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AN INSTITUTIONAL ANALYSIS OF THE MAIZE SEED INDUSTRY IN SOUTHERN AFRICA

By

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ABSTRACT

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Policy makers, farmers, agribusiness managers, and donors are grappling with the difficult problem of how to solve Africa's Ricardian food bottleneck and harness agriculture an engine of economic growth. Under pressure from the International Monetary Fund, the World Bank, and major donors, 30 of the 48 countries in Sub-Saharan Africa are currently implementing structural adjustment and policy reforms to revitalize their economies. Since agriculture employs two thirds of the population in Africa, the ultimate success of these policy reforms hinges on increasing the aggregate supply response of agriculture. Maize is the staple food and the foundation of household and national food security in Southern Africa. Currently, there is a major policy debate over the relative roles of the public and private sectors in increasing maize production, including the role of the state and private companies in the distribution of agricultural inputs. This study reviews the literature on transaction costs and develops a life cycle model of the development of the seed industry. The model is used to analyze the evolution of the maize seed industry in twelve countries, including six in Africa and six in Asia, Europe, North and Latin America.

The study found that the maize seed industry evolves in a path dependent process where the crafting of seed laws and enforcement of quality standards play a strategic role in reducing adverse selection, inducing specialized investments in the seed industry, and increasing the rate of adoption of high-quality seed. Although the ultimate effect of structural

adjustment programs on the performance of the seed industry is unknown at this time, the economic reforms to date have encouraged multinational seed companies to enter the seed industries in Southern Africa and invest in plant breeding, seed production, conditioning, and marketing facilities. The entry of new private seed companies and the formation of public and private strategic alliances have revitalized seed industries in Southern Africa. This revitalization has increased the number of maize hybrids for farmers, improved seed quality and increased the proportion of the maize area planted to certified seed and national average maize yields in South Africa, Zimbabwe, Zambia and Malawi.

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CHAPTER ONE

INTRODUCTION

1.1 Background

Policy makers, farmers, agribusiness managers, and donors in Africa are grappling with the difficult problem of how to reorganize agriculture and harness it as an engine of economic growth. Under pressure from the International Monetary Fund (IMF), the World Bank, and major donors, 30 of the 48 Sub-Sahara African countries are currently implementing structural adjustment programs to revitalize their economies. In most countries, governments are devaluing their currencies, reducing the domestic money supply, and retrenching civil servants (Mosley and Smith, 1989). Also, governments are implementing structural adjustment policies to remove consumption subsidies and production taxes, deregulate agricultural markets, decontrol interest rates and foreign exchange, liberalize trade, and privatize government-owned companies. South Africa adopted "home-grown" economic reforms in the 1980s to liberalize financial markets, decontrol the exchange rate and interest rates, remove subsidies, deregulate agricultural markets, and abolish segregationist Land Acts (Kassier *et al*, 1992).

The various economic reforms that are being pursued under structural adjustment programs are intended to "get prices right" and accelerate economic growth and development. Within the framework of reforms, governments are implementing policies to encourage private sector participation in crop research, variety development, seed production, and marketing in order to speed up the delivery of high-quality varietal and hybrid seed to farmers at competitive prices.[1] For example, as recently as 1991, the seed industries in Zambia and

[1] There are several different types of maize seed that can be supplied to farmers depending on the sophistication of the breeding and production technology and the degree of heterosis achieved: open-pollinated varieties, composites, synthetics, topcross, single cross, double cross, and three way cross hybrids. Single crosses have the highest yield potential followed by double crosses, three-way crosses, topcrosses, synthetics, and varieties.

Malawi were controlled by government monopolies: the Zambia Seed Company and the National Seed Company of Malawi. However, because of political and economic reforms, several multinational seed companies have recently entered the seed markets in these countries.

Maize is the staple food crop in Southern Africa, supplying more than half of the total calorie intake of the average consumer in South Africa, Malawi, Zambia, and Zimbabwe. Maize is the food security and political crop in the region. Increasing productivity in maize production, processing, and distribution can lead to a reduction in the real cost of maize and solve the region's Ricardian food bottleneck, the prerequisite of any structural adjustment program. The maize seed industry has significant opportunities to increase productivity and profitability in maize production by supplying farmers with genetically-improved open-pollinated varieties and hybrids and agronomic technologies from around the world.[2]

1.2 Problem Statement

Because technological and organizational innovations are the principal engine of economic growth, it is important to examine how structural adjustment programs are affecting investments in agricultural research and development and the institutions that govern the commercialization and transfer of new technologies.[3] After more than a decade of structural adjustment lending, analysts still cannot explain large differences in the outcomes of virtually identical structural adjustment policies (de Capitani and North, 1994). It is clear that something is missing in the body of economic theory and the economic models that analysts

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[2] Following Dosi (1982), this study defines technology as pieces of practical knowledge, knowhow, methods, procedures, experience of successes and failures, and physical devices and equipment. But it distinguishes between the technology of production and the technology of organization (Williamson, 1988b).

[3] Commercialization is the process of placing a product into the marketplace and turning it into economic success. Technology transfer is ensuring access to technological knowledge for the production of a product.

currently employ. North (1994) argues that the role of institutions should be incorporated into structural adjustment programs in the years ahead.

