usually pressed at a high temperature (up to 150 °C) in order to extract the maximum amount of oil. Overseas, pressing and soaking generally takes place at a temperature below 90 °C, thereby leaving 30% oil content in the meal (Daun 1993). If rapeseed is pressed at a temperature below 100 °C, protein in the meal will not be destroyed. In short, the method used to produce more oil (with little consideration of meal) actually destroys protein, or amino acids, necessary for the use of rapeseed meal as an animal feed (Li

1995). Dr. Yang Luliang (1995) at the Institute of Feed Research (IFR) of the CAAS pointed out that a Danish study showed 15-20% lower digestibility of rapeseed meal produced in the PRC than that from other countries.

Nevertheless, as pointed out early in this chapter, research concerning rapeseed cultivation and the use of rapeseed as an animal feed is conducted by institutes under the MOA *xitong*, while research related to oil processing technology is done by those under the MIT *xitong*. According to Dr. Li, government officials at the MOA and the MIT have tried to cooperate with each other, but have not reached any agreement on which processing method would be the best for producing both edible oil and animal feed. This illustrates the lack of a comprehensive program for rapeseed R&D from breeding to the use of meal in the PRC. Unfortunately, research and extension projects on rapeseed meal are suspended for the 9th Five-Year Plan period (1996-2000). Currently, more efforts are being placed on extension of canola varieties, rather than on research on meal itself.

The use of rapeseed as a source of animal feed is something very new to most human actors in the PRC, and requires a different way of understanding and treating the crop than that with which they have been familiar. Moreover, more actors (both human and nonhuman) need to get involved to make it possible to turn the crop into an animal feed. Each of these actors must act in a uniform manner in order to produce rapeseed meal with uniform quality as animal feed.

CONCLUSION: KNOWLEDGE, COMMODITIES, AND NETWORKS

The analysis of rapeseed research in the PRC for the last four decades suggests that a distinctive concept of uniformity is embedded in each type of technoscientific product.

Furthermore, this concept is shaped by the simultaneous transformations of rapeseed as commodities and as knowledge as well as the extension of networks surrounding rapeseed technoscientific activities. Until the late 1970s, rapeseed research overwhelmingly focused on producing local knowledge that consisted of “mutable immobiles,” or knowledge in immediate agricultural settings that was inseparable from a particular place and a particular labor process in which the knowledge was embedded (Kloppenborg 1991). There was minimal differentiation in the kinds of commodities produced in rapeseed cultivation (high erucic acid oil, forage and organic fertilizer). Particularly, the notable shift in the research focus in the late 1970s including the establishment of new research themes (e.g., breeding of canola and hybrid varieties, refinement techniques) and the creation of new types of products (e.g., low erucic acid oil, low glucosinolate meal) were coterminous with inclusion of new actors (e.g., foreign researchers, overseas investors, international agencies) in the network surrounding technical change in rapeseed. By the late 1980s, the type of knowledge produced from research shifted away from local knowledge to more abstract knowledge (see Figure 6.4). Therefore, more researchers began to pursue research activities independent of the situation of rapeseed production activities in the region where their institutes were located. In other words, much of the knowledge they produce can be used anywhere in the networks where the researchers have established linkages, rather than only in the regions of production. For example, the hybrid varieties developed by Chinese scientists have benefitted seed companies in Canada and Europe more than their Chinese counterparts (Imamura 1994).

The more rapeseed technoscientists extend their networks, the more modifications they can perform on the plant, the more abstract knowledge on rapeseed they can produce. As Juska and Busch (1994: 594) point out, “[a]bstract knowledge occurs when the academic

field reaches the stage where rapeseed is studied as an object in itself -- without a clearly articulated relationship to any of the elements of the [commodity chain].” Latour (1987) calls such knowledge “immutable mobiles.” In fact, in more recent years, some research projects on rapeseed in the PRC have had very little relationship with the production aspects of the crop.

Nevertheless, technoscience products alone are not sufficient to *induce* technical change because the behavior of other chain actors must change in order to create and maintain the benefits of these products. In other words, the fate of a technoscientific product lies in the hands of later users (Latour 1987).

In this chapter, I have demonstrated that the rapeseed research community in the PRC is far more than just technically competent to develop products beneficial to China’s rapeseed production. Contributions of Chinese technoscientists in rapeseed breeding and genetics have been highly recognized throughout the world. In the next two chapters, I will show that when potential users are not involved in research processes, a brilliant product of technoscience is likely to fail, even with a central economic plan that specifies the technical changes necessary to meet production quotas.

**NEGOTIATING THE UNIFORMITY OF A COMMODITY:
THE RAPESEED COMMODITY CHAIN
IN THE PEOPLE'S REPUBLIC OF CHINA**

VOLUME II

By

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Chapter 7

NEGOTIATING FOR THE LEGITIMATION OF UNIFORMITY: POLICY CHANGES AND STANDARDIZATION

A commodity is...an object outside us,
a thing that by its properties satisfies human wants of some sort or another.

--- Karl Marx (McLellan 1977: 421)

INTRODUCTION

In Western capitalist societies, commodities are taken for granted. We define anything that can be sold or bought as a commodity. We also assume that they are the product of human labor on the one hand, and that they are capable of satisfying human wants on the other. Everything that makes up our material lives appears to involve some type of monetary exchange. It may be argued that constant commoditization of our social lives is a feature of the capitalist economic system. Therefore, there is little concern to raise such questions as what commodities are and how these commodities have ended up in our hands.

Moreover, as Kopytoff (1986: 64) points out, we tend to dichotomize between individualized or singularized (that is, decommoditized) persons and commoditized things. Things represent the natural universe of commodities, while people represent the natural universe of individuation and singularization. Hence, the world of things is considered as

inert and mute, and is set in motion only by persons and their knowledge about it. Yet, this conceptual dichotomy between things and people is misleading. Hence, the symmetrical treatment of things and people, repeatedly discussed in the previous chapters, must be extended to understand the process of commoditization.

Throughout human history, people have been commoditized as in the cases of slaves and prostitutes. Similarly, things often have their own social lives and biographies during the life span. Moreover, just as every person has many biographies or different aspects (e.g., physical, psychological, political, familial, economic) of their life history, biographies of things are also multidimensional. For example, computers have an economic biography concerning their prices (manufacturing, retail and resale), the rate of depreciation, the costs of maintenance and upgrade, and so forth. These computer also offers various social biographies: one may focus on different uses of computers as a tool for business, education, research and communication. Another may relate to the history of ownership and its impact on (re)producing boundaries between the rich and the poor. A third may concern the role of computers in social interaction among people across distance and cultures. Finally, the technical biography of the computer may include various modifications in shape, size, color and necessary hardware components (e.g., disk drive, CD ROM drive) as well as technical changes (e.g., from 386 to Pentium® processors) and repair records.

Neither are all commodities things, nor are all things available in society commodities. Only some things are considered appropriate to be classified as commodities at a given time and place. Then, what are commodities? What processes are required for a given thing to become a commodity? Commodities are things that are in a certain situation, or what Appadurai (1986a) calls a *commodity situation*.

In this chapter, I examine the life history of rapeseed as a commodity in the PRC. The first section summarizes my conceptual understandings of commodities. Using the arguments of Appadurai (1986a) and Kopytoff (1986), I define commodities as things in a particular situation in which their exchangeability for other things is recognized as their socially relevant feature. Then, I delineate three dimensions of the commodity situation: the commodity phase, the commodity candidacy and the commodity context. The second section examines current tests and trials to which rapeseed in the PRC is subjected. These tests represent political processes that create a link between exchanges and values surrounding rapeseed and human actors who handle it while legitimatizing the uniformity of rapeseed during its life span. Therefore, I argue that on the one hand the results of these tests (i.e., the commodity candidacy) determine the exchangeability and transmutability of rapeseed (i.e., the commodity phase) and legitimate contexts in which the commodity can be traded. On the other hand, the value of each human actor as a market participant is also manifested in these results. In the third section, I discuss the role of tests in the creation of markets and the redistribution of power. I conclude this chapter by arguing that the analysis of tests and trials reestablishes the link between the world of things and that of humans.

COMMODITY-HOOD

In Capital, Marx begins his investigation of capitalist society with the analysis of commodities. According to him, each commodity bears two types of value -- its use value and exchange value. Use value is defined by the utility of a commodity. Although this utility arises from the intrinsic qualities of that commodity, it can be realized only by use or consumption. On the other hand, exchange value is a quantitative relation as it emerges when

a commodity is exchanged for some thing. Because the exchange of commodities takes place independently of their use, Marx argues that “their exchange value manifests itself as something totally independent of their use value” (McLellan 1977: 423). He points out that this separation between the two sources of value is a distinctive feature of the capitalist mode of production. Moreover, in order for commodities to be exchanged, there must be a universal measure of value, that is, price, as the basis of comparison. Marx goes on to argue that the labor time necessary to produce them determines the value of commodities. In capitalist society, money becomes the primary source to express the exchange value of commodities, and thus a symbol of the human labor embodied in them. Consequently, the accumulation of money becomes the main drive.

Although Marx does not deny that commodities exist in a very wide range of societies including pre- and noncapitalist ones, most sociological studies of the economy tend to limit the meaning of commodities to those manufactured goods (e.g., automobiles, clothes) exchanged for money, and associate them only with the capitalist mode of production. However, not all commodities are manufactured through industrial processes. In modern capitalist societies, non-tangible commodities, or services such as medical care and insurance, play a far more important role in the economy than in non capitalist societies. Moreover, commodity exchange may take place without any involvement of money even in capitalist society. Appadurai (1986a) points out that barter has been used to avoid the growing number of barriers in international trade (e.g., Pepsico syrup for Russian vodka).

Furthermore, Marx’s argument about the fetishism of commodities leads to an overemphasis on the production and the producers of a given commodity, neglecting the analysis of that commodity in the distribution and consumption stages. This is particularly

problematic when we try to understand what it takes to turn price into a universal measure of value in commodity exchange. In short, the Marxian notion of commodity is too narrowly focused to understand the meaning of commodities and the processes by which things become commodities.

As Marx emphasized, the analysis of commodities and commoditization allows us to illuminate the relationships between humans, between things, and between human labor and things that are embedded in exchange processes. Moreover, I agree with him not only that commodities are things with economic value, but that it is economic exchange that creates such value in them. However, I follow Appadurai (1986a) in defining a commodity as “*anything intended for exchange*” (original emphasis). This definition permits me to remove myself “from the exclusive preoccupation with the ‘product,’ ‘production,’ and the original or dominant intention of the ‘producer,’” and instead focus on “the dynamics of exchange” (p. 9). Therefore, I can conceptualize commoditization as a process that involves actors who engage not only in production, but also distribution, research, legislation and consumption of commodities. Throughout this chapter, the term commoditization is used to refer to the processes in which certain desirable characteristics are created and maintained in a thing through exchange activities.

The Commodity Phase

Kopytoff (1986: 69) summarizes ideal types of commodity and non-commodity in the following way:

The perfect commodity would be one that is exchangeable with anything and everything else, as the perfectly commoditized world would be one in which everything is exchangeable or for sale. By the same token, the perfectly

decommoditized world would be one in which everything is singular, unique, and unexchangeable.

In reality, no economic system can be classified as either. Moreover, he argues that things move in and out of the commodity state, or what Appadurai calls the *commodity phase*, that is, the state in which a thing's exchangeability for other things is defined as its relevant feature in a given society at a certain time. This means that not only human labor but also diverse values are embedded into things in exchange. For example, when I purchase a pencil and bring it home, the pencil is no longer a commodity. Eventually, the pencil will be thrown out once I use it up. Thus, the life history of the pencil may be quite short -- probably a year or two. However, some things such as paintings, sculptures, heirlooms, furniture and collectible books may have long life histories of being commoditized, decommoditized and recommoditized. In addition, things tend to be transformed into various *commodities*, each of which often has a set of more or less distinctive biographies. Some things may be turned into more commodities than other things. This *transmutability* of a given thing may differ considerably over time and across space, depending on social and cultural knowledge about and appreciation for specific characteristics of that thing as well as socioeconomic, political and technological capacity to actually transform it.

Indeed, in China rapeseed has undergone several phases as a viable commodity over the millennium. According to early records (e.g., Tongsuwen [second century], Qimin Yaoshu [534 A.D.], cited in SAAS 1964), rapeseed was originally used as a vegetable, green manure and medicine. However, during these early days, cultivation remained on an extremely small scale and was restricted to some northern regions (e.g., current Qinghai and Gansu provinces, Xinjiang and Neimenggu autonomous regions). Because spring rape resists

the cold climate better than most vegetables, it is believed that it became an important source of vitamins for the northern people. By the Yuan Dynasty (1206-1368), winter rape was recognized as a beneficial rotation crop for rice cultivation as well as an important oil crop for the southern people. With rapid urbanization, commercialization of agriculture and the improvement of oil extraction and processing technology during the Qing Dynasty (1644-1911), rapeseed came to be processed into and was traded widely as edible oil, lamp oil, candles, paints, and soap. About the same time, stir-frying became a popular cooking method, particularly among the bourgeois class. Within the last several decades, as the standard of living has improved, the demand for byproducts of rapeseed has further accelerated. In short, the transmutability of rapeseed in China has been influenced by various events including urbanization, agricultural commercialization, the development of oil extraction and processing technology, the improvement of living standards, and changes in diet.

As a thing changes into more commodities, more and more humans and nonhumans enter to shape various aspects of its life, forming multiple commodity chains surrounding that thing. In this study, I am interested in the entirety of rapeseed's life from cultivation as an agricultural crop to consumption as edible oil, animal feed, organic fertilizer, soap, paints, and other industrial products. Each of these things are in fact distinctive commodities with their own commodity phase in Appadurai's sense. Nonetheless, these byproducts are brought into being for some specific qualities of rapeseed that are found essential in a given society at a certain time. Thus, I argue that the commodity phase of a given thing encompasses multiple stages of its transformations and multiple steps of transactions between humans. This conceptualization allows me to examine complex relationships among that thing, and human

and nonhuman actors that exist in the commodity phase of rapeseed from production of input supplies to final consumption.

The Commodity Candidacy

In order to obtain an exchange value, singular things must be arranged into several classes, each of which has distinctive value, so that their similarities and dissimilarities are cognitively recognizable. Moreover, this classification of things allows us to attach meanings and values to each category of things, and to develop rules and practices concerning the circulation of these objects in society. Therefore, standards and criteria (symbolic, classificatory and moral), or the *commodity candidacy* of things (Appadurai 1986a: 15-16), define the exchangeability of things at a given stage of their life cycle in any particular social and historical context.

Today, many things often are exchanged among various human actors and undergo several transformations as commodities before finally being consumed. At each stage of their social life, these things must be successively classified as commodities. As more and more humans and nonhumans begin to enter into the life of a thing, the number of standards that apply at each stage of its career as various commodities increases. Some standards are set by the seller and the buyer of a commodity at the time of exchange, and are not applicable to their future exchanges with others. Therefore, these standards reflect on a *specific* exchange relationship between the two. However, some standards are developed and enforced by governmental agencies, trade associations, and consumer groups, and consistently applied to commodities regardless of between whom, where, when, and how they are exchanged. The development of uniform standards for a commodity helps to regulate its quality

characteristics, human practices to create such characteristics in the commodity, and social relationships involved in its exchange activities. These standards allow exchange relationships surrounding that commodity to be more or less *generalized* in a given society at a certain time. In fact, without uniform standards, the examination of a commodity chain has little sociological relevance as I will discuss in the final section. In other words, I can categorize and arrange singular humans into distinctive groups such as farmers, processors, marketers, or retailers because the rapeseed standards in the PRC specify rules and necessary practices that individuals in each group have to follow in order to transform and circulate rapeseed in the PRC.

Furthermore, the commodity candidacy of things determines not only the value of the commodity but also that of human actors who engage in exchange activities. This is because each standard or criterion of a given thing is an outcome of negotiations over creating, maintaining and/or changing its exchangeability between two or more human actors with socially and culturally distinctive understandings about that thing -- their values of what are desired quality characteristics of that commodity for exchange, and what are necessary human actions to create such characteristics. For example, large-scale rapeseed oil processors may want standards that restrict the use of high erucic acid rapeseed varieties so that they can export their oil products. Yet, most farmers do not want the content of erucic acid to be standardized so that they can continue to use high erucic acid varieties. Thus, the process of standardization requires at least some kind of compromise between these human actors with varied socio-cultural backgrounds, understanding of and relationships to rapeseed, and skills and abilities to manage it so as to produce the minimum quality characteristics required for it to sustain its career as a commodity. As Wise (1995: 11) points out, "[a]ny standards

ultimately established ... represent a complex set of negotiations among all of these parties before they can move freely through the nation as objective tests".

Standards for things must be reflective of the capability and willingness of human actors to create and maintain the required features in those commodities without drastic modifications to their activities. If the maximum erucic acid level were set too low, most farmers in the PRC would be reluctant to cultivate rapeseed as low-erucic varieties yield considerably less than traditional ones, and many small-scale oil processors would lose their business because they have no means to sort out low erucic acid seed from others. In short, the entire commodity chain of rapeseed would collapse by virtue of this new standard, and thus rapeseed would lose its exchangeability altogether.

As I have pointed out above, the development of uniform standards for a given commodity helps to generalize exchange relationships between individuals for that commodity. However, these standards also allow us to evaluate the quality of both singular things and individual humans in a given classification. For example, a bag of perfect shape and color of rapeseed at Mr. Ming's farm may be eventually discarded by a processor at County Z Oil Factory because it was damaged during transportation or storage. Thus, whoever is in charge of transporting or storing Mr. Ming's rapeseed failed to carry out his or her duties to ensure its commodity phase. In short, he or she was not a good transporter or storage manager. Therefore, the commodity candidacy of a given thing determines not only its commodity phase, but also affects the career of individual humans in a specific occupation and the fate of the commodity chain in a society.

Nevertheless, standards and criteria are temporally and culturally specific. In Canada, the maximum level of erucic acid changed from 5 percent in 1973 to 2 percent in 1987. The

sale of rapeseed oil with the erucic acid content of more than 2 percent is prohibited in Canada and the US, while high erucic acid rapeseed varieties (approximately 40 percent of the oil) are commonly used in the PRC, India, Pakistan, and Bangladesh. Some standards are more uniformly practiced than others in a given social context at a certain time. Therefore, the tests and trials of rapeseed described in the next section are the shared values of human actors explicit within the commodity chain in the PRC at the present time. As Busch and Tanaka (1996: 17) argue:

The relative malleability or resistance of [rapeseed] and other nonhuman actors that form the [commodity chain] is reflected in the malleability of these values. It appears that shared values in a commodity [chain], including the ethical commitments that are implicit in notions of goodness, are revealed in the products that the [chain] delivers, both to other members of the [chain] and to its clients.

Furthermore, these products also reveal differing organizational patterns of actor networks in commodity chains and differing values in chains across cultures.

The Commodity Context

In order to negotiate and agree about the terms of trade, various actors are brought together in what Appadurai (1986a) calls the *commodity context*. This term “refers to the variety of social arenas, within or between cultural units, that help link the commodity candidacy of a thing to the commodity phase of its career” (Appadurai 1986: 15). Such social arenas include commodity markets, barter trades and gift exchange rituals where things are actually exchanged for money, credit or other things. In the commodity context, two or more parties at least must recognize a given thing to be exchangeable for something, whether or not the symbolic or moral value they impute to the thing varies considerably. Then, these

actors must agree to actually employ certain standards and criteria as the measure of its exchange value. In short, both parties must consider certain quality features of the thing as necessary to determine its exchange value.

Many products of technoscience are themselves commodities that can be bought, sold and exchanged for money or other things. At the same time, any technical change in a given commodity has a tremendous impact on that commodity's life. Scientist Liu's variety makes it possible to process rapeseed into animal feed, baby food, nutrition supplements, and other new products, and to export both seed and byproducts of rapeseed. Therefore, this new technology allows actors in the rapeseed commodity chain to extend and diversify the life of rapeseed far beyond what traditional varieties could.

In general, the required technology for production, distribution and consumption of a given commodity is inscribed -- whether explicitly or implicitly -- in various types of standards. Thus, changes in a commodity standard often reflect changes in the available technology for handling that commodity, and require human actors to alter their production methods including, but not limited to, upgrading machinery and tools, restricting the use of certain chemicals, and adding new procedures. For example, the change in the maximum erucic acid content of rapeseed oil from 5 to 2 percent in Canada was only possible after double-zero varieties of rapeseed became widely available to farmers. Without that, the new standard of rapeseed oil would have been merely a piece of inscription without any merit since no one would have been able to implement it. In short, new technology developed by technoscientists or new standards enacted by policy makers for a given commodity require more than research or policy-making processes. Even with the successful development of new technology and standards, the exchange value of that commodity may not be at all

affected. Both must be incorporated into the commodity and embraced as a legitimate part of exchange activities in the commodity context by other human actors.

As Appadurai argues (1986a), modern capitalist societies are distinct from traditional ones in that more things tend to undergo a commodity phase in their lives, and that more standards of commodity candidacy are uniform. However, these two features of modern capitalist societies do not necessarily help us distinguish them from socialist societies. In the cases of the former USSR or Eastern European nations, as many things as capitalist societies, were produced, distributed and consumed in their societies. Some commodities were highly standardized. Thus, I argue that the diversity of social arenas for commodity exchange is what demarcates modern capitalist from socialist societies. The major change after the fall of socialist governments, or the dismantling of the planned economic system in the case of the PRC, lies in the fact that more contexts have become legitimate commodity contexts.

Indeed, the context in which rapeseed is traded in China has changed over the last two millennia. Until the 1950s, the crop cultivation remained largely for household consumption. Most peasants crushed their own harvest into oil and meal, and used each as they saw fit. Only the surplus was traded for cash or other necessities. However, a most dramatic shift in the value of rapeseed occurred in China within the last forty-five years.

Starting in the late 1950s, the communist government created a monopoly over all exchange activities in the life of rapeseed -- the amount, price, criteria, and methods by which rapeseed and its byproducts were to be produced, processed, distributed and consumed in the nation. Not only the exchange value of these commodities, but also the symbolic and moral values to be held by various human actors were controlled under the planned economic system. The increased production of rapeseed and consumption of its oil as vegetable oil

(rather than industrial oil), and later its meal as animal feed (rather than green manure), came to symbolize the improved standard of living among the population. This signified the superiority of socialism over capitalism. However, rapeseed and its products lacked any formal standards until the late 1980s or the early 1990s. In a society where edible oil was scarce, meeting the annual production quota was what mattered the most to every human actor in the rapeseed commodity chain. The quality of rapeseed at each stage was of little concern to them.

After rapeseed was removed from the central agricultural production plan in the 1980s, social arenas for commodity exchange have become increasingly diversified. Today, small community markets flourish in every rural township and county; small mom-and-pop style shops and enormous department stores (run by private enterprises) both proliferate at every major intersection in urban areas. This means that there are various prices, criteria, and contexts to be used for determining the exchange value of each commodity derived from rapeseed. This diversification of commodity contexts also coincides with the multiplication of formal standards on rapeseed and its byproducts issued by the national and provincial governments (see Figure 7.1). Therefore, the examination of these standards can allow me to illuminate changes in the commodity-hood of rapeseed, the role of human actors in the commodity chain, and the organizational pattern of actor networks in the chain -- all of which are important aspects for understanding the PRC's transition from a planned to a more market-oriented economy.

SEED OF RAPE

Developing a New Variety

- Field experiment
- National/provincial variety performance test
- Production test:
 - ★ Superior agronomic/quality characteristics



Marketing a New Variety

- Seed registration/certification indicated in the *Rules for Agricultural Seed Testing*:
 - ★ Purity, cleanness, germination rate, weed content, pest/disease infection rate
- National standards indicated in the *Seed of Oil Crops*:
 - ★ Purity, cleanness, germination rate, moisture
- Provincial standards of seed of rape



Growing a New Variety

- Higher yield than previous varieties
- Better resistance to disease, pests, climate damage



Marketing Grain

- National standards indicated in the *Rape Seed (8 grades)*:
 - ★ Fat content, moisture, freedom from undesirable seeds, inert matter, color, flavor, mildew content
- Grain survey based on provincial grades and grading methods:
 - ★ Fat content, mildew content
- Grain packaging standards:
 - ★ Labeling, bag

Figure 7.1 - Tests and Trials of Rapeseed, the PRC.

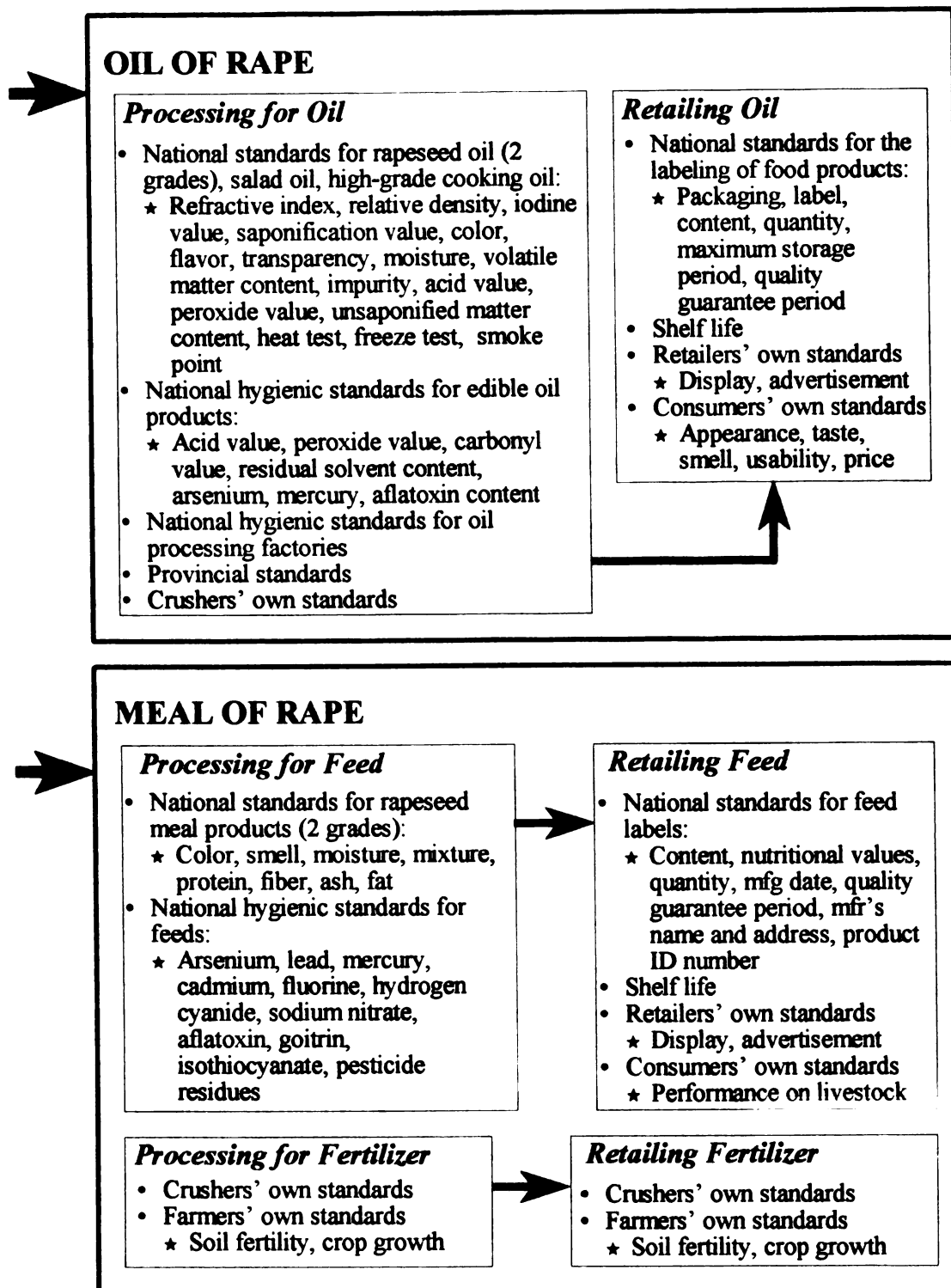


Figure 7.1. (cont'd)

TESTS AND TRIALS FOR UNIFORMITY

Today, in order to become and remain a commodity, all rapeseed must pass a series of highly standardized tests set by the national, provincial or county governments, performed at each stage from seed sales to consumption of various rapeseed products. National standards only apply to rapeseed commodities traded beyond provincial boundaries. Each provincial bureau of standards establishes standards for those products traded within the province. As shown in Figure 7.2, standards are usually first drafted either by a ministry (or department of the provincial government) or a special technical committee appointed by multiple ministries (departments), and then are enacted by the State (Provincial) Bureau of Technical Supervision (SBTS or PBTS).

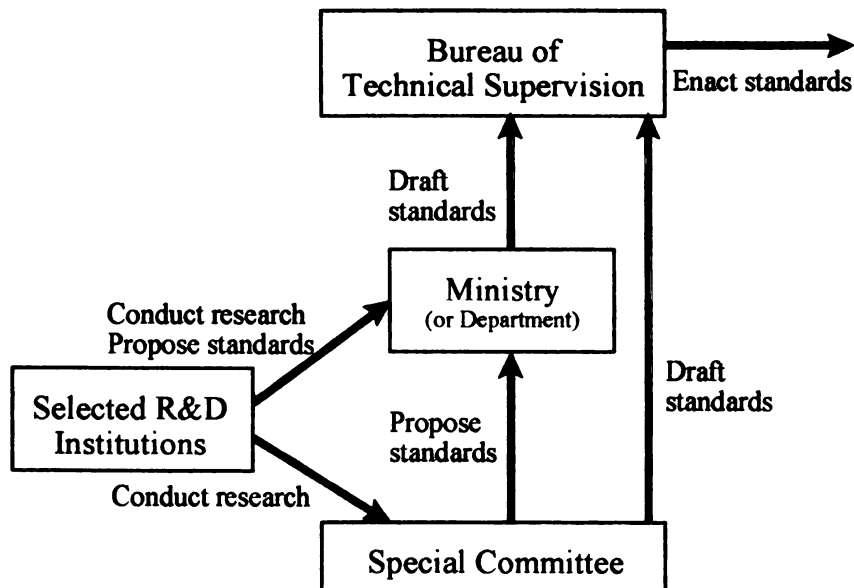


Figure 7.2 - Institutional Process of Enacting an Official Standard.

Below, I describe formal standards (see Appendix G for the list) that rapeseed in the PRC goes through at each phase to remain as a viable commodity in society. All these tests

specify uniform quality characteristics required from rapeseed at each stage during its life span. This means that each human actor must care for rapeseed in a uniform fashion. Therefore, as I have pointed out repeatedly above, these standards simultaneously test the quality of rapeseed and human actors who care for it at a given stage.

Variety Trials

Variety trials measure the quality of new varieties, and therefore, of plant researchers and breeders. Development of a new variety for licensing usually takes anywhere between six and nine years. A field experiment involves pedigree selection, hybridization selection, strain tests, and seed yield comparison tests. After preliminary yield tests, new selections go through the variety performance test at the national and provincial or municipal¹) levels for another six years (two three-year periods). Each performance test is usually divided into several regional groups for field trials, each of which consists of eight to fifteen locations according to its agroecological characteristics (MOA 1992). Then, the selections undergo a variety production test for two years.

The results of these trials are evaluated and licensed by the Agricultural Crop Variety Approval Committee at the provincial and national levels. The National Committee directs provincial committees for their licensing work, and approves and licenses new varieties to be introduced to multiple provinces. Each committee consists of representatives from agricultural administrative, seed management (e.g., Seed Company), research, educational,

¹ Hereafter, the term “provincial” refers to the administrative level of province, municipality and autonomous district.

and extension agencies within the jurisdiction appointed by either the Provincial Department of Agriculture or the Ministry of Agriculture. According to the Enforcement Rules for the Seed of Agriculture Crops (*Zhongzi Guanli Tiaoli Nongzuowu Zhongzi Shishi Xize*, hereafter the Enforcement Rules) (Nongyebu 1991, III[27]), in order to be licensed, a new variety is required to demonstrate that:

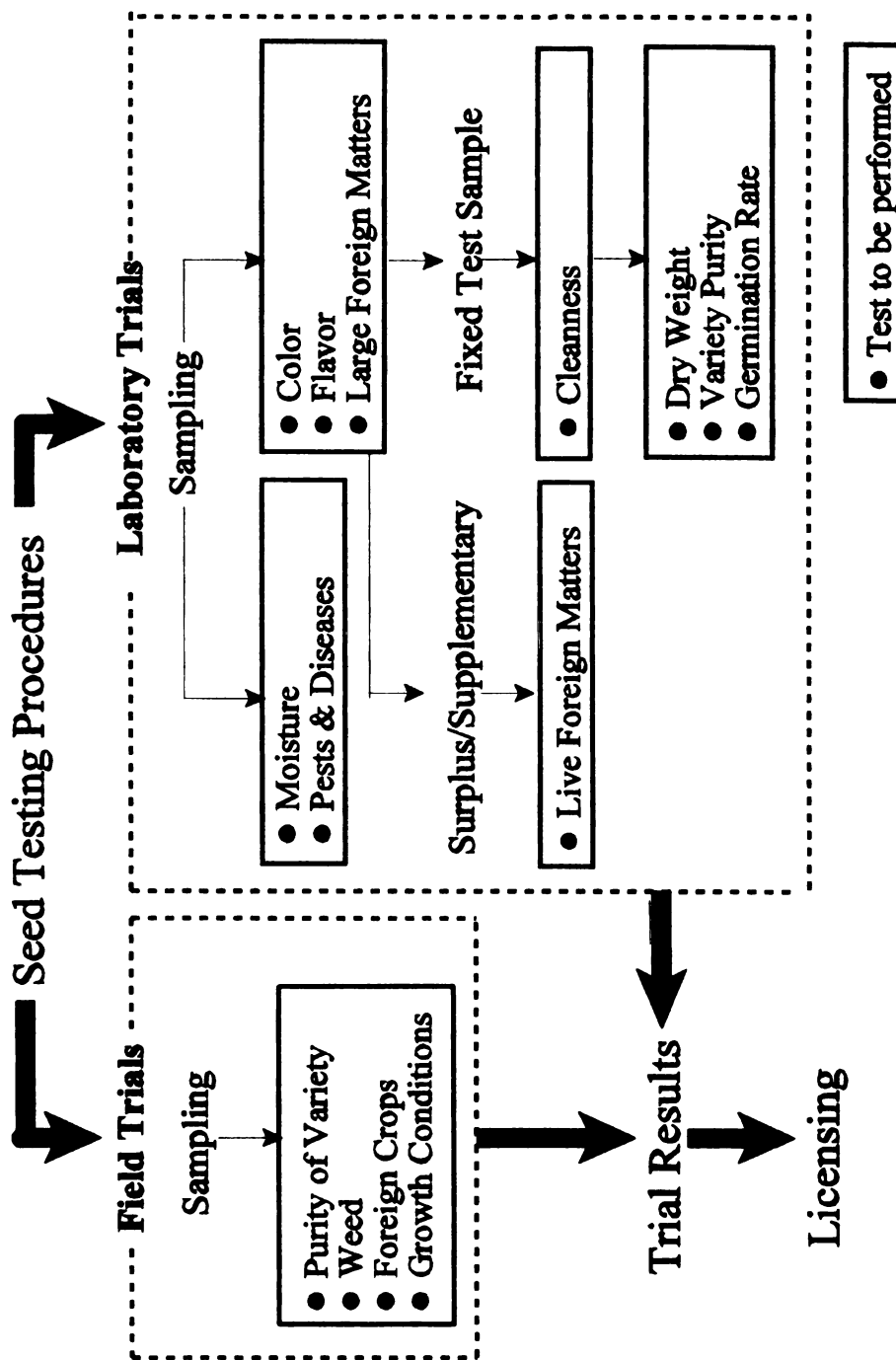
- (1) its genetic characteristics must be stable and distinct from other varieties,
- (2) it has undergone three-year regional tests twice successively and two-year production tests once (they can be carried out simultaneously), and
- (3) its yield must be at least 5% higher than the major available varieties of a similar kind, or equivalent to them but excelling in other agronomic characteristics such as the quality, the maturation period, and resistance to diseases and pests.