In most Southern African countries, structural adjustment reforms are having a traumatic effect on agribusiness firms, government organizations and farmers. For example, in some countries devaluation has increased import and production costs, thereby constraining export growth and the availability of foreign exchange. The reduction in public sector wages is frustrating civil servants and eroding the organizational capability to implement reforms. There is some evidence that across-the-board cuts in government expenditures are unintentionally undermining the institutional foundations for expanding private investments and revitalizing the growth of economies in the region. For example, in 1993 Pioneer Hi-Bred International wrote off some US$ 54 million investments in Nigeria, Cote D'Ivoire, Ethiopia, Sudan, Cameroon, and Zambia because the profit opportunities failed to support its investments, forcing it to shut down operations in some countries and downsize them in others (Pioneer Hi-Bred International, 1993).

One of the critical agricultural policy debates in Southern Africa is the following: What is the mix of public and private sector roles in the seed industry that can achieve the multiple objectives of increasing maize productivity and profitability of smallholder and commercial farmers, the profitability of seed companies, and national food security. Basic information is needed to inform this debate. For example, what are the relative capabilities of public and private organizations to develop, commercialize, and disseminate high-quality seed of locally-adapted, superior maize varieties and hybrids? How can governments, agribusiness firms, and cooperatives develop and manage successful seed businesses that meet the region's growing needs for food and other basic products and services?

This study examines the organization and performance of the maize seed industry in four countries in Southern Africa: South Africa, Zimbabwe, Zambia, and Malawi. The study

focuses on the impact of structural adjustment programs on the organization and performance of the seed industry in meeting the objectives of increasing farmer innovation and profitability, food security, and the profitability of the seed industry.[4] South Africa is included in this comparative study because of its historical role as a supplier of elite germplasm in the region and because it recently became a member of the Southern African Development Community (SADC) that aims to create a free trade area and a common monetary unit among 11 countries in the region.[5]

1.3 Objectives of the Study

The general objective of the study is to analyze the impact of economic policy reforms on the performance of the maize seed industry in four countries in Southern Africa. The specific objectives are to:

1. Develop a conceptual framework for analyzing the performance of the maize seed industry under different institutional arrangements and use the framework to examine the globalization of the maize seed industry in selected industrialized and developing countries;[6]
2. Analyze the economic history of the maize seed industry in Southern Africa from 1900 to 1980; and

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[4] Danagro (1987) and Cromwell (1992) have conducted research on the seed industry in Southern Africa with emphasis on seed supply and demand constraints and structure-conduct-performance issues respectfully.

[5] Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, Swaziland, South Africa, Tanzania, Zambia, and Zimbabwe.

[6] According to North (1990) the separation of institutions from organizations is crucial if one is to get a handle on the dynamics of institutional change. Institutions are the rules of the game and organizations are the players. Institutional arrangements are sets of institutions and organizations that govern the ways in which they can cooperate or compete.

3. Carry out a business strategy analysis of seed firms in South Africa, Zimbabwe, Zambia and Malawi and determine the impact of structural adjustment on the Southern African seed industry from 1980 to 1993 and discuss the implications for policy makers, the seed industry, regional and international organizations.

1.4 Organization of the Study

The study is organized into six chapters. Chapter 1 presents the background to the study, problem statement, and research objectives. Chapter 2 reviews the theoretical work on transaction costs and develops a conceptual framework and a life cycle model for analyzing the impact of institutional and technological change on the economic performance of the seed industry. Chapter 3 examines the globalization of the maize seed industry and investigates the proposition that the transition of the maize seed industry from farmer to farmer exchange of seed to a specialized seed industry requires market signaling which, in turn, is influenced by a path dependent evolution of institutions that support credible commitments to make investments in specific assets. Chapter 4 examines the economic history of the maize seed industry in South Africa, Zimbabwe, Zambia, and Malawi from 1900 to 1980 and tests the consistency of their experiences with the path dependence proposition. Chapter 5 analyzes the impact of structural adjustment in Southern Africa on the strategies that seed companies are using to compete in the seed industry. The chapter investigates the proposition that structural adjustment programs in Southern Africa have created incentives to promote the transition from public sector-dominated maize seed industry to new public and private strategic alliances that have a potential to facilitate market signaling and improve the performance of the seed industry. The final chapter summarizes the results of this study and draws implications for policy and future research.

CHAPTER TWO

LITERATURE REVIEW AND RESEARCH APPROACH

The advent of structural adjustment programs in Sub-Saharan Africa in the early 1980s raised questions about the appropriate roles of public and private organizations in agricultural research and development, commercialization, and the transfer of technology to farmers. Because of the poor performance of parastatals and government organizations, there is a belief that private firms can improve the performance of agricultural input supply systems (Thirtle and Echeverria, 1994). Although there has been substantial research on the impact of structural adjustment programs on grain marketing boards in Africa, there is a large gap in the literature on how input delivery systems have fared under structural adjustment.

This chapter reviews the theoretical work on transaction costs and develops a conceptual framework for analyzing the performance of the maize seed industry under changing institutional arrangements. The conceptual framework is used to derive two propositions about the organization and performance of maize seed industries. The first proposition is that the transition of the seed industry from farmer to farmer exchange of seed through stages of increasing organizational complexity to a specialized seed industry requires market signaling and is shaped by the history of the evolution of political and market institutions. This proposition is investigated by analyzing the economic history of the maize seed industry in selected industrialized and developing countries in Chapter 3 and in four countries in Southern Africa in Chapter 4. The second proposition is that structural adjustment programs in Southern Africa have created incentives to induce changes in the organization of the maize seed industry from the public sector to hybrid organizational arrangements that have a potential to improve economic performance. This proposition is investigated in Chapter 5 by analyzing the strategies of seed firms in South Africa,

Zimbabwe, Zambia and Malawi and the impact of structural adjustment on the Southern African seed industry.

2.1 Literature Review: Transaction Costs

Transaction costs theory began with John Commons and Ronald Coase. Commons (1934) introduced the transaction as the unit of economic analysis. Coase (1937) argued that both the firm and the market are methods of organizing production and that firms replace markets whenever the costs of conducting transactions through the firm are less than the costs of conducting the same transactions through the market.[1] Coase theorized that the costs of administering transactions internally versus the costs of conducting the same transactions through the market determine what the firm buys, produces, and sells. Coase (1960) further argued that economic policy alternatives should be based on a comparative analysis of the institutional arrangement such as the market, government ownership, government regulation, or nonprofit organization that is most cost-effective in undertaking the activity.[2]

Two major strands of research relating transaction costs and institutional and technological development and economic performance build on Coase's contributions.[3] The first strand is represented by Oliver Williamson and it focuses on how transaction costs influence the governances of organizations through make-or-buy decisions, taking the technology and institutions as given (Williamson, 1985a). The second strand is represented by Douglass North and it focuses on how changes in institutions and technologies over time

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[1] According to Williamson (1988a), the argument originally advanced by Coase was a tautology because almost anything could be rationalized by invoking suitably specified transaction costs.

[2] The comparison is between imperfect alternatives and not between an idealized private sector and failing public sector or vice versa.

[3] Williamson (1992) contends that the literature on economic organization is still at a pre-unified state of development and that several well-focused and internally consistent perspectives are needed to inform different sets of problems.

interact with transaction and transformation costs and influence long-term economic performance (North, 1990).

2.1.1 Oliver Williamson

Williamson's approach assumes that people are boundedly rational and opportunistic (Williamson, 1985a). Because of bounded rationality all complex contracts are unavoidably incomplete. Because of opportunism contract as promise is fraught with hazard. To engage in contracts and adapt to disturbances, potential parties require institutional supports that economize on bounded rationality while simultaneously safeguarding the transactions in question against the hazards of opportunism (Williamson, 1993a).

Williamson argues that the variety of ways of organizing economic activities reflects four basic attributes of transactions: the uncertainties to which transactions are subject, the frequency with which they recur, the degree of asset specificity, and the ease of measurement of the performance of contracting parties (Williamson, 1979; 1991a; 1991b).[4] He argues that asset specificity, which is the degree to which transactions are supported by durable and nonredeployable investments, is the major determinant of transaction costs. Asset specificity includes site specificity that results from the need to locate key activities in one place and economize on inventory and transportation expenses; physical asset specificity that results from specialized plant, machinery, and equipment; human asset specificity that results from knowledge, skills, and labor acquired through specialized training and learning-by-doing; dedicated assets that result from investments that are made to supply products to special buyers on a long-term basis; brand name capital that results from investments in reputation; and temporal specificity that results from the need for timely responsiveness by on-site human assets.

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[4] Milgrom and Roberts (1992) consider the connectedness of a transaction to other transactions involving other people as another transaction attribute.

Williamson posits that there are four generic forms of organization: markets; hybrids such as licensing agreements, strategic alliances, and joint ventures; hierarchies; and government bureaus (Williamson, 1990; 1991a; 1991b; 1991c). The forms of governance differ in their incentive structures, administrative costs, ability to adapt to disturbances, and the contract law defining and supporting their organization. Markets have high-powered incentives and low administrative costs; hierarchies and bureaus have low-powered incentives and high administrative costs; and hybrids have intermediate degrees of incentive intensity and administrative costs.[5] Adaptations are autonomous, bilateral or multilateral. Autonomous adaptations require little information and market prices are sufficient statistics to coordinate activities. Bilateral adaptations require coordinated responses between transacting parties to communicate information that cannot be transmitted by market prices. Hierarchies and bureaus evolve as organizational solutions to bilateral adaptability information problems. Multilateral adaptations require both market prices and coordinated responses. Hybrids evolve as organizational solutions to mixed information problems. Markets are supported by classical contract law because classical contract law elicits strong incentive intensity and enables different parties to terminate contracts at negligible cost if there are disputes. Hybrids are supported by neoclassical contract law and excuse doctrine because neoclassical contract law confers flexibility to parties and enables them to deal with unforeseen disturbances and arbitration to resolve any disputes. Hierarchies are supported by forbearance contract law. Forbearance law supports the efficacy of fiat and enables parties to resolve disputes internally and avoid the high costs of going through the courts as all parties are well informed of the

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[5] Markets have high-powered incentives because they align residual rights of control with residual returns of income from assets that remains after all fixed obligations are met (Milgrom and Roberts, 1992). By contrast hierarchies and bureaus have low-powered incentives because the changes in the efforts of workers and managers and public officials have little effect on their compensation. However, hierarchies and bureaus have internal controls that reduce noncooperation and induce greater cooperation compared to markets (Williamson, 1988b; 1991b).

circumstances surrounding the disputes and solutions. Bureaus are supported by civil-service law in combination with administrative law (Williamson, 1990). This is because civil-service and administrative law reduces the hazards of political instability and stabilizes political exchanges.