These variety trials are not merely tests for the quality of rapeseed, but also that of human actors who are involved in the process. On the one hand, those strains that do not pass the required tests will not be licensed and therefore will remain as research materials to undergo further transformations. On the other hand, agricultural research units whose varieties are consistently successful in exceeding expectations in these tests will be praised for the quality of their research, and hence increase their chance to receive more research funding from the national and provincial governments during the subsequent five-year plan period. Meanwhile, successful breeders may be recognized for their skills by national and provincial medals for scientific achievement, permission to go abroad for additional training, research grants offered to individual researchers by government agencies and international organizations, and increased publication opportunities in national and international journals. However, those units and breeders who generally fail to meet the above tests will lose

research funding from the governmental agencies and be ignored by the international technoscientific community.

Seed Quality

Licensed varieties face another series of tests of their quality. The first set of tests are required by the Enforcement Rules regarding seed certification, production and distribution. The varieties must be certified for production and distribution by an appropriate administrative agency at every level above the county. The certified rapeseed must meet the criteria specified in either national or provincial standards depending on the extent to which the seed is traded. Among them, the Seed of Oil Crops (GB 4407-84) (Biaozhunju 1984) are the national standards applied to any oilseed used by state farms, and/or licensed by the National Committee. Although provincial standards, which apply to all seed traded within a given province, are more lenient than the national standards, both types of standards limit the marketing of any seed of rape that does not meet the minimum requirement for cleanliness, purity of variety, germination rate and moisture content. Moreover, these quality characteristics are determined by field and laboratory trials conducted on a small quantity of seed samples. Both types of trials must include the tests (see Figure 7.3) performed in a specific manner regardless of the national or provincial certification according to the Rules for Agricultural Seed Testing (hereafter the Test Rules) (Biaozhunju 1983).



Source: BNS. 1983. *Rules for Agricultural Seed Testing*, GB3543-83 2.

Figure 7.3 - Seed Testing Procedures in the PRC.

On the one hand, the Test Rules define in detail what uniform characteristics are required of seed of rape. The seed that successfully undergoes the entire process receives a certificate indicating that it possesses for a given grade the minimum degree of uniformity in purity, cleanness, germination rate, moisture, amount of weed seed, and the rate of disease and pest infection. Moreover, the newly certified seed will be allowed to advance to the next series of trials. In short, for seed of rape, a copy of the Seed Certificate is a necessary ally for its survival in the rapeseed commodity chain.

On the other hand, in order for these trials to be performed properly, a new set of actors must be enrolled in the chain including, but not limited to, test equipment and materials, inspectors, weeds, pests, seed producers and seed marketers. The Test Rules further mandate what each actor is to do at each test. For example, for the laboratory trial process, the total sample of rapeseed must be at least 100 grams. Of only 400 grains, 200 large-size grains and 100 each for medium- and small-size, undergo the test for the germination rate. The test requires different types of seed beds including a bed with sand of 0.5-1 mm diameter for large grains, and petri dishes with absorbent paper or gauze for small grains. Medium-size grains are divided into two groups and germinated in both types of seed beds. Of course, these seed beds must be cleaned and sanitized beforehand. Moreover, the Test Rules specify for inspectors in what condition the seed beds must be maintained and for how long. In short, in order for the trials to be valid, other nonhuman actors also must be uniform in quality while human actors must behave in uniform fashion.

In addition, just as the Enforcement Rules require seed of rape to obtain a certificate, it mandates seed producers and marketers to procure respectively a copy of the “Seed Production Permit” and “Seed Management Permit” issued by the national and/or provincial

governments to handle certified seed (Nongyebu 1991) in order to participate in the rapeseed chain. Moreover, those seed suppliers must meet the national standards for seed packing (GB 7414-87) (Biaozhunju 1987b) and storage (GB 7415-87) (Biaozhunju 1987c). Even with the permits, those suppliers who consistently fail either to obtain seed certificates or to prepare seed appropriately for trade will not be allowed to engage in marketing activities. Similarly, those with nothing but rapeseed with the lowest grade (Grade 3) will not successfully compete in the market. In short, all these formal standards encourage seed suppliers to produce and market a higher quality of seed in order to sustain and improve their position in the rapeseed chain. This requires them to increasingly handle seed of rape in a uniform fashion as that is the best possible method to guarantee the uniformity of their seed quality.

New varieties of rapeseed encounter another set of tests to demonstrate their seed quality. Besides seed certificates, they need farmers' approval and willingness to grow them. Farmers usually determine the adoption or rejection of a new variety by various criteria and methods. They may be persuaded by extension agents, breeders and/or technically specialized farmers at the demonstration field of a newly licensed variety. They may also grow the variety in a small patch of their field. Farmers evaluate the quality of the variety based on a combination of yield, resistance to insects, weed, diseases and climatic damages, maturity dates, physical characteristics of the mature plants (e.g., tallness, bushiness, color, fragrance, the number of seed per plant), and/or ease for plant management. Unlike formal tests described above, the criteria for these tests are usually specific to the needs of each farmer and the environmental conditions of his/her field. Those varieties which yielded higher than the previous varieties in an experiment or demonstration field may not necessarily do so in Farmer Li's field. Then, he may go back to his familiar variety after one year of trial with the

new variety. Moreover, Farmer Zhang has little interest in the same variety because, despite its superior yield, the plant grows to be too bushy for him to cultivate by hand.

Once farmers choose their preferred variety, they usually select their seed for the following season based on their own ideas about what constitutes good rapeseed. Although the number has been increasing, those who purchase seed from seed suppliers remain a minority in the PRC. Because the agroecological and social (e.g., available labor, tools) conditions for cultivation ranges widely among farmers even within a township, their specific need for uniform characteristics in rapeseed also varies. Therefore, the concept of uniformity that farmers use is extremely important for rapeseed to remain in the commodity chain. Probably this is the most difficult and critical stage of trials that the plant has to endure because this concept is locally specific. Even with a copy of a license and certificate with the highest grade from the national government that have been attained after a long process of trials and alliances with countless actors, a given variety may completely disappear from the chain if farmers reject it for production.

This in turn also implies that the quality of those human actors whose rapeseed varieties have been rejected by farmers may not be praiseworthy after all. For example, a national and/or provincial medal for scientific and technical achievement is given only to those breeders who have been successful not only in developing and licensing, but also in popularizing a new variety of rapeseed. Similarly, agricultural research and extension institutions will not receive increased funding from the government unless they have proven their varieties indeed benefit rapeseed production in the nation and/or province. Moreover, seed suppliers will suffer financial loss if they do not improve their ability to deliver products that meet farmers' needs.

Grading

After harvest, rapeseed is delivered to local grain stations and becomes subject to testing once again. The PRC maintains a two-tier grading system in which all rapeseed is classified by the basis of minimum oil content, maximum portion of foreign substances, minimum moisture content, maximum mildew damage, and color and flavor. While the National Standards of Rapeseed (GB 11762-89) (Jishu Jianduju 1989) provides general guidelines for grading criteria and testing methods, the provincial standards specify detailed indexes and procedures for actual grades used within a given province according to its agroecological and economic conditions and needs. However, in order to be processed into oil or meal, rapeseed must at least meet the standards of No. 8 national grade with minimum oil content of 33%, maximum foreign substance content of 3%, minimum moisture content of 8%, maximum mildew damage of 2%, and normal color and flavor (Jishu Jianduju 1989). Whether national or provincial, these standards define the uniform characteristics required from the grain of rapeseed. Moreover, they suggest to human actors how to handle rapeseed in order for it to be successfully graded and to be passed on to the next stage. The grain station does not accept rapeseed that fails to be classified as the lowest grade for its poor quality. This implies that the farmer who delivered such grain is also regarded as a poor farmer. Therefore, he/she must improve his/her rapeseed cultivation practices for the following seasons in order to produce a harvest that passes the grading tests for uniform quality.

Moreover, grading must be performed by only those people who have been licensed by the MIT or the Provincial Department of Commerce, and each test must be conducted with appropriate equipment and procedures specified in various national standards. In addition,

graded rapeseed must be packaged according to the national standards indicated in the Grain Packaging and Gunny Bag (GB 8115) (Shangyebu 1987b). Therefore, the grading procedure is a test of not only the rapeseed and the farmer, but also the grading equipment, the grader, the marketer and the packaging materials. Successful grading of rapeseed implies that each human and nonhuman actor who is involved in the procedure possesses the specific uniform quality required to interact with the crop.

In order for rapeseed produced in the PRC to be exported, China National Cereals, Oils and Foodstuffs Import and Export Corporation (CEROILS) as well as similar organization at the provincial level must follow the international standards for quality testing procedures. Major rapeseed importing countries (e.g., EU countries, Japan, the US) specify the minimum content of oil and protein as well as the maximum content of moisture, erucic acid and glucosinolates. Thus, Chinese rapeseed must undergo a new series of tests to determine these quality characteristics. Although the quality standards of rapeseed may vary among countries, these technical standards ensure that tests and trials of rapeseed are performed uniformly on rapeseed regardless of its national origin. Success in meeting these standards will allow the PRC's rapeseed industry as a whole to expand its network globally. Thus, these standards can be measures of the goodness of all the human and nonhuman actors in the nation who engage in rapeseed production, distribution, research, extension and administration.

Oil Standards

Uniform characteristics required in rapeseed oil products are defined in several different types of standards and measures by various tests concerning sensory characteristics

(e.g., flavor, color, transparency), moisture content, the level of impurity, relative density, refractive index, saponification value, content of unsaponifiable matter, peroxide value, iodine value, and smoke and freezing points. These standards apply both to provincial and interprovincial sales of rapeseed oil. The SBTS enacted national standards for the quality of edible vegetable oil products during the late 1970s before most agricultural crops were even standardized.² Consequently, these standards underwent several changes, mainly adding new tests and restricting specifications.

Moreover, as the number of crushing factories with oil refinement technologies (e.g., degumming, deoxidization, decolorization, deodorization) began to increase in the PRC during the 1980s, the SBTS established separate national standards for “Rapeseed Salad Oil” (GB 7654-87) and “High-Grade Rapeseed Cooking Oil” (ZB/X 14011-87) (Shangyebu 1987a), and hygienic standards for “Salad Oil” (GB 13109-91) and “Edible Frying Oils” (GB 7102-86) (Weishengbu 1986), each of which require distinctive tests for specific quality characteristics. Moreover, any rapeseed oil used as a raw material for processed food products must meet these newly added standards. Although the consumption of refined rapeseed oil has dramatically increased among the urban population since the abolition of edible oil rationing in the late 1980s, most rapeseed oil consumed in the PRC is not refined. The amount of rapeseed oil used as a raw material by food processing companies remains

² “Hygienic Standard for Edible Oil” was the earliest quality standard I could find concerning edible oil. Originally, the standard (then classified as GBn 2) was enacted in 1977. Then, in 1981 it was modified and enacted as GB 2716. The current version was enacted on April 26, 1985 (Weishengbu 1985). In 1986, “Rapeseed Oil” (GB 1536) was also modified from the earlier version enacted in 1979 (Shangyebu 1986).

small compared to that of soybean oil. Therefore, most rapeseed oil is graded according to tests specified in the national standards of “Rapeseed Oil” (GB 1536-86) (Shangyebu 1986).

Crushers hope to extract the maximum amount of oil from seed while maintaining the quality of that oil. Rapeseed oil that fails to make No. 2 grade of “Rapeseed Oil” will not be sold at the national list price (*guojia paijia*). Such oil must be graded by provincial standards and given the provincial price in order to remain viable as a commodity. For crushers, particularly those operated by the provincial or county Edible Oils and Fats Company, having the national price on their products symbolizes carrying a seal of quality award by the national government. Annually, those crushers who are consistent in producing No. 1 grade rapeseed oil are awarded with a provincial or national medal of excellence. This often attracts foreign investors to sign a contract for joint venture, and thus allows the crushers to upgrade their oil processing facility. In turn, the upgraded facility helps those crushers to process rapeseed in a more uniform fashion and produce higher quality rapeseed oil products.

However, the majority of oil crushers in the PRC are owned collectively by rural townships (or villages) or individually by farming households, and are operated on an extremely small scale. Unlike provincial or county crushers, these crushers usually lack the necessary equipment and personnel not only to refine rapeseed oil, but also to conduct the appropriate quality tests of their oil products required in the national or provincial standards. Therefore, they often negotiate with seed sellers and oil buyers, who are usually the same people (i.e., farmers), to set their own quality standards. These standards are almost always less restrictive than the official quality standards set by the SBTS. Consequently, their rapeseed oil products remain within a small locale; their market activities are confined within a local commodity chain network.

Oil to be exported is subjected to another set of tests to determine relative density, the value of Crismer,³ the level of erucic acid, and fatty acid composition. The FAO/WHO (1990a, 1990b) limits the international trade of edible rapeseed oil to that which has a refractive index at 20 C° more than 1.469 and less than 1.465 (1.467 for low-erucic acid rapeseed oil), while the SBTS of the PRC accepts oil with refractive index⁴ between 1.4710 and 1.4755. Moreover, these international standards are far more restrictive and cover a broader range of quality factors than do those of the SBTS. For example, rapeseed oil with more than 5 percent erucic acid is not allowed to be traded as “Edible Low-Erucic Acid Oil” (CODEX STAN 123-1981) in the international market. Canada and the U.S. restrict the use for edible purposes of rapeseed oil with more than 2 percent erucic acid. Most of the quality characteristics specified in the international standards of rapeseed oil products involve test procedures that are not even performed at all on those produced in the PRC. Since little rapeseed oil is produced to meet the international standards, the amount of rapeseed oil exported from the PRC remains extremely small.

On the one hand, these discrepancies in the standards of rapeseed oil products among the local, provincial, national and international markets illustrate that quality testing is a culturally, spatially and temporally specific activity. What is considered as good quality rapeseed oil in Hubei Province may not be so in Sichuan Province. Canada’s high grade

³ Crismer value (corrected) = Turbidity observed (°C) + (% acidity x correction factor). The Crismer test determines the miscibility of the sample (i.e., how well chemicals can be mixed in all proportions) The values are characteristics for each kind of animal and vegetable fats and oils.

⁴ The refractive index is a measure of the degree in which a ray of light bends to go through oils.

canola oil has very different quality characteristics from its counterpart in the PRC. Since these standards differ as to what kind of uniform characteristics are required in rapeseed oil, each standard represents a concept of uniformity specific to a given culture, space and time as valuable in relation to that commodity.

On other hand, the existence of dissimilar standards at different regions exemplifies the major difficulty in the PRC's effort to establish uniformity in the quality of rapeseed oil. The failure of most rapeseed oil in making the No. 2 grade indicates the SBTS's failure to standardize the quality standards for rapeseed oil throughout the nation, and the behavior of provincial and local agents at the Office of Standards and Technical Control. As each quality control agent uses his/her own tools and equipment to conduct a series of tests according to the provincial, county or factory standards for rapeseed oil, each crusher uses his/her own equipment and methods to process rapeseed oil. In short, the lack of uniformity in the quality standards for rapeseed oil makes it impossible for the commodity to have uniform characteristics throughout the nation on the one hand, and for such human actors as crushers and quality control agents to handle the commodity in a uniform manner on the other. This limits the ability of both the commodity and human actors to extend easily their network beyond given geographical and cultural boundaries. Instead, this leads most Chinese actors to remain outsiders to the global rapeseed commodity chain while creating numerous fragmented chains surrounding domestic rapeseed throughout the PRC.

Meal Standards

Until very recently, use of rapeseed meal as animal feed has been of little importance in the PRC, and therefore its quality standards have not been a concern. In 1989, the SBTS

for the first time issued national standards including “Rapeseed Meal (Expeller) for Feedstuffs” (GB 10374-89) (Nongyebu 1989a) and “Rapeseed Meal (Solvent) for Feedstuffs” (GB 10375-89) (Nongyebu 1989b). According to these standards, rapeseed meal must be uniform in moisture content (maximum 12%), crude fiber (maximum 14%), crude ash (maximum 12% for the meal from the expeller method, 14% for the meal from the solvent method), and crude fat (maximum 10% for the meal from the expeller method only). Moreover, three grades of meal are determined by the content of crude protein. In order to obtain such uniform quality characteristics in meal, the quality of oil must be also uniform since rapeseed meal is the residual product after oil is extracted from rapeseed seed. Moreover, the “Hygienical Standards for Feeds” (GB 13078-91) (Jishu Jianduju 1991) describes the maximum amount of antinutritional compounds (e.g., arsenic, lead, mercury, cadmium, fluorine) allowed in different types of animal feed products (e.g., compound feed for chickens, compound feed for hogs, mixed feed). In order to meet and exceed these standards, feed producers must maintain a certain uniformity in processing equipment and procedures as well as in hygienic conditions in their factories.

In principle, any rapeseed meals that do not meet No. 3 grade will be discarded while their producers will be judged as “poor feed producers.” In reality, most rapeseed meal is consumed as organic fertilizer or used as a raw material for compound and mixed feed (Zhou 1995). The number of factories that specialize in animal feed production remains extremely small. Therefore, most crushers negotiate with farmers to determine appropriate standards for rapeseed meal. In such a case, the quality of meal is evaluated by its effectiveness to fertilize the soil and increase crop yields. Moreover, the value of crushers is judged by their ability to provide farmers with productive organic fertilizer while maintaining a competitive

price within the region. However, because agroecological characteristics vary tremendously among fields within a given township or village, each farmer is likely to desire distinctive characteristics from his or her rapeseed meal. Uniformity in quality may be unimportant.

Retailing Standards

At retail stores, commercial products of rapeseed oil and meal must meet certain standards with respect to packaging, labeling and storage. Those standards described above give general guidelines as to how each product must be handled before it reaches the hands of retailers. For example, both rapeseed salad oil and high-grade cooking oil must carry an appropriate label that contains the name, identification number, weight, and manufacturing date of the product as well as the name and address of the manufacturer. Moreover, the “General Standards for the Labeling of Foods” (GB 7718-87) (Biaozhunju 1987a) and “Feed Label” (GB 10648-93) (Jishu Jianduju 1993) also give more specific instructions as to what information must be included in each label.

Although packaging and labeling are the main responsibilities of oil or feed producers, retailers must also maintain the quality of packages and labels through proper storage conditions for stock. Moreover, they need to rotate stock so as to ensure that no oil or meal products remain on the shelf after the expiration date on the label. Therefore, the consumers evaluate the quality of the retailers based on the freshness of stock and the uniformity of each product.

Usability

Consumers carry out the final test of rapeseed. Their satisfaction with rapeseed products determines whether or not these products remain on the market. The quality of the oil products is judged by such tests as taste, smell, appearance, and performance when cooled in salad dressings or heated for frying. The animal feed products made from rapeseed meal are assessed by the purchasers as to how these products are preferred by their livestock (i.e., pigs and chickens) and their effectiveness in maintaining the well being of their livestock. As discussed above, farmers also evaluate the performance of rapeseed meal as organic fertilizer based on the growth of their crops. For each product, the quality is expected be uniform by the consumers.

The results of these tests performed by consumers are a judgement of not only the goodness of the rapeseed products but also of all the human actors in the commodity chain who have participated in shaping these products. As the Chinese consumers are introduced to new products of edible oil and fat, fertilizer and animal feed, and nutritional information, they will perform these tests with more stringent standards before choosing products. Consequently, this will encourage other human actors to subject rapeseed to more rigorous tests throughout its lifespan on the one hand, and to discipline their own behavior in caring for the commodity on the other.

The tests of rapeseed described above reflect the shared values of human actors within a commodity chain as to what is good rapeseed and what is good care for it. Uniformity in the quality of human and nonhuman actors required by these tests is therefore intrinsically linked to notions of goodness shared in the commodity chain about actors (both rapeseed and humans) and markets that bring them together. In other words, tests also suggest what are

good markets. Good markets are where tests and trials are actually performed or enforced to create and maintain uniformity in the goodness of human and nonhuman actors. This point raises some sociological issues that help me to reestablish the relationship between things and humans, and understand the nature of modern capitalist markets.

CREATING CAPITALIST MARKETS AND REDISTRIBUTING POWER

The national plan to standardize commodity quality and production technology was initiated in the early 1970s as a part of the effort to end the political and economic turmoil created by the Cultural Revolution, and to modernize the nation's economic system. The CPC called for the development of uniform standards that apply to every product and production process in the nation. The CPC reasoned that standardization was "an important technological policy to quickly build a *socialist* economy as well as an imperative means to ensure good quality, advance performance, and rationalize the economy" (HGK 1972: 4, emphasis added). Therefore, along with the increased production, standardization was perceived as an essential tool to strengthen both the *Party's* leadership and the *socialist* economic system. Moreover, the CPC argued that the lack of standards would create confusion and chaos in economic activities, therefore eventually leading the PRC into a "*capitalist, free market* economy" (HGK 1972: 4, emphasis added).

By the late 1970s, the focus of standardization began to shift away from building a *socialist* to building a *modern* economy in the nation. On April 9, 1979, an article in The People's Daily argued that standards would help "create one *uniform* economic system ... by linking together science and technology, engineering, production, distribution, and consumption" (Renmin Ribao 1979: 1, emphasis added). The article goes on to argue that

the degree to which standardization is carried out in a country is an important indicator of how that nation is modernized, what level of production technology is available to that nation, and how effectively its government can administer the nation:

Without standardization, there is no way to modernize production. Without standardization, there would be no specialization [in production]. [Therefore, products] would lack quality and the [economy] would lack momentum for growth.

More recent documents openly celebrate the benefits of standardization for the PRC's enterprises and farmers to improve not only productivity and efficiency but also *profitability* and *competitiveness*. As in the case of rapeseed, within the last decade, the number of national and provincial standards has multiplied, and mechanisms for enforcing those standards have been tightened significantly.

Why has standardization of commodity quality and production technology become so important in the PRC, particularly as the nation relaxes central control over market activities? In order to answer this question, we must clarify the role of standards in making capitalist markets and redistributing power.

Markets and Transaction Costs

Williamson (1975) has argued that commodity exchanges may take place either in markets or through hierarchies. According to him, the costs for the parties involved of a transaction with uncertainty about a given commodity would be higher in a market than in an organization. Moreover, he pointed out that the relative efficiency of each should determine whether to use markets or hierarchies in a given commodity context. Of course, Williamson's work is based on the assumption that markets already preexist even before these choices

become available to whoever enters into a transaction. He does not concern himself with how new markets and the choice between markets and hierarchies come into existence in society. Nevertheless, his distinction between markets and hierarchies is quite useful to understand recent economic transitions in the PRC.

Let us first return to the PRC before the nation's standardization program began, and imagine how rapeseed and its byproducts were exchanged in the commodity chain. With the exception of farmers and consumers, all actors belonged to the government (whether central, provincial or local) and their activities were supervised by the CPC. Most communes had their own input supplier, granary, oil processing factory, and edible oil retailer. Most work units (*danwei*) operated their own mess halls and stores that distributed grain and other agricultural products to their workers. Without exception, farmers from every production team and brigade within Commune Y went to sell their harvest to Granary Y, instead of granaries in other communes. Similarly, urban consumers received edible oil ration coupons from their work unit every month that restricted the amount of their rapeseed oil consumption and the stores for their purchases. Any changes in the amount, price, quality, methods, rules, and moral values concerning these commodity exchange activities had to be initiated at the top and implemented by each administrative level in the PRC. In short, exchanges took place only within the hierarchy in Williamson's sense. There were no markets for rapeseed or its byproducts.

Under these circumstances, money played little role in the economy because the goal was not to reduce transaction costs, but to maintain hierarchical order in the PRC's bureaucracy. In the highly ideologically charged system, loyalty and commitment to the CPC and its ideology largely replaced money in mediating these exchanges. For example, Comrade

Zhang who helped his commune increase rapeseed delivery to Granary Y may not have received any more monetary income to purchase more goods, but certainly would have been praised as a “model comrade” in the commune. Furthermore, under the food ration system, commodities could often be used as compensations or fines for urban workers. For example, the ration of edible oil was increased for technoscientists during the readjustment period between the Great Leap Forward and the Cultural Revolution in order to recognize the importance of “intellectual labor” or *naoli laodong* (as opposed to “physical labor” or *routi laodong*) for building the new socialist nation (Liang, Wen and Liu 1992a; Zhang 1989).

Furthermore, with only one price available for each commodity -- the one set by the hierarchy--, the price could not become a measurement of the quality in different things classified as that commodity in society. With no other prices with which to compare, most commodities did not require any formal standards, except military products and extremely limited export goods that required a certain degree of competitiveness with the counterpart good in rival nations. Each human actor in the rapeseed commodity chain decided which things should enter into the commodity phase depending on the prospect of meeting that year’s production quota or the available stock for rationing. In short, the price became an expression of the quantity rather than quality necessary for each commodity in the PRC at a given time.

As diplomatic relationships with most of the capitalist countries began to normalize since the early 1970s, the choice between markets and hierarchies suddenly became available to the enterprise called the People’s Republic of China. In order to be recognized as a market participant, this *PRC Enterprise* must follow rules and practices accepted in global markets. In order for its goods and services to be classified as commodities in global markets, the

enterprise must give each product a price that reflects its exchange value in comparison to competitors'. Moreover, the enterprise must be able to compare the goods and services offered by its sellers. In short, the central government needed to ensure that Chinese goods and services met the international standards on the one hand, and that the goods and services from other nations met its own criteria. This created a need for formal standards for potential export and import commodities so that the PRC's interests would be protected in the global market system.

Ironically, standards allow free and protectionist market practices to coexist. On the one hand, as long as standards are met, actors can freely participate in market activities and compete with each other solely on the basis of the cost to produce a good at a given level of quality. In short, whoever produces it cheaply can win the game. Moreover, as long as standards are met at each step, the seller can spread across the globe various activities involved in producing that good. This encourages corporations to move the site for production activities to developing countries where labor, capital and land are cheap. In this sense, standards make the ideal of the free market possible by *globalizing* economic activities. On the other hand, standards can be also used as a tool to block certain actors from entering into the network surrounding a given commodity. For example, Japan often sets standards stricter than other nations in order to control the flow of imports and protect its domestic commodity chains. With the establishment of the World Trade Organization, standards will likely replace tariffs as the dominant strategy for trade protectionism.

However, the development of formal commodity standards not only helped to turn *PRC Enterprise* into an actor in global markets, but in the long-run also allowed it to carry out economic and political reforms simultaneously within the nation. Modernization of the

economic system was clearly perceived as making *PRC Enterprise* efficient and *competitive* in the global market economy. This ambitious program began with collecting numerous statistical data that indicated the state of economic activities throughout the nation, and making them available for analysis by research organizations and foreign aid agencies.⁵ Yet, it soon became clear that data collected through the bottom-up chain of command were hardly reliable. The terror of being accused of failure during the Great Leap Forward and the Cultural Revolution created a habit among local cadres of fudging any data in order to make their own work-unit look good. Furthermore, despite the use of standardized measurements in weight and size, variations in machines and tools for measurements, methods of data collection, and quality standards of commodities made these data incomparable among different communes, state enterprises, or regions. In short, highly uncertain transactions of commodities with little uniformity in quality made it extremely difficult to grasp the economic condition of the nation, let alone to modernize the economic system without any drastic reforms.

In the 1980s, the modernization program unfolded as two-tier reforms: (1) the breaking up of the PRC's hierarchy including decentralization of political authority, decollectivization of communes and state enterprises, and the separation between administrative and economic organizations; and (2) the creation of markets. In the case of the rapeseed commodity chain, such corporate actors as seed companies, input supply companies, grain marketing companies, oil processing companies, and grocers became

⁵ Until the late 1970s, the types of statistical data collected by the central government were extremely limited. Some data were collected only periodically. Moreover, most of these data were not readily available for analysis by researchers and low-ranking officials.

financially independent, and autonomous from the respective administrative authority to make *business* decisions. Today, farmers decide who will be the buyer for their rapeseed harvest, and the seller of seed or farm inputs; some process their harvest and sell oil and meal directly to consumers. Similarly, consumers buy as much rapeseed oil as they please from a seller of their choice. Moreover, the bottom-up revenue sharing system has encouraged each township, county, district and provincial government to develop its own policies, regulations and rules that help to boost market activities within its territory. In short, each of these human actors can now choose whether exchanges should take place either in markets or through hierarchies. However, in order for this choice to become a genuine choice, markets have to exist. Moreover, these markets must allow the PRC's economic system to be recognized as modern and competitive by foreign nations. Therefore, by markets, I mean those commodity contexts in which the price of each thing becomes a clear measure of its exchange value, thus reducing uncertainty in transactions (or reducing the transaction costs in Williamson's term).

Compare rapeseed oil sold by farmers at a village market in Xishui County with that sold at a department store in Wuhan. In Xishui, each farmer has a large tin can filled with rapeseed oil extracted from his or her harvest. The oils range in color from almost blackish brown to slightly dark brown. They also range from being murky to clear. People bring their own bottles of different sizes and shapes to be filled with oil. Then, each seller uses his or her measuring tools to approximate the amount in the transactions. At a department store in Wuhan, on the other hand, rapeseed oils are sold in clear plastic bottles with uniform sizes and shapes. The oil is also uniform in color and clarity. Each bottle has a label that indicates the exact amount of the oil and the address of the processing factory among other things.

What are the major differences between these two examples in the nature of the market? One might notice the difficulty in identifying the price of rapeseed oil at the village market. Although we can calculate the average price of all the rapeseed sold there, it does not reflect any *real* price. Furthermore, in such a market, the physical presence of both buyer and seller is the only possible way to engage in exchanges. This is why most sellers come from either that village or somewhere very close by. Therefore, any exchanges are *singular* in nature, and their transaction costs are extremely high. In contrast, the price of rapeseed oil at the department store is easily recognizable. Moreover, in this market, buyers and sellers can engage in transactions without their physical presence. Indeed, some oils come from outside of Hubei Province. In short, at the department store exchanges form quite *generalized* relationships between the two parties.

In fact, these two types of markets represent an example of what Busch and Tanaka (1996) distinguish as noncapitalist and capitalist markets. While the former lacks standards for oil quality, weight, packaging and so on, these standards are pervasive in the latter example. As Busch and Tanaka (1996: 20) argue, “[s]uch standards serve to reduce transaction costs in Williamson’s terms, but they also serve to create simultaneously both the (capitalist) market with its restricted number of well-defined commodities and the ability of economists to analyze it.” In noncapitalist markets, such as the village market, standards are entirely local (i.e., mutable immobiles), whereas they are national and global (i.e., immutable mobiles) in capitalist markets. In the PRC where rapeseed and its byproducts were traded through the hierarchy, the development of national and provincial standards have made it possible to transform them into highly standardized commodities that could be traded in

markets well beyond the original location of production. Again, to quote Busch and Tanaka (1996: 21):

What differentiates capitalist markets from noncapitalist markets is that these standards allow human actors to engage in exchange with other distant human actors while transforming nonhuman actors (and sometimes 'labor') into immutable mobiles, known as commodities, that can be exchanged in the market.

In short, those standards described in the previous section literally create the markets for rapeseed as a provincially and nationally traded commodity in the PRC. At the same time, they also provide confidence in the ability of provincial and national governments to collect and compile economic statistical data about rapeseed in order to analyze the rapeseed market using the tools of economics. Only with standards in place, does the price become a meaningful and interpretable measurement of economics. Moreover, the use of market analyses and macroeconomic indicators generated by economists makes it possible for human actors in the rapeseed commodity chain to transform their activities and rapeseed itself in order to further reduce costs and increase efficiency, thereby turning humans into rational economic actors and contributing to the development of the modern and competitive economic system in the nation.

The Power of Tests, The Tests of Power

In market economies, the process of creating these standards usually involves negotiations between two successive human actors (e.g., farmers and grain marketers; crushers and food processors; retailers and consumers) with particular interests, needs and demands. On the one hand, these standards reflect the power relations that exist between the two human actors. On the other hand, they also suggest the malleability or defiance of the

nonhuman actors since a change in a standard causes changes in their behavior. Therefore, I argue that the creation of a test legitimizes the power of some actors to control the behavior of other (both human and nonhuman) actors. In short, they are the tests of power among actors in networks.

In contemporary society, such testing has become so pervasive that we hardly recognize the presence of tests involved in our lives. As Foucault (1979) has noted, power in the modern age lies in the ability to monitor and control minute detail. Therefore, the creation of formal standards must also be accompanied by the development of well-functioning monitoring mechanisms to enforce these standards. Thus, the tests described earlier must create, maintain, and change rapeseed as a commodity while monitoring, controlling, and organizing the behaviors of each human actor in the commodity chain. Then, the power of tests can be actualized by creating, maintaining and changing capitalist markets, and by producing and reproducing economic data necessary to modern economics.

Because tests involve multiple actors, they help to link actors together into networks. For example, seed quality tests of rapeseed link seed producers to farmers while rapeseed grain grades link farmers to grain marketers. These tests help to inscribe the points of transformation in rapeseed through its life as various commodities and to inscribe the points of exchange within the commodity chain. Moreover, the formalization of rapeseed standards helps to link the central and provincial governments to all the actors involved in the commodity chain. It allows various governmental agents to trace these inscriptions, and provides them with a powerful tool to monitor the behavior of both human and nonhuman actors, and to control the redistribution of power within the rapeseed commodity chain.

Therefore, the ultimate tests of power that the government at each level holds lie in its ability to enforce formal standards strictly in minute detail throughout the administrative territory.

In one sense, the current effort of standardization in the PRC inevitably works to fragment economic and political power over the nation by creating distinctive differences in the quality of a given commodity among different administrative levels. As noted earlier, farmers in Xishui County do not have to produce rapeseed that meets the national grading standards as long as their harvest is not marketed outside of Hubei Province. Similarly, oil crushers there are only concerned about meeting provincial standards since their oil products are sold only within the province. In other words, the central government has no control over the ways in which the life of rapeseed is shaped by human actors in the rapeseed commodity chain in Xishui County.

Nevertheless, the creation of national standards has increased the redistributive power of the central government within the nation. Any commodities that are traded inter-provincially and/or internationally must conform to national standards. Most rapeseed and its byproducts from Xishui County are not classified as viable commodities in the national or international markets because they do not meet the national standards. This means that human actors in the commodity chain in the county are not participants in these markets. In short, the central government dominates the creation of capitalist markets, defines actors who can be in them, changes the behaviors of these actors, and redistributes power among them. At the same time, this also becomes a source of corruption among government officials.