Williamson argues that the forms of governance are embedded in the institutional environment that defines the politics, laws, and norms. If the institutional environment is unchanging, then the parties to a contract perceive the present and future benefits and costs of alternative forms of governance and choose the technology, prices and institutional arrangements simultaneously by aligning transactions with the governance structures in a discriminating way to economize on the sum of transaction and transformation costs (Williamson, 1991a; 1991b). Williamson (1993b) argues that in the short-run intertemporal changes in institutional environment factors such as uncertainty, security of property rights, contract law regimes and reputation effects shift the comparative costs of governance and induce shifts between the different forms of governance. In the long-run the governance structures and individuals influence the institutional environment through the electoral process and individuals are influenced by the governance structures and institutional environment through learning and social conditioning (Williamson, 1994). The institutional arrangements that minimize transaction and transformation costs evolve because market competition eliminates inefficient forms of organization.[6] Also, the institutional arrangements that minimize transaction and transformation costs may evolve because of careful planning by especially competent management and imitation of successful organization by less successful ones and the growth of efficiently managed organizations and the decline of inefficiently managed ones (Nelson and Winter, 1982)

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[6] Williamson (1987) suggests that inefficient arrangements are eliminated through weak rather than strong-form selection, that is the fitter survive but there is no reason to suppose that they are the fittest in absolute sense.

Williamson's approach has been criticized for overemphasizing the role of transaction cost economizing as a factor explaining different forms of organization and overlooking the role of politics, authority, loyalty, ideology and identification (Dow, 1987; Kay, 1990). Although Williamson's approach provides analytical tools for understanding the implications of specific governance structures for organizing economic activity, it is limited because it fails to explain how institutions are transformed over time and the interdependencies between institutions, transaction costs, and technology (Englander, 1987). Also, the approach is limited because it explains the institutional arrangements that develop in an economy as the ones that are most efficient for governing transactions in that economy. But under nonequilibrium conditions, institutional arrangements that minimize transaction and transformation costs are indeterminate because organizations have strategic alternatives (Robins, 1987). Finally, the approach focuses on institutions of Western capitalist economies and ignores those of other economies (Hamilton and Biggart, 1988).

Williamson (1993b, 1994) contends that the most pressing public policy issue in countries undergoing economic reforms is how to get the institutions right whereupon the prices will largely take care of themselves. He also contends that differences in fundamental political, social and legal rules result in differences in credibility features among countries. Credibility features include two attributes: the degree of investment confidence that results from property laws, the nature of the political process, and the autonomy of the judiciary; and the degree of contractual confidence that results from contract laws, reputation effects, and the competence of the judiciary.

2.1.2 Douglass North

North's approach is based on three assumptions (North, 1984; 1990b). The first is that individuals maximize their own utility. Therefore, if information costs are high, individuals

gain by disobeying the rules that they agree other people obey. The second assumption is that it is costly to specify and enforce rules because commodities have multiple valuable attributes that cannot be perfectly measured to determine when contracts are fulfilled and assess damages to injured parties when contracts are abrogated.[7] The third assumption is that ideology enables people to economize on information costs and form judgements about the fairness and legitimacy of institutional arrangements. Therefore, ideological consensus reduces the transaction costs of defining and enforcing rules while ideological alienation increases transaction costs.

North argues that transaction costs increase during economic development because increasing interdependency, frequency of exchanges, ideological alienation, and complexity of products increase the possibilities of opportunistic behavior. For an economy to realize the gains from trade resulting from the division of labor and specialization, economies of scale and scope, and advanced technology, complex political and market institutions are needed to provide the credible commitment to hold down measurement, contract enforcement and transformation costs in capital and other markets and permit anonymous, impersonal exchange across time and space.[8] The institutions are enforced by reputation effects, informal norms of behavior, and third party policing. For an economy to generate the high productivity levels that characterize high-income countries, a government third party is needed to specify and enforce property rights. North argues that the conditions of low measurement and

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[7] North (1990a) argues that it takes resources to measure the attributes of commodities exchanged and additional resources to define and enforce the contracts embodying the exchange process.

[8] A commitment is credible in the motivational or imperative sense (Shepsle, 1991). A commitment is motivationally credible if it is incentive compatible and the players continue to want to honor agreements at the time of performance. A commitment is imperatively credible if players continue to honor agreements because performance is coerced or discretion is disabled.

enforcement costs are not met in many developing countries and therefore they have high transaction and transformation costs in their factor and product markets.