Moreover, the standardization of commodities at the provincial level enables the central government to supervise market activities of each province and redistribute power among provinces within the nation. If the degree of standardization in a nation is an indicator

of modernization in that nation as noted in the People's Daily article (Renmin Ribao 1979:

1) cited earlier, then the degree of standardization in a province is an indicator of modernization in that province. The creation and enforcement of provincial standards allows the central government to collect economic data based on provinces and analyze these data as macroeconomic indicators for the entire nation. Based on such economic indicators, the central government determines how much tax is to be collected from each province, and how much national funds are to be distributed to each province.

In short, the formalization of standards serves to change radically the role of the state as a modernizer of the nation. As the *socialist modernizer*, the central government as well as the CPC often relied on physical force to control society and establish its order. As noted in Chapter 4, public persecutions of *rightists*, *capitalist traders* and anti-Maoists during the Cultural Revolution were very much similar to public torture of criminals in pre-revolutionary France that Foucault (1979) describes. Party doctrines served as a measuring stick to classify people and things. Anyone who did not measure up to these standards was accused as a traitor, purged and reeducated. Things were also transformed to serve the effort for achieving the socialist ideal. The backyard steel drive and the health campaign against the four pests (i.e., rats, sparrows, flies, mosquitoes) in the late 1950s are good examples as to how nonhumans can be subjected to the force of ideologies. Moreover, five-year plans, production quotas and rations of consumer goods represented the authority of the CPC to dictate the commodity-hood of things.

However, as the *capitalist modernizer*, the central government no longer relies on these coercive strategies to restore its authority in society. Formal standards allow the government to control minute aspects of both humans and things by making them objects to

be judged and providing the government with knowledge about them. This minute power makes the government a powerful actor in the networks surrounding commodities.

CONCLUSION

My analysis of tests and trials for rapeseed demonstrates that each test of a thing is also a test of the persons who interact with it. As Busch and Tanaka (1996: 23, original emphasis) observed correctly:

People care about tests of things *because* they are also tests of people. Tests are measures of nature at the same time as they are measures of culture.

Although we, humans, try to create such tests in order to construct the world the way we would like it, nature often resists and redirects our endeavor to do so. We cannot set the protein content of rapeseed oil above what rapeseed is capable of providing for us. If many livestock begin to die from consuming rapeseed oil meal with 30 $\mu\text{mol/mg}$ of glucosinolates, the meal standard will be inevitably changed, forcing plant breeders to breed varieties with lower glucosinolate content and meal processing to employ new processing techniques. In short, nature and society are co-constructed by things and people.

However, the only nature available to us is the one we experience, and therefore it is our world (Busch and Tanaka 1996). Instead of dichotomous worlds of things and people as Kopytoff (1986) describes, there is only one world in which one finds both things and people. In other words, things are as much part of our lives as we are of their lives. To modify Marx's quote, a commodity is an object *inside* us. This is why we value tests as "measures of the value of our world" (Busch and Tanaka 1996: 23).

Let us move on to the next chapter and examine the specific values which each human actor holds about his or her interaction with rapeseed in Xishui County.

Chapter 8

NEGOTIATING FOR THE VALUE OF UNIFORMITY: THE CASE OF XISHUI COUNTY

INTRODUCTION

In the previous two chapters, I examined how the creation of uniformity in rapeseed has become a goal in research activities and the formalization of quality standards in the PRC. For the last two decades, technical change in rapeseed has focused mainly on the elimination of erucic acid and glucosinolates through plant breeding. On the one hand, new standards aim to improve the quality of rapeseed and its byproducts in the domestic markets. On the other hand, these standards were written based on the international standards in order to help transform China's rapeseed into an export crop.

In this chapter, I argue that the fate of technical change and standards are in later user's hands. For example, in a given network actors other than technoscientists may or may not find new technology useful. When making decisions about the use of the technology, each actor brings in his or her own interests, motivations, ethical commitments and values, and adjusts his or her behavior according to changes in the behavior of other actors in the network. Contrary to a common assumption in the diffusion literature (e.g., Rogers 1983), as I will show below, actors are usually confronted with more than the choice of either accepting or rejecting these changes. For example, a farmer may use a new variety of

rapeseed for one year before making his or her final decision. Another farmer may watch his or her neighbors use the new variety for one season. A third farmer may modify the new variety through plant breeding. Moreover, the bases for farmers' decisions may have little to do with the superiority or inferiority of the new variety over traditional ones. If all grain marketers in a region decide to accept rapeseed harvested only from the new variety, farmers have little choice but to switch to the new variety or to abandon production for the market. It takes the entire network of actors to manage the new technology and standards. In this sense, the changes in technology or standards are not based on the rational decision of each individual actor. But instead, they are a collective decision based on negotiations of diverse *rationales* among actors. During the process, the original goals and intentions for such changes envisioned by technoscientists and government agents may be modified, subverted, or realized.

Using the case of rapeseed in Xishui County, Hubei Province, I demonstrate how the value of uniformity explicit in new technology and standards has failed to effectively change actors' behaviors in the rapeseed commodity chain. In the first section, I discuss how human actors in the chain actually handle rapeseed at each stage from input production to final consumption. I argue that contrary to the policy goal of expanding the market for rapeseed, the commodity chain in Xishui is confined within a small locale. In fact, there are numerous rapeseed chains in the PRC, each of which may have its unique needs for technical or legal change, and employ its own strategy to maintain the chain itself.

The second section focuses on multiple notions of uniformity as a value in the rapeseed chain in Xishui. This means that each human actor desires a different type of quality changes in rapeseed through technology and standards. I conclude that the technology and

standards introduced recently in Xishui are ineffective in allowing human actors to strengthen their links with other actors in the chain on the one hand, and in helping the chain to extend its network beyond a limited locale. These weaknesses largely stem from continual reliance of the central government on its hierarchical mechanisms rather than a self-organized commodity chain to develop and introduce new technology and standards, thereby limiting the participation of actors other than technoscientists and governmental agents.

LOCAL CHAINS

Within the last three decades, rapeseed production in Hubei Province has grown dramatically. Between 1975 and 1995, the total area increased nearly fourfold, production ninefold, and yield by threefold (Hubeisheng Tongjiju 1995). Mr. Wang Yinyuan (1995c), the Division Chief of Cereals and Oil Crops in the Hubei Bureau of Agriculture, attributes this rapid growth in rapeseed production to six events, including: (1) the introduction of the household responsibility system which made farmers autonomous in selecting crops to be planted, (2) the open market policy for rapeseed and edible oil, (3) the establishment of a floor price for rapeseed, (4) the introduction of HYVs, (5) the increased availability of chemical inputs, and (6) the increased autonomy of provincial and local governments in establishing their own policies and regulations to encourage production of important crops in their district.

However, such macro-policy explanations do not explain actual changes in production practices that resulted in a large expansion in rapeseed production in the province. Moreover, the growth in rapeseed production may not have benefitted every actor equally within the province. For these reasons, I visited Xishui County three times for a total of ten days to examine how a commodity chain is built, maintained and transformed over time and space

through specific actions each actor performs in relation to the commodity. However, before we begin to examine how each actor handles rapeseed today, let us first briefly look at the formation of networks among actors surrounding rapeseed before the breakup of communes in Xishui.

Collective Agriculture and the Government-Imposed Rapeseed Chain

Under the centrally planned economy, the decisions on the production, distribution, and consumption of rapeseed and its byproducts were handed down from the central government to communes as *orders*, using hierarchical institutional networks. The network (*xitong*) under the MOA handled pre-harvest issues (e.g., cultivation, plant breeding) while that under the Ministry of Commerce (MOC) dealt with post-harvest issues such as oil and meal processing. Most stages of rapeseed transformation took place within communes as shown in Figure 8.1.

Note that the divisions of the harvest I use in Figure 8.1 is significantly different from those of Oi (1989). She divides the harvest into: (a) state share (i.e., agricultural tax), (b) collective share (i.e., seed, fodder and grain rations), and (c) surplus (i.e., state grain procurement, local grain reserve, and team utility fund). The agricultural tax for each team was fixed and calculated based on the area of cultivated land, estimated output, and population regardless of yield. Moreover, each team was also responsible for selling a mandated portion of what Oi calls the surplus to the state at a minimum state-set price (*paijia*) after the tax and the collective share. The only difference of this basic quota from the agricultural tax was that peasants were paid for their procurement sales.

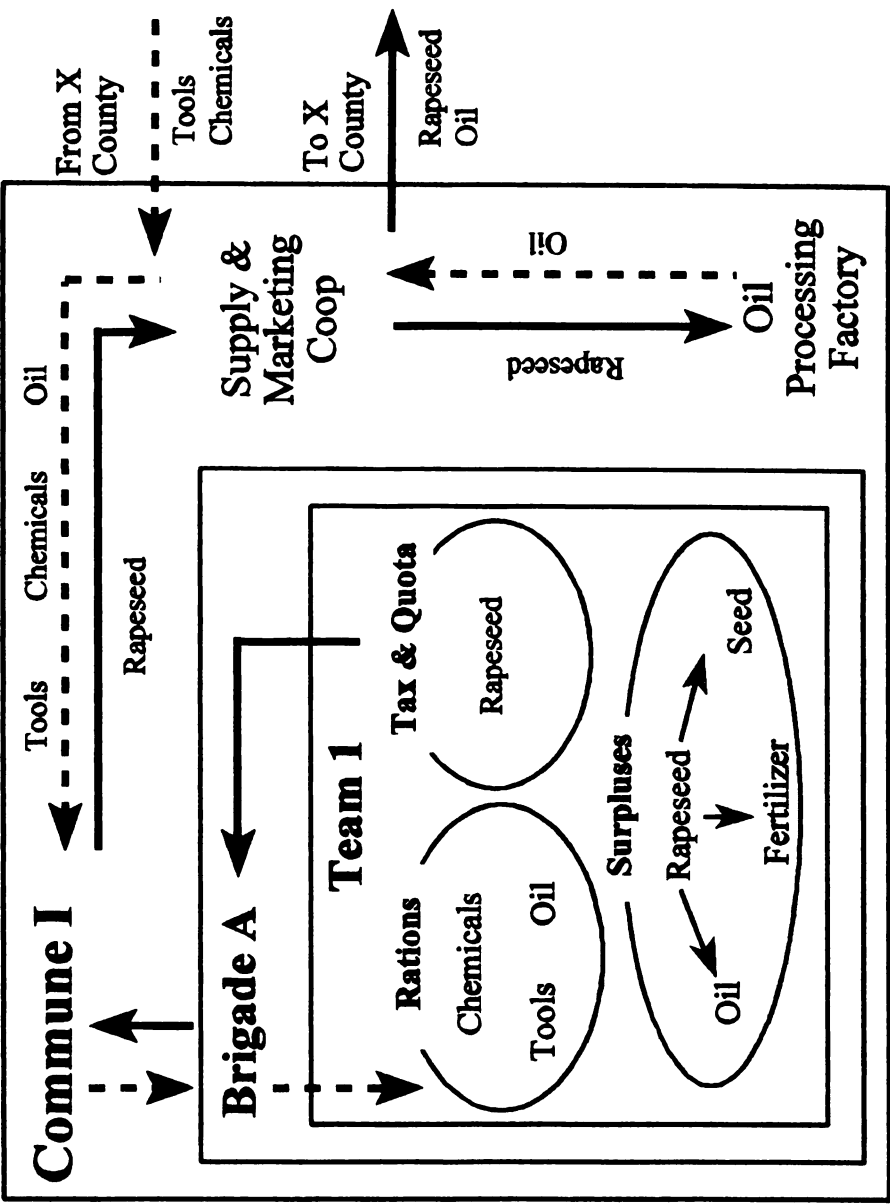


Figure 8.1 - Rapeseed Chain Under the Collective Agricultural System in the PRC.

As Oi points out, however, this quota sale was regarded by peasants as “forced delivery” or a type of “hidden taxation.” Moreover, the grain-first policy resulted in a constant shortage of the mandated rapeseed deliveries. In reality, the quota delivery was no different from the tax payment. And, the profit margin of rapeseed from the basic quota was almost nonexistent and occasionally negative. For this reason, I classify both the agricultural tax and the basic quota as the “state share”, and whatever each team kept for their own subsistence and production (what Oi calls the “collective share”) as “surplus.”

Each commune was responsible for delivering the annual rapeseed tax as well as the procurement quota to the Xishui County Grain Station to be processed into edible oil and rationed to urban consumers. Moreover, each commune purchased chemical inputs, tools, machinery, clothing, food, and other household items from the county to be distributed to its brigades and production teams. Nevertheless, these rationed items were never enough to meet the demand of the commune members. Therefore, in reality, most peasants relied on themselves to produce necessary farming inputs, family subsistence, and household supplies (various interviews, 1995, 1996).

Each production team reserved a certain proportion of the rapeseed harvest as seed and organic fertilizer for the following season, and to be crushed by peasants and consumed as oil in their households. If the state took too much rapeseed, the team and its members suffered. As Oi (1989) and Shue (1988) demonstrate in their village studies, the most intense negotiations between the state and peasants over controlling the distribution of the grain harvest took place in the team, rather than in the brigade or commune. For example, peasants often hid a part of their grain harvest from cadres. In order to obtain favorable results from grain testing, some team leaders tried to develop friendly relationships with local granary

cadres. Although I am not certain if similar practices existed in Xishui with rapeseed, my interviewees (1994, 1995, 1996) suggested that local granary cadres used subjective methods to determine rapeseed grades. Therefore, only a small portion of the harvest delivered as tax or procurement was rejected.

Although the central and provincial governments were largely responsible for rapeseed research, communes were used as a basic unit for local adaptation and dissemination of new technology. An extension agent pointed out that it was much easier to induce the adoption of a new technology on a large scale before the breakup of the communes (Township A 1995). Several researchers in Wuhan also complained that within the last two decades it has become extremely laborious to convince individual farmers in Xishui to switch from their traditional variety to a new and high quality variety. In this sense, the individuality of peasants is an outcome of the HRS.

In short, each commune in Xishui County appears to have existed as a separate commodity chain. More precisely, it functioned as a self-sufficient hierarchical network of actors linked for production, distribution, and consumption of rapeseed. However, as I demonstrate below, after the economic and political reforms in the 1980s the state reduced its ability to impose and control the formation of such networks. The decollectivization of production activities and the relaxation of central plans gave human actors a choice between the hierarchy and markets for commodity transactions. Moreover, the institutionalization of the legal system provided them with individual rights in economic activities. In short, the reforms in the last two decades have reorganized mechanisms that create, monitor and control social relationships in the nation. New mechanisms such as standards, commercial laws, contract laws and property rights have made each human actor to be autonomous and

independent from the hierarchical network of commodity chains. This made it possible that for a commodity chain to form as a more or less *self-organized* network among human actors based on their own distinctive interests, motivations, ethical commitments, and values. Therefore, unlike in communes, no two networks surrounding rapeseed within Xishui are exactly the same. Now, let us move on to discuss how network formation has changed since the introduction of the HRS in 1985, and what allows these networks to be self-organized relationships.

Supplying Inputs

After the decollectivization, the central government gradually released its control over domestic sales (not production or international trade) of chemical inputs, seed, tools and machinery, and allowed these essential farm inputs to be openly traded in the market. On the one hand, this helped existing input production and supply organizations to become more or less independent and autonomous actors from their corresponding administrative authority. On the other hand, other actors such as research institutes, university research centers and governmental offices also began to start their own enterprises (or *kaifa gongsi*) for producing and distributing farm inputs. Currently, there are essentially three types of input suppliers and three varieties of seed available in Xishui County as shown in Table 8.1.

Input supply agencies include the Input Supply Company (ISC), Seed Company (SC), and Machine Supply Company (MSC) from the central to township level. During the collective agriculture period, these corporations formed a rigid hierarchical network under the MOA. Every operational decision from the amount to be produced and distributed to the prices of the products was made at the central level and handed down. Since the late 1970s,

however, this hierarchy has gradually broken down, and administrative and business activities of each organization were more or less separated. In other words, these corporations gained autonomy in making operational decisions.

Table 8.1 - Input Supplying Organizations in Xishui County, 1996.

Organization Type	Operation Type	Products	Example (Seed Variety)
Input supply agencies	Sales for profit	New & popular products	<i>Zhongyou 821</i> <i>Huaza Nos. 2 & 3</i>
Research & extension organizations	Sales for profit; free distribution	New & recommended products	<i>Huaza Nos. 2 & 3</i>
Farmers	No exchange	High performance varieties in their fields	<i>Zhongyou 821</i>

For example, the Xishui Input Supply Corporation (XISC) -- the largest chemical input supplier in the county -- decides the amount of input production by three methods including: (1) last year's use, (2) its own investigation of farmers' needs, and (3) trends in the market (e.g., prices of rapeseed and its oil, demand/supply of rapeseed) (Wang 1995a). Despite guidelines from the MOA and the Hubei Bureau of Agriculture (HBA) to set different prices for various rapeseed varieties, Xishui Seed Company (XSC) continues to sell rapeseed varieties with little price differentiation (Meng 1995).

Today, individual companies compete with each other in the market. These companies also form a type of subsidiary relationship where technical and policy information are exchanged. For example, these input companies closely collaborate with the Xishui Office of Agriculture (XOA) to design and carry out extension programs for new rapeseed

technology. However, their sources of raw materials or processed products are no longer limited to those immediately above their administrative level. Furthermore, their clients are not restricted to farmers within their locale, or companies immediately below the administrative level.

In addition, many research and extension institutions have begun to start their own business enterprises that sell farm inputs. For example, the Hubei Center for High Quality of Rapeseed R&D (HCHQR) is a *kaifa gongsi* (development company) of the rapeseed breeding team at HAU. The HCHQR produces original seed of double-zero and hybrid varieties, and sells them to seed companies in Hubei. In addition to the free distribution of new technical products to farmers for production trials, the Xishui Extension Service Station (XESS) also sells recommended seed varieties and chemical input products. Since the breakdown of collective agriculture, the sales of such products have become an important source of funding for research and extension institutions.

In general, the XESS dominates the sale of seeds in targeted areas of rapeseed production -- those areas classified by the HBA as experimental bases for the demonstration and introduction of new production techniques. However, the XISC sells a larger proportion of chemical fertilizer and pesticides used in the county than the XESS.

On the one hand, this open market policy has contributed to a dramatic increase in the availability of farm inputs. On the other hand, it has also resulted in a rise in the price of farm inputs. Although the government continues to subsidize the production of farm inputs by setting floor prices for their raw materials and funding variety development programs, it no longer provides farmers with input rations. Because the area for rapeseed production is small

compared to that of rice, wheat or cotton, for many farmers it is not economical to spend a large proportion of their income for inputs.

Consequently, many farmers produce their own inputs for rapeseed production, particularly seed, organic fertilizer and tools. Furthermore, these farmers tend to avoid rapeseed varieties that are known to require an increased amount of pesticide and herbicide. In fact, most rapeseed farmers whom I interviewed formally or informally spoke to rarely *purchase* farm inputs, except chemical fertilizer, in order to keep the cost of production low. In other words, farmers are the dominant producers of farm inputs in Xishui County, not input supply companies who sell products derived from R&D activities and monitored by public standards for their quality.

Nevertheless, fully private input companies are not yet allowed in the PRC. Therefore, farmers are technically forbidden to sell other farmers those inputs produced for their own consumption. Only those individuals and organizations selected by the state using hierarchical rather than market mechanisms are allowed to engage in “free market” competition. This does not change the fact that farmers play a far more influential role than the XISC or the XESS as input suppliers in the rapeseed chain in Xishui. For example, as mentioned in Chapter 7, despite the government’s effort, the quality of seed in Xishui is not at all standardized because farmers select their own seed for the following season. These farmers decide what are desired characteristics in rapeseed based on their socioeconomic needs, the agroecological conditions of their fields, and their aesthetic preferences. In short, they transform nonhuman actors as inputs based on their own values and through their knowledge and skills.

Growing Rapeseed

Unlike farmers in Canada and the U.S., farmers in Xishui grow rapeseed in wet paddy fields as a rotation crop after two crops of rice.¹ In general, seeds are planted in seed beds in September, and are transplanted into the field in October. Fertilizer and pesticide are applied three times including: (a) 10-15 days after transplanting, (b) about one month after the first application, and (c) about another month after the second applications. Between April and May, farmers harvest their crop.

As already discussed in Chapter 3, one major characteristic of Xishui farmers is that their land holdings are extremely small, even compared with farmers in Northern China, with the average landholding is somewhere between 0.1 - 0.5 hectare per household. Usually, each household divides its land into three fields²: (a) a dry field for wheat and a cash crop such as cotton, (b) a wet field for rice and rapeseed, and (c) a vegetable field for household consumption (various interviews, 1995, 1996). In other words, each farming household grows several crops within a small land holding. Some researchers and extension agents complain that this lack of specialization in agricultural production limits farmers' knowledge about specific crops, and therefore, hampers technological development in Chinese agriculture (various interviews, 1994, 1995, 1996). Although the validity of such complaints is questionable, it is safe to assume that farmers make an operational decision about one crop based on its (both financial and agroecological) effect on the cultivation of other crops.

¹ This cultivation method is most common in Central and Southern China (the winter rapeseed area). In Northern China (the spring rapeseed area), rapeseed production takes place in dry fields as in Canada in the U.S.

² This multiple cropping strategy may have something to do with their memory of starvation during the Great Famine of 1959-1961.

Moreover, the multi-cropping system allows farmers to prevent a large financial loss from crop failure (such as the one during the Great Leap Forward period) while a small land area per crop makes the use of farm machinery extremely inefficient, if not impossible.

Based on various interviews (1995, 1996), I estimate that the average contribution of rapeseed sales to farmers' household income is no more than 30% in Xishui County. However, rapeseed is valued as a crop with high economic return compared to rice, wheat, or cotton which are still highly controlled by state planning and pricing. Moreover, unlike cotton the crop does not exhaust, but rather helps to enrich soil fertility. Since the area available for rapeseed cultivation is limited, farmers tend to maximize the profit from the crop by economizing on the cost of production. This explains why many farmers try to supply their own seed, fertilizer, pesticides, and tools as much as possible, and avoid varieties that require the application of chemical pesticides. However, these farming practices are commonly used not necessarily because of farmers' ecological consciousness *per se*. Instead, organic and non-mechanized cultivation techniques have been chosen because farmers know that they are the best ways to manage and survive current socioeconomic (e.g., lack of cheap chemical inputs) and agroecological conditions surrounding their farm. Indeed, Xishui farmers do not oppose technical innovations such as chemical inputs, machinery and high performance varieties; they hope to be able to take advantage of them once their income reaches an adequate level to regularly purchase them (interviews, 1996). An annual survey of rapeseed cultivation techniques by the XESS³ reveals increases in the use of chemical inputs specifically

³ The methods for this annual survey are not clear. Some researchers and extension agents in the province question its reliability as the sample size appears to be extremely small (around 20 households). I find these data useful in showing certain *trends* in technical change.

for rapeseed cultivation as shown in Table 8.2 (Hubeisheng Tongjiju 1991; Hubeisheng Tongjiju 1992; Hubeisheng Tongjiju 1993; Hubeisheng Tongjiju 1994).

Table 8.2 - Use of Chemical Inputs for Rapeseed Cultivation in Xishui County, Hubei, 1990-93.

	1990	1991	1992	1993
Chemical Fertilizer				
Boron (B)	87%	86%	89%	91%
Mixed	81%	76%	82%	83%
Ammonium	2%	4%	4%	4%
Chemical Pesticides				
Herbicides	1%	7%	9%	17%
Multipurpose	7%	16%	26%	11%

Sources: Hubeisheng Tongjiju (1991, 1992, 1993, 1994).

Farmer's choice of rapeseed variety also reflects such knowledge. As the nation's center of rapeseed research, low-erucic acid and low-glucosinolates varieties have been available in Hubei Province since HAU registered the first double-low⁴ variety in 1985. Thereafter, researchers, extension agents and government officials have been tirelessly recommending these new varieties to farmers through demonstrations at experimental farms, presentations at meetings in rural villages, and publications circulated directly to farmers. Nevertheless, two decades later, farmers still remain indifferent about switching from double-high to double low varieties.⁵

⁴ In this chapter, the term double-low rapeseed (*shuangdi youcai*) is used instead of canola because most of my interviewees used it.

⁵ In Canada, the success of popularizing canola varieties was brought about by banning sale of other types.

Table 8.3 - Major Characteristics of Rapeseed Varieties, Xishui County.*

	C ₂₂ & Glucosinolates	Yield	Resistance to Diseases	Required Fertilizer
<i>Zhongyou 821</i>	Double High	100 %	High	Moderate
<i>Huaza No. 2</i>	Low C ₂₂	80-90%	Low	High
<i>Huaza No. 3</i>	Double Low	100-120%	Low	High

Note: * These characteristics were constructed largely based on the testimony of farmers and extension agents in Xishui about the on-farm performance of these varieties.

Sources: Various interviews (1994, 1995, 1996).

For nearly a decade, *Zhongyou 821* (double-high variety) developed by the IOCR has been the dominant variety in the province. According to the same survey by the XESS (Hubeisheng Tongjiju 1991, 1992, 1993, 1994) mentioned above, 59% of the rapeseed area was cultivated with it in 1990, the first year that the variety became available to the public. Based on the interviews with input suppliers (1995, 1996), I estimate that today roughly 40-50% of the rapeseed area in Xishui is seeded with *Zhongyou 821*, and that a large portion of the rest is seeded with farmers' own varieties selected from *Zhongyou 821*. The area for double-low and hybrid varieties together seems no more than 10-20%.⁶ This popularity of *Zhongyou 821* comes from its superior performance in yield, and resistance to diseases, pests and unfavorable climatic conditions. Although hybrid varieties, particularly *Huaza No. 3*, can yield 7-10% higher than *Zhongyou 821* (Liu 1995), their high susceptibility to diseases and

⁶ This estimation excludes the rapeseed area in state farms in Xishui. In Hubei Province, the total area cultivated with double-low varieties (i.e., *Huashuang Nos. 1* and *2*, *Zhongshuang Nos. 2* and *4*) and low erucic acid hybrid varieties (i.e., *Huaza No. 2*) was 30.4% in 1993 (Dong 1994: 67). However, since most state farms tend to grow only recommended varieties, the total area of these new varieties in non-state farms would be substantially smaller.

pests makes them unattractive to cost-conscious farmers. More importantly, hybrid varieties need to be purchased every year.

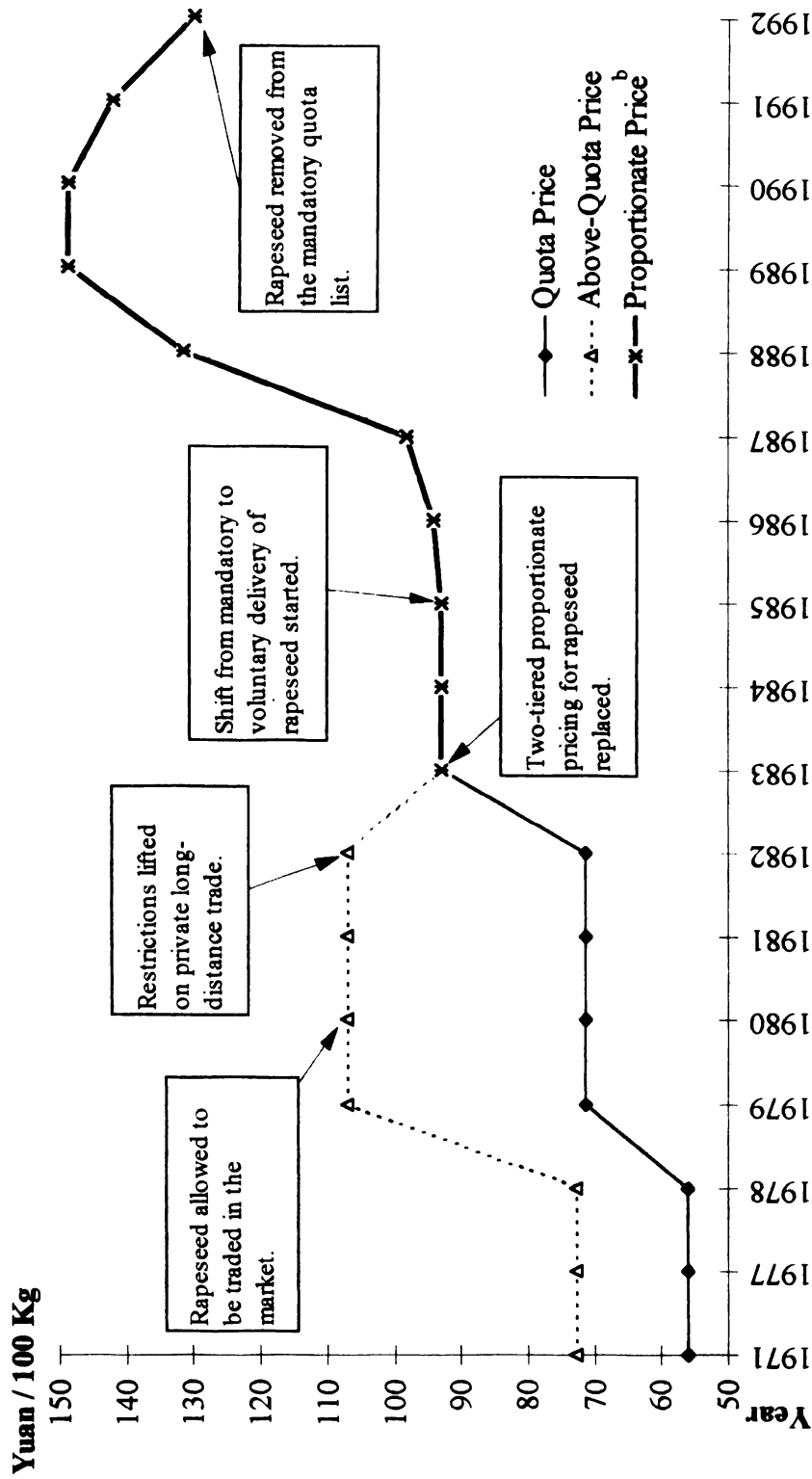
After two decades of collective agriculture where most operational decisions were made by cadres in the commune, today's farmers seem to enjoy autonomy and freedom in managing their own fields. My interviewees were proud to tell me that *they* decide which crops are to be planted, how each crop will be treated, whether or not to adopt a new technological product, and how their harvest will be delivered. Many do indeed receive some type of advice from the township agricultural station, input supply companies, and/or the village committee. However, they are careful in making *their own choices* of new technology -- choices that these farmers did not have until the introduction of the HRS. As Dr. Liu Houli at HAU, the nation's authority in rapeseed breeding for the last 50 years, pointed out:

Farmers are very realistic people. Unless they can actually see [the benefit of using a new variety] with their own eyes, they won't use it no matter what we [breeders] say about the variety.

In short, the failure of popularizing double-low and hybrid varieties lies in the fact that farmers do not see its superiority over *Zhongyou 821*.

Marketing Grain

Before 1979, the central government monopolized the marketing of rapeseed by setting the national delivery quota and procurement prices of the crop. Market trade of the crop was strictly prohibited. As shown in Figure 8.2., the initial reforms in the rapeseed marketing policy during the 1979-85 period entailed increases in the quota and above-quota prices, and gradual removal of restrictions on market trade of the crop.



Notes: ^a The national average price is an average of provincial prices among various grades. Although I used three different sources, the price differentials are insignificantly small. ^b The single price equals the weighted average of the old quota (40%) and above-quota (60%) prices. Sources: Sicular (1993:58-62) from 1971 to 1985; USDA (1990:272) from 1986 to 1989; Zhongguo Wujiaju (1991, 1992, 1993) from 1990 to 1992.

Figure 8.2 - The National Average Price of Rapeseed in the PRC, 1971-92.^a

In 1985, the central government announced that it would gradually shift mandatory planning of rapeseed towards a combination of guidance planning and market allocation.⁷ At the same time, provincial governments gained control over setting the target and prices of the crop according to their regional needs and agroecological conditions. In 1992, rapeseed was finally dropped from a list of farm products subject to planned procurement and pricing (Zhongguo Wujiaju 1993). This supposedly allowed the market alone to freely determine the price of the crop according to grade.

After nearly two decades of transition from the state unified procurement to free-market allocation of rapeseed, there are clear changes in the way in which the rapeseed harvest is marketed in Xishui County. First, there are more individual and corporate actors for marketing, transporting⁸ and processing rapeseed. Xishui Oils and Fats Company (XOFC) and its subsidiaries (i.e., township granaries) no longer monopolize rapeseed trading.⁹ Within the last few years, farmers have begun to market and process the crop. Various state commercial agencies (e.g., OFCs, Supply and Marketing Co-ops, Grain Stations), composed of multiple branches with offices at central, provincial and local levels, also began to compete with each other. Farmers are also free to select a marketer for their harvest delivery including

⁷ See Ash (1993) and Sicular (1993) for explanations of reforms in the unified procurement and sales system during the 1978-1989 period; and Sicular (1995) for reforms in agricultural commerce in the 1990s.

⁸ Currently, the lack of infrastructure to transport rapeseed and its byproducts is not a critical issue because these commodities are largely consumed within a small area. However, it is important in the long run.

⁹ Sicular (1995: 1031-1032) points out that between 1978 and 1992 the share of designated state commercial agencies (e.g., those currently under the Ministry of Internal Trade) in total procurement of farm products and in retail sales of consumer goods fell from over 70% to under 35%.

one outside their township. Without mediation of local granaries, the harvest can theoretically be sold directly to XOFC, OFCs in other counties, or large-scale private processing companies in Wuhan and other major cities in the nation. In reality, most Xishui farmers choose to sell their harvest to: (1) a township granary, (b) XOFC, or (c) local oil mills. Managers at township grain and oil stations (GOSs) complained that their businesses began to decline within the last four years because of the increased competition with farmers who operate small oil mills. This is largely because many farmers find it more convenient to sell their harvest to these small mills located nearby or even within their villages.

Second, related closely to the first, there are now more variations among marketers not only in prices of the crop, but more importantly, methods of handling the crop. According to Mr. Zhou (1995), the director of XOFC, the Hubei Oils and Fats Company (HOFC) recommends prices of rapeseed at different grades to be used by county OFCs and township granaries. However, as pointed out in the previous chapter, the quality grades to which the rapeseed harvest is subjected depend on the administrative boundary in which it is traded. Since the provincial and county standards of rapeseed have not yet been formalized, there seem to be differences in the number of grades and the criteria for each among granaries. For example, the manager of GOS in Township B (1996) divides the procured rapeseed into five grades, while the manager in Township C (1996) divides his into three grades. It is likely that local oil mills operated by farmers use the most relaxed grading schemes while the XOFC applies the most strict ones. Moreover, I assume that rapeseed with the highest grade would be sold to XOFC or even HOFC to be processed into refined oil, while the lowest grade would be sold to small-scale processors without an oil refinement facility. Since the grades determine both the amount and price of the harvest that farmers can

sell, in principle it becomes extremely important for farmers to compare how each buyer grades their harvest.

Finally, while the open-market policy for rapeseed created new opportunities for some (e.g., farmers, foreign investors), it also threw others deep into an unknown world called the “capitalist market.” After four decades of unified procurement and sales, many managers at previously state-run marketing facilities have not yet acquired the necessary skills and knowledge to effectively and efficiently run the business. Some feel very uncomfortable about making their own operational decisions and continue to rely on policy interventions from the central government. For example, the manager of GOS in Township A told me that:

Rapeseed production area is not stable anymore.... Sometimes large and sometimes small. That's why it is now very difficult for us to forecast and maintain our business activities on rapeseed. We hope that the [central] government will develop some kind of policies to stabilize the area of rapeseed production. The larger the rapeseed area, the better for our business. We rather want to know how much area will be seeded with rapeseed beforehand.