North suggests that the ability to develop low cost specification of the attributes being exchanged and effective enforcement of agreements depends on the state because it is the polity that specifies the property rights and provides the instruments and resources to enforce contracts. To get the state to become an impartial third party, there needs to be in place a well-specified legal system; and a set of attitudes about honesty, integrity, fairness and justice that encourages people to contract and trade at low transaction costs. He argues that the evolution of polities from single absolute rulers to democratic governments develops third-party enforcement of contracts with an independent judiciary and reduces transaction costs per exchange. However, because the number of exchanges and agency costs increase, the evolution of democracy does not guarantee the development of low transaction cost and efficient markets.

North hypothesizes that markets and institutions change over time because entrepreneurs and members of organizations invest in the knowledge and skills that lead to revised evaluations of opportunities which, in turn, induce the alteration of rules or the gradual revision of informal constraints. The acquisition of skills and knowledge by organizations changes relative prices, technology, and information costs. Fundamental and persistent changes in relative prices result largely from population growth. Changes in information costs result mostly from new technologies inducing organizations to alter their perceptions about the fairness of contracts. Changes in perceptions about the fairness of contracts induce contracting parties to perceive that they could be better off under alternative institutional arrangements. The changes cause incremental changes in institutions through modifications in contracting, implicit contracts, and the basic constitutional framework. However, the changes sometimes occur discontinuously through political conflict and

revolution when incremental changes are blocked by parties benefiting from prevailing institutional arrangements.

North posits that the way institutions evolve over time explains the differing levels of performance between different economies cross-sectionally and longitudinally. This is because institutional innovations have economies of scale and scope, complementarities, and network externalities that make institutional change incremental and path dependent.

Path dependence is defined as a sequence of economic changes in which important influences upon the eventual outcome can be exerted by temporally remote events, including happenings dominated by chance elements rather than systematic forces (David, 1985).[9] The kinds of skills and knowledge perceived to have a high payoff will reflect the incentives embodied in the institutional framework. If the institutional framework provides incentives for productive activities, then increasing returns to institutions will create organizations that will shape the polity to provide rewards for increases in useful knowledge and drive the economy along a path of economic progress. By contrast, if the institutional framework provides incentives for unproductive activities, the economy will stagnate.

North's approach has been criticized for explaining the evolution of institutions as a cognitive process in which individuals and organizations rationally choose institutions over time to minimize transaction and transformation costs. However, the intrinsic uncertainties of technological and institutional innovations make it impossible to choose *ex ante* between plausible alternative paths (Basu, Jones and Schlicht, 1987). Therefore, this approach fails to explain how and why productive and unproductive evolutionary paths emerge and how the paths might be reversed (Poirot, 1993). Field (1981) has argued that it may be impossible to make institutions endogenous within a general equilibrium framework because of the need to

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[9] Path dependent stochastic processes are non-ergodic and do not converge automatically to a fixed-point distribution of outcomes. The concept of path dependence has been rigorously formulated by Arthur (1988, 1989).

appeal to exogenous variables such as taste, technology, endowments, and rules to close the models. Bardhan (1989) has argued the approach does not take into account how power is established and the role that power plays in shaping evolutionary paths and economic performance.

North (1993; 1994) asserts that the most pressing policy issue in countries that are implementing structural adjustment programs is the creation of institutions that provide credible commitment for the development of low cost transactions in capital and other markets. Therefore, the policies that are required for successful structural adjustment programs are different from "getting prices right" by eliminating price and exchange controls. North argues that "getting prices right" achieves the desired consequences only when the are property rights and enforcement systems in place that will produce the competitive conditions that result in low transaction costs markets. The restructuring of property rights requires the creation of formal rules and a judicial system that impartially enforces the rules. North contends that because it takes longer to evolve norms of behavior than to create formal rules, the reconstruction of institutions in countries undergoing structural adjustment programs is going to be a long and uncertain process because of the lack of a heritage of norms underpinning market economies. The key to successful structural adjustment is to create viable polities that will create and enforce adaptively efficient institutional arrangements that induce a variety of alternative technological and organizational solutions to problems.

2.2 The Conceptual Framework

The pioneering work by Williamson, North and others suggests that an analysis of the impact of structural adjustment on the seed industry requires a conceptual framework that captures the unique characteristics of the maize seed industry which shape the ways that it is organized and the factors influencing transaction and transformation costs. A conceptual framework is

also required to capture the role played by market signaling in reducing information asymmetry and the set of market and political institutions that provide the credible commitment necessary for the development of seed markets with low transaction costs.

2.2.1 The Characteristics of the Maize Seed Industry

Five characteristics shape the variety of ways in which the maize seed industry is organized. The first characteristic is that it is based on plant breeding research to improve the inherent productiveness of crops which are extremely complex systems. The heredity of a crop can be improved by simple mass selection, conventional plant breeding, tissue culture, and recombinant DNA, depending on the level of the technology. Modern plant breeding involves the identification of morphological traits and physiological and pathological responses of plants that are important for adaptation, yield and quality, searching for germplasm with the desired traits, combining plants containing the traits and creating improved open-pollinated varieties and hybrids, and testing in order to evaluate the performance of improved varieties and hybrids under the different agronomic and climatic conditions faced by farmers. Because of bounded rationality, plant breeders cannot comprehend the full range of choices of breeding methods that are available to them for improving plant productiveness and they lack an accurate understanding of all the components influencing the performance of different varieties in different environments to reliably design cultivars with traits that are needed in specific growing environments.[10] Plant breeders create improved hybrids by isolating and cross-breeding as many inbreds as possible and evaluating the crosses for desirable traits under a wide range of climates and growing conditions. Thus, maize varieties and hybrids require an enormous amount of selection, selfing, crossing, sib-mating, testing, selection,

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[10] For example, yield is influenced by three groups of components: ear components such as ear length, kernel rows, and weight per kernel; vegetative components such as leaf dimensions, leaf number, and ear placement; and growth dynamics components such as growth and development rates and patterns.

backcrossing, retesting and selection before their performance characteristics are understood well enough to warrant commercial production.[11] Because different varieties usually perform differently in different environments, there are genotype by environment interactions that complicate the selection of the best varieties. The complexity of maize traits and uncertainties involved in the design, cost, and performance of improved cultivars affect the organization of the seed industry because science and technology and public knowledge and proprietary intellectual property are inextricably mixed together, raising special issues about plant variety protection and plant patent policy (Sehgal and Van Rompaey, 1994).

Second, seed products have multiple attributes of quality that are difficult to recognize and measure because they are influenced by physical and physiological factors. Seed quality is reflected in several ways, including varietal purity and trueness-to-type, germination, seedling vigor, physical purity, uniformity in size and phytosanitary standard. Varietal purity and trueness depends on the genetics of the seed and is achieved by multiplying genetically pure foundation seed, isolation of seed crops from related crops, detasseling, and rogueing of off-types. High germination and seedling vigor are achieved by stringent cultural practices such as timely fertilizer application, irrigation, disease control and minimizing mechanical damage during harvesting and conditioning. Physical purity is freedom from weed seed, inert material such as broken seed, chaff, stalk and soil and is affected by the way the seed is harvested, threshed, cleaned, stored, and prepared for sale. Phytosanitary standard is freedom from seed-borne diseases and can be achieved by the stringent selection of uninfected seed and seed treatment. The high costs of measuring seed quality affect the organization of the seed industry because farmers require institutional safeguards to believe the information about seed

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[11] For example, Pioneer Hi-Bred International, the world's largest seed company, creates more than 70,000 experimental hybrids each year at 90 testing stations scattered around the world out of which it commercializes less than a dozen hybrids (Freedman, 1993).

quality provided by seed sellers. Seed suppliers need to establish credibility and long-term relationships with their farmer-customers to obtain repeat business.

Third, research and development investment costs need to be incurred before a new product is ready to be employed by farmers and there are high risks involved in developing new innovations. It normally takes an average of 10 to 15 years to develop and release a new maize hybrid using conventional breeding methods. Furthermore, because proprietary seed products can be easily duplicated, private firms are reluctant to invest in long-term plant breeding unless there are safeguards such as trade secrets, plant variety protection, or plant patents laws to enable them to profit from their investments.

Fourth, because most seed is produced during one season for sale in the next season, the industry is characterized by high inventory costs as a percentage of sales. Also, the biological nature of seed production demands conditions that keep it viable while the geographical dispersion of farmer-customers requires seed suppliers to market a wide assortment of products in different containers. This affects the organization of the seed industry because it is an enormous logistical problem to synchronize inventories from the planting of seed crops through the dockage of seed lots, conditioning, warehousing and storage to the timely delivery of seed lots to widely dispersed farmers at competitive prices.

The fifth characteristic of the seed industry is that activities which add value to seed such as plant breeding, seed production, conditioning, and marketing are connected and cumulative over time because past scientific advances and technologies input into current and future technology development. Because technology development and commercialization depend on inherited organization, management, and marketing capabilities, the seed industry evolves over time in a path dependent way (Arthur, 1988).

2.2.2 Transformation and Transaction Costs in the Seed Industry

The total costs of supplying seed to farmers consist of resources used in transforming inputs into outputs, searching for trading opportunities, trading, and specifying and enforcing property rights. The transformation costs are determined by the technology employed, the quantity and prices of inputs used, economies of scale and scope, capacity utilization and the nature of the experience curve. The transaction costs are determined by the way transactions are organized and the technology employed.[12] The way transactions are organized depends on the transaction costs borne by farmers, domestic seed companies, multinational seed companies and government organizations. In turn, transaction costs depend on whether each of these four actors makes or buys seed value-adding activities such as plant breeding, foundation seed production, seed growing, quality control, conditioning, and marketing.

Farmers' transaction costs depend on whether they make or buy seed. If a farmer makes seed then he incurs transaction costs of acquiring information about the performance of varieties in different environments. If a farmer buys seed then he incurs transaction costs of obtaining and evaluating information about technologies, obtaining quality seed products and complementary inputs, measuring the attributes of seed quality, uncertain prices, timeliness and reliability of supply, and obtaining legal redress if suppliers break contracts.