Some marketers often end up with a significant economic loss from the rapeseed trade. For example, in 1995 XOFC ended the year with 3 million kilograms of overstocked rapeseed oil because (Zhou 1995):

In the 1980s and the early 1990s, we sold more rapeseed oil than ever before. But, this year it declined because more imported edible oil became available. Now, its cheaper to buy imported oil¹⁰ than processing domestic oil crops. Meanwhile, the purchasing prices of harvested rapeseed continued to rise. Consequently, the amount of rapeseed production continued to increase. Because we want to protect the interests of farmers, we kept buying more rapeseed from farmers than we were actually able to sell in the form of edible oil. ... The [county] government knows our problems with the overstock. It gave us an extra storage facility. ... The [central and provincial] governments

¹⁰ CEROILS continues to assert monopoly over China's imports of vegetable oils (US Embassy, 1994, 1995).

should protect the interests of both farmers and oil processors [by discouraging the purchasing of imported oil].

The manager at GOS in Township C (1996) said: “China cannot afford to buy foreign [edible oil] products.”

Despite many changes brought by recent reform policies, what has not changed at all since the introduction of new (i.e., low erucic acid or double-low) varieties in the late 1980s is the way in which various different varieties are marketed. Currently, there are three different types of rapeseed varieties grown in Xishui including: (1) double-high varieties (e.g., *Zhongyou 821*), (2) low-erucic acid varieties (e.g., *Huaza No. 2*) and (3) double-low varieties (e.g., *Zhongshuan Nos. 1 and 2*; *Huashuang No. 2*). As discussed in Chapter 6, the latter two types allow rapeseed oil to be traded on the international market while the last type allows the crop to be processed into animal feed as well. Indeed, the national rapeseed research programs for two decades have been exclusively aimed at the transition from double-high to double-low varieties. Therefore, the differentiation in the economic value of these three types of rapeseed seems to make sense.

Yet, there is no special regulation for handling these different types of rapeseed varieties at the marketing stage for three reasons. First, commodity prices and marketing are supervised by the Hubei Bureau of Internal Trade (HBIT), not by the HBOA which directs research and extension programs to replace double-high with double-low varieties. Hence, XOFC or township granaries do not offer any price differentiation among these varieties. Moreover, when rapeseed grain is procured and graded, it is mixed together regardless of the variety, thereby undermining the benefits of single/double-low varieties. Second, rapeseed grades are determined by oil content and have nothing to do with the levels of erucic acid or

glucosinolates. In fact, since single/double-low varieties have lower oil content than double-high varieties, the former tend to receive a lower grade than the latter. In short, for the exact same amount of harvest, farmers would receive less money from a single/double-low variety, and therefore have little economic incentive for planting it. Finally, not every marketer is familiar with the qualitative differences among these three varieties. Even those with highly sophisticated understanding of varietal differences are not particularly concerned about the levels of erucic acid and glucosinolates as discussed below. In short, technical change in rapeseed has had little effect on modifying the behavior of marketers.

Finally, the open-market policy for rapeseed has not yet inspired marketers to embrace the importance of grades and grading. Many farmers prefer to deliver their harvest to local oil mills. These mills tend to accept a larger portion of their harvest than township granaries or XOFC, partly because they are not required to follow official grading guidelines from the province or county and partly because their owners are likely to be a relative, neighbor, and/or friend of the sellers. In a society where villages function as the basic unit for political, economic and social activities, the dichotomies between personal and non-personal, and between private and public play little role (Fei 1992). Therefore, it is the quality of personal relationships between a seller and a buyer, rather than that of rapeseed that determines the value of the harvest.

Processing into Oil and Meal

In 1992, not only rapeseed but also edible oil products were removed from the list of state controlled commodities. As with the case of rapeseed marketing, this had a tremendous impact on oil and meal processing activities. First, it encouraged the emergence of new

processors. Anyone who is willing to invest in an oil press machine can start a processing business and sell its products as edible oil, animal feed and organic fertilizer. In Xishui County, currently there are three types of oil processors: (1) XOFC, (2) township granaries with an oil processing facility, and (3) local oil mills operated by farmers. However, none of these processors specifically process single or double-low varieties of rapeseed.¹¹ Such specialized processing would require separate collection of rapeseed grain with a new set of tests at grading, special treatment at the storage stage, and modifications in processing methods and equipment to ensure the benefits of these new varieties. However, since the total amount of single or double-low varieties procured in the entire county remains small, it would not be cost effective for any processor to give special care to these new varieties. This is another reason why all marketers in Xishui, mentioned above, mixed single/double-low with double-high varieties at the marketing stage.

Second, the existing processors such as state commercial agencies like OFCs and Grain Stations became independent from their provincial and central branches, and therefore both inter- and intra-agency competition became notable. For example, XOFC competes with HOFC and OFCs in other counties (intra-agency competitions). At the same time, the company also competes with township Grain Stations that operate processing facilities (inter-agency competitions). Moreover, each of these state agencies can determine its own buyers and sellers as well as methods of processing the crop.

¹¹ The only exception in the county is Binjiang State Farm (various interviews, 1995, 1996). In 1996, this state farm planted 47 hectares of a double-low hybrid variety, and processed its harvest in its own facility. Unfortunately, I was unable to collect further information about the farm.

Finally, because of differences in processing methods and technology among various processors, there is far more diversity in the quality and prices of oil and meal products. This is often the case even among OFCs within the province who usually try to follow the technical and financial guidance of HOFC. For example, in the recent years the XOFC changed processing methods and improved equipment in its factory. Thus, the company is currently the only processor within the county that can refine oil. However, because the price of edible oil is largely determined by the cost of processing, the XOFC's price is significantly higher than products from smaller oil mills in the county.

Within the last five years, XOFC's share in total rapeseed processing has dropped significantly. Currently, XOFC processes about one third of rapeseed harvested in the county (Wang 1995b). Nevertheless, it is safe to assume that XOFC as a single actor continues to have the largest share in rapeseed processing in the county. According to Mr. Zhou at XOFC (1995), approximately 95% of the company's business is used specifically for marketing and processing of rapeseed.¹² It processes 50 metric tons of rapeseed per day. Rapeseed oil makes up about 40% of the total sales from rapeseed products, while 60% of that comes from cake that is used as fertilizer and animal feed. Although a large proportion of cake is used as feed, the high level of glucosinolates in the crop is not a problem. Mr. Zhou explained that most feed is used for raising fish, or mixed with other compounds. For example, only 3-5% of the pig feed comes from rapeseed. XOFC also exports rapeseed meal to Russia as fish feed.

¹² What proportion of the company's revenue comes from rapeseed is not clear.

The company's advantage as a business entity over other processors lies in its extensive links with government agencies, collective and state-owned enterprises, banks, local private enterprises, and other organizations like schools, hospitals, and the military. Even before the reforms, it already had capital, labor, access to credit, and political and business networks. Moreover, urban consumers in the county have begun to gradually switch from unrefined to refined oil as their standard of living has improved. Finally, the explosion of rural markets, as well as restaurants and hotels in urban areas has helped XOFC to secure new types of consumers.

However, in a county where nearly 90% of the population live in areas in which the dominant economic activity is agriculture, local oil mills (including those operated by township granaries)¹³ offer several advantages to rapeseed farmers and rural consumers. First, these mills process rapeseed cheaply even though the quality of their products may be inferior to that of the XOFC. Second, they are located within or near their village. This lowers the cost of purchasing oil and meal products for rural consumers who are unlikely to have free transportation to an XOFC retail outlet. Since farmers consume somewhere between 30% and 50% of their rapeseed harvest in their household and they have always consumed unrefined oil and used meal as organic fertilizer, the prices of oil and meal products matter more than their quality.

¹³ Note that the amount of rapeseed processed by each oil mill is extremely small. For example, GOS at Township B processes merely 100 metric ton *per year*. Often, there are a few mills in a given village of 20-30 households.

Retailing Oil and Meal

From the above descriptions of recent changes in marketing and processing of rapeseed, the increased complexity of relationships among human actors surrounding the crop is clear. In wholesaling and retailing, there are more diverse channels from which each actor can choose for circulating rapeseed and its byproducts in Xishui. In addition to marketing and processing, XOFC, local oil mills, and township granaries also wholesale and retail rapeseed oil and meal products. There are also other retailers such as Xishui Grain Oil Supply Company (XGOSC) which is the state designated retail agency of XOFC, collective and state-owned department stores, and private sellers at rural markets.

The XOFC wholesales oil and meal products to township GOS. Although XGOSC stores are XOFC's retail outlets, the company has its own independent store on the first level of its office building. The company also directly exchanges processed oil and meal for the rapeseed harvested by farmers.

The XGOSC sells both unrefined rapeseed oil (80%) and refined oil (20%) supplied by XOFC. Rapeseed products consist of 15% of its business, but only 5% of its total sales. Mr. Hu (1996), General Manager of the XGOSC, pointed out that in recent years the XGOSC sold: (1) more "high quality" (i.e., refined) rapeseed oil, and (2) a larger variety of vegetable oil products (e.g., soybean, sesame, and peanut oils). Then, he explained that the XGOSC had sold only unrefined oil with low quality "because the planned economy suppressed the price of edible oil from rising." In other words, under the state rationing system, the cost of edible oil production needed to be controlled. This is likely why oil refining technology was never popularized in rural oil processing factories. According to Mr.

Hu, the amount of refined oil sold by the company remains small because many customers in the county cannot afford to buy refined oil products.

The XGOSC has twenty four stores in the county capital. However, it does not have any outlets outside the capital. Township grain stations act as the state-designated retailer of edible oil products in rural areas of the county. For example, GOS in Township C purchases rapeseed oil and meal products from XOFC, and then sells them to local farmers. According to the manager (Township C 1996), 20% of its total sales consist of rapeseed oil products.

When purchasing rapeseed oil, consumers usually bring their own container¹⁴ to a store. After having the container weighed, they pump oil into it by themselves. Then, a store clerk weighs the amount of oil and charges for it. However, in 1996 XGOSC and its outlets in the county capital adopted the open-shelving system (*kaijia xuanhuo*) where customers can freely put already packaged products into a basket and cash out at the register. Along with this new system, these stores began to carry edible oil products other than those produced locally, including soybean, corn and sesame oils produced both domestically and internationally.

As already discussed above, the emergence of small oil mills in rural villages reduced significantly their total share of edible oil sales to farming households. While for these small oil mill operators processing the crop and retailing oil and meal products is a side-business to supplement their farm incomes, for the state-designated processors rapeseed products comprise a significant portion of their business. Therefore, while the latter have an advantage

¹⁴ In recent years, one-liter soda bottles (usually empty Coke® or Sprite® bottles) have become the most popular choice.

over the former in securing capital, labor, credit and more advanced technology through the use of the nearly four-decades old networks, the former has far more flexibility than the latter in adjusting to price fluctuations in rapeseed and its oil products. For example, when the price advantage of rapeseed falls, farm households reduce the area of rapeseed cultivation and their financial dependence on rapeseed-related activities. At the same time, they try to increase their income from other sideline activities such as construction and commerce (various interviews, 1996). In contrast, the XOFC and its outlets do not have as many sources of revenue as farm households. Moreover, its ability to collect production data is not yet adequate to predict the total amount of rapeseed production in the county. Consequently, financial losses and debts among these state entities continue to increase. In short, despite the effort to make them financially independent and autonomous *business entities*, their dependency on the (particularly, provincial) government in terms of financing and decision making remains strong.

Consuming Rapeseed Oil

Although rapeseed oil dominates the edible oil market in Xishui County, if given a choice, most consumers prefer peanut oil because it has better taste and smell than rapeseed oil (interviews, 1995, 1996). Yet, both urban and rural households in the county select rapeseed oil for two reasons. First, it has a higher smoke point than peanut or sesame oil, and thus works better when stir-frying food. Second, peanut oil is significantly more expensive than rapeseed oil. Therefore, the former is purchased for cooking special meals (e.g., holiday and ceremonial banquets) while the latter is used for everyday meals.

Contrary to the popular assumption in the West, it is only within the last four or five decades that stir-frying has become common in everyday cooking in China, including Taiwan and Hong Kong. Even today, the low amount of edible oil consumption in the rural PRC suggests that this cooking method continues to be a luxury for many farming households. Boiling and steaming are far more common than stir-frying. In fact, during my visit to a rural village, I was offered a bowl of boiled dumplings (*shuijiao*) as a specially prepared meal by the mother of my research assistant who returned home for first time in a few years.

Nevertheless, we cannot ignore three noticeable trends in the consumption of rapeseed oil products in Xishui County within the last decade including: (1) an increase in the total amount of rapeseed oil consumption, (2) a gradual growth in the consumption of refined rapeseed oil products, and (3) the diversification of edible oil products available to consumers. These trends have helped to increase the role of consumers in the development of rapeseed commodity chains in the county. Currently, rural households (farming or non-farming) tend to purchase their edible oils from local mills because among all the products available in the county unrefined rapeseed oil is the most affordable one. However, in those villages that are financially better off, oil mills have already disappeared because most of their dwellers prefer to use refined rapeseed oil from the XOFC.

This case study shows that economic and political reforms in the PRC since the late 1970s have altered the way in which the commodity chain is organized, changed, expanded and contracted. After the breakup of communes and the removal of rapeseed and its oil from the list of unified procurement commodities, humans became market participants, and nonhumans became things to be exchanged in the market. Each human actor can determine

how to treat his or her rapeseed at a particular stage of its life cycle. In turn, rapeseed at a particular commodity phase is a reflection of the distinctive interests, motivations, perspectives, values, and ethical commitments of human actors.

At the same time, these changes in the environment for organizing the commodity chain encouraged each actor to seek network links different from the officially-designated ones in order to satisfy their individual needs from commodity transactions. Today, rather than a single network *imposed* by the government, there are *multiple* voluntary and self-organized networks surrounding rapeseed to which each actor can decide to belong. Human actors can select many possible networks in which to participate. Moreover, each network is open to enrolling as many actors and extending its links as far as its participants desire. In other words, the commodity chain is no longer a state imposed and controlled instrument for strengthening the power of the CPC and the central government. Rather, it has become a self-organized and autonomous network that constantly restructures itself by redistributing power among its actors.

During the 1980s, the state-designated chain in Xishui County lost its dominance in rapeseed production activities and was replaced by a small network in which most decisions are made by local farmers (see Figure 8.3). Even the XSC, XSIC, XOFC, the XGOC, GOSs, and other county government agencies began to search for links with networks beyond the state-designated one in order to gain more autonomy and independence from the central and provincial governments.

This emergence of numerous rapeseed networks, each of which serves an extremely small locality, has affected enormously the process of technical change within the county. Technical change can no longer be instituted as an *official order* as was the case during the

collective agriculture period. Today, it is up to each actor to adopt or reject a new technology. Therefore, decisions for technical change in a given crop must be made through negotiations among various actors surrounding it. Since there are so many rapeseed networks within the county, researchers and county extension agents often visit every township and village to meet with farmers, marketers and processors in order to convince them of the superiority of new technology. In short, the process of technical change has begun to involve more arduous tasks than ever before.

My interviews with chain actors in Xishui demonstrate that neither new technology nor official standards currently promoted by researchers, county extension agents and various government officials help actors extend their networks beyond their locality. The new tools of researchers and government officials designed to create uniformity in rapeseed have not been enrolled in rapeseed networks in Xishui. Consequently, these researchers, extension agents and government officials were forced to adjust their behavior so as to deliver products that other actors find necessary and useful. Then, what do input suppliers, farmers, marketers, processors, retailers and consumers desire? Why have new varieties and official standards failed to realize their original goal of allowing Chinese rapeseed and its products to be accepted in the international markets? Let us now move to examine the diverse values of uniformity in rapeseed chains in Xishui.

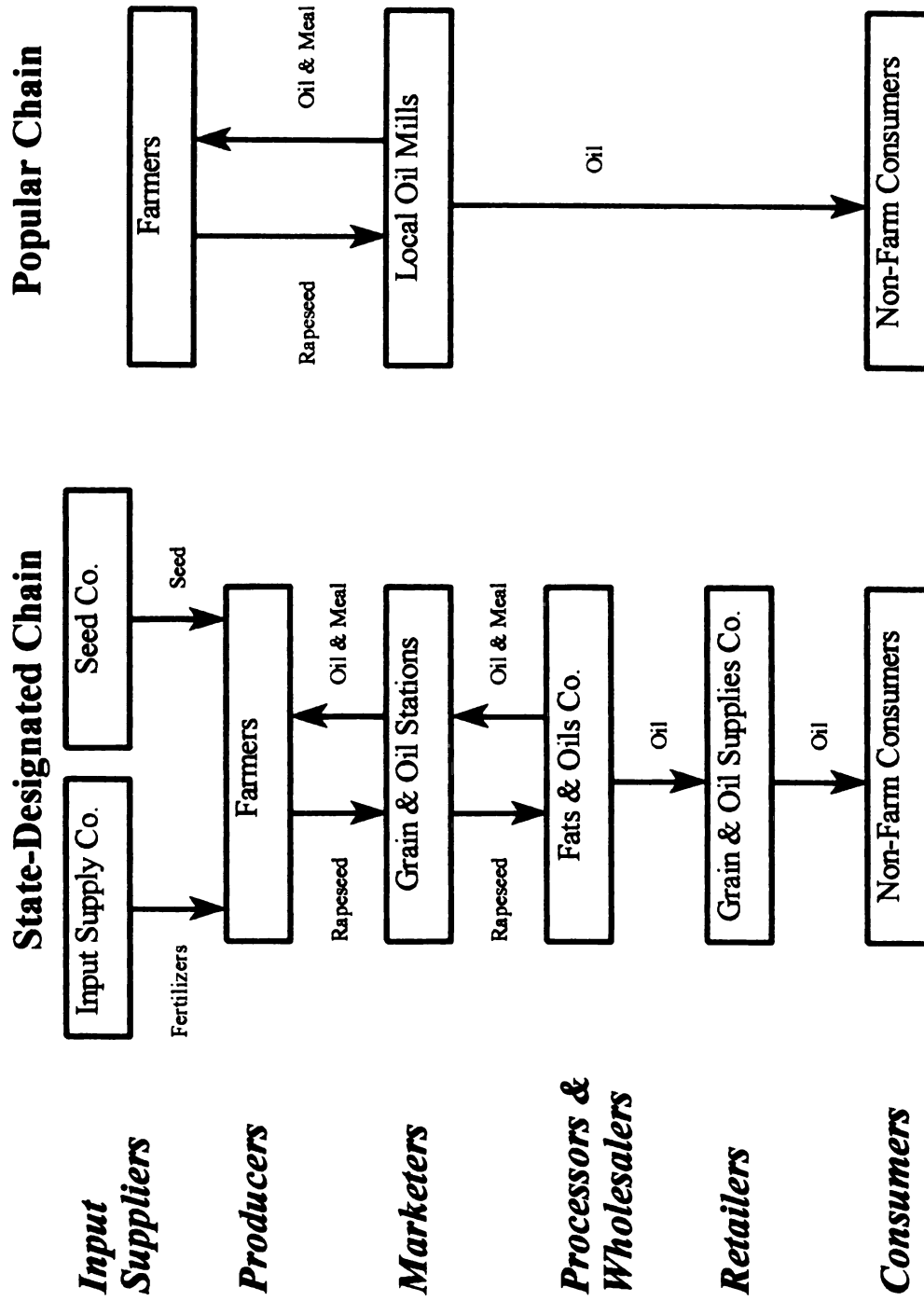


Figure 8.3 - Rapeseed Commodity Chains in Xishui County, 1996.

LOCAL VALUES

A commodity chain is more than the sum of its individual actors. It is their vehicle for *collectively* transforming a given commodity and (re)distributing income, wealth, status and power. On the one hand, participation in a particular network reflects the values of individual actors. On the other hand, all actors negotiate with others and make some modifications to their behavior and values so that the chain articulates collective values about their relationships with the commodity and with other human actors. This is why each network has its own unique needs for technical and legal change, and employs its own strategy to maintain the network itself. Table 8.4 summarizes the primary changes in rapeseed technology and standards desired by actors in Xishui County. These specific demands suggest which uniform quality characteristics each actor values as necessary in rapeseed and/or its byproducts.

As I have described above, currently chain actors in Xishui County have not modified their behavior specifically to realize the quality changes that the central government and national researchers have tirelessly worked to create through new technology and standards. Because rapeseed networks have not expanded beyond the county, technical and policy changes initiated at the national level do not reflect locally specific values of chain actors about the commodity. Moreover, the emergence of multiple rapeseed networks within the last two decades suggests that there are heterogeneous notions of uniformity in rapeseed not only among actors at different stages (e.g., farmers vs. processors) but also among those at a given stage (e.g., Farmer Li vs. Farmer Zhang).

Table 8.4 - Desired Technology and Standards, and Values of Uniformity, Xishui County.

Actor ¹	Technology ²	Standards	Values
County Government Officials	HCVs	Local → Provincial	Commodities
Researchers/County Extension Agts.	HCVs	National → International	C ₁₂ /glucosinolate levels
Township Extension Agents	HYVs	Local → Provincial	Agronomic characteristics
Input Suppliers	HYVs; HQVs	Provincial → National	Agronomic characteristics
Farmers	HYVs	Local → Provincial	Yield
Marketers & Transporters			
XOFC	HQVs	Provincial → National	Grain quality
GOSs & Small Mills	Storage; HYVs; HQVs	Local → Provincial	Grain quality
Oil Processors			
XOFC	Refining → HQVs	Provincial → National	Oil quality (inc. C ₁₂ /glucosinolate levels)
Small Mills	HYVs → Refining	Local → Provincial	Oil quality (exc. C ₁₂ /glucosinolate levels)
Retailers			
XOFC & XGOSC	Refining	Provincial → National	Oil quality (appearance & storage life)
GOSs & Small Mills	Refining	Local → Provincial	Oil quality (appearance & storage life)
Consumers	Refining	Local → Provincial	Oil quality (taste, odor, performance, etc.)

Notes: ¹ Abbreviations used in the column are: Xishui Oils & Fats Company (XOFC), Grain & Oil Stations (GOSs), and Xishui Grain & Oil Supplying Company (XGOSC). ² Abbreviations used in the column are: hybrid canola varieties (HCVs), high yielding varieties (HYVs), and high quality varieties (HQVs).

Sources: Various interviews (1994, 1995, 1996)

Governmental Agents

Until the 1980s, the XOA very closely followed orders, instructions and guidelines of the HBA as well as the MOA for rapeseed production. The primary goal of technical change was to ensure a steady increase in production without any addition of rapeseed area so as to meet the demand for edible oil within the county without compromising grain production.

In the last two decades, with rapid increases in domestic rapeseed production and the availability of cheap edible oil from overseas, the perception of a constant shortage in edible oil crops seems to have begun to fade away. This has affected the way in which government officials conceptualize desired transformations in rapeseed through policy and technical change in two ways: First, both the XOA and the HBA are more concerned about *qualitative* rather *quantitative* improvements in rapeseed. Second, rapeseed is now viewed as a *raw material* for edible oil and animal feed products. Previously, official policy and technical guidelines for rapeseed by the MOA *xitong* only pertained to cultivation of the crop, and ignored the effect on marketing, processing and consumption. The recent efforts by the XOA and the HBA aim at qualitative improvements in the plant itself in order to derive better byproducts from it. Nevertheless, their desire for self-sufficiency in grain and edible oil crops¹⁵ within the province compels them to demand research and extension programs that aim at *both* quantitative and qualitative improvements in the crop (Wang 1995c). This is why government officials are very excited about double-low hybrid rapeseed varieties (i.e., double-

¹⁵ I speculate that provincial and local government officials regard the achievement and maintenance of grain and edible oil crops as important to preserve the province's autonomy from the central government.

low hybrid varieties) that allow farmers to increase yield while upgrading the quality of edible oil and animal feed.

Despite the desire to switch from double-high to double-low varieties throughout the province, neither Hubei province or Xishui county governments have yet developed official standards for rapeseed or its byproducts. Moreover, they cannot enforce national standards for these commodities as Mr. Wang Yiyuan at the Division of Cereals and Oil Crops of HBA explained to me (Wang 1995c):

Principally, everyone in the PRC should obey national standards. However, it is very difficult because the level [of these quality standards] is set too high [i.e., strict] for many districts to follow. That's why the national standards are not implemented at all [at the provincial and local levels]. ... The central government wants to [raise the level of] rapeseed quality standards up to [that of] the international standards. But, in Hubei, ... quality standards are just at the beginning of conception. Only a handful of local governments have just recently started to develop standards according to their local conditions.

Consequently, there are tremendous gaps among different administrative levels both in the ability to conceptualize specific uniform features necessary in rapeseed and its byproducts, and to articulate means to realize these features in the crop.

Since the majority of farmers cultivate a double-high variety, the Xishui Office of Standards (XOS) cannot develop county standards that specify the maximum levels of erucic acid and glucosinolates. The XOS cannot use the national rapeseed grades because a large proportion of rapeseed produced in Xishui would not make it to the lowest grade. In that case, the county's rapeseed production would collapse! Therefore, on the one hand, county officials at every branches seek means to control rapeseed chain activities and monitor the uniformity of the commodity. On the other hand, instead of using standards to modify the

behavior of chain actors, they are in reality obliged to design standards that accord with present practices of chain actors in their region.

Interestingly, both the HBA and the XOA see the switch to double-low hybrid varieties as another, less painful way to the development and enforcement of quality standards that are satisfactory in the eyes of the central government, and national and international marketers of rapeseed and its products. Mr. Wang at the HBA explained that:

Huaza No. 3[, developed by Dr. Fu Tingdong at the HAU,] not only yields higher but also contains lower erucic acid (1.3%) than the maximum level allowed in the international standard (2.0%) and higher levels of oil and protein than currently popular varieties. Therefore, if more and more farmers begin using this variety, the quality of rapeseed oil and meal improves. And, we no longer need to worry about gaps in the quality standards among the local, provincial, national, and international levels. We can all follow international standards!

In short, local government officials in Xishui and Hubei have not yet developed an understanding that technical change and quality standards can be simultaneously used to transform commodities, modify the behavior of chain actors, and reorganize commodity chains. While the process of technical change often tends to be slow and drawn out, the effect of new standards tends to be instantaneous and could be drastic. Local officials opt to direct substantially more of their effort into the former than the latter in order to avoid financial and political risks.

Extension Agents

According to Mr. Wang Youping (Wang 1995b) at the XESS, the current goals of Xishui's extension programs are indeed the diffusion of single/double-low varieties (since 1983) and hybrid varieties (since 1988). Using the annual training program for extension

agents at the township and village levels and free publications to farmers, the XESS tries to achieve this goal. In reality, however, this extension goal of the county is often subverted by township and village agents (interviews, 1995, 1996). Instead of single/double-low hybrid varieties, these agents continue to recommend *Zhongyou 821* as they consider the enhancement of yield as the primary objective in the rapeseed extension program.

This discrepancy largely comes from weak vertical links between organizations at different administrative levels (see Chapter 5). Township extension agents are only accountable to the township government, not the XESS. The township government makes decisions on funding, personnel, extension goals and targets, and clients though the agriculture station (in which one or two extension agents work) office may receive instructions from the XESS. Therefore, township agents recommend new technology beneficial to rapeseed production at the township level though it may not be recommended by the XESS. At the same time, township agents are more in tune with actual conditions in the field than county agents who spend more time with administrative tasks in the office in the county capital. Indeed, most township and village agents are either married to a farmer or work as an extension agent as a side job. Therefore, extension agents at the county level act as official bureaucrats while those at the township and village levels represent the interests of farmers and local residents.

With the breakup of the communes, large-scale extension of new technology has become increasingly more difficult though individual farmers tend to be more eager to accept new technologies in order to improve their production. For local extension agents, the value of their work depends on whether or not farmers adopt a new technology. In other words,

a good agent is someone who can convince farmers to use a new technology. Therefore, a good new technology must be something widely accepted by farmers.

According to an agent in Township A (1995), the success of a new technology depends largely on its effect on crop yield. When farmers can actually see an increase in yield, they are excited about trying out a new technology immediately for the following season. She told me that high quality rapeseed (*gaoji youcai*) means *Zhongyou 821*, and that high resistance to diseases and pests and high yield determine the quality of rapeseed. This suggests that the new varieties recommended by the XESS would not be recognized by her as high quality varieties (HQVs) at all because of their high susceptibility to diseases. Moreover, she continued:

Uniformity in the growth of rapeseed [e.g., height, bushiness, the number of seeds, speed of maturity] is not important. But, farmers in a given area should grow a single variety in order to protect its genetic [purity] and make it easier to prepare for the next crop [usually rice].

This is the case largely because it would allow her to give the same recommendations to all farmers within the township for caring the crop and managing their fields.

My interviews with farmers suggest that other township extension agents share the views of the one in Township A. It is clear that the XESS has not been successful in persuading local extension agents to care about the levels of erucic acid and glucosinolates in rapeseed. Moreover, they are not concerned about the standardization of rapeseed and its products as long as the rapeseed grading procedure does not discourage farmers from expanding crop production or prevent them from increasing their income. Instead, what matters most to township and village agents is that farmers grow only the varieties (i.e., *Zhongyou 821*) recommended by them uniformly throughout their locality. In short, they

value uniformity in agronomic characteristics of rapeseed in a given area. They assert that this would first minimize the outbreak of diseases and pests,¹⁶ thereby ensuring consistently high yield and economic return from rapeseed production. Second, if a given village decides to use a single variety for each crop, or a few with similar agronomic characteristics, then each year its residents would plant, apply inputs to, and harvest all their crops at about the same time. This would allow these farmers to maintain a steady rhythm in agricultural production, and therefore would help the village to effectively coordinate agricultural and community labor among its residents. Finally, the cultivation of a few varieties in their locality would make the work of extension agents easier.

Input Suppliers

Like local extension agents, input suppliers tend to be concerned about uniformity in agronomic characteristics of rapeseed varieties. However, depending on the products they sell and organization type (see Table 8.5), they vary as to which agronomic characteristic they value most. Since the sale of *Zhongyou 821* makes up 90% of the revenue from rapeseed-related products, the XSC regards high yield performance as the primary determinant of rapeseed quality. On the other hand, the XISC pays close attention to each variety's resistance to diseases and pests since farmers purchase pesticide products specific to rapeseed production but not fertilizers. For research and extension organizations as well as farmers, the sales of input products are a sideline activity that aims to supplement their revenue, and

¹⁶ Various case studies have shown that the reliance on only one or a few varieties often lead to a plant epidemic. See Lewontin (1990) for corn, and Juska (1997) for rapeseed in Canada.

therefore does not directly affect the value of their work as researchers, extension agents, or farmers. Consequently, their concern with uniformity in rapeseed is not based on their role as input suppliers. Since the national and provincial rapeseed research program calls for a switch from double-high to double-low varieties, both the XESS and the HCHQR consider the levels of erucic acid and glucosinolates more important than agronomic characteristics.

Table 8.5 - Valued Characteristics by Input Suppliers, Xishui County.

Organization	Products Distributed	Valued Characteristic
<i>Input Supplying Agencies</i>		
XISC	Fertilizer, insecticide, and herbicide	(1) Resistance to diseases & pests; (2) Responsiveness to fertilizers
XSC	(1) Seed (Zhongyou 821, Huaza 2-3); (2) Pesticide (small amount)	Yield
XMSC	Tools, machinery	Physiological characteristics (e.g., height, bushiness)
<i>Research & Extension Organizations</i>		
XESS	(1) Seed (Huaza 3); (2) Chemical inputs	Levels of C ₂₂ & glucosinolates
HCHQR	Seed (Huaza 3)	Levels of C ₂₂ & glucosinolates
<i>Farmers</i>	(1) Seed; (2) Organic inputs; (3) Tools No monetary exchange	Yield

Sources: Various interviews (1994, 1995, 1996).

Among all the rapeseed chain actors in Xishui, input suppliers (excluding farmers) probably have been most affected by the standardization of agrofood commodities at the national and provincial levels. Chemical input products were standardized before agricultural crops, and their distribution was monopolized by the central government until recently.

Because adulteration of farming inputs can cause tremendous financial damage,¹⁷ input suppliers need to be licensed and to follow formal standards (both national and provincial).¹⁸ Therefore, quality tests are conducted regularly by both internal and external inspectors to ensure uniformity of input products. These products are also packaged in a uniform manner. Moreover, they are priced according to their quality.

Despite a dramatic increase in the sales of chemical inputs by the XISC and the XESS in recent years, the total share of the XSC, XESS and HCHQR together in supplying seed of rapeseed remains stagnant because farmers continue to select their own varieties. The representatives of these organizations argue that this popular practice of farmers impairs the genetic purity of each variety, thereby undermining the uniformity of the agronomic and quality characteristics valued by breeders who developed the variety, by the government officials who funded the breeding project, and by the seed suppliers who sold the product to farmers. However, these actors also realize that farmers cannot be stopped from selecting their own seed. Even researchers and extension agents admit from the point of view of input suppliers that high yield would be a far more relevant feature in rapeseed technology than low erucic acid and low glucosinolates (interviews, 1995, 1996, 1997). Furthermore, they explain that this is the primary reason for pushing the popularization of hybrid varieties. In other words, if these new varieties demonstrate that they can yield more than *Zhongyou 821*, farmers will adopt them regardless of their erucic acid and glucosinolate content. Since

¹⁷ For example, fourteen people in Hunan Province were arrested on charges of selling 53,450 kilograms of mislabeled rice seeds, which led to total crop failure on 2,667 hectares of farmland last summer (China Daily 1996).

¹⁸ Of course, this is not the case for farmers who sell seed, organic inputs and tools to their neighbors.

hybrid seed cannot be saved for the following season, farmers will begin to purchase their seed from a licensed distributor that meets provincial or even national standards. Therefore, this will optimize uniformity in seed quality at the crop production stage.

Farmers

Most farmers agree that good rapeseed must have three characteristics including: (1) high yield, (2) high resistance to diseases, pests, and adverse climatic conditions, and (3) high adaptability to their local conditions. Moreover, they also swear that new varieties recommended by researchers and extension agents are no match to *Zhongyou 821*. Their understanding of the new varieties does not come from erroneous knowledge about them or their skepticism with modern science, but instead from their empiricism including actual observations at demonstration fields and their own trials with the varieties. For example, many farmers in Xishui County indeed tried to grow a double-low variety for the 1988-90 seasons, and a hybrid variety for the 1990-92 seasons.¹⁹ According to farmers in one village, they abandoned these varieties because of their dissatisfaction with them (interviews, 1995, 1996):

In 1988, we all grew a double-low variety. But, it did not yield well at all. So, we switched back to our old variety. ... Then, we tried a hybrid variety in 1990. We did not like it either because it was more susceptible to a disease [probably, *sclerotinia*]...and required more days to mature. [The plant] grew so tall and bushy that it was very cumbersome for us to harvest by hand. ... The variety surely yielded higher than *Zhongyou 821*. But, it also cost us more because we needed to buy more chemical pesticides and fertilizers. We

¹⁹ These farmers did not specify which variety was planted for each trial. However, based on my knowledge about the village and county, I assume that for the double-low variety they are likely to have planted *Huashuang No. 2*, while for the hybrid variety they grew *Huaza No. 2* -- two varieties developed and registered by breeders at HAU.

lost money from growing [both varieties].... Of course, we did not get any compensation [from the local government or research institution who recommended these varieties] for these losses. ...We are happy with *Zhongyou 821*.