Similarly, domestic private seed companies' transaction costs depend on whether they make or buy value-adding activities such as research and development, seed production, and marketing. If a firm makes an activity then it incurs transaction costs of acquiring information about seed products that are responsive to the varied needs of farmers in different regions and the technological knowledge for breeding superior cultivars, and producing and marketing seed at quality. The firm also incurs uncertain demand, specialized investments in plant and machinery and personnel to manage operations, principal-agency costs,

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[12] Because production and transaction costs depend on the organization and technology employed, production and transaction costs are not independent in practice.

appropriation of investments in technology by the government, suppliers, buyers and rivals, and uncertain government policies. If a firm buys a activity then it incurs transaction costs from its suppliers, competitors, potential entrants, and substitute products. Suppliers' transaction costs include the costs of finding suppliers of materials; negotiating prices, product quality, and delivery schedules; physical distribution and materials management; measuring performance and enforcing breaches of contract; and unwanted disclosure of trade secrets, particularly genetics. Competitors' transaction costs include the pilfering of trade secrets, uncertain technological change, prices, and value-adding activities. Potential entrants' costs are the same as competitors' costs. Substitutes' costs include uncertainties of apomixis replacing improved varieties and hybrid seed and farmers switching to alternative crops.[13]

Multinational seed companies' transaction costs depend on whether they make or buy value-adding activities. If a multinational makes an activity, then it incurs the same transaction costs as a domestic private seed company. Because multinationality involves multiple markets, legal systems, and currencies, multinationals incur additional costs of acquiring information about several agroclimatic conditions and countries, developing products responsive to different customers in different countries, monitoring and coordinating production tasks among dispersed facilities, transferring technology, information, and financial resources among different divisions, unpredictable exchange rates, and expropriation of assets by governments. Similarly, if a multinational buys a activity, it incurs additional costs of searching for suppliers in different countries, coordinating purchases of inputs, measuring of quality and quantity, uncertain government policies, political, and financial conditions.

The government's transaction costs depend on whether public organizations make seed by directly undertaking the seed value-adding activities or buy seed by contracting with

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[13] Apomixis is a new technology of asexually producing seed that farmers could use to obtain seed from hybrids while retaining the hybrid vigor of the first generation.

private organizations. If the government makes a value-adding activity, then public organizations incur transaction costs of acquiring information about seed products responsive to market needs and scientific and technological knowledge for developing, producing and distributing seed at quality. Also, public organizations incur the transaction costs of cumbersome and time-consuming decision-making procedures; uncertain demand; specialized investments in plant and machinery and personnel to manage operations; and principal-agency costs. If government buys an activity then public organizations incur transaction costs of searching for information, negotiating contracts, monitoring exchanges, and enforcing agreements; the dumping of untested and unadapted cultivars from international sources; the uncertain development of superior varieties and hybrids and production technology because of the lack of profit potential. Public organizations also incur transaction costs of uncertain development of products responsive to the needs of resource-poor farmers; uncertain seed quality, quantity and prices; reduced flow of genetic information; and the uncertainty that the genetic material originating from the country will not be freely available to the country if it is improved through breeding and protected as intellectual property in other countries.

Focusing on the government seed activity buying option, the transaction costs depend on the kind of the legal rules. If the government regulates the seed industry by *caveat emptor* or "buyers beware" rules which do not require seed suppliers to be liable for defective products provided they are truthfully labelled, then simple monitoring activities can produce low transaction costs for government agencies.[14] But the government may incur the costs of providing impartial information to farmers on the relative performance of different varieties and hybrids. If the government regulates the seed industry by *caveat venditor* or "sellers

[14] *Caveat emptor* assumes that all seed suppliers are honest unless proved guilty.

beware" rules which require seed suppliers to be liable for defective products, then complex monitoring activities can result in high transaction costs for government agencies.[15]

There are tradeoffs among the different kinds of transaction and transformation costs in the seed industry. If farmers grow their own seed, transaction costs are low because of the personalized exchanges and repeat contracting but transformation costs are high because the specialization and division of labor, which generates economies of scale and scope in agricultural research and development and production, finance, and marketing, is limited by the extent of the market. If farmers buy seed then transaction costs are high because the increased interdependence, impersonal exchanges, and complexity of products give rise to opportunism but transformation costs are low because specialization and division of labor generates economies of scale and scope and technological innovations that permit the capturing of gains from trade. To summarize, the evolution of the seed industry from farmer to farmer seed exchange to a specialized seed industry requires a set of institutions that can credibly commit farmers, the government, and seed companies to develop seed markets with low transaction costs.

2.2.3 Asymmetric Information and Market Signaling

The major source of transaction costs in the seed industry is asymmetric distribution of information about the attributes of seed products and the identity of market participants. For example, farmers cannot determine the attributes of seed quality through observation at the time of purchase and cannot trust the information provided by seed sellers because the suppliers have incentives to misrepresent their products. Therefore the seed industry is a classic example of a "market for lemons". A seminal analysis of transaction costs by Akerlof (1970) examined the problem of asymmetric information in the market for used cars. Akerlof

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[15] *Caveat venditor* assumes that seed suppliers are dishonest unless proved guilty.

showed that a competitive equilibrium cannot exist in a "lemons" market because adverse selection by the sellers of low-quality goods drives out the sellers of high-quality products. Furthermore, the market may break down even though buyers and sellers can realize the gains from trade. But Wilson (1980) showed that if buyers or sellers set the price, then there is a market equilibrium that is characterized by a distribution of price with excess supply at some or all of the prices. Wilson showed that the presence of adverse selection may give rise to multiple equilibria. The equilibria can be ranked according to the Pareto criterion with higher price equilibria generating higher welfare for market participants. However, the market will not automatically adjust to the Pareto-best equilibrium because sellers with low-quality goods have incentives to misrepresent their products and the welfare effects are ambiguous.