Moreover, these new varieties tend to require more precise care (e.g., exact timing and amount of pesticide and fertilizer applications) than Xishui farmers are used to (interviews, 1996).

Farmers are not concerned about the levels of erucic acid and glucosinolates in rapeseed because they and their ancestors have always consumed its oil without any notable health problems and used its meal as organic fertilizer. Thus, farmers cannot see with their eyes the benefit of double-low varieties! Rather, the benefit of double-low varieties would not be realized unless farmers were willing to sell their crop to a processor who specialized in producing low erucic acid and low glucosinolate edible oil and animal feed. However, there are not many such processors available in the county. Moreover, the use of a hybrid variety would be more costly because they have to buy not only more chemical inputs but also seed. Thus, farmers would no longer be able to select their own seed. Since there is no price difference between double-high and double-low rapeseed, farmers have no incentive in switching to these new varieties. Finally, switching to a double-low hybrid variety also implies that farmers would be willing to give up their roles as input suppliers, marketers, processors and retailers of their own products, and start relying on researchers and extension agents for the development of new cultivation technology. In short, farmers would be giving up the autonomy and independence that they finally gained after the breakup of the agricultural communes.

Rapeseed farmers value uniform yield because this is what determines the quality of their work as farmers. A good rapeseed farmer gets higher yields and earns more income from the crop than his/her neighbors. Because Xishui farmers plant the crop in such a small patch of the field and care for it by hand, uniformity in the growth of the plant is not as important as that in yield. Moreover, they are satisfied as long as they can sell their harvest to a local granary or mill at the highest possible price. In short, their rapeseed is “good enough” as long as it passes the grading tests at the local level.

Marketers and Transporters

The content of erucic acid and glucosinolates is irrelevant to marketers and transporters because the grade of rapeseed is measured by cleanliness, dryness, and oil content. At the grain procurement stage, therefore, they hope that each farmer brings rapeseed that is uniform in these measures of grain quality. For example, township granaries consider the following quality characteristics as important (interviews, 1996): (1) Harvested grain will remain dry, (2) the quantity of impurities is low, (3) grains are plump, and (4) the content of oil is high. They regard good rapeseed as that which can meet the highest grade of the national standards.

Township granaries and transporters recognize the inadequacy of their grain storage facilities, and hope that such machines as grain dryers will become available to improve their ability to store the rapeseed harvest. However, they also desire the further development and popularization of HYVs and HQVs for two reasons. First, the level of yield affects their business in terms of prices, volume exchanged and total revenue. Despite an overstock of rapeseed oil at the XOFC, most marketers desire to see a continued growth in rapeseed

production so that the income of farming households increases. Second, agronomic characteristics of a variety, particularly susceptibility to diseases and pests, influences both the quality and quantity of rapeseed grain that can be marketed. Therefore, marketers and transporters define HQVs as those including: (1) high oil content, (2) high yield, and (3) low susceptibility to diseases and pests.

Processors

Although many processors purchase rapeseed harvests directly from farmers, their view of HQVs is quite different from that of grain marketers. For processors, the quality of rapeseed is determined by the quality of oil extracted from the crop. Usually, oil quality is judged by the marketability of their products. However, because different types of processors try to satisfy rather distinct market niches (e.g., villagers for small mill operators, urban consumers for the XOFC), the definition of what constitutes high quality oil tends to vary. In short, although all processors agree that the value of uniformity in rapeseed lies in its oil quality, they disagree as to which oil quality characteristics must be uniform.

For example, small mill operators do not care about the contents of erucic acid and glucosinolates since most of their customers ignore them. Their oil products need to meet local and possibly county standards since these products rarely go beyond the township boundaries. On the other hand, the XOFC is concerned about not only oil content but the contents of erucic acid, glucosinolates, and other compounds as well as color, flavor, and odor of oil because the company hopes to eventually expand its market beyond the county, and possibly beyond the province and the nation. Therefore, for the XOFC high quality rapeseed oil must be able to meet national and international quality standards. By HQVs,

therefore, small oil mills mean rapeseed varieties high in both yield and oil content in order to maximize the total quantity of their oil and meal products available for sale; the XOFC includes not only those varieties high in oil content but low in both erucic acid and glucosinolates (interviews, 1995, 1996).

Moreover, processors also diverge in the demand for technical change in rapeseed production. Because most small mill operators in Xishui cannot afford to purchase oil refining equipment, they rely on the quality of rapeseed grain alone to produce what they consider as high quality oil products. Thus, they strongly desire the development and extension of HQVs in their village and township. However, at medium (or large-scale in Wuhan) processing factories, refining methods, equipment, and chemical solvents also affect the quality of oil and meal products. Such quality characteristics of oil as color, flavor, smell, and clarity are particularly dependent on the refining process rather than the quality of the crop. Because the unpopularity of double-low varieties in the county makes it impossible for the XOFC to process the harvest from these varieties separately from others, the development of new refining technology becomes more important to the XOFC than creation of new HQVs.

Nevertheless, until recently research and development on post-harvest technology has been greatly neglected in the PRC as pointed out in Chapter 6. None of the rapeseed chain actors in Xishui who engage in post-harvest activities have developed a link to a research institution or university under the MIT *xitong*. The XOFC is currently preparing to develop such a link in order to improve its processing facilities, techniques, and standards (Zhou 1995). It is only within the last two decades that oil refining technology has become available to factories under the HOFC. Further improvements in the XOFC's facility would be too

costly when its business is actually losing money from an overstock of rapeseed oil. Therefore, at the present time it is far more realistic for the XOFC to urge the county government to develop policy measures that encourage farmers to switch to double-low varieties and discourage small mills to market unrefined edible oil products.

Retailers

Oil retailers seem to be more in agreement than processors about the definition of oil quality, regardless of the market niche they target. They care that their oil products appear attractive to customers and can be kept for a long time in the store. Of course, there are differences among retailers in their view of “attractive” oil, depending on the technical capability of their processing facilities. Unrefined oil is dark and murky with an unpleasant odor. However, small mill operators use their own standards about the color, clarity and odor to classify the quality of unrefined oil. Even among oil refiners, there are differences in the degree of acceptability of physical appearance.

No retailer denies that refined rapeseed oil looks better than unrefined oil, or that improvement in refining technology is essential to their business. In fact, many process rapeseed or contract with more than one processor, and they often carry both products. But, managers of the XGOSC, township GOSs, and local mills all pointed out that refined oil products are too expensive for their customers. Therefore, as long as the physical appearance and the shelf life are uniform throughout a given type of oil product -- refined or unrefined, rapeseed or peanut, and domestic or import -- these retailers are satisfied for the present.

However, most retailers foresee a growing demand for refined oil products in a decade or two as the income of farming households continues to increase. Moreover, they must expand their market beyond the current niche if they wish to stay in this business. From the standpoint of retailers, therefore, even small mill operators feel the need to improve their processing facilities so that their products meet the provincial standards for rapeseed oil.

Consumers

Consumers, regardless of their place of residence or occupation, share concerns similar to those of retailers. Refined rapeseed oil is currently beyond their reach, though all consumers I interviewed hope to switch to refined oil in the near future. From the consumers' perspective, good rapeseed equals high quality rapeseed oil that consists of features including: (1) attractive appearance, (2) pleasant odor and flavor, (3) good performance when used for frying, and (4) long storage life.

In reality, however, most rapeseed consumers tend to speak from a perspective other than that of consumers. The number of consumers who do not get involved in rapeseed production activities at all is small in Xishui County. Therefore, their values as producers of rapeseed oil usually dominate their thoughts and behavior. More importantly, the role of consumer is something new to many in the PRC. For three decades, under the planned production and distribution of commodities, the government distributed whatever was available to the people; in turn, they consumed whatever was being rationed. Therefore, the dominant concern in economic activities was always the *quantity* of products *produced* and *distributed*, never the *quality* of products *consumed*. In other words, in the planned economy, everyone was a laborer, that is, a producer, but not a consumer. Being immersed

in the role of consumer would have been considered as being bourgeois and an enemy of labor, and therefore being incorrect in Communist China. This strong denial of acting as a consumer has not disappeared quickly in the PRC, particularly in rural areas where available commodities are still far more limited than in urban areas. This is why most Xishui people with whom I spoke appeared uncomfortable talking about the quality of rapeseed oil they *consumed* rather than what they *produced*.

We have seen that there are diverse values associated with uniformity in rapeseed among chain actors in Xishui County. Each actor uses different standards to judge the qualities of the crop, the oil, the meal, and his or her work. In fact, not only rapeseed at each life stage, but also the behavior and values of humans at each production stage are not uniform in the county. Because the networks are extremely local and numerous, none of the actors needs to develop strong linkages with others. If one is dissatisfied with the behavior of other participants in a given network, he or she can break the link and join another chain. Such weak linkages between actors make negotiations to create uniformity in rapeseed through either technical change or standards extremely difficult, if not impossible.

The unpopularity of new rapeseed varieties in Xishui demonstrates the lack of negotiations among chain actors *before* the development of new technology. Both researchers and government officials largely ignored the reality of rapeseed production and the processes of commodity chain (re)organization. Thus, neither these new varieties nor official standards integrate what other actors value as essential to determine the quality of rapeseed. Consequently, most actors do not view double-low varieties as *good technology* or national standards as *good standards*. Moreover, in the eyes of chain actors in Xishui,

technoscientists are not *good technoscientists*, and government officials who created these national standards are not *good bureaucrats*. In short, the intended technical change and standardization in rapeseed failed because other chain actors did not incorporate these new technologies and official standards into their activities.

CONCLUSION

The emergence of small local rapeseed chains after the breakup of communes in Xishui County is a key to understanding what happens to people, things and networks during the transition from a planned to a more-market economy. Between the 1960s and 1990s, rapeseed production techniques in Xishui have not changed significantly. As they did in communes, peasants continue to work in their rapeseed fields by hand with simple tools. Moreover, the demand for technical change in rapeseed has always varied among human actors. Because there is little specialization in a given rapeseed production activity both in the collective agricultural system and in the household responsibility system, their values, interests, and perspectives on the crop have been rather complex.

However, what has changed dramatically during the nation's transition from a planned to more a market-oriented economy is the organizational mechanisms and tools for (re)organizing, monitoring and controlling people and things through technical change. In the context of a centrally planned economy, the hierarchical network from the central government to peasants in communes was a vehicle for making decisions about and implementing new technologies as *policy directives* from the central government. Very few actors actually participated in the decision making process for technical change. Instead, the government officials and the CPC members coerced other actors to change their behavior.

On the one hand, in this organizational form a new technology could be adopted over a large area within a short period. As we saw above, HYVs such as *Shengli* and selections from it were planted in approximately 80% of the winter rapeseed area in the PRC. Certainly, these varieties contributed to a stable increase in rapeseed yield during the Cultural Revolution when laboratory research on rapeseed stopped completely. On the other hand, when a new technology did not meet the need of human actors, and/or reflect production activities, the magnitude of failure was disruptive to maintaining the vitality of both the agroecosystem and the agrofood system. The Great Famine of 1959-1961 was a good example of this. The extent of damage from consecutive years of drought and outbreak of pests (i.e., *natural* disaster) was probably intensified by the simultaneous introduction of late-maturing varieties (e.g., *Shengli*) and triple-cropping in rapeseed production.²⁰ In short, it was a *human-made* disaster.

In contrast, in the context of a market economy, self-organized networks surrounding commodities have begun to replace the hierarchy as a vehicle for technical change. Each human actor can directly or indirectly participate in making decisions for creating, implementing or maintaining a new technology. Nevertheless, in small local chains like the ones in Xishui, farmers tend to dominate the decision making process because they wear many hats in it. Moreover, regardless of their multiple roles in a given chain, these farmers have a strongly tendency to speak as cultivators rather than marketers, processors, wholesalers, retailers, or consumers. As the case of *Zhongyou 821* shows, in this new context, when farmers see the advantage in a new technology, the intended technical change can be carried

²⁰ Of course, I am not claiming that this is the only event that led to the agricultural collapse of 1949-61.

out in a large area at a very rapid pace and affect the behavior of various actors in the commodity chain. However, as in the case of double-low varieties, when farmers see no advantage in a new technology, the intended technical change within the chain will not happen no matter how much other human actors desire it. Instead, other actors must make adjustments in their behaviors and values to accommodate the needs of farmers.

For the last two decades, the development and extension of double-low varieties have taken precedence in rapeseed research in the PRC. Despite notable changes in the organizational form of networks surrounding the crop, researchers and government officials did not alter their approach to *creating* technical change. They did not allow other key actors such as farmers, marketers and processors to participate in planning rapeseed research projects. Moreover, most research projects were included in the central plans. However, the process of *implementing* and *maintaining* technical change has changed as pointed out above. No longer can a new technology be implemented as a policy directive, *per se*.

After a decade of tireless effort by researchers and government officials including county extension agents, double-low varieties have had little impact on changing the behavior of rapeseed chain actors in Xishui. Only a small number of farmers plant them. Marketers and processors do not even treat the harvest from these varieties separately, thereby undermining the advantage of the new technology. None of the government officials are yet willing to establish official standards that encourage the switch from the current to new varieties. Most consumers are not aware of technical debates surrounding the toxicity of erucic acid. In fact, many actors do not even desire these new varieties. They want something else from the rapeseed technoscience community.

Furthermore, despite the effort by the national and provincial governments to standardize commodities, small local rapeseed chains in Xishui County limit the context in which rapeseed and its byproducts are considered as commodities. Because these *things* do not undergo rigorous testing required by official standards, they cannot be traded as *commodities* outside the small locality. Those national standards discussed in Chapter 7 have been largely ignored as phantoms because they do not reflect the reality of commodity production activities within the county. The provincial and county governments also have difficulties in enacting and enforcing official standards, and therefore have begun to view technical change as a painless way to standardize commodities and production processes at the provincial and county levels. As summarized in Figure 8.4, instead of using both official standards and technical change simultaneously to create uniformity in the commodity, county government officials argue that the creation of uniformity through technical change will allow the development of new standards.

As pointed out repeatedly, both official standards and technical change are tools to monitor, control and transform things, people and networks surrounding them. These tools represent a form of power. The establishment of national standards has helped the central government to dominate the creation of *modern capitalist* markets and redistribute power among actors in these markets. Thus, the establishment of official grades and standards shows the transformation in the nature of power that the central government tries to practice over other actors. Those official standards described in the last chapter reflect the central government's expectation for disciplining minute details of people and things.

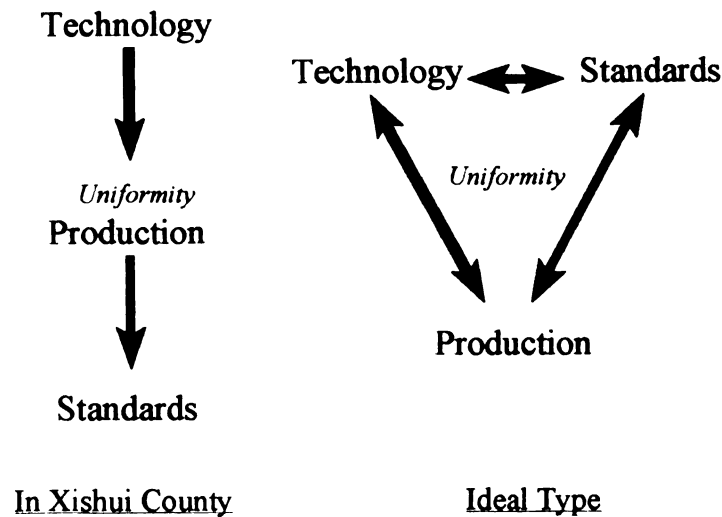


Figure 8.4 - Strategies to Create Uniformity.

However, in this chapter, I have shown that these standards have had little or no direct impact on the (re)organization of rapeseed markets and commodity chains in Xishui. Instead, we have seen that farmers dominate the creation of *non-capitalist* markets where the conception of uniformity is defined through their own local standards. Thus, the inability of national, provincial and county governments to effectively establish and implement rapeseed standards demonstrates that these actors have not been successful in mastering the use of their new tool. Consequently, their power in the rapeseed chain is limited, although they remain important actors. Instead of strengthening the links between actors within the rapeseed chain that existed before the breakup of communes and expanding its network beyond the county and province, in Xishui County both new technology and official standards have resulted in fostering the fragmentation of the rapeseed chain into numerous small local ones. Many farmers choose to deliver their harvest to whichever granary accepts it, rather than trying to

improve the quality of their harvest to meet official grading standards. Small oil mills together outsell the XOFC because they can produce and sell rapeseed oil and meal products with lower quality but at a cheaper price than the XOFC.

In short, the story of rapeseed technical change in Xishui County illustrates enthusiasm, ambivalence and frustration that human actors experience in reinventing their role as viable actors in the network surrounding the crop. Despite increased autonomy and independence from the state, researchers, provincial and county officials including extension agents, and managers of state and local enterprises (e.g., XOFC, XISC, XSC) continue to belong to the state hierarchy. Thus, when unexpected or undesired situations occur, these actors (and even sometimes farmers) tend to expect top-down administrative decrees to solve the problems instead of negotiations between actors. On the other hand, non-state actors such as farmers, small mill operators, local extension agents, and rural non-farm workers are far more self-reliant in calibrating their activities and roles to the market-oriented economy. Instead of relying on administrative decrees, they seek alternative chain links to satisfy their needs and interests.

As I will discuss in the concluding chapter, the organizational form of the rapeseed commodity chain in Xishui County is still in flux because human actors vary in their willingness to use new tools, strategies, mechanisms and values to reinvent their roles and reorganize their links with other actors. In 1995, the XOFC kept buying more rapeseed from farmers than it could actually sell in the form of oil (see above). Although such behavior would be laughed at as foolish and irrational in the context of a market economy, it would have been considered conventional in the context of a planned economy. Furthermore, the company's commitment to protecting the interest of peasants would have been rewarded as

a noble act under the communist ideology. Of course, this is not to say that the company does not care about profitability in its business.

On the one hand, all interviewees were aware of current national policies that encourage them to financially independent from the hierarchical network. Many welcome the current reform policies with a high hope for bringing them a better material life. On the other hand, these Xishui residents also expressed their frustration with implementing these policies into their daily operation, and their ambivalence about the impact of capitalism toward their values and moral spirit. These discrepancies illuminate that the transition from a planned to more market-oriented economy is not uniformly accepted among rapeseed chain actors as the best and only path to *modernize* the nation. In short, they might not agree that a modern capitalist economy and technoscience would help them construct a *good society*.

Chapter 9

CONCLUSION

Every technology has its own life cycle from its conception as a grant proposal and its birth in a laboratory, to the introduction to a given production procedure to its final death when it is replaced by a newer technology. In this life cycle of technology, we, humans, try to collectively answer social and ethical questions such as: Is this technology necessary for us? Is this technology good or bad for us? What are its environmental consequences? What are its benefits to us? Who will be hurt by it? Thus, the fate of a given technology tell us about ourselves and our society. This is because technical change always involves in social change. Technology reorders our society/nature by transforming our practices, values and relationships. At the same time, technology reflects our knowledge and values about the social/natural world in which live. Moreover, technology represents our hopes and fears for the future.

Nevertheless, all actors are not equal in participating in the process of answering these questions. In general, those with the most influence on the decision making process receive the most benefit from a given new technology; those excluded from the process may be negatively affected by it. In short, the fate of a new technology also suggests the power relationships among different actors in our society. But, technology does not distribute power

to those who create the technology because technoscientists are often not entirely in control of their own activities (Fuller 1988; Rouse 1987).

Therefore, as social scientists, we must not assume that every technical change is progress and blackbox the process of technoscience. Otherwise, we would not be able to understand why the fate and impact of a given new technology differs among networks in various locations (e.g., Xishui vs. Shanghai, the PRC vs. Canada), and why that technology elicits different responses and involvements from various actors in a given network (e.g., farmers vs. processors) for creating, maintaining and changing that technology. Moreover, without an analysis of the technoscientific process, we would not be able to comprehend technical change as both an outcome and a source of network building.

When analyzing the technoscientific process, we must examine the entire life cycle of a given technoscientific product (including knowledge) from design to execution. As we saw in the case of canola varieties in the PRC, technoscientific products alone are not enough to induce technical change because their fate lies in the hands of later users (Latour 1987). Therefore, we must examine what happens to technoscientific products *before* and *after* they leave the hands of technoscientists. Without the analysis of their post-laboratory stages, we can not grasp the interaction between technoscience and economic development.

TECHNOSCIENCE AND ECONOMIC DEVELOPMENT

The historical analysis of rapeseed R&D shows that rapeseed research has been as much influenced by as it has influenced the transformation of rapeseed from a secondary crop to a major cash crop, and then to a global crop. Starting in the late 1970s, the institutionalization of rapeseed technoscience was accelerated partly as a result of various

legal and policy changes and market measures that have encouraged an expansion in rapeseed production. Moreover, the expansion of rapeseed production began at least a decade before the results of technical collaborations between Chinese and foreign institutions became available to growers. In fact, few state officials had expected growth in rapeseed area in the mid 1970s when some provinces and counties began to gradually allow farming households to make their own decisions about land use. However, this unexpected result convinced government officials to develop and support a national R&D program in order to make the crop into an export commodity.

Yet, two decades after the effort to modernize rapeseed R&D and production, neither new varieties nor formal standards have been effective in changing the behavior of actors in the commodity chain in the nation. As illustrated by the case of Xishui County, rapeseed produced in a given county continues to be consumed only within that county. Rapeseed and its byproducts from a given county are not commodities outside that county. In turn, human actors who handle these commodities in that county are not participants in any market activities pertaining to rapeseed outside the county. In other words, neither producing new varieties nor allowing actors to strengthen their links with other actors within the chain has extended the network beyond its original space. Moreover, the goal of making rapeseed into an export crop has never been realized. Instead, within the last decade, the nation became an importer of rapeseed from Canada and of rapeseed oil from Europe and North America. Although the PRC has become the world's largest exporter of rapeseed meal, the product is exclusively used as an ingredient for chemical fertilizer, and the total value of trade is very small.

Is this another example of how a Third World country fail to achieve agricultural development because of inadequate technoscience? Absolutely not. As I have pointed out repeatedly throughout this dissertation, rapeseed technoscientists in the PRC are internationally recognized for their technical achievements, particularly in the areas of rapeseed genetics and hybrid breeding. They have also succeeded in the development of their own canola cultivars.

According to breeders (Fu 1995a; Liu 1995; Meng 1994; Wang 1994), adoption rates for the new varieties have been low because: (1) These new varieties have lower yield than the varieties high in erucic acid and glucosinolates. (2) Farmers are not concerned about the level of glucosinolates because (a) the leftover from crushing is largely used as fertilizer, and (b) the demand for rapeseed meal is small owing to underdevelopment of the poultry and hog sectors. (3) The Chinese (70% of whom are farmers) have been using rapeseed oil for so long that they are not concerned about the alleged health risk of erucic acid. (4) Chinese farmers continue to select their own seed instead of purchasing them from seed companies. (5) Standards of agricultural commodities established in 1984 are not closely enforced by the government. As the result, the purity of varieties developed by the research institutions is not well maintained.

However, these breeders do not realize that they have failed to integrate different needs for and interests in rapeseed research held by domestic actors such as farmers and processors into the development of effective research programs. Instead, they have been preoccupied with seizing opportunities to extend their links with the international rapeseed research network. This improved the rapeseed research capability to the international level on the one hand, and made it easier for overseas actors (e.g., seed companies, food

processors) to penetrate into the Chinese market on the other. Today, many urban consumers purchase high quality rapeseed oil, made from canola varieties grown in Canada and processed by joint-venture companies in Coastal China (non-rapeseed producing provinces). Meanwhile, rural consumers continue to use unrefined rapeseed oil processed in their township or county. The PRC's dependence on imported rapeseed is expected to increase for the next decade, regardless of the success in the diffusion of canola varieties, because a rapid growth in the consumption of animal products will make the demand for oilseed crops skyrocket.

Then, will the PRC succeed in the diffusion of canola varieties if rapeseed chains are properly ordered and come to look like the ones in Canada or Europe? With reorganization of the rapeseed chain through appropriate *macro-policies* and *micro-measures*, would canola varieties and formal standards be adopted by human actors in the chain? Would this allow the PRC to become a rapeseed exporter?

My illustration of the rapeseed R&D community in the PRC could be understood as evidence that the nation was on the right track in modernizing technoscientific institutions by accepting universalist problems, methods, equipment, tools, personnel qualifications and training, and end products for rapeseed R&D. Moreover, we could argue that the nation's transition to a more market-oriented economy was the main engine behind this successful institutionalization of technoscience in the PRC. And, we could blame farmers for hindering the improvement of rapeseed production in the PRC. If they accept the improved varieties, other actors such as input suppliers, marketers, processors, retailers, and consumers would follow, making adjustments to their behavior in order to accommodate a shift from traditional to new varieties.

Yet, such a view assumes that canola varieties are the right solution to problems in rapeseed production in the PRC. Moreover, it presupposes that these varieties would be good for every actor in the rapeseed commodity chain, and would affect the chain in the same way as they did in the chains in Canada and Europe.

What can we learn from this study of rapeseed technical change about the current sociopolitical and economic transitions in the PRC? What can we learn from this study about the interaction between technoscience and economic development? The current social transitions in the PRC involve more than replacing central production plans with market mechanisms. They also encompass changing tools, strategies, organizational forms, knowledge, expertise and values for creating, monitoring, controlling and reorganizing networks of people and things, redefining their roles and relationships with other actors in these networks, and redistributing power among these actors. In short, these instruments for ordering society have transformed quantitatively and qualitatively the context in which rapeseed is constructed, maintained and modified as knowledge/technology and commodity.

People, Things and Networks

In order to bridge the gap between the SSST that ignores development issues and the SSID that blackboxes technoscience, I began this dissertation by marrying commodity chain analysis with actor network theory. Rather than technoscientists, I followed rapeseed as both knowledge and commodity, and examined human practices toward it. Indeed, this dissertation is about rapeseed, its life cycle and the process of its socialization as knowledge and commodity for nearly five decades in the PRC. This allowed me to examine how

products of rapeseed research in the PRC were made into commodities, exchanged among human actors and consumed by the final users. At the same time, I also analyzed technical change in rapeseed as the process of constructing facts about the plant and articulating human values about it. This marriage between these two theoretically-grounded methods helped me understand the interaction between technoscience and economic development by extending the principle of symmetry into four relationships¹ in my study including facts and values, technoscience *before* and *after* the hands of technoscientists, humans (Society) and nonhumans (Nature), and the multidimensionality and specificity of the network building process. Below I discuss these symmetries. But, because these symmetrical relationships are intertwined with each other, my discussion does not treat them separately.

The analysis of rapeseed research in the PRC for the last four decades shows that each type of technoscientific product reflects a distinctive concept of uniformity considered necessary to the plant and those humans who handled it. Furthermore, this concept was shaped by the simultaneous transformations of rapeseed as commodities and as knowledge as well as the extension of networks surrounding rapeseed technoscientific activities. In other words, the more rapeseed technoscientists extended their networks, the more modifications they performed on the plant. On the one hand, this allowed actors in the rapeseed chain to differentiate the use of the plant into specific commodities (e.g., edible oils, feeds, fertilizers, and industrial products). On the other hand, this also permitted technoscientists to produce more abstract knowledge on rapeseed. These changes suggest that rapeseed technoscience

¹ These four are among many possible symmetric relations.

in the PRC has become institutionalized and integrated into the global networks surrounding the plant.

However, the increased abstraction as knowledge and differentiation as a commodity requires more precise control over human and nonhuman actors in the network. Therefore, the construction of technoscientific products concerning rapeseed is an effort to manipulate the plant and the environment for plant cultivation as well as to modify the behavior of people and their relationships with each other. At the same time, these products also reflect the specific value of those who have participated in the process as to what kind of modifications are necessary, desirable and/or useful to the plant and to people. In short, the technoscientific process involves both the construction of facts and the articulation of values in order to simultaneously transform things (Nature) and people (Society).

Yet, an explicit portrayal of the characteristics of rapeseed over time in the PRC illuminated the fact that nonhuman actors indeed participate in the knowledge construction process by providing humans with new problems (e.g., late maturity of *Shengli*, lower yield), solutions (e.g., double-low cultivars to reduce the level of toxicity for human and animal consumption, high yielding *Zhongyou 821*) and procedures (e.g., self-male sterility of *Polima*, oil refining). For example, the *Shengli* cultivar, selected in the 1950s, shaped the nation's rapeseed breeding projects for the next three decades as much as did famous breeders as Liu Houli and Fu Tingdong at HAU.

Moreover, I showed how the later users adopted, modified and rejected many of the products of technoscience. Technoscientists are not entirely in control of the fate of their creations after they leave their laboratory. We saw in some examples that technoscientific products made by best rapeseed researchers with the most advanced knowledge and

techniques have not been sufficient to induce the intended technical change in rapeseed agriculture in the PRC. This is because the behavior of other chain actors must change in order to create and maintain the benefits of these products. However, certain actors find these products unattractive, useless and/or harmful to their interests, demands, needs, values and ethical commitments to the crop as knowledge/technology and commodity. In short, non-technoscientists bring to the process of technical change their own notion of uniformity and other values as to what kind of modifications are necessary, desirable and/or useful to the plant and people.

In fact, the analysis of post-laboratory stages of technoscientific products reveals that the process of maintaining the benefits of these products is equally, if not more, important than creating them in the laboratory. In Chapter 7 I argued that the results of tests required for each standard determine the fate of humans as market participants and that of nonhumans as commodities. These tests represent political processes that create a link between exchanges and values surrounding rapeseed and human actors who handle it while legitimatizing the uniformity of rapeseed during its life span.

The required technology for production, distribution and consumption of a given commodity is often explicitly or implicitly addressed in various types of standards. Thus, changes in a commodity standard suggest changes in the available technology and the required behavior of human actors for handling that commodity. Standards make it possible for technoscientific products to be exchanged as commodities and incorporated into production activities. In short, they are an imperative tool for maintaining the life of technoscientific products.

Then, I also showed that new technoscientific products developed by researchers or new standards enacted by policy makers for a given commodity require more than research or policy-making processes. In Xishui County, the exchange value of rapeseed has not been affected by the successful development of double-zero varieties or national standards. Neither have been incorporated into rapeseed or embraced as a legitimate part of exchange activities by other human actors such as farmers, marketers, processors and consumers.

Nevertheless, the symmetrical treatment of humans and nonhumans is only possible by following a given nonhuman and analyzing human acts and practices -- those not *unique* but *common* to a given group of actors -- on that thing during its life cycle as knowledge/technology and commodity. On the one hand, markets, policies, laws, technical innovations, ethics and values are among some outcomes of human actions in the network surrounding rapeseed. Thus, they represent the multidimensionality of the network. By examining them, I was able to delineate the role of the crop, its life cycle, and its relationships with human actors and other nonhumans in each domain of the social world in the PRC.

On the other hand, markets, policies, laws, technical innovations, ethics and values are also among some tools that shape human knowledge, practices and values about rapeseed. At the same time, these tools make it possible for actors to create, extend and modify linkages with other actors. This is because these tools allow each actor to monitor, control and transform the behavior of humans and the characteristics of nonhumans in the network. Thus, each human actor tries to use a different combination of tools for advancing their position in the network. This is why the process of network building is historically, spatially and culturally specific.

Good Technoscience, Good Technoscientists, Good Technoscientific Products

In Chapter 4, I divided the history of the technoscientific system in the PRC into seven distinct periods. Then, I argued that the historical transformation of technoscience as an institution was closely linked to the changing notion of what constitutes *good technoscientists* and *good technoscience*. During the first five periods, technoscience was highly politicized in the debate over the dialectical relationship between *red* and *expert*. A constant shift in the result of this debate hampered the institutionalization of technoscience. It was not until the last two periods that the notion of what constitutes a legitimate technoscientific system has stabilized. However, note that each period differed in actors, tools, practices and organizational forms involved in shaping both the dominant ideology and the technoscientific system. Thus, research publications and innovations from each period are the outcome of what researchers have done in a specific organizational form of the network with a particular set of actors and tools to demonstrate that they practice *good technoscience* and are *good technoscientists*. These publications and innovations are products/knowledge that technoscientists produce as *good technoscientific products*. Thus, as illustrated in the analysis of research publications, this notion of *good technoscientific products* is closely linked to the question of *whose* interests and needs the research community should serve through these products.

During the Great Leap Forward and the Cultural Revolution periods, the goal of rapeseed research was to strengthen the link between production and technoscience. In order to achieve that goal, peasants and villagers were given a more active role in the process of creating, maintaining and changing these new technical innovations. These actors became the main agents and indigenous knowledge became the main tool in the network surrounding

rapeseed research. During these periods non-technical topics dominated in rapeseed research. This is because understanding of rapeseed as an object of knowledge in these periods came largely from everyday interaction (practices) of these humans with the plant in local agroecological and socio-cultural conditions. Consequently, technical innovations constructed from such knowledge do not separate the role of the plant between knowledge/technology and commodities. Thus, most research products designed and introduced during these periods (e.g., Shengli and selections from it, triple-cropping, oil crushing machines) had strong relevancy to rapeseed production activities. HYVs such as *Xishuibai* and *Shengli* could be adopted in a large area within a relatively short period of time.

In contrast, during the last two periods, the role of traditional actors such as farmers, small mill operators, and granary managers has rapidly diminished in the process of technoscience. Today, the Chinese notion of *good technoscientists* and *good technoscience* is not significantly different from that in the U.S., Canada, or other Western countries. Furthermore, abstract (or technoscientific) knowledge rather than from local (or indigenous) knowledge has increasingly come to dominate the understanding of rapeseed in the PRC. Double-low cultivars and hybrids are among some products of such abstract knowledge because rapeseed as the plant itself became an object to be studied. They had little relevance to the practices of those who cultivated, processed, distributed and consumed the plant because abstract knowledge separates the role of plant as knowledge/technology and as commodity. Therefore, on the one hand, these varieties are “immutable mobiles” (Latour 1987) that are used by Japanese and Canadian technoscientists as varietal resources for their research. On the other hand, as a commodity, these varieties are not *good technoscientific products*.

In fact, *good technoscientists* with *good technoscience* do not necessarily produce *good technoscientific products*. This is largely because such a notion differs among actors in the network surrounding a given technoscientific product. Moreover, although technoscience, politics, economy and ideology are among some dimensions of the network, they are different types of practices directed to achieving different goals with different tools, strategies, organization, expertise, knowledge and values. Therefore, there are no guarantees that new products of technoscience for a given commodity in a given network will improve the production capacity of that network so as to take advantage of the new knowledge. The capacity of Canadian and Japanese researchers to benefit from hybrids developed by Chinese researchers is a good example. In fact, these hybrids have actually contributed to widening the gap between the Canadian canola industry and the PRC's rapeseed industry in the global market. Moreover, even if every human actor agrees on the notion of what constitutes *good technoscientific products*, these products may not be good for society/nature. For example, successfully adopted cultivars such as *Shengli* and *Zhongyou 821* have contributed to narrowing genetic diversity in the fields, thereby increasing the chance for an outbreak of diseases.

It is very easy to forget that there are multiple ways to use technoscience to benefit society. As the cost of technoscientific endeavor continues to rise, most developing nations have to make a difficult decision as to how to distribute their limited funds and personnel among various programs and projects. In fact, the major weakness of technoscience studies within SSID is that they never question the desirability of a given product of technoscience in a country. Moreover, these studies rarely ask what kind of technology various human actors in that country want.

In the rapeseed commodity chain in the PRC, many actors such as farmers, marketers, processors, local extension agents and consumers do not consider a switch from double-high to double-low varieties and hybrids as either necessary or desirable. In addition, a switch to double-zero varieties and hybrids will likely bring several environmental problems including, but not limited to: (1) a decline in genetic diversity among cultivars, (2) an increased chance for the outbreak of diseases, and (3) the intensification of soil and water contamination due to the increased need of these varieties for chemical inputs.

Many rapeseed cultivars are open pollinated. Because the size of rapeseed fields is very small in the PRC, the benefit of double-low varieties will not be maintained unless every farmer in the neighborhood adopts them. Also, the switch will likely lead to the demise of local knowledge about cultivating, processing and consuming rapeseed. In order to maintain the genetic integrity and benefit of these new varieties, farmers must rely on seed companies, research institutions, and chemical input suppliers to provide them with necessary products and knowledge for cultivation. Oil mills will have to use sophisticated refining machinery to control temperature, moisture, chemical solvent, procedures, etc. to *properly* process the grain from these new cultivars.

Besides the development of double-low varieties and hybrids, technoscientists could have pursued other paths for technical change on rapeseed. Probably an improvement in oil crushing and refining technology would have had served the entire rapeseed chain better than these varieties. The design and introduction of relatively inexpensive oil refining equipment would have improved the quality of rapeseed oil among the rural population, and allowed oil to be traded in urban markets. Therefore, such a new technology would have helped to expand the context in which rapeseed is traded as a commodity, strengthened linkages among

actors in the commodity chain within a given locality, and allowed the chain to extend its linkages outside that locality.

Therefore, the choice and fate of technical change suggests strong and weak links within the network. This is because technology is both an outcome and tool to redistribute power among actors in the network. Then, the power of a given network can be only realized when that network itself actually becomes a tool for organizing society/nature by redefining roles of people and things and the relationships among them.

The Power of Chains, the Chain of Power

Starting in the late 1970s, the modernization program unfolded as two-tier reforms: (1) the breaking up of the PRC's hierarchy by decentralizing political authority, decollectivizing communes and state enterprises, and separating administrative and economic organizations; and (2) the creation of markets. Today, the commodity context of rapeseed is fundamentally different from the time when the crop was produced, distributed, and consumed under the mechanisms of a centrally planned economy. The creation of rapeseed markets involved reordering the processes and participants that determine the commodity situation of the crop. It began by ending the state monopoly over commodity exchanges. Certainly, this encouraged human actors to pursue economic activities concerning rapeseed and its byproducts autonomously and independently from the government. However, the conversion from a centrally planned to a more market oriented economy in itself has not automatically made these humans into market participants, or rapeseed into commodities.

Modern capitalist markets do not come into existence merely because the government allows people to exchange things freely without its intervention. Entrepreneurs, bankers,

stockbrokers, and traders do not emerge only because individuals want to become one. Certain tools must be available in society that allow those individuals to become entrepreneurs, bankers, and so on. These tools must also allow both human and nonhuman actors to build self-organized networks surrounding a commodity. These tools must allow each actor to simultaneously articulate and protect their interests in commodity transactions, while reducing what Williamson calls transaction costs. In short, the transition from a non-capitalist to a *capitalistic* society requires the alteration in the role of the nation-state in dealing with and resolving distributive justice issues surrounding the transformation of society/nature.

During Mao's reign, the state dominated decision making about technical change. The state coerced peasants to accept new rapeseed varieties and cultivation techniques. Although peasants constantly struggled against the state's dominance over their activities and harvest as detailed by Oi (1989), the state held the ultimate authority over making decisions as to how to transform the society/nature. The coercive force of central plans, mass campaigns and purges is powerful so far as to inflict pains on people's bodies and elicit fear in their minds. However, these devices were limited in monitoring and controlling minute details of people and things in the hierarchical network. In a large bureaucratic network of actors, like the one in the PRC before the reform, the force of hierarchy for controlling and monitoring the behavior of people diminished from the top to the bottom in the chain of command. Particularly because rules and regulations that governed the bureaucracy shifted constantly, direct observations and physical contacts were the main device of surveillance. In fact, most intense negotiations, persuasions and coercions usually took place between those immediately above and below in the hierarchy (Oi 1989; Shue 1988; Yang 1994). In addition, the power

of the mass-campaign during the Great Leap Forward and the Cultural Revolution lay in that it implanted the fear of being watched not by cadres, police and CPC leaders, but by friends, family members, neighbors and those who are close in one's life.

Under the new economic arrangements, the state has become an actor that shares with other actors the responsibility for maintaining the power of the rapeseed chain to transform things into commodities and humans into market participants. Nevertheless, it is an important, and still powerful, actor in the Chinese society. After all, the state developed the policies, laws, market measures, and programs that encouraged the growth in rapeseed production and technoscientific activities. In fact, after the state decollectivized agriculture and eliminated the unified production quota and food rationing systems, actors other than government officials gained autonomy and independence to participate in the decision making process.

In the modern age, power lies in the ability to monitor and control minute detail (Foucault 1979). Grades, standards, contracts, property rights, patents, taxes, technical innovations, time cards and values are among some tools commonly used in modern capitalist societies. Unlike demonstrations, mass movements, public meetings and purges used in the PRC during the Great Leap Forward and the Cultural Revolution eras, these tools do not rely on infliction of physical and psychological pain as a means to control social relations and restore the power of the nation-state. These tools are powerful surveillance devices because they not only punish for bad behavior (e.g., not meeting a standard) but also often reward for good behavior (e.g., meeting a standard). By doing so, these surveillance devices ensure that the notion of *incentive* can be meaningful in capitalist market activities. In other words, people follow, for example, grades and standards not because they are afraid of being

punished. Instead, they know the economic incentives for meeting these standards. At the same time, these tools also allow human actors to simultaneously articulate and protect their interests in commodity transactions. For example, standards ensure the quality of a commodity being exchanged, thereby protecting the interests of both seller and buyer. Indeed, these tools permit actors to form self-organized networks by defining what is socially acceptable human behavior and what things are at the minimum level in order to be included in them. Therefore, the creation of grades, standards, property rights, contracts, patents, etc. must be also accompanied by the development of well-functioning monitoring mechanisms to enforce them. These tools must create, maintain, and change a thing as a commodity while monitoring, controlling, and organizing the behavior of humans as market participants in the network. Then, the power of the network can be actualized by mastering these tools to create, maintain and change capitalist markets, and by producing and reproducing economic data necessary to modern economics.

At the same time, these networks are also a vehicle for redistributing power among actors in society. For example, those national standards described in Chapter 7 are both a product and source of the power relationships between human actors in the network. On the one hand, the current effort of standardization in the PRC leads to the fragmentation of economic and political power over the nation by allowing other human actors to participate in the decision making process while creating distinctive differences in the quality of a given commodity among different administrative levels. On the other hand, the creation of national standards has indeed increased the redistributive power of the central government because any commodities that are traded inter-provincially and/or internationally must conform to national standards.

Despite frequent fluctuations in central policies, the PRC as a whole has been successful in maintaining political stability while managing rapid growth in the economy. Instead of dismantling and creating new chains for every commodity at once, the state has strategically restructured existing networks one by one through grades and standards, technical change, market measures, legal procedures, and policies. The central government continues to maintain firm control over certain commodities (e.g., grain, military machinery). However, for most commodities, the central government no longer monopolizes the process, allowing most actors to autonomously extend their links to other actors.

Therefore, the power of the central government during the reform-era can be realized by its success in using various tools of surveillance in order to reorganize social relations by disciplining minute aspects of people and things. These devices make both people and things the object to be judged and provide the government with knowledge about them. This allows the normalization of judgements about people's behavior, their relationships with things and other humans. Furthermore, these devices make it possible to institutionalize the use of minute power of the central government over society/nature.

Nevertheless, as illustrated in this dissertation, in the PRC, both new rapeseed technology and formal standards do not reflect the reality of rapeseed production activities or respond to the needs of many of the human actors in the rapeseed commodity chain. And, this gap between the goal and the reality of technical change and standardization emerges because such actors as peasants, marketers, processors, retailers, input suppliers, and consumers have been largely excluded from the decision making process for technical change. Currently, various networks exist for each commodity in the PRC. The dominant form of a given commodity chain will be undoubtedly affected by, and in turn will affect, the activities

of chain actors not only in the PRC but also in the rest of the world. As shown in this case study, however, simply following the world's dominant path for technical change for a commodity does not guarantee success in reorganizing the nation's commodity chain.

Moreover, the transition from socialism to capitalism does not signify progress in China's history or good for the people. Although I believe that the current transition of the PRC toward a more capitalistic society cannot be reversed, the nation does not need to, and probably will not, move to the same sort of capitalism as is found in the U.S., Canada, Europe or its neighboring nations. Many Chinese people have already begun to express their concerns with the widening gap in wealth,² the increased crime rate, the emergence of the unemployed³ and homeless, frequent corruption among government and party officials. Some directly blame the market-oriented reform measures as the cause of such social ills. Others worry about the future of the nation. Certainly, many rural residents continue to worship Mao Zedong. Urban youth still learn about the ideology of Chinese communism. According to my friends in Beijing, the number of young intellectuals who join the CPC has recently begun to increase again. In two or three decades, the PRC will be quite a different society from the one we have known for the last five decades. However, I strongly believe that the nation will maintain the name *People's Republic* because CPC leaders will be the one to maneuver new tools such as standards, grades, technical innovations, laws, policy measures and market procedures for maintain their power in various networks.

² Besides the difference between the rural and the urban population, the gap between the residents in costal China and those in inland China is widening. However, compared with most developing countries, these gaps are relatively small.

³ With the population of 1.2 billion, the consequence of even a low rate of unemployment can be detrimental to the entire society.

Nevertheless, whatever path to capitalism the nation chooses, other actors must be also allowed to ask how to reorganize people, things and networks in their society. This can begin with permitting human actors such as farmers, marketers, small oil mill operators and rural consumers in the rapeseed chain to participate in creating, maintaining and changing formal standards and technical innovations. Through the decision making process, these actors will be able to collectively ask how technoscience can contribute to the kind of society/nature they want. This enables the state to make appropriate strategic choices to shape production and R&D activities in the nation. And, by making appropriate choices and minimizing failures, the state will be able to maintain its power in the network.

Contributions to China Studies

Until the late 1970s, China studies in the West were largely limited in research topics, theoretical frameworks and methods. Foreign scholars were not allowed to engage in research activities, particularly interviews and participant observation, in the PRC. Thus, many scholars largely relied on documentary data, although the reliability of primary data was always uncertain. Among social science disciplines, political science studies dominated, particularly those that analyzed the PRC's government, party and military organizations at the central level, because of their relevance to improving Western nations' diplomatic and strategic relations with the PRC. Sociological studies were not allowed in the PRC as the CPC considered sociology as a dangerous discipline.

However, the 1980s was a turning point in China studies in that diversity in research topics, methodology, and theoretical framework began to emerge. Native and overseas Chinese as well as foreign scholars began to take full advantage of Deng Xiaoping's open-

door policy to carry out extensive fieldwork and large-scale surveys in the PRC. By the late 1980s, the China studies section of bookstores began to include anthropological and sociological studies, though they remain a minority, with rich descriptions of farmers, urban workers, students, ethnic minorities, villages, cities, factories, etc. Moreover, these recent publications strongly reflect ongoing theoretical debates within each discipline.

I hope that this dissertation has made a contribution to enriching the field of China studies. By integrating commodity chain analysis and actor network theory, I focused my analysis on ongoing *processes* of, rather than *events* that signify, social change in the PRC. In doing so, the symmetrical treatment of humans and nonhumans was particularly important to criticize two dominant tendencies in China studies.

First, many studies tend to overly focus on the role of central policies and leadership to explain social change in the PRC. Although I do not deny their importance, such studies tend to simplify the relationship between policies and their outcome. In this dissertation, I argued that social change involves the transformation of social relations not only between people, but also between people and things, and between things.

Second, there is a tendency in China studies (as the case in many area studies) to attribute the uniqueness of Chinese culture (e.g., Confucianism, Taoism, Buddhism) to those phenomena that sociologists, political scientists, economists, historians and geographers cannot explain. Thus, it becomes a job of anthropologists to describe and explain what is unique about Chinese culture. Yet, this conceptualization treats *culture* as something static. Although not once did I use the term *Chinese culture* in this dissertation, this dissertation is indeed about Chinese culture as rapeseed and its byproducts are cultural artifacts. With the symmetric treatment of humans and nonhumans, I was able to describe what constitutes the

Chinese culture of producing, distributing, consuming, researching, and monitoring rapeseed in society, and demonstrate that such culture is in constant flux.

Without a doubt, the direction of the PRC's transformations has tremendous impact in the future of global politics, economy and environment. I hope that my dissertation contributes to the improvement of our ability to understand the PRC.

LESSONS FOR INTERNATIONAL DEVELOPMENT EFFORTS

I began this dissertation with the goal of understanding the interaction between technoscience and economic development. Moreover, I hoped to integrate three specialties within sociology including the sociology of S&T, the sociology of agriculture, and the sociology of international development. I am certainly neither the first nor the last one to advocate the need to narrow the existing gap between the SSID and the SSST.

Past attempts (e.g., Chamarik and Goonatilake 1994; Gaillard, Krishna and Waast 1997; Gaillard 1992) have been successful in rejecting the universalist mode of technoscience and demonstrating a complex power interplay among domestic and foreign institutions in shaping technoscientific policies and programs in Third World countries. Yet, scholars of non-Western technoscience continue to struggle to go beyond the institutional analysis of technoscience. They continue to ignore the analysis of knowledge construction activities. Moreover, they rarely examine what happens between the successful manufacturing of a given technoscientific product by technoscientists and the adoption of that product by farmers or factory managers. In short, these attempts have been unsuccessful in challenging the tenet that there are necessary steps for development. In this study, there are three lessons each for development theories and practices.

For Development Theories

Lesson 1. Capitalist markets do not preexist. In fact, economic development involves creating, maintaining, and changing these markets. Things *become* commodities; people *become* market participants. Grades and standards for commodities articulate how markets are organized. And, capitalist markets are a particular form of markets. By accepting this lesson, we are able to ask: What are the necessary political and economic institutions for a capitalist society? Which institutions does a given Third World nation need to change, create, and maintain? How can that country implement and monitor these institutions?

Lesson 2. Technoscience and production are intricately linked, but not in a unidirectional manner. Although technoscience may be integral part of sociopolitical and economic development, it is one of many strategies that actors in a given society can use. Moreover, there are many ways to use technoscience in order to benefit a given society as a whole. The case of rapeseed R&D in the PRC demonstrates that technoscience does not necessarily make domestic production more productive and efficient. Similarly, what is investigated in research institutes is not necessarily specific to the needs and problems of actors in the particular location where these institutions are located. Research activities are influenced in various ways. This is largely because although research and production are in the same network, they are different types of practices directed to achieving different goals and requiring different tools, expertise, and organizations. Therefore, what is considered good technoscience by technoscientists may have no use in production. Likewise, what industrialists view as good technoscience may not be inspiring at all to technoscientists.

Lesson 3. Only networks of actors exist instead of macro structure and micro organizations. The centerpiece of this dissertation lies in notions that sociopolitical and

economic transformations in the PRC are indeed processes of reordering networks in society by redefining who the actors are, how they are linked, and what their goals are. As repeatedly argued, technical change, market measures, legal procedures, grades and standards, and policies are tools that can be used to create, maintain, and change social networks. We, humans, develop our values and ethics through our association with various social networks. In these networks, things are (re)fashioned to serve our interests, needs, desires, values, and ethics. In short, networks socialize both humans and things, and regulate the process of shaping what we call *structure* at the same time.

For Development Practices

By accepting the above three lessons, we can challenge the existing paradigm for international development and reject the deterministic process of development. This will allow us to critically appraise past and current strategies in international development, and then, approach development practices from a non-universalistic fashion.

Lesson 1. Both the macro-structural and the micro-organizational approach are inadequate. I pointed out that the popular paradigm for international development creates a macro/micro division in the development effort. Moreover, this division has also promoted our tendency to separate the domain of the economy from that of politics, society, culture, and nature. Thus, most development projects tend to focus only on specific parts of a given society and specific activities in a given domain (e.g., trade, health care, currency exchange). Therefore, these projects are unable to address distributive and environmental justice issues prior to their execution. By accepting the notion that a society consists of networks instead of macro-structure and micro-organizations, we can design development projects that focus

on the entire network of actors surrounding a given commodity rather than its individual parts. Then, we can ask: How can these projects help to reorganize the network in a way beneficial to both human and nonhuman actors?

Lesson 2. Development projects must help to strengthen weak links in each chain.

By focusing on the entirety of a given chain, we can evaluate strengths and weaknesses of linkages between actors in the network. Then, these assessments can help us recommend how to use technical change, grades and standards, market measures, legal procedures, and policies. For example, some projects assist the development of grades and standards for key commodities in a given nation. Similarly, some projects facilitate designing and implementing technical change that benefits the entire chain. These tools must be used in a fashion that reflects the reality of chain activities, responds to the needs of chain actors, and allows actors to strengthen their linkages. When successful, the network will extend its linkages by enrolling new actors.

Lesson 3. Development projects must allow actors to be empowered in self-organized commodity chains. The PRC's failure in popularizing canola cultivars illustrates that the exclusion of certain chain actors from the decision making process not only hinders technical change but also is very costly to society. However, instead of focusing on the empowerment of particular human actors (e.g., farmers in farming system research projects, rural poor in community development projects), we must design projects that empower every actor in a given commodity chain. Thus, the network is not organized by coercive power of the nation-state as was the case with the rapeseed chain in the PRC during the collectivization period. Instead, the network is organized by negotiations among human actors with distinctive needs, interests, values, ethics, and perspectives on the commodity. Thus, whether for the

development of grades and standards, or technical change, development projects must help to bring together all chain actors to make decisions about key commodities in a given nation. By bringing them together, we, development practitioners, can ask them: What kind of society do you want? What kind of nature do you want? How can we assist you to create the society/nature you want?

FUTURE STUDIES NEEDED

My hope in writing this work is to encourage other students of social sciences to join the effort to bring together two divergent fields in the social sciences, namely SSID and SSST. I hope that this dissertation has provided a number of doorways to develop future studies. To conclude my work, I suggest several possibilities in two major areas. Of course, the selection of these future studies are biased by my own interests as a sociologist.

Technoscience in the Making in Third World Countries

As pointed out repeatedly, few studies look at non-Western technoscience in action. Some studies might examine technical controversies and laboratory activities in a Third World country. These studies would help us appreciate the different ways of constructing technoscientific knowledge. Moreover, findings from these studies would allow us to assess the main weaknesses of the technoscientific community in that country, and therefore, design development projects that strengthen the community.

Some studies of Third World technoscience might exclusively focus on research collaborations between domestic and overseas technoscientists. For example, various research institutes in the PRC began to engage in collaborative projects with researchers from Canada,

Sweden, England, and Japan in the 1980s and 1990s. And, these research collaborations have shaped the rapeseed R&D program both in the PRC and foreign countries.

As technoscience is more and more globalized, the analysis of research collaborations will become increasingly important. First, such analyses would allow us to understand the intersection between economic globalization and technoscientific globalization. Second, studies of research collaborations would help us learn how conflicting cultural values are negotiated and incorporated into the process of making technoscience.

Comparative Studies of Grades and Standards Systems

In the past, grades and standards have been treated as unimportant for sociological analysis because they seem to raise only technical issues. Grades and standards, by specifying desirable features in a thing, also define necessary actions for human actors to create such features in that thing in society. Thus, a change in a standard often modifies the behavior of human actors. It may also reorganize links between two or more actors affected by the revision in the standard. Therefore, what appear to be merely technical issues are indeed social issues.

Moreover, the system of grades and standards suggests how social networks are organized around commodities in a given country. Comparative studies of such systems between two or more countries would improve our understanding of different strategies for development. Some countries use their own grades and standards (e.g., Japan) as a tool to block imports. One reason for the success of East Asian nations in export-oriented development may lie in their ability to modify social networks surrounding key commodities so that these commodities meet the international grades and standards. Similarly, analysis of

the systems in some African and Latin American countries may suggest why these nations have taken the import-substitution approach to economic development.

Finally, more studies are needed to examine how grades and standards are used with services and information. With the advancement of computer, communication, and transportation technologies, services and information have become increasingly imperative in modern capitalist economies. Yet, little work has been done to examine networks surrounding immaterial commodities. Therefore, we know little about how grades and standards are developed, implemented, and monitored for these commodities. My hope is that studies of grades and standards for services and information will improve our grasp of the changing nature of capitalism and improve our ability to manage it.

APPENDICES

APPENDIX A

Per Capita National Income and Consumption of Selected Commodities, the PRC, 1952-90

Year	National Income	Edible Oil	Grain	Pork	Sugar	Year	National Income	Edible Oil	Grain	Pork	Sugar
	Y1,000		---- kg ----				Y1,000		---- kg ----		
1952	102	2.10	197.67	5.92	0.91	1972	245	1.67	172.51	7.56	2.13
1953	121	2.02	197.07	6.06	1.17	1973	260	1.66	191.57	7.63	2.26
1954	124	1.80	196.38	6.01	1.21	1974	258	1.71	187.64	7.67	2.35
1955	128	2.20	198.27	4.94	1.29	1975	271	1.73	190.52	7.63	2.26
1956	140	2.57	204.29	4.66	1.49	1976	259	1.60	190.28	7.38	2.33
1957	140	2.42	203.06	5.08	1.51	1977	278	1.56	192.07	7.25	2.92
1958	169	2.36	198.23	5.23	1.62	1978	313	1.60	195.46	7.67	3.42
1959	182	2.25	186.59	3.08	1.53	1979	343	1.96	207.03	9.66	3.56
1960	184	1.87	163.62	1.53	1.05	1980	374	2.30	213.81	11.16	3.83
1961	151	1.38	158.79	1.41	1.79	1981	394	2.94	219.18	11.08	4.10
1962	137	1.09	164.63	2.22	1.60	1982	419	3.54	225.46	11.76	4.42
1963	145	1.13	164.65	4.27	1.35	1983	460	4.03	232.23	12.35	4.47
1964	165	1.39	181.96	5.62	1.47	1984	542	4.70	251.34	13.02	4.88
1965	191	1.72	182.24	6.29	1.68	1985	663	5.13	254.35	13.99	5.63
1966	213	1.76	189.57	7.04	1.96	1986	731	5.24	255.94	14.41	6.12
1967	195	1.76	186.18	6.89	2.26	1987	852	5.66	251.44	14.54	6.66
1968	180	1.61	173.81	6.57	2.37	1988	1,057	5.94	249.08	14.91	6.25
1969	200	1.59	173.89	5.91	2.52	1989	1,169	5.35	239.12	15.36	4.92
1970	232	1.61	187.22	6.02	2.06	1990	1,262	5.67	238.80	16.64	4.98
1971	244	1.64	188.27	7.03	2.10						

Source: USDA (1992).

APPENDIX B

Sample Interview Questions

FOR RAPESEED RESEARCHERS

1. Please tell us about past and present rapeseed research programs in your institution, particularly in terms of how research goals, sources of funding, personnel, major achievements, and clients have shifted over the years.
 - a. Who do you usually report to?
 - b. Who are your clients?
 - c. How are decisions on funding, personnel, research goals and targets, and clients made?
2. For each project, how do you choose a research topic and design, evaluate research results, and disseminate them to your clients and with the scientific community?
3. What are some barriers and obstacles to success in your research projects (e.g., lack of funding, bureaucratic red-tapes, technical etc.)? Who do you usually consult when having:
 - a. technical difficulties?
 - b. non-technical difficulties?
4. What services does your institution provide other than research (e.g., extension, seed sales, training, etc.)?
5. How do you communicate with your clients, administrative authorities, and other research institutions in your prefecture, province, nation, and overseas about your projects (e.g., information exchange, personnel exchange, publications, demonstrations, meetings, etc.)?
6. How do you integrate the needs of those concerned with production, processing, distribution and consumption of rapeseed and its products into your research projects?
 - a. Do those groups ever participate in the process of making decisions on your research project?
 - b. When you had conflicts with them, how did you resolve them?
7. What do you see as positive or negative impacts of your research results on rapeseed production, distribution, processing, consumption, and research?

Appendix B (cont'd)

8. What have been the major technological changes with respect to rapeseed over the years?
 - a. How have you responded to these changes?
 - b. What types of changes would you like to see in the future?
9. What have been the major policy and regulatory changes with respect to rapeseed over the years?
 - a. How have you responded to these changes?
 - b. What types of changes would you like to see in the future?
10. In your view, what constitutes good rapeseed?
 - a. What factors determine the quality of rapeseed?
 - b. What are some major changes needed to improve the quality of rapeseed?
11. Are there anything we have left out in this interview that you would like to add (e.g., any insights, suggestions, thoughts, etc.)?
12. Are there anyone you can introduce to us who might be helpful as interviewees for our research project?

FOR RAPESEED GROWERS

1. Please tell us about your farm.
 - a. How much (ha.) land do you lease from the government?
 - b. How many people are in your household?
 - c. How do you finance your operation (e.g., any other income sources)?
 - d. What crops do you grow in your farm? How do you grow them together (mono-, multiple-, or inter-cropping)?
 - e. How much of your harvest is usually consumed by your household?
2. How do you make decisions on operation in your farm in terms of:
 - a. which crops to be planted?
 - b. which varieties and inputs to be used?
 - c. how each crop to be treated?
 - d. whether or not to adapt a new technological products (e.g., seed variety, fertilizer)?
 - e. when and to whom your harvest is sold, and how it is delivered?

Appendix B (cont'd)

3. Please tell us about your past and present experience with growing rapeseed.
 - a. When and why did you first start growing rapeseed?
 - b. What proportion of your land is used for rapeseed production?
 - c. In your household, who are involved in rapeseed production in your land?
 - d. How and when is rapeseed planted, cared for, harvested, and sold?
 - e. What types of inputs and machinery do you use for grow rapeseed? Where do you purchase or rent them?
 - f. Where do you purchase your rapeseed to be planted? What varieties of rapeseed do you grow?
 - g. How much of your income comes from sales of rapeseed?
4. What other varieties of rapeseed are you aware of being planted by other farmers in your district?
5. What activities (e.g., processing, marketing, input production) do you perform on rapeseed other than raising them?
6. Are there any changes in the way in which your farming operation is conducted over the years? In your view, what are some major factors for those changes?
7. What are some barriers and obstacles to success in producing rapeseed? Who do you usually consult when having:
 - a. technical difficulties?
 - b. non-technical difficulties?
8. What kind of farming services (e.g., extension, equipment/tool rental, storage, transportation, etc.) available in your community? What kind of services do you actually use?
9. What activities (e.g., construction, food processing) do you engage other than farming?
10. How do you communicate with your administrative authorities, and research and extension institutions in your district?
 - a. How do they involve in your operation?
 - b. How do you ensure your needs are integrated into their activities? (e.g., participation to the decision-making process; regular meeting with them)
11. What have been the major technological changes with respect to rapeseed over the years?
 - a. How have you responded to these changes?
 - b. What do you see as their positive or negative impacts on your business?

Appendix B (cont'd)

- c. What types of changes would you like to see in the future?
- 12. What have been the major policy and regulatory changes with respect to rapeseed over the years?
 - a. How have you responded to these changes?
 - b. What types of changes would you like to see in the future?
- 13. In your view, what constitutes good rapeseed?
 - a. What factors determine the quality of rapeseed?
 - b. What are some major changes needed to improve the quality of rapeseed?
- 14. Are there anything we have left out in this interview that you would like to add (e.g., any insights, suggestions, thoughts, etc.)?
- 15. Are there anyone you can introduce to us who might be helpful as interviewees for our research project?

APPENDIX C

Rapeseed Area, Production and Yield in the PRC, 1949-94

Year	Area 1,000 ha	Production 1,000 tons	Yield kg/ha	Year	Area 1,000 ha	Production 1,000 tons	Yield kg/ha
1949	1,515	734	484	1973	2,096	1,353	646
1950	1,424	683	480	1974	2,063	1,382	670
1951	1,568	778	496	1975	2,313	1,535	664
1952	1,863	932	500	1976	2,346	1,348	575
1953	1,667	879	527	1977	2,217	1,170	528
1954	1,707	878	514	1978	2,599	1,868	719
1955	2,338	969	414	1979	2,761	2,402	870
1956	2,165	923	426	1980	2,844	2,384	838
1957	2,308	888	385	1981	3,801	4,065	1,069
1958	2,288	999	437	1982	4,122	5,656	1,372
1959	2,031	936	461	1983	3,669	4,287	1,168
1960	2,415	746	309	1984	3,413	4,205	1,232
1961	1,467	380	259	1985	4,494	5,607	1,248
1962	1,361	488	359	1986	4,916	5,881	1,196
1963	1,443	518	359	1987	5,267	6,605	1,254
1964	1,789	939	525	1988	4,936	5,044	1,022
1965	1,822	1,089	598	1989	4,993	5,436	1,089
1966	1,748	906	518	1990	5,503	6,958	1,264
1967	1,665	1,007	605	1991	6,133	7,436	1,212
1968	1,405	905	644	1992	5,976	7,653	1,281
1969	1,427	878	615	1993	5,301	6,939	1,309
1970	1,453	965	664	1994	5,783	7,492	1,296
1971	1,616	1,233	763				
1972	1,967	1,397	710				

Sources: Nongyebu (1992, 1993, 1994, 1995); USDA (1992).

APPENDIX D

Annual Per Capita Consumption of Edible Oils and Pork, the Rural vs. Urban Population, 1952-92

Year	Pork kg / person			Edible Oil kg / person			Year	Pork kg / person			Edible Oil kg / person		
	Natl.	Urban	Rural	Natl.	Urban	Rural		Natl.	Urban	Rural	Natl.	Urban	Rural
1952	5.92	8.92	5.50	2.10	5.12	1.68	1975	7.63	14.92	6.23	1.73	4.66	1.17
1953	6.06	10.10	5.47	2.02	5.36	1.53	1976	7.38	13.85	6.12	1.60	4.62	1.01
1954	6.01	10.15	5.36	1.80	4.67	1.36	1977	7.25	12.88	6.08	1.56	4.14	1.03
1955	4.94	9.65	4.19	2.20	5.20	1.72	1978	7.67	13.70	6.37	1.60	4.11	1.05
1956	4.66	8.38	4.00	2.57	5.08	2.11	1979	9.66	17.40	7.95	1.96	4.99	1.29
1957	5.08	8.98	4.35	2.42	5.15	1.86	1980	11.16	18.98	9.39	2.30	5.45	1.59
1958	5.23	8.03	4.61	2.36	4.55	1.89	1981	11.08	16.98	9.73	2.94	6.89	2.04
1959	3.08	4.99	2.61	2.25	4.04	1.82	1982	11.76	17.56	10.41	3.54	8.95	2.28
1960	1.53	2.71	1.22	1.87	3.55	1.43	1983	12.35	18.04	11.01	4.03	9.98	2.63
1961	1.41	1.75	1.33	1.38	2.70	1.05	1984	13.02	18.71	11.67	4.70	11.07	3.19
1962	2.22	3.79	1.89	1.09	2.46	0.80	1985	13.99	19.71	12.62	5.13	12.27	3.43
1963	4.27	8.28	3.49	1.13	3.06	0.74	1986	14.41	20.43	12.95	5.24	12.42	3.50
1964	5.62	10.80	4.57	1.39	3.72	0.92	1987	14.54	21.04	12.91	5.66	13.54	3.69
1965	6.29	10.37	5.45	1.72	4.82	1.09	1988	14.91	21.24	13.31	5.94	13.56	4.01
1966	7.04	12.88	5.92	1.76	5.27	1.08	1989	15.36	22.59	13.74	5.35	12.20	3.66
1967	6.89	11.91	5.90	1.76	4.95	1.13	1990	16.64	24.61	14.51	5.67	12.68	3.79
1968	6.57	11.67	5.58	1.61	4.54	1.05	1991				5.89	13.06	3.97
1969	5.91	10.53	5.03	1.59	4.56	1.02							
1970	6.02	10.75	5.20	1.61	4.24	1.10							
1971	7.03	11.19	6.19	1.64	4.24	1.12							
1972	7.56	12.52	6.59	1.67	4.41	1.13							
1973	7.63	13.48	6.50	1.66	4.36	1.14							
1974	7.67	14.32	6.39	1.71	4.45	1.19							

Sources: Shangyebu (1992, 1993); USDA (1992).

APPENDIX E

Technical Publications on Rapeseed in the PRC, 1949-93

<i>Codes¹</i> Year	Plant Manipulation			Plant Protection			Post-Harvest Treatment				Farmg. Pract.	Other		Total
	<i>BR</i>	<i>PH</i>	<i>VT</i>	<i>EN</i>	<i>PA</i>	<i>SF</i>	<i>ML</i>	<i>OL</i>	<i>PR</i>	<i>SO</i>	<i>CP</i>	<i>ST</i>	<i>OT</i>	<i>Total</i>
1949	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	0	0	0	0	0	0	0	1	0	1
1951	0	1	0	2	1	0	0	2	1	0	5	2	1	9
1952	1	0	0	1	0	0	1	1	1	0	0	1	1	5
1953	0	0	0	0	0	0	0	1	0	0	4	0	0	5
1954	1	1	0	2	1	0	0	0	0	1	24	18	10	42
1955	12	9	0	2	3	4	3	3	2	1	93	31	11	127
1956	11	16	7	3	7	9	3	2	4	0	77	25	14	126
1957	11	16	3	4	1	9	1	3	1	2	74	41	10	130
1958	17	19	0	2	6	6	1	29	28	1	95	135	26	263
1959	10	26	3	8	23	11	2	6	7	2	112	70	29	220
1960	9	22	2	6	18	11	4	8	8	0	95	49	14	166
1961	1	5	2	2	7	8	1	0	0	0	28	5	5	42
1962	5	13	1	2	13	6	2	2	0	1	34	13	3	61
1963	7	20	4	6	16	11	1	1	0	0	39	12	8	87
1964	12	29	3	3	15	9	1	3	0	0	28	13	17	94
1965	14	19	2	3	11	15	0	5	5	0	44	27	11	108
1966	8	3	0	2	3	3	0	5	3	0	21	4	5	36
1967	0	0	0	0	1	0	0	0	1	0	1	0	0	3
1968	0	0	0	0	1	0	0	0	0	0	1	0	0	1
1969	0	0	0	0	1	0	0	0	0	0	1	0	0	1
1970	0	1	0	0	0	0	0	0	0	0	2	0	0	2
1971	2	0	0	1	2	0	0	0	0	0	3	3	1	8
1972	7	3	0	2	1	2	0	1	0	0	9	5	4	20
1973	11	7	5	3	4	9	0	2	0	0	43	19	8	74
1974	11	12	5	2	10	12	1	2	2	1	57	22	13	106
1975	20	8	0	2	8	5	4	5	2	0	68	33	10	111

Appendix E (cont'd)

<i>Codes Year</i>	Plant Manipulation			Plant Protection			Post-Harvest				Farmg. Pract.	Other		Total
	<i>BR</i>	<i>PH</i>	<i>VT</i>	<i>EN</i>	<i>PA</i>	<i>SF</i>	<i>ML</i>	<i>OL</i>	<i>PR</i>	<i>SO</i>	<i>CP</i>	<i>ST</i>	<i>OT</i>	<i>Total</i>
1976	17	11	2	0	15	8	3	3	2	1	79	38	11	137
1977	34	24	3	0	8	16	8	6	2	0	109	31	17	162
1978	42	35	2	9	14	25	15	5	4	0	111	31	12	205
1979	63	40	2	5	11	21	32	7	5	1	113	24	19	231
1980	45	58	2	12	16	23	29	24	5	0	117	47	24	280
1981	42	34	13	4	4	17	35	18	2	0	94	17	7	210
1982	60	36	7	6	9	20	16	23	2	1	75	15	6	203
1983	53	36	10	5	14	27	17	12	6	0	81	13	12	215
1984	48	37	8	6	9	18	12	5	2	0	57	12	9	175
1985	86	31	10	9	15	33	18	17	2	1	93	4	7	245
1986	67	21	1	10	11	20	17	9	2	9	80	7	6	198
1987	99	55	7	9	27	47	25	20	4	2	115	19	9	316
1988	69	35	2	6	13	27	17	12	3	1	71	9	18	199
1989	87	20	17	8	35	37	6	12	3	3	101	19	6	283
1990	92	36	2	8	20	34	10	13	5	3	107	12	6	261
1991	69	34	1	9	27	57	11	8	5	1	125	13	3	276
1992	65	32	1	5	10	50	6	4	3	1	58	4	0	190
1993	77	56	3	1	23	49	23	13	10	3	66	6	16	231
Total	1285	861	130	170	434	659	325	292	132	36	2610	850	389	5865

Note: ¹ Topic codes used here are: BR = breeding, CP = cultural practice, EN = entomology, ML = meal, OL = oil, PA = plant pathology, PH = plant physiology, PR = processing, SF = soil, fertilizer, pesticide, herbicide, etc., ST = statistics, SO = storage, VT = variety trial, OT = other; ² The absolute number is used here. Many publications were categorized into more than two topics.

Sources: CAAS (1981-95), CAAS (1983).

APPENDIX F

Economic Indicators Concerning Rapeseed, 1952-93

Year	Procurement Price of Oil crops ¹	Retail Price of Edible Oil ¹	Consumption of Edible Oil	Year	Procurement Price of Oil crops ¹	Retail Price of Edible Oil ¹	Consumption of Edible Oil
Unit	RMB/ton	RMB/ton	1,000 t	Unit	RMB/ton	RMB/ton	1,000 t
1952	606	860	1,190	1973	1,666	1,638	1,460
1953	678	878	1,170	1974	1,679	1,643	1,540
1954	689	967	1,070	1975	1,692	1,641	1,580
1955	686	1,040	1,335	1976	1,669	1,653	1,485
1956	706	1,040	1,590	1977	1,673	1,653	1,470
1957	940	1,131	1,510	1978	1,746	1,647	1,525
1958	940	1,154	1,540	1979	2,458	1,690	1,895
1959	1,000	1,180	1,490	1980	2,641	1,714	2,260
1960	1,100	1,210	1,240	1981	2,819	1,967	2,925
1961	1,300	1,393	905	1982	2,773	1,969	3,565
1962	1,314	1,471	720	1983	1,654	1,930	4,105
1963	1,420	1,476	765	1984	2,624	2,071	4,835
1964	1,474	1,532	965	1985	2,701	2,179	5,340
1965	1,450	1,640	1,235	1986	2,846	2,278	5,516
1966	1,434	1,640	1,300	1987	3,078	2,396	6,071
1967	1,410	1,640	1,330	1988	3,676	2,673	6,464
1968	1,384	1,640	1,250	1989	4,318	3,365	5,980
1969	1,386	1,640	1,265	1990	4,425	3,426	6,435
1970	1,387	1,640	1,315	1991	4,495	4,194	6,773
1971	1,613	1,640	1,380	1992	4,307	3,868	
1972	1,599	1,640	1,435				

Notes: ¹ Mixed average price is used here. It is an average of fixed, negotiated and open market prices, as well as an average of various standards, grades and qualities.

Sources: SSB (1992); USDA (1992).

APPENDIX G

National Standards and Regulations Concerning Rapeseed and its Byproducts in the PRC

Title (Code Number)	Submitted by	Enacted Date
Seed of Rape		
Enforcement Rules for the Seed of Agricultural Crops	MOA	6/19/91
Rules for Agricultural Seed Testing (GB 3543-83)		11/16/89
Seed Packing of Main Agricultural Crops (GB 3543-83)	MOA	10/16/89
Seed Storage of Main Agricultural Crops (GB 7415-87)	MOA	3/13/87
Grain of Rape		
Rapeseed (GB11762-89)	MIT	5/21/84
Gunny Bag for Packing of Grain (GB 8115-87)	MIT	8/3/87
Oil of Rape		
Rapeseed Oil (GB 1536-86)	MIT	5/6/86
Rapeseed Salad Oil (GB 7654-87)	MIT	5/14/87
Rapeseed Cooking Oil (ZB/X 14011-87)	MIT	3/16/87
Hygienic Standard for Edible Vegetable Oil (GB 2716-88)	TC	1/10/88
Hygienic Standard for Salad Oil (GB 13109-91)	MOPH	6/7/92
Hygienic Standard for Edible Flying Oil (GB 7612-86)	TC	12/9/87
Hygienic Standard for Edible Vegetable Oil Factories (GB 5009.37-85)	TC	4/4/88
General Standard for the Labeling of Foods (GB 7718-87)	TC	5/13/88
Feed of Rape		
Rapeseed Meal (Solvent) for Feedstuffs (GB 10375-89)	MOA; MIT	10/11/88
Rapeseed Meal (Expeller) for Feedstuffs (GB 10374-89)	MOA; MIT	10/11/88
Hygienic Standard for Feed (GB 13078-91)	TC	2/15/91
Feed Label (GB 10648-89)	MIT	2/15/93

Note: MOA = Ministry of Agriculture; MIT = Ministry of Internal Trade; MOPH = Ministry of Public Health; TC = a specially appointed technical committee.

BIBLIOGRAPHY

BIBLIOGRAPHY

- Ainsworth, G.C. 1981. Introduction to the History of Plant Pathology. Cambridge, UK: Cambridge University Press.
- Altieri, Miguel A. 1990. "Why Study Traditional Agriculture?" Pp. 551-554 in Agroecology, edited by C. Rohald Carroll, John H. Vandermeer, and Peter M. Rosset. New York: McGraw Hill Publishing Company.
- Appadurai, Arjun. 1986a. "Introduction: Commodities and the Politics of Value." Pp. 3-63 in The Social Life of Things: Commodities in Social Perspective, edited by Arjun Appadurai. Cambridge: Cambridge University Press.
- Appadurai, Arjun (ed.). 1986b. The Social Life of Things: Commodities in Social Perspective. Cambridge: Cambridge University Press.
- Appelbaum, Richard P., David Smith, and Brad Christerson. 1994. "Commodity Chains and Industrial Restructuring in the Pacific Rim: Garment Trade and Manufacturing." Pp. 187-204 in Commodity Chains and Global Capitalism, edited by Gary Gereffi and Miguel Korzeniewicz. Westport: Praeger.
- Ash, Robert F. 1993. "Agricultural Policy Under the Impact of Reform." Pp. 11-45 in Economic Trends in Chinese Agriculture: The Impact of Post-Mao Reforms, edited by Y.Y. Kueh and Robert F. Ash. Oxford: Clarendon Press.
- Baark, Erik. 1986. Know-How as a Commodity: Contracts and Markets in the Diffusion of Technology in China (Discussion Paper). Lund, Sweden: Research Policy Institute
- Baark, Erik. 1992. "Fragmented Innovation: China's Science and Technology Policy Reforms in Retrospect." Pp. 531-545 in China's Economic Dilemmas in the 1990s: The Problems of Reforms, Modernization, and Interdependence, edited by U.S. Congress Joint Economic Committee. New York: M.E. Sharpe.
- Bailey, Conner. 1991. "International Development." Pp. 320-332 in Rural Policies for the 1990s, edited by Cornelia B. Flora and James A. Christenson. Boulder, CO: Westview Press.

- Baran, Paul A. 1952. "On the Political Economy of Backwardness." Manchester School of Economic and Social Studies 20:66-84.
- Barnes, Barry. 1974. Scientific Knowledge and Sociological Theory. London and Boston: Routledge and Keagan Paul.
- Barnes, Barry. 1977. Interests and Growth of Knowledge. London and Boston: Routledge and Keagan Paul.
- Barnes, Barry. 1982. "The Science-Technology Relationship: A Model and a Query." Social Studies of Science 12: 309-314.
- Bauzon, Kenneth E. 1992. "Introduction: Democratization in the Third World -- Myth or Reality?" Pp. 1-31 in Development and Democratization in the Third World: Myths, Hopes, and Realities, edited by Kenneth E. Bauzon. Washington, DC: Taylor & Francis.
- Beijing Review. 1991a. "CPC CC's Proposal for 10 Year Development Program and 8th Five Year Plan." Beijing Review 34(7-8):21-27.
- Beijing Review. 1991b. "Protecting Intellectual Property Rights." Beijing Review 34(48):9-12.
- Benjamin, Martin. 1990. Splitting the Difference: Compromise and Integrity in Ethics and Politics. Lawrence, KS: University Press of Kansas.
- Benson, J. Kenneth. 1975. "The Interorganizational Network as a Political Economy." Administrative Science Quarterly 20:229-249.
- Biaozhunju. 1983. "Nongzuowu Zhongzi Jianyan Guicheng [Rules for Agricultural Seed Testing] (GB 3543-83/UDC 633.1/.3-154)." Zhonghua Renmin Gongheguo Guojia Biaozhun [National Standards of the People's Republic of China]. Guojia Biaozhunju. (3 March 1983).
- Biaozhunju. 1984. "Youliao Zhongzi [Seed of Oil Crops] (GB 3543-83/UDC 633.1/.3-154)." Zhonghua Renmin Gongheguo Guojia Biaozhun [National Standards of the People's Republic of China]. Guojia Biaozhunju. (21 May 1984).
- Biaozhunju. 1987a. "Shipin Biaoqian Tongyong Biaozhun [General Standard for the Labelling of Foods] (GB 7718-87/UDC 664.004.24)." Zhonghua Renmin Gongheguo Guojia Biaozhun [National Standards of the People's Republic of China]. Guojia Biaozhunju. (13 May 1987).
- Biaozhunju. 1987b. "Zhuyao Nongzuo Zhongzi Baozhuang [Seed Packing of Main Agricultural Crops] (GB 7414-87/UDC 633-156)." Zhonghua Renmin Gongheguo

- Guojia Biaozhun [National Standards of the People's Republic of China]. Guojia Biaozhunju. (1 October 1987).
- Biaozhunju. 1987c. "Zhuyao Nongzuo Zhongzi Zhucang [Seed Storage of Main Agricultural Crops] (GB 7415-87/UDC 633-156)." Zhonghua Renmin Gongheguo Guojia Biaozhun [National Standards of the People's Republic of China]. Guojia Biaozhunju. (1 October 1987).
- Biggelaar, Christoffel den. 1991. "Farming Systems Development: Synthesizing Indigenous and Scientific Knowledge." Agriculture and Human Values 7(1-2):25-36.
- Bijker, Wiebe E., Thomas P. Hughes, and Trevor Pinch (eds.). 1990. The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology. Cambridge, MA: The MIT Press.
- Bird, Elizabeth. 1987. "The Social Construction of Nature: Theoretical Approaches to the History of Environmental Problems." Environmental Review 11(4):257-264.
- Blatz, Charles V. 1992. "The Very Idea of Sustainability." Agriculture and Human Values Fall:12-28.
- Bloor, David. 1976. Knowledge and Social Imagery. London and Boston: Routledge and Kegan Paul.
- Boltanski, Luc, and Laurent Thévenot. 1991. De La Justification: Les Économies de la Grandeur. Paris: Gallimard.
- Bonanno, Alessandro, Lawrence Busch, William Friedland, Lourdes Gouveia, and Enzo Mingione (eds.). 1994. From Columbus to ConAgra: The Globalization of Agriculture and Food. Lawrence, KS: University Press of Kansas.
- Booth, David. 1992. "Social Development Research: An Agenda for the 1990s." The European Journal of Development Research 4(1):1-39.
- Braudel, Fernand. 1992. The Structure of Everyday Life. Berkeley, CA: University of California Press.
- Browne, William P., Jerry R. Skees, Louis E. Swanson, Paul B. Thompson, and Laurian J. Unnevr. 1992. Sacred Cows and Hot Potatoes. Boulder, Co: Westview Press.
- Bullock, Mary Brown. 1992. "The Effects of Tiananmen on China's International Scientific and Educational Cooperation." Pp. 611-628 in China's Economic Dilemmas in the 1990s: the Problems of Reforms, Modernization, and Interdependence, edited by U.S. Congress Joint Economic Committee. New York:

M.E. Sharpe.

Busch, Lawrence. 1984. "Science, Technology, Agriculture, and Everyday Life." Pp. 289-314 in Research in Rural Sociology and Development, Vol. 1. Greenwich, CT: JAI Press, Inc.

Busch, Lawrence. 1990. "How to Study Agricultural Commodity Chains: A Methodological Proposal." Pp. 13-24 in Economie des Filières en Régions Chaudes: Formation des Prix et Echanges Agricoles, edited by Michel Griffon. Paris: CIRAD.

Busch, Lawrence. 1991a. "Manufacturing Plants: Notes on the Culture of Nature and the Nature of Culture." International Journal of Sociology of Agriculture and Food 1:105-115.

Busch, Lawrence. 1991b. "What Kind of Nature Do We Want?" A paper presented at Sustainable Agriculture Discussion Group Seminar, 7 November 1991, Michigan State University, East Lansing MI.

Busch, Lawrence, Alessandro Bonanno, and William B. Lacy. 1989. "Science, Technology, and the Restructuring of Agriculture." Sociologia Ruralis 29(2):118-130.

Busch, Lawrence, Valerie Gunter, Theodore Mentele, Masashi Tachikawa, and Keiko Tanaka. 1994. "Socializing Nature: Technoscience and the Transformation of Rapeseed into Canola." Crop Science 34(3):607-614.

Busch, Lawrence, William Lacy, Laura Lacy, and Jeff Burkhardt. 1991. Plant, Power and Profits: Social, Economic, and Ethical Consequences of the New Biotechnologies. Oxford: Basil Blackwell.

Busch, Lawrence, and William B. Lacy. 1983. Science, Agriculture, and the Politics of Research. Boulder, CO: Westview Press.

Busch, Lawrence, and Keiko Tanaka. 1996. "Rites of Passage: The Negotiation of Quality in a Commodity Subsector." Science, Technology and Human Values 21(1):3-27.

Buttel, Frederick H. 1990a. "Biotechnology, Agriculture, and Rural America: Socioeconomic and Ethical Issues." Pp. 227-250 in Agricultural Bioethics: Implications of Agricultural Biotechnology, edited by Steven M. Gendel, A. David Kline, D. Michael Warren, and Faye Yates. Ames, IA: Iowa State University Press.

Buttel, Frederick H. 1990b. "Social Relations and the Growth of Modern Agriculture." Pp. 113-145 in Agroecology, edited by C. Ronald Carroll, John H. Vandermeer,

and Peter Rosset. New York: McGraw-Hill Publishing Company.

- CAAS (Chinese Academy of Agricultural Sciences). 1981-95. Zhongwen Keji Mulu: Nongye [Index of Chinese Sciences: Agriculture Section 1981-95]. Beijing: Zhongguo Nongye Kexueyuan.
- CAAS. 1983. Zhongwen Nongye Wenxian Mulu: Youliao Fence B & C [Index of Chinese Agricultural Literature: Rapeseed Sections B & C]. Beijing: Zhongguo Nongye Kexueyuan.
- CAAS. 1991. "Duokang(nai)xing Youcai Xinpinzhong *Zhongyou 821* [New Cultivar with High Resistance, *Zhongyou 821*]." Pp. 45-47 in Nongmuyuye Keji Jinbu Jianghuojiang Chengguo Nianbao 1990 [Annual Report of Recipients of Science and Technology Achievement Awards in the Areas of Agriculture, Animal Husbandry and Fishery.]. Beijing: Zhongguo Nongye Kexueyuan.
- CAAS. 1992. Zhongguo Nongye Keji zhi Yanjiu [Research on Agricultural Science and Technology in China]. Beijing: Zhongguo Nongye Kexueyuan.
- CAAS-IOCR (CAAS-Institute of Oil Crop Research). 1961a. Guanyu Jiaqiang Youliao Zuowu Pinzhong Ziyuan Yanjiu Gongzuo de Yijian [Regarding Strengthening Research on Varietal Resources in Edible Oil Crops] (Meeting Report). Wuhan: Zhongguo Nongye Kexueyuan Youliao Yanjiusuo.
- CAAS-IOCR. 1961b. Guanyu Zuzhi Quanguo Youliao Zuowu Pinzhong Quyu Shiyan de Chubu Yijian [Preliminary Opinions Regarding Organizing the National Variety Testing for Edible Oil Crops] (Meeting Report). Wuhan: Zhongguo Nongye Kexueyuan Youliao Yanjiusuo.
- CAAS-IOCR (ed.). 1961c. Quanguo Youliao Kexueyuan Yanjiu Gongzuo Huiyi Wenjian [Meeting Reports from the National Oilseed Crop Research Meeting of 1961]. Beijing: Zhongguo Nongye Kexueyuan.
- CAAS-IOCR. 1961d. Youcai Fengchang Caipei Jishu yu Fengchang Guilu Yanjiu [Rapeseed Cultivation Techniques for High Yield, and Research on Rules of High Yielding] (Meeting Report). Wuhan: Zhongguo Nongye Kexueyuan Youliaosuo.
- CAAS-IOCR. 1963. Quanguo Youcai Kexue Jishu Zuotanhui Jianjie [Brief Summary of the National Symposium of Rapeseed Science and Technology] (Meeting Report). Wuhan: Zhongguo Nongye Kexueyuan Youliao Yanjiusuo.
- CAAS-IOCR. 1965a. Quanguo (Dong) Youcai Pinzhong Quyu Shiyan Gongzuo Zongjie (Diyige Shiyan Niandu 1963-1965) [Summary of the National Winter Rapeseed Varietal Trials (First Test Experiment Period, 1963-1965)] (Meeting Report). Wuhan: Zhongguo Nongye Kexueyuan Youliao Yanjiusuo.

- CAAS-IOCR. 1965b. Quanguo Youcai Pinzhong Quyu Shiyan Shishi Fang'an (Dierge Shiyan Niandu Xiuzheng Caoan) [Plan for Conducting the National Rapeseed Varietal Trials (Revised Draft for the Second Experiment Period)] (Meeting Report). Wuhan: Zhongguo Nongye Kexueyuan Youliao Yanjiusuo.
- CAAS-IOCR. 1988. Zhongguo Youcai Pinzhongzhi [The Annals of Rapeseed Varieties in China]. Beijing: Nongye Chubanshe.
- CAAS-IOCR (ed.). 1990. Zhongguo Youcai Zaipeixue [Leaning of Rapeseed Cultivation in China]. Beijing: Nongye Chubanshe.
- Callon, Michel. 1986. "Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fisherman of St. Brieux Bay." Pp. 196-229 in Post, Action and Belief: A New Sociology of Knowledge?, edited by John Law. Keele: University of Keele.
- Callon, Michel, and Bruno Latour. 1992. "Don't Throw the Baby Out with the Bath School! A Reply to Collins and Yearly." Pp. 343-368 in Science as Practice and Culture, edited by Andrew Pickering. Chicago: University of Chicago Press.
- Carroll, C. Ronald. 1990. "The Interface between Natural Areas and Agroecosystems." Pp. 365-383 in Agroecology, edited by C. Ronald Carroll, John H. Vandermeer, and Peter M. Rosset. New York: McGraw-Hill Publishing Company.
- Carroll, C. Ronald, John H. Vandermeer, and Peter M. Rosset (eds.). 1990a. Agroecology. New York: McGraw-Hill Publishing Company.
- Carroll, C. Ronald, John H. Vandermeer, and Peter M. Rosset. 1990b. "Preface." Pp. x-xiii in Agroecology, edited by C. Ronald Carroll, John H. Vandermeer, and Peter M. Rosset. New York: McGraw-Hill Publishing Company.
- Cashman, Kristin. 1991. "Systems of Knowledge as Systems of Domination: The Limitations of Established Meaning." Agriculture and Human Values 7(1-2):49-58.
- CCAAS (Central China Academy of Agricultural Sciences). 1954a. 1955-67 Research Projects Plan (research plan). Wuhan: Huazhong Nongye Kexueyuan.
- CCAAS, Central China Academy of Agricultural Sciences. 1954b. 1955 Annual Research Plan (research plan). Wuhan: Huazhong Nongye Kexueyuan.
- Cerne, Michael M. (ed.). 1985a. Putting People First: Sociological Variables in Rural Development. Oxford: Oxford University Press.
- Cerne, Michael M. 1985b. "Sociological Knowledge for Development Project." Pp. 3-21 in Putting People First: Sociological Variables in Rural Development, edited by

Michael M. Cernea. Oxford: Oxford University Press.

Chamarik, Saneh, and Susantha Goonatilake (eds.). 1994. Technological Independence: The Asian Experience. Tokyo, New York, and Paris: United Nations University Press.

Chambers, R. 1983. Rural Development: Putting the Last First. New York: Longman.

Chekki, Dan A. (ed.). 1979. Community Development: Theory and Method of Planned Change. New Delhi: Vikas.

China Daily. 1996. "Four Seized for Selling Mislabeled Rice Seeds" China Daily 19 January 1996. Beijing.

Clague, Christopher. 1997. "The New Institutional Economics and Economic Development." Pp. 13-36 in Institutions and Economic Development: Growth and Governance in Less-Developed and Post-Socialist Countries, edited by Christopher Clague. Baltimore and London: Johns Hopkins University Press.

Clarke, Adle. 1990. "A Social Worlds Research Adventure." Pp. 15-42 in Theories of Science in Society, edited by Susan E. Cozzens and Thomas F. Gieryn. Bloomington and Indianapolis, IN: Indiana University Press.

Clarke, Adele, and Joan Fujimura (eds.). 1992. The Right Tool for the Job: At Work in Twentieth-Century Life Sciences. Princeton: Princeton University Press.

Collins, H.M. 1985. Changing Order: Replication and Induction in Scientific Practice. Beverly Hills: Sage Publications.

Collins, H.M. , and Steven Yearley. 1992. "Epistemological Chicken." Pp. 301-326 in Science as Practice and Culture, edited by Andrew Pickering. Chicago: The University of Chicago Press.

Conroy, Richard J. 1987. "The Disintegration and Reconstruction of the Rural Science and Technology System: Evaluation and Implications." Pp. 137-172 in The Reemergence of the Chinese Peasantry, edited by Ashwanti Saith. London: Croom Helm.

Conroy, R.J. 1989. "The Role of the Higher Education Sector in China's Research and Development System." China Quarterly no. 117:38-70.

Cook, Karen S. 1978. "Exchange and Power in Networks of Interorganizational Relations." American Sociological Review 43:721-739.

Cozzens, Susan E., and Thomas F. Gieryn (eds.). 1990. Theories of Science in Society.

Bloomington and Indianapolis, IN: Indiana University Press.

Croll, Elizabeth. 1994. From Heaven to Earth: Images and Experiences of Development in China. London: Routledge.

Croll, Elizabeth, and David Parkin. 1992a. "Anthropology, the Environment and Development." Pp. 3-10 in Bush Base: Forest Farm. Culture, Environment and Development, edited by Elizabeth Croll and David Parkin. London: Routledge.

Croll, Elizabeth, and David Parkin. 1992b. "Cultural Understandings of the Environment." Pp. 11-36 in Bush Base: Forest Farm. Culture, Environment and Development, edited by Elizabeth Croll and David Parkin. London: Routledge.

Daun, James K. 1993. "Oilseeds -- Processing." Pp. 883-935 in Grains and Oilseeds: Handling, Marketing, Processing (4th Ed.), edited by Canada International Grain Institute. Winnipeg: Canadian International Grains Institute.

Delman, Jorgen. 1988. The Agricultural Extension System in China (Network Paper). London: Agricultural Administration Unit, Overseas Development Institute, Agricultural Administration Network.

Deng, Xiaoping. 1978. "Speech at the Opening Ceremony of the National Conference on Science." Pp. 339-448 in White Paper on Science and Technology No. 1: Guide to China's Science and Technology Policy, edited by State Science and Technology Commission. Oxford: International Academic Publishers.

Deo, Shepard D., and Louis E. Swanson. 1991. "Structure of Agriculture Research in the Third World." Pp. 583-612 in Agroecology, edited by C. Ronald Carroll, John H. Vandermeer, and Peter Rosset. New York: McGraw-Hill Publishing Company.

Dong, Wenzhong. 1994. "Hubeisheng Kaifa Youzhi Yousai de Huigu yu Meixiang [Reviews and Thoughts on the Development of Rapeseed for Oil in Hubei Province]." Zhongguo Youliao [Oil Crops in China] 16(2):67-69.

Doyle, Jack. 1985. Altered Harvest: Agriculture, Genetics, and the Fate of the World's Food Supply. New York: Viking Penguin.

Editor and Publisher. 1997. Editor and Publisher 130(32):26.

Edwards, Clive a., Rattan Lal, Patric Madden, Robert Miller, and Gar House. 1990. Sustainable Agricultural System. Deleray Beach: St. Lucie Press.

Elmer-DeWitt, Philip. 1996. "Turning the Tide (Time Man of the Year: David Ho)." Time 148(29):52-55. 30 December 1996.

- Fan, Shenggen, and Philip G. Pardey. 1993. Agricultural Research in China: Its Institutional Development and Impact. The Hague: ISNAR.
- Fan, Tie. Deputy Director, Cereal Oil and Food Research Center. Interview (16 November 1995).
- FAO. 1996. FAO Production Yearbook, 1996. Rome: United Nations.
- Fei, Xiaotong. 1992. From the Soil: The Foundations of Chinese Society. A Translation of Fei Xiaotong's Xiangtu Zhongguo. Berkeley: University of California Press.
- Feyerabend, Paul. 1975. Against Method. London: Verso.
- Feyerabend, Paul. 1978. Science in a Free Society. London: NLB.
- Flora, Cornelia Butler. 1990. "Presidential Address: Rural Peoples in a Global Economy." Rural Sociology 55(2):157-177.
- Foucault, Michel. 1979. Discipline and Punish: The Birth of the Prison. New York: Vintage Books.
- Frank, Andre Gunder. 1972. "The Development of Underdevelopment." Pp. 3-17 in Dependence and Underdevelopment: Latin America's Political Economy, edited by James D. Cockcroft and Dale Johnson. New York: Anchor Books.
- Friedland, William H. 1984. "Commodity Systems Analysis: An Approach to the Sociology of Agriculture." Pp. 221-235 in Research in Rural Sociology and Development. Greenwich, CT: JAI Press, Inc.
- Friedland, William H., and Amy Barton. 1975. Destalking the Wily Tomato (Research Monograph). Davis: Department of Applied Behavioral Sciences, University of California
- Friedland, William H., Amy E. Barton, and Robert J. Thomas. 1981. Manufacturing Green Gold: Capital, Labor, and Technology in the Lettuce Industry. Cambridge, UK: Cambridge University Press.
- Friedmann, Harriet. 1982. "The Political Economy of Food: The Rise and Fall of the Postwar International Food Order." American Journal of Sociology 88(supp):S248-S286.
- Fu, Tingdong. Director, Institute of Crop Genetics and Breeding,. Interview (1 December 1995).
- Fu, Tingdong (ed.). 1995b. Zajiao Youcai-de Yuzhong yu Liyong [Breeding and

- Utilization of Rapeseed Hybrid]. Wuhan: Hubei Kexue Jishu Chubanshe.
- Fuller, Steve. 1988. Social Epistemology. Bloomington, IN: Indiana University Press.
- Gaillard, Jacques, V.V. Krishna, and Roland Waast (eds.). 1997. Scientific Communities in the Developing World. New Delhi, Thousand Oaks, and London: Sage Publications.
- Gaillard, Jacques F. 1992a. "Scientists and Scientific Communities in the Third World" A paper presented at CASID Special Seminars, 4 February 1992, Michigan State University, East Lansing, MI.
- Gaillard, Jacques F. 1992b. Scientists in the Third World. Lexington: University Press of Kentucky.
- Galaskiewicz, Joseph. 1985. "Interorganizational Relations." Annual Review of Sociology 11:281-304.
- Gao, Yongtong. 1991a. "Youcai Yuzhong [Rapeseed Breeding]." Pp. 740-741 in Zhongguo Nongye Baike Quanshu: Nongzuowu-jian Xia [Encyclopedia of Chinese Agriculture: Agricultural Crops, Vol. 2], edited by Zhongguo Nongye Baike Quanshu Bianji-bu. Beijing: Nongye Chubanshe.
- Gao, Yongtong. 1991b. "Youcai Zhongshi Ziyuan [Rapeseed Germplasm Resources]." Pp. 744-746 in Zhongguo Nongye Baike Quanshu: Nongzuowu-jian Xia [Encyclopedia of Chinese Agriculture: Agricultural Crops, Vol. 2], edited by Zhongguo Nongye Baike Quanshu Bianji-bu. Beijing: Nongye Chubanshe.
- Gereffi, Gary, Miguel Korzeniewicz, and Roberto P. Korzeniewicz. 1994. "Global Commodity Chains." Pp. 1-14 in Commodity Chains and Global Capitalism, edited by Gary Gereffi and Miguel Korzeniewicz. Westport, CT: Praeger.
- Giedion, Siegfried. 1975. "Mechanization and the Soil: Agriculture." Pp. 130-256 in Mechanization Takes Command. Boulder, CO: Westview Press.
- Goe, W. Richard, and Martin Kenney. 1991. "The Restructuring of the Global Economy and the Future of U.S. Agriculture." Pp. 137-155 in The Future of Rural America: Anticipating Policies for Constructive Change, edited by Kenneth E. Pigg. Boulder, CO: Westview Press.
- Goldberg, Ray A. 1968. Agribusiness Coordination: A Systems Approach to the Wheat, Soybeans, and Florida Orange Economies. Boston: Harvard University Graduate School of Business Administration.
- Goldman, Merle. 1981. China's Intellectuals: Advise and Dissent. Cambridge: Harvard

University Press.

Goodman, David, and Michael Redclift. 1991. Refashioning Nature: Food, Ecology and Culture. London: Routledge.

Goodman, David, Derrado Sorj, and John Wilkinson. 1987. From Farming to Biotechnology: A Theory of Agro-Industrial Development. Oxford: Basil Blackwell.

Goonatilake, Susantha. 1984. Aborted Discovery: Science and Creativity in the Third World. London: Zed Books, Ltd.

Goonatilake, Susantha. 1992. "The Voyages of Discovery and the Loss and Rediscovery of Others' Knowledge." Impact of Science on Society 42(3):241-264.

HAAS (Hubei Academy of Agricultural Sciences). 1977. "Quanguo Youcai Keyan Xiezu Huiyi Qingkuang Baogao [Report from the National Conference of Rapeseed Research]." in 1977 nien Quanguo Youliao Keyan Xiezu Huiyi Ziliao Huiji [Collection of Meeting Materials from the National Conference of Rapeseed Research], edited by Zhongguo Nongye Kexueyuan. Beijing: Zhongguo Nongye Kexueyuan.

Hagendijk, Rob. 1990. "Structuration Theory, Constructivism, and Scientific Change." Pp. 43-65 in Theories of Science in Society, edited by Susan E. Cozzens and Thomas F. Gieryn. Bloomington and Indianapolis: Indiana University Press.

Hayami, Yujiro. 1975. A Century of Agricultural Growth in Japan. Minneapolis: University of Minnesota Press.

Hayami, Yujiro, and Vernon W. Ruttan. 1990. Agricultural Development: An International Perspective. Baltimore: Johns Hopkins University Press.

Heffernan, William, Douglas Constance, and Robert Gronska. 1993. "Concentration of Agricultural Markets" A paper presented at the Annual Meeting of Rural Sociological Society, August 1993, Orlando, FL.

Heffernan, William D. 1984. "Constraints in the U.S. Poultry Industry." Pp. 237-260 in Research in Rural Sociology and Development, Vol. 1. Greenwich, CT: JAI Press, Inc.

Heffernan, William D., and Douglas H. Constance. 1994. "Transnational Corporations and the Globalization of the Food System." Pp. 29-51 in From Columbus to ConAgra: The Globalization of Agriculture and Food, edited by Alessandro Bonanno, Lawrence Busch, William Friedland, Lourdes Gouveia, and Enzo Mingione. Lawrence: University Press of Kansas.

- Hess, David. 1995. Science and Technology in a Multicultural World: The Cultural Politics of Facts and Artifacts. New York: Columbia University Press.
- Hessen, Boris M. 1968. "The Social and Economic Roots of Newton's 'Principia'." Pp. 31-38 in The Rise of Modern Science: External or Internal Factors?, edited by George Basalla. Lexington, MA: Raytheon Education Company.
- HGK (Ha'erbingshi Geweihui Kejiju). 1972. "Guanyu Jiaqiang Biaozhunhua Gongzuo de Yijian [Opinions on Strengthening Standardization]." Biaozhunhua Tongxun [Standardization Report] 1972(3):3-5.
- Hirschman, Albert. 1958. The Strategy of Economic Development. New Haven: Yale University Press.
- Holden, John, James Peacock, and Trevor Williams. 1993. Genes, Crops and the Environment. Cambridge: Cambridge University Press.
- Hopkins, Terence K., and Immanuel Wallerstein. 1986. "Commodity Chains in the World-Economy Prior to 1800." Review 10(1):157-170.
- Hu, Chu. General Manager, Xishui Grain Oil Supply Company. Interview (2 April 1996).
- Hubeisheng Sipin Siliao Bangongshi. 1992. "Hubei Siliao Gongye [Food Industry in Hubei]." Pp. II37 in Zhongguo Siliao Gongye Nianjian 1991-nian [Food Industry Yearbook of China, 1991], edited by Zhongguo Nongyebu. Beijing: Nongye Chubanshe.
- Hubeisheng Tongjiju. 1985. Hubei Tongji Nianjian 1985 nian [Statistical Yearbook of Hubei, 1985]. Wuhan: Hubeisheng Tongjiju.
- Hubeisheng Tongjiju. 1991. Hubei Tongji Nianjian 1991 nian [Statistical Yearbook of Hubei, 1991]. Wuhan: Hubeisheng Tongjiju.
- Hubeisheng Tongjiju. 1992. Hubei Tongji Nianjian 1992 nian [Statistical Yearbook of Hubei, 1992]. Wuhan: Hubeisheng Tongjiju.
- Hubeisheng Tongjiju. 1993. Hubei Tongji Nianjian 1993 nian [Statistical Yearbook of Hubei, 1993]. Wuhan: Hubeisheng Tongjiju.
- Hubeisheng Tongjiju. 1994. Hubei Tongji Nianjian 1994 nian [Statistical Yearbook of Hubei, 1994]. Wuhan: Hubeisheng Tongjiju.
- Hubeisheng Tongjiju. 1995. Hubei Tongji Nianjian 1995 nian [Statistical Yearbook of Hubei, 1995]. Wuhan: Hubeisheng Tongjiju.

- Hussain, Arthar. 1989. "Science and Technology in the Chinese Countryside." Pp. 223-249 in Science and Technology in Post-Mao China, edited by Denis Fred Simon and Merle Goldman. Cambridge, MA: Harvard University Press.
- Imamura, Jun. Senior Research Scientist, Plantech Research Institute. Interview (July 10 1995).
- Ingold, Tim. 1992. "Culture and the Perception of the Environment." Pp. 39-56 in Busch Base: Forest Farm, Culture, Environment and Development, edited by Elizabeth Croll and David Perkin. London: Routledge.
- Jishu Jianduju. 1989. "Youcaizi [Rapeseed] (GB 11762-89)." Liangyou Biaozhun Ziliao Huibian [Collection of Documents Concerning Grain and Edible Oil Standards]. Guojia Jishu Jianduju. (11 November 1989).
- Jishu Jianduju. 1991. "Siliao Weisheng Biaozhun [Hygienic Standard for Feeds] (GB 13078-91)." Zhonghua Renmin Gongheguo Guojia Biaozhun [National Standards of the People's Republic of China]. Guojia Biaozhunju. (16 July 1991).
- Jishu Jianduju. 1993. "Siliao Biaoqian [Feed Label] (GB 10648-93)." Zhonghua Renmin Gongheguo Guojia Biaozhun [National Standards of the People's Republic of China]. Guojia Biaozhunju. (15 February 1993).
- Johnson, Hillary J. 1997. "Dr. David Ho and the Lazarus Equation: An Inquiry into the Extraordinary Rise of a Young AIDS Scientists and the Long-Term Efficacy of the New Lifesaving Drugs." Rolling Stone no. 755:49-60. 6 March 1997.
- Johnston, Bruce E., and John W. Mellor. 1961. "The Role of Agriculture in Economic Development." American Economic Review 451(4):566-593.
- Juma, Calestous. 1989. The Gene Hunters: Biotechnology and the Scramble for Seeds. Princeton: Princeton University Press.
- Juska, Arunas, and Lawrence Busch. 1994. "The Production of Knowledge and the Production of Commodities: The Case of Rapeseed Technoscience." Rural Sociology 59(4):581-597.
- Juska, Arunas, Lawrence Busch, and Keiko Tanaka. 1997. "The Blackleg Epidemic in Canadian Rapeseed as a 'Normal Agricultural Accident'." Ecological Applications forthcoming.
- Juska, Arunas, and Arthur E. Paris. 1993. "Student Computer Use: Its Organizational Structure and Institutional Support." Collegiate Microcomputer 11(1):42-50.
- Kane, Penny. 1988. Famine in China, 1959-61: Demographic and Social Implications.

London: MacMillan Press.

- Kim, Hyung Kook, and Su-hoon Lee. 1994. "Commodity Chains and the Korean Automobile Industry." Pp. 281-296 in Commodity Chains and Global Capitalism, edited by Gary Gereffi and Miguel Korzeniewicz. Westport: Praeger.
- Kloppenborg, Jack. 1991. "Social Theory and the De/Reconstruction of Agricultural Science: Local Knowledge for an Alternative Agriculture." Rural Sociology 55(4):519-548.
- Knorr-Cetina, Karin. 1981. The Manufacture of Knowledge: An Essay on the Constructivist and Contextual Nature of Science. New York: Pergamon Press.
- Kopytoff, Igor. 1986. "The Cultural Biography of Things: Commoditization as Process." Pp. 64-91 in The Social Life of Things, edited by Arjun Appadurai. Cambridge: Cambridge University Press.
- Korzeniewicz, Miguel. 1994. "Commodity Chains and Marketing Strategies: Nike and the Global Athletic Footwear Industry." Pp. 247-265 in Commodity Chains and Global Capitalism, edited by Gary Gereffi and Miguel Korzeniewicz. Westport: Praeger.
- Korzeniewicz, Roberto P., and William Martin. 1994. "The Global Distribution of Commodity Chains." Pp. 68-91 in Commodity Chains and Global Capitalism, edited by Gary Gereffi and Miguel Korzeniewicz. Westport: Praeger.
- Kueh, Y. Y. 1988. "Food Consumption and Peasant Incomes in the Post-Mao Era." The China Quarterly no. 116:634-670.
- Kuhn, Thomas. 1970. The Structure of Scientific Revolutions. Chicago: The University of Chicago Press.
- Latour, Bruno. 1987. Science in Action. Cambridge, MA: Harvard University Press.
- Latour, Bruno. 1988. The Pasteurization of France. Cambridge, MA: Harvard University Press.
- Latour, Bruno. 1993. We Have Never Been Modern. Cambridge, MA: Harvard University Press.
- Latour, Bruno, Philippe Mauguin, and Genevieve Teil. 1992. "A Note on Socio-Technical Graphs." Social Studies of Science 22:33-57.
- Latour, Bruno, and Steve Woolgar. 1979. Laboratory Life: The Construction of Scientific Facts. Princeton: Princeton University Press.

- Law, John. 1994. Organizing Modernity. Oxford: Blackwell.
- Layton, E. 1977. "Conditions of Technological Development." Pp. 197-222 in Science, Technology and Society: A Cross-Disciplinary Perspective, edited by I. Spiegel-Rösing and D. de Solla Price. London and Beverly Hills: Sage.
- Lee, Naeyoung, and Jefferey Cason. 1994. "Automobile Commodity Chains in the NICs: A Comparison of South Korea, Mexico, and Brazil." Pp. 205-243 in Commodity Chains and Global Capitalism, edited by Gary Gereffi and Miguel Korzeniewicz. Westport: Praeger.
- Lele, Uma. 1975. The Design of Rural Development: Lessons from Africa. Baltimore: Johns Hopkins University.
- Levenstein, Harvey. 1988. Revolution at the Table. New York: Oxford University Press.
- Lewis, W. Arthur. 1954. "Economic Development with Unlimited Supplies of Labor." The Manchester School 22(2):139-191.
- Lewontin, Richard C., and Jean-Pierre Berlan. 1990. "The Political Economy of Agricultural Research: The Case of Hybrid Corn." Pp. 613-628 in Agroecology, edited by C. Ronald Carroll, John H. Vandermeer, and Peter M. Rosset. New York: McGraw-Hill Publishing Company.
- Li, C.C. 1950. "Genetics Dies in China." The Journal of Heredity 41(4):90.
- Li, Jianfan. Professor, Molecular Biology Lab, Institute of Animal Sciences. Interview (8 November 1995).
- Li, Peishan. 1989. "Genetics in China: The Qingdao Symposium of 1956." ISIS 79:227-236.
- Liang, Qinghai, Xingwu Wen, and Ziqing Liu (eds.). 1992a. Dandai Zhongguo Kexue Jishu Zonglan [General Overview of Science and Technology in Contemporary China]. Beijing: Zhongguo Kexue Jishu Chubanshe.
- Liang, Qinghai, Xingwu Wen, and Ziqing Liu. 1992b. "Dang he Guojia Lingdaoren Lun Kexue Jishu [Party and Government Leaders Discuss about Science and Technology]." Pp. 3-40 in Dandai Zhongguo Kexue Jishu Zonglan [General Overview of Science and Technology in Contemporary China], edited by Qinghai Liang, Xingwu Wen, and Ziqing Liu. Beijing: Zhongguo Kexue Jishu Chubanshe.
- Lieberthal, Kenneth, and Michel Oksenberg. 1988. Policy Making in China: Leaders, Structures, and Processes. Princeton, NJ: Princeton University Press.

- Lipton, Michael, and Richard Longhurst. 1989. New Seeds and Poor People. Baltimore: Johns Hopkins University Press.
- Liu, Houli. 1991. "Youcai [Rapeseed]." Pp. 727-731 in Zhongguo Nongye Baike Quanshu: Nongzuowu-jian Xian [Encyclopedia of Chinese Agriculture: Agricultural Crops, Vol. 2], edited by Zhongguo Nongye Baike Quanshu Bianjibu. Beijing: Nongye Chubanshe.
- Liu, Houli. 1994. "Sishi Nianlai Zhongguo Youliao Zuowu (Youcai Bufen) Kexue Yanjiu Dashiji [Major Events in Research in Edible Oil Crops for the Last 40 Years (Rapeseed)]." Pp. 249-253 in Liu Houli Kexue Lunwen Xuanji [Liu Houli: Selected Scientific Treatises], edited by Fu Tingdong. Beijing: Beijing Nongye Daxue Chubanshe.
- Liu, Houli. Professor, Center of Hybrid Rapeseed Research, Institute of Crop Genetics and Breeding. Interview (29 November 1995).
- MacFarquhar, Roderick. 1960. The Hundred Flowers Campaign and the Chinese Intellectuals. New York: Praeger.
- MacFarquhar, Roderick. 1983. The Origins of the Cultural Revolution 2: The Great Leap Forward 1958-1960. New York: Columbia University Press.
- MacIntyre, Alasdair. 1984. After Virtue. Notre Dame, IN: University of Notre Dame Press.
- Marion, Bruce W. 1986. The Organization and Performance of the US Food System. Lexington, MA: Lexington Books.
- Marshall, Eliot. 1993. "Will Profits Override Political Protests?" Science 262(15 October):363.
- Mather, Robin. 1995. A Garden of Unearthly Delights: Bioengineering and the Future of Food. New York: Penguin Books.
- Matson, P.A., W.J. Parton, A.G. Power, and M.J. Swift. 1997. "Agricultural Intensification and Ecosystem Properties." Science 227:504-509.
- McLellan, David. 1977. Karl Marx Selected Writings. Oxford: Oxford University Press.
- Mellor, John. 1990. "Agriculture on the Road to Industrialization." Pp. 70-88 in Agricultural Development in the Third World, edited by Carl K. Eicher and John M. Staatz. Baltimore, MD: Johns Hopkins University Press.
- Meng, Jiling. Professor, Center of Hybrid Rapeseed Research, Institute of Crop Genetics

and Breeding. Interview (15 July 1994).

Meng, Jiling. Professor, Center of Hybrid Rapeseed Research, Institute of Crop Genetics and Breeding. Interview (4 December 1995).

Merton, Robert K. 1973. The Sociology of Science: Theoretical and Empirical Investigations. Chicago: The University of Chicago Press.

Miller, H. Lyman. 1996. Science and Dissent in Post-Mao China: The Politics of Knowledge. Seattle and London: University of Washington Press.

MOA (Ministry of Agriculture). 1992. Report of Rapeseed Project for 1983-91 Beijing: Ministry of Agriculture

Moore, W.F. 1970. "Origin and Spread of Southern Corn Leaf Blight in 1970." Plant Disease Report 54:1104-1108.

Mulkay, Michael. 1991. Sociology of Science: A Sociological Pilgrimage. Bloomington: Indiana University Press.

Murdoch, Jonathan. 1994. "Weaving the Seamless Web: A Consideration of Network Analysis and its Potential Application to the Study of Rural Economy." in Center for Rural Economy Working Paper No. 3 Department of Agricultural Economics and Food Marketing, University of Newcastle upon Tyne.

Needham, Joseph. 1954-96. Science and Civilization in China. Cambridge: Cambridge University Press.

Newsweek. 1995. "Cover: Twenty Seconds of Terror of Kobe. What California Can Learn From Kobe's Disaster." Newsweek 125(5):18-30. January 30.

Niu, Nuofeng, and Fang Chen. 1994. Zhongguo Nongye Keyan Tizhi yu Zhengce Yanjiu [Study on the Chinese Agricultural Research System and Policy]. Beijing: Zhongguo Nongye Kexueyuan Nongye Jingji Yanjiusuo.

Nongyebu. 1989a. "Siliaoyong Caizibing [Rapeseed Meal (Expeller) for Feedstuffs] (GB 10374-89)." Zhonghua Renmin Gongheguo Guojia Biaozhun [National Standards of the People's Republic of China]. Guojia Biaozhunju. (1 September 1989).

Nongyebu. 1989b. "Siliaoyong Caizibo [Rapeseed Meal (Solvent) for Feedstuffs] (GB 10375-89)." Zhonghua Renmin Gongheguo Guojia Biaozhun [National Standards of the People's Republic of China]. Guojia Biaozhunju. (1 September 1989).

Nongyebu. 1989c. Zhongguo Nongye Keji Gongzuo Sishinian [Forty Years of Work in Agricultural Science and Technology in China]. Beijing: Zhongguo Kexue Jishu

Chubanshe.

- Nongyebu. 1991. "Zhonghua Renmin Gongheguo Zhongzi Guanli Tiaoli Nongzuowu Zhongzi Shishi Xize [the Enforcement Rules for Seed of Agricultural Crops under the Seed Management Regulations of the PRC] Zhonghua Renmin Gongheguo Zhongzi Guanli Tiaoli Nongzuowu Zhongzi Shishi Xize [the Enforcement Rules for Seed of Agricultural Crops under the Seed Management Regulations of the PRC]. Nongyebu. (24 June 1991).
- Nongyebu. 1993. Zhongguo Nongye Tongji Ziliao 1992 [Agricultural Statistical Materials in China, 1992]. Beijing: Nongye Chubanshe.
- Nongyebu. 1994. Zhongguo Nongye Tongji Ziliao 1993 [Agricultural Statistical Materials in China, 1993]. Beijing: Nongye Chubanshe.
- Nongyebu. 1995. Zhongguo Nongye Tongji Ziliao 1994 [Agricultural Statistical Materials in China, 1994]. Beijing: Nongye Chubanshe.
- Norgaard, Richard B. 1981. "Sociosystem and Ecosystem Coevolution in the Amazon." Journal of Environmental Economics and Management 8:238-354.
- Norgaard, Richard B. 1994. Development Betrayed: The End of Progress and a Coevolutionary Revisioning of the Future. New York: Routledge.
- O'Connell, Joseph. 1993. "Metrology: The Creation of Universality by the Circulation of Particulars." Social Studies of Science 23:129-173.
- O'Connor, James. 1984. Accumulation Crisis. New York: Basil Blackwell.
- Ogura, Takekazu (ed.). 1970. Agricultural Development in Modern Japan. Tokyo: Fuji Publishing Co., Ltd.
- Oi, Jean C. 1989. State and Peasant in Contemporary China: The Political Economy of Village Government. Berkeley, CA: University of California Press.
- Orleans, Leo A. 1992. "Loss and Misuse of China's Cultivated Land." Pp. 403-417 in China's Economic Dilemmas in the 1990s: The Problems of Reforms, Modernization, and Interdependence, edited by US Congress Joint Economic Committee. New York: M.E. Sharpe.
- Pancho, J.V. 1983. "Plants Poisonous to Livestock in the Philippines [*Chromolaena odorata*, *Lantana camara*, *Pteridium quilimum*]." Kalikasan-Philippine Journal of Plant Pathology 12(3):193-284.
- Perkins, John H. 1990. "The Rockefeller Foundation and the Green Revolution, 1941-

- 1956." Agriculture and Human Values 7(Summer/Fall):6-18.
- Pickering, Andrew. 1992a. "From Science as Knowledge to Science as Practice." Pp. 1-26 in Science as Practice and Culture, edited by Andrew Pickering. Chicago: The Chicago University Press.
- Pickering, Andrewing (ed.). 1992b. Science as Practice and Culture. Chicago: The University of Chicago Press.
- Pigden, W.J. 1983. "World Production and Trade of Rapeseed and Rapeseed Products." Pp. 21-59 in High and Low Erucic Acid Rapeseed Oils, edited by John K.G. Kramer, Frank D. Sauer, and Wallace J. Pigden. Ottawa: Academic Press Canada.
- Pimentel, David, Ulrich Stachow, David A. Takacs, Hans W. Brubaker, Amy R. Dumas, John J. Meaney, John A.S. O'Neil, Douglas E. Onsi, and David B. Corzilius. 1992. "Conserving Biological Diversity in Agricultural/Forestry Systems." BioScience 42(5):354-362.
- Pinch, Trevor. 1993. "'Testing -- One, Two, Three ... Testing!' Toward a Sociology of Testing." Science, Technology, and Human Values 18(1):25-41.
- Pinch, Trevor and Wiebe E. Bijker. 1987. "The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefits Each Other." Pp. 17-50 in The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology, edited by Wiebe E. Bijker, Thomas P. Hughes, and Trevor Pinch. Cambridge, MA: The MIT Press.
- Platt, H.W. (Bud). 1992. "Potato Late Blight." Pp. 93-123 in Plant Diseases of International Importance, edited by H.S. Chaube, J. Kumar, A.N. Mukhopadhyoy, and U.S. Singh. Englewood Cliffs, NJ: Prentice Hall.
- Ploeg, Jan Douwe van der. 1990. Labor, Markets, and Agricultural Production. Boulder, CO: Westview Press.
- Prebisch, Faul. 1963. The Economic Development of Latin America: Toward a Dynamic Development Policy for Latin America. New York: United Nations.
- Qinggongyebu. 1987. Zhongguo Sipin Gongye Nianjian 1986 nian [Food Industry Yearbook of China, 1986]. Beijing: Zhongguo Qinggongyebu Chubanshe.
- Qinggongyebu. 1989. Zhongguo Sipin Gongye Nianjian 1988 nian [Food Industry Yearbook of China, 1988]. Beijing: Zhongguo Qinggongyebu Chubanshe.
- Qinggongyebu. 1990. Zhongguo Sipin Gongye Nianjian 1989 nian [Food Industry

- Yearbook of China, 1989]. Beijing: Zhongguo Qinggongye bu Chubanshe.
- Qinggongye bu. 1991. Zhongguo Sipin Gongye Nianjian 1990 nian [Food Industry Yearbook of China, 1990]. Beijing: Zhongguo Qinggongye bu Chubanshe.
- Qinggongye bu. 1992. Zhongguo Sipin Gongye Nianjian 1991 nian [Food Industry Yearbook of China, 1991]. Beijing: Zhongguo Qinggongye bu Chubanshe.
- Ranis, Gustav, and John C.H. Fei. 1961. "A Theory of Economic Development." American Economic Review 51(4):533-565.
- Renmin Ribao. 1979. "Yiding Yao Gao hao Biaozhunhua [Must Standardize Well]." Biaozhunhua Tongxun [Standardization Report] 1979(3):1-2.
- Richards, Paul. 1985. Indigenous Agricultural Revolution: Ecology and Food Production in West Africa. Boulder: Westview Press.
- Richards, Paul. 1989. "Farmers also Experiment: A Neglected Intellectual Resource in African Science." Discovery and Innovation 1(1):19-25.
- Rogers, Everett. 1983. Diffusion of Innovations. New York: Free Press.
- Ronan, Colin, and Joseph Needham. 1978. The Shorter Science and Civilization in China, vol. 1 (An Abridgement of Joseph Needham's Original Text. Volumes I and II of the Major Series). Cambridge: Cambridge University Press.
- Rouse, Joseph. 1987. Knowledge and Power: Toward a Political Philosophy of Science. Ithaca, NY: Cornell University Press.
- Ruttan, Vernon. 1982. Agricultural Research Policy. Minneapolis, MN: The University of Minnesota Press.
- Ruttan, Vernon W. 1990. "Models of Agricultural Development." Pp. 89-96 in Agricultural Development in the Third World, edited by Carl K. Eicher and John M. Staatz. Baltimore, MD: Johns Hopkins University Press.
- Ruttan, Vernon W., and Yujiro Hayami. 1990. "Induced Innovation Model of Agricultural Development." Pp. 97-112 in Agricultural Development in the Third World, edited by Carl K. Eicher and John M. Staatz. Baltimore, MD: Johns Hopkins University Press.
- SAAS (Sichuan Academy of Agricultural Sciences). 1964. Zhongguo Youcai Zaipei [Rapeseed Cultivation in China]. Beijing: Nongye Chubanshe.
- Saich, Tony. 1989. China's Science Policy in the 80s. Manchester: Manchester University

Press.

- Salick, Jan, and Laura C. Merrick. 1990. "Use and Maintenance of Genetic Resources: Crops and Their Wild Relatives." Pp. 517-548 in Agroecology, edited by C. Ronald Carroll, John H. Vandermeer, and Peter M. Rossett. New York: McGraw-Hill.
- SCAAS, (South Central Academy of Agricultural Sciences). 1951. 1951 Annual Research Plan (Research Plan). Wuhan: Zhongnan Nongye Kexueyuan.
- SCAAS, (South Central Academy of Agricultural Sciences). 1952. 1953-57 Research Plan (Research Plan). Wuhan: Zhongnan Nongye Kexueyuan.
- Schneider, L.A. 1989. "Learning from Russia: Lysenkoism and the Fate of Genetics in China, 1959-1986." Pp. 45-65 in Science and Technology in Post-Mao China, edited by Denis Fred Simon and Merle Goldman. Cambridge, MA: Harvard University Press.
- Science. 1993. "Science in Asia: Asia Puts its Stamp on Science." Science 262(15 Oct.):345-387.
- Shaffer, James D. 1968. A Working Paper Concerning Public Supported Economic Research in Agricultural Marketing Washington, DC: USDA, Economic Research Service
- Shangyebu. 1986. "Caiziyou [Rapeseed Oil] (GB 1536-86)." Zhonghua Renmin Gongheguo Guojia Biaozhun [National Standards of the People's Republic of China]. Guojia Biaozhunju. (6 May 1986).
- Shangyebu. 1987a. "Gaoji Caizi Pengtiaoyou [High-Grade Rapeseed Cooking Oil] (ZBX 14011-87)." Zhonghua Renmin Gongheguo Guojia Biaozhun [National Standards of the People's Republic of China]. Guojia Biaozhunju. (16 March 1987).
- Shangyebu. 1987b. "[Gunny Bag for Packing of Grain] (GB 811-87)." Zhonghua Renmin Gongheguo Guojia Biaozhun [National Standards of the People's Republic of China]. Guojia Biaozhunju. (3 August 1987).
- Shangyebu. 1988. Zhongguo Shangye Nianjian 1988 [Commerce Yearbook of China, 1988]. Beijing: Shangyebu.
- Shangyebu. 1990. Zhongguo Shangye Nianjian 1990 [Commerce Yearbook of China, 1990]. Beijing: Shangyebu.
- Shangyebu. 1992. Zhongguo Shangye Nianjian 1992 [Commerce Yearbook of China, 1992]. Beijing: Shangyebu.

- Shapin, Steven. 1979. "The Politics of Observation: Cerebral Anatomy and Social Interests in the Edinburgh Phrenology Disputes." Pp. 139-178 in On the Margins of Science: The Social Construction of Rejected Knowledge, edited by R. Wallin. Keele: University of Keele.
- Shapin, Steven, and Simon Schaffer. 1985. Leviathan and the Air Pump. Princeton: Princeton University Press.
- Shrum, Wesley, Carl L. Bankston III, and D. Stephen Voss (eds.). 1995. Science, Technology, and Society in the Third World: An Annotated Bibliography. Metuchen, NJ: The Scarecrow Press, Inc.
- Shue, Vivienne. 1988. The Reach of the State: Sketches of the Chinese Body Politics. Stanford, CA: Stanford University Press.
- Sicular, Terry. 1993. "Ten Years of Reform: Progress and Setbacks in Agricultural Planning and Pricing." Pp. 47-96 in Economic Trends in Chinese Agriculture: The Impact of Post-Mao Reforms, edited by Y.Y. Kueh and Robert F. Ash. Oxford: Clarendon Press.
- Sicular, Terry. 1995. "Redefining State, Plan and Market: China's Reforms in Agricultural Commerce." China Quarterly no. 144:1020-1046.
- Simon, Denis Fred. 1992. "China's Acquisition and Assimilation of Foreign Technology: Beijing's Search for Excellence." Pp. 565-598 in China's Economic Dilemmas in the 1990s: The Problems of Reforms, Modernization, and Interdependence, edited by US Congress Joint Economic Committee. New York: M.E. Sharpe.
- Simon, Denis Fred, and Merle Goldman (eds.). 1989. Science and Technology in Post-Mao China. Cambridge, MA: Harvard University Press.
- Singer, H.W. 1950. "The Distribution of Gains between Inventing and Borrowing Countries." American Economic Review 40(May):473-483.
- Solinger, Dorothy J. 1996. "Despite Decentralization: Disadvantages, Dependence and Ongoing Central Power in the Inland -- the Case of Wuhan." The China Quarterly no. 145:1-34.
- Soule, Judy, Danielle Carre, and Wes Jackson. 1990. "Ecological Impact of Modern Agriculture." Pp. 165-188 in Agroecology, edited by C. Ronald Carroll, John H. Vandermeer, and Peter Rosset. New York: McGraw-Hill Publishing Company.
- Soule, Judith D., and Jon K. Piper. 1992. Farming in Nature's Image: An Ecological Approach to Agriculture. Washington, DC: Island Press.

- SSTC (State Science Technology Commission). 1987. White Paper on Science and Technology: Guide to China's Science and Technology Policy. Oxford: International Academic Publisher.
- SSTC, (State Science Technology Commission). 1989. White Paper on Science and Technology: Guide to China's Science and Technology Policy. Oxford: International Academic Publisher.
- Staatz, John M., and Carl K. Eicher. 1990. "Agricultural Development Ideas in Historical Perspective." Pp. 3-38 in Agricultural Development in the Third World, edited by Carl K. Eicher and John M. Staatz. Baltimore, MD: Johns Hopkins University Press.
- Stavis, Benedict. 1978a. "Agricultural Research and Extension Services in China." World Development 6:631-645.
- Stavis, Benedict. 1978b. The Politics of Agricultural Mechanization in China. Ithaca: Cornell University Press.
- Strauss, Anselm. 1978. Negotiations: Varieties, Contexts, Processes, and Social Order. San Francisco: Jossey-Bass.
- Strauss, Anselm. 1990. Qualitative Analysis for Social Scientists. Newbury Park, CA: Sage Publications.
- Suttmeier, Richard P. 1986. "New Directions in Chinese Science and Technology." Pp. 91-102 in China Briefing, edited by John Major. Boulder: Westview Press.
- Suttmeier, Richard P. 1989. "Reform, Modernization, and the Changing Constitution of Science in China." Asian Survey 29(10):999-1015.
- Suttmeier, Richard P. 1992. "China's High Technology: Programs, Problems, and Prospects." Pp. 546-564 in China's Economic Dilemmas in the 1990s: The Problems of Reforms, Modernization, and Interdependence, edited by US Congress Joint Economic Committee. New York: M.E. Sharpe.
- Swanson, Louis E. 1990. "Rethinking Assumptions About Farm and Community." Pp. 19-33 in American Rural Community, edited by A.E. Luloff and Louis E. Swanson. Boulder: Westview Press.
- Tang, Tong B. 1984. Science and Technology in China. London: Longman.
- Taplin, Ian M. 1994. "Strategic Reorientations of U.S. Apparel Firms." Pp. 205-222 in Commodity Chains and Global Capitalism, edited by Gary Gereffi and Miguel Korzeniewicz. Westport: Praeger.

- Time. 1995. "Cover: Killer Quake." Time 145(4):24-36. January 30.
- Timmer, C. Peter, Walter P. Falcon, and Scott R. Pearson. 1983. "Macroeconomic Policies and the Food System." Pp. 215-259 in Food Policy Analysis. Baltimore, MD: John Hopkins University Press.
- Township A. Extension Agent, Agriculture Station. Interview (22 December 1995).
- Township B. General Manager, Grain and Oil Station. Interview (2 April 1996).
- Township C. General Manager, Grain and Oil Station. Interview (3 April 1996).
- Tuan, Francis C. 1993. "The Livestock Sector." Pp. 203-228 in Economic Trends in Chinese Agriculture: The Impact of Post-Mao Reforms, edited by Y.Y. Kueh and Robert F. Ash. Oxford: Claredon Press.
- US Embassy. 23 September 1994. [Online] Vegetable Oil Imports Under Central Control. Available: <http://ffas.usda.gov/ntdb/agwrld/htmlfiles/CH4040.html> [27 July 1996].
- US Embassy. 3 August 1995. Oilseeds and Products [Online]. Available: <http://ffas.usda.gov/ntdb/agwrld/htmlfiles/CH4040.html> [27 July, 1996].
- USDA (United States Department of Agriculture). 1992. Agricultural Statistics of the People's Republic of China. Washington, DC: U.S. Government Printing Office.
- USDC (United States Department of Commerce). 1996. "US Travel to Foreign Countries, With Projections 1985 to 1995." P. 265 in Statistical Abstract of the US 1996: the National Data Book, edited by Economics and Statistics Administration US Department of Commerce, Bureau of the Census. Washington, DC: Government Printing Office.
- Veblen, Thorstein Bunde. 1921. The Place of Science in Modern Civilization. New York: B.W. Huebsch.
- Wallerstein, Immanuel. 1974a. The Modern World System: Capitalist Agriculture and the Origins of the European World Economy in the Sixteenth Century. New York: Academic Press.
- Wallerstein, Immanuel. 1974b. "The Rise and Demise of the World Capitalist System: Concepts for Comparative Analysis." Comparative Studies in Society and History 16:389-415.
- Wallin, J.R. 1970. "Preliminary Investigation of the Southern Corn Leaf Blight Epiphytotic of 1970." Plant Disease Report 54:1129-1130.

- Waltzer, Michael. 1983. Spheres of Justice: A Defense of Pluralism and Equality. New York: Basic Books.
- Wang, Beiyuan. Director of Science Education Department. Interview (21 December 1995).
- Wang, Delu, and Zhenzhen Li. 1986. Thirty Year's Historical Review Over the Policy of "Let the Hundred Flowers Bloom and Let the Hundred Schools Content". Beijing: Journal of Dialectics of Nature Press.
- Wang, Hanzhong. Head, Brassica Genetics and Breeding Department. Interview (11 and 13 July 1994).
- Wang, Lianzheng. 1987. "Diverse Sources of Edible Oils." Pp. 241-251 in Feeding a Billion: Frontiers of Chinese Agriculture, edited by Sylvan Wittwer, Yu Youtai, Sun Han, and Wang Lianzheng. East Lansing: Michigan State University Press.
- Wang, Youping. Officer, Extension Service, Xishui County Office of Agriculture. Interview (21 December 1995).
- Wang, Yinyuan. Senior Agronomist and Chief, the Division of Cereals and Oil Crops. Interview (13 December 1995).
- Wang, Yeu-Farn. 1993. China's Science and Technology Policy: 1949-1989. Aldershot: Avebury.
- Weishengbu. 1985. "Shiyong Zhiwuyou Weisheng Biaozhun [Hygienic Standard for Edible Vegetable Oil] (GB 2716-85)." Zhonghua Renmin Gongheguo Guojia Biaozhun [National Standards of the People's Republic of China]. Guojia Biaozhunju. (26 April 1985).
- Weishengbu. 1986. "Shiyong Jianzha Weisheng Biaozhun [Hygienic Standard for Edible Flying Oil] (GB 7612-86/UDC 613-268)." Zhonghua Renmin Gongheguo Guojia Biaozhun [National Standards of the People's Republic of China]. Guojia Biaozhunju. (9 December 1987).
- Wen, Zimei. Professor, Institute of Nutrition and Food Hygiene, CAPM. Interview (13 November 1995).
- Wen, Z.M., Xu J.K., Fu P., and Dai Y. 1995. "Effect of Rapeseed Oil Observed in Chinese People" A paper presented at Meetings of the Asian Congress of Nutrition, 7-11 October 1995, Beijing.
- Whyte, R.O. 1972. Rural Nutrition in China. Hong Kong: Oxford University Press.

- Wiens, Thomas. 1978. "The Evolution of Policy and Capabilities in China's Agricultural Technology." Pp. 671-703 in Chinese Economy Post-Mao: A Compendium of Papers, edited by US Congress Joint Economic Committee. Washington, DC: Government Printing Office.
- Williamson, Oliver E. 1975. Markets and Hierarchies. New York: Free Press.
- Williamson, Oliver E. 1985. The Economic Institution of Capitalism: Firms, Markets, and Relational Contracting. New York: Free Press.
- Wilson, Suzanne, and Marta Zambrano. 1994. "Cocaine, Commodity Chains, and Drug Politics: A Transnational Approach." Pp. 297-315 in Commodity Chains and Global Capitalism, edited by Gary Gereffi and Miguel Korzeniewicz. Westport: Praeger.
- Wise, M. Norton. 1995a. "Introduction." Pp. 3-13 in The Values of Precision, edited by M. Norton Wise. Princeton, NJ: Princeton University Press.
- Wise, M. Norton (ed.). 1995b. The Values of Precision. Princeton, NJ: Princeton University Press.
- Woolgar, Steve (ed.). 1988. Knowledge and Reflexivity: New Frontiers in the Sociology of Knowledge. Beverly Hills: Sage.
- Woolgar, Steve. 1992. "Some Remarks about Positivism: A Reply to Collins and Yearly." Pp. 327-342 in Science as Practice and Culture, edited by Andrew Pickering. Chicago: The Chicago University Press.
- World Bank. 1985. China: Agriculture to the Year 2000. Annex 2 to China: Long-Term Development Issues and Options. Washington, DC: World Bank.
- World Bank. 1987. China: The Livestock Sector. A World Bank Country Study. Washington, DC: World Bank.
- World Bank, The. 1997. World Development Report 1997: The State in A Changing World. New York: Oxford University Press.
- Yang, Luliang. Researcher, Institute of Feed Research. Interview (14 November 1995).
- Yang, Mayfair Mei-hui. 1994. Gifts, Favors and Banquets: The Art of Social Relationships in China. Ithaca and London: Cornell University Press.
- Zhang, Yingwu (ed.). 1989. Zhongguo Renmin Gongheguo Kexue Jishu Dashiji 1949-99 [Major Events in Science and Technology in the People's Republic of China]. Beijing: Kexue Jishu Wenxian Chubanshe.

Zhao, Quanren, and Ruhui Huang. 1993. Bioazhunhua Fazhanshi. Beijing: Zhongguo Biaoazhun Chubanshe.

Zhongguo Wujiaju. 1993. Zhongguo Wujia Nianjian 1993 [China Commodity Price Yearbook 1993]. Beijing: Zhongguo Wujia Chubanshe.

Zhou, Enlai. 1992 (1963). "Jiancheng Shehui Zhuyi Qiangguo Guanjian Zaiyu Shixian Kexue Jishu Xiandaihua [Key to Build Strong Socialist Nation Lies in Actualizing the Modernization of Science and Technology]." Pp. 77-81 in Dang he Guojia Lingdaoren Lun Kexue Jishu Gongzuo [Speeches of Party and Government Leaders on Science and Technology], edited by Zhonggong Zhongyang Bangongting Diaoyanshi. Beijing: Kexue Chubanshe.

Zhou, Fang. 1987. "Organization and Structure of the National Agricultural Research System in China" A paper presented at the International Workshop on Agricultural Research Management, International Service for National Agricultural Research,, 1987, the Hague.

Zhou, Wenxuan. Director, Oils and Fats Company. Interview (21 December 1995).