In markets where there is asymmetric distribution of information between sellers and buyers and sellers know more about the products than buyers, the sellers have incentives to signal the quality of goods and the buyers have incentives to observe the signals and infer information about the unobservable characteristics and identity of sellers (Spence, 1974a; 1974b). Spence analyzed this problem in the case of a labor market in which workers invest in education that they use to transmit the marginal productivity of their labor to employers. Employers read the education signals and hire the workers. Spence showed that in markets with signaling there are two types of competitive equilibria: pooling equilibria in which all workers purchase the same education level and there is no signaling; and separating equilibria in which high ability workers purchase education and distinguish themselves from low ability workers who buy no education. Separating equilibria generally Pareto-dominate pooling equilibria but society incurs the cost of firms being able to separate different types of workers. However, if the proportion of low ability workers is small then pooling equilibria can Pareto-dominate separating equilibria because high ability workers invest in signals in

order to distinguish themselves beyond what they would if there was complete information. Therefore the welfare implications of the model are ambiguous.

Cho and Kreps (1987) analyzed Spence's signaling model using noncooperative game theory in the case where different types of workers first learn about their marginal productivity. A worker then moves by choosing an education level and two risk-neutral firms observe the choice of the worker and then bid for his services using Bertrand competition and finally the worker chooses the firm that offers the highest wage. Cho and Kreps found that there are multiple sequential Nash equilibria, including pooling, separating, and semi-separating equilibria in which workers use mixed strategies. They showed that if restrictions are placed on the out-of-equilibrium beliefs of market participants to ensure existence, then the only plausible equilibrium outcome is the separating equilibrium. The separating equilibrium is the Pareto-best equilibrium because the least able type of worker chooses his first best education level while the more able types just invest enough to separate themselves from their less able colleagues. Cho and Kreps demonstrated that signaling plays a very important role in revealing privately-held information and that the pattern of beliefs formed by market participants over time determines whether the market evolves along a pooling or separating equilibrium path.

Because the major source of transaction costs is asymmetric information, the development of low transaction cost seed markets requires a set of market institutions to be in place to provide incentives for high-quality seed suppliers to signal the existence and characteristics of their products and distinguish themselves from low-quality seed sellers. Also, market institutions are essential to prevent low-quality seed sellers from mimicking high-quality seed sellers in order to generate a separating equilibrium path. The required institutions are mutually supporting formal and informal rules that standardize plant breeding methods of measurement, dimensions of varietal performance, and crop variety release

procedures; the knowledge and skills of crop scientists, seed technologists, and extension agents; the minimum acceptable standards of seed quality and licensing of seed sellers; and the norms of seed trade.

Standardizing plant breeding methods of measurement reduce transaction costs by formalizing methods of collecting, conserving plant and evaluating plant genetic resources, testing of breeding materials, and embodying standards of technical performance in the design of trials of new varieties and criteria for releasing new cultivars to farmers. The standards predetermine what people do and ensure that they coordinate their work. Standardization of knowledge and skills reduces transaction costs by imparting uniform scientific and technological information to people for doing certain jobs in organizations through professional and hands-on training. The learned skills are then applied to work and serve as inputs to coordinate different activities.

Standardization of seed quality can be achieved by establishing uniform seed certification standard operating procedures. Seed certification reduces transaction costs by specifying minimum field and laboratory testing standards governing the genetic origin of parent material used to grow seed crops, inspection of seed crops in the field, laboratory testing of seed samples, labelling and sealing of seed lots and having the standards for certified seed recognized in trade laws. Seed certification guarantees farmers that certified seed has been produced according to acceptable standards and corresponds to minimum purity and germination standards. Standardization of the characteristics of seed sellers can be achieved by the licensing of seed traders that reduces transaction costs by eliminating dishonest trading practices, unscrupulous traders and false advertizing. Standardization of norms can be achieved by specialized education that reduces transactions costs by developing

common standards of conduct such as expertise, loyalty, and integrity that can be used to achieve coordination.[16]

The standards can be established and enforced by private or public institutions. Private institutions are based on trust and the threat of bad reputations to ensure that parties to a contract comply with the terms of the agreement. Public institutions are based on the threat of legal action to ensure that the parties to a contract comply with the terms of the agreement. The state legal system has five disadvantages for contract enforcement (Milgrom and Roberts, 1992). The first disadvantage is that the state legal system for contract enforcement relies on general rules that may be poorly tailored for the particular industry where the dispute arises. The second is that the state legal system for contract enforcement involves cumbersome, time-consuming and expensive procedures. The third is that the state's legal rules are based on historical precedents and may be unresponsive to changing technologies. The fourth is that the judges may lack the technical expertise to evaluate industry disputes and may be biased and corrupt, giving rise to costly and random court decisions. The fifth disadvantage is that in international disputes the courts may lack the authority to enforce their decision. Therefore reputation effects can be more effective that the state legal system in supporting credible commitments to make specialized investments essential for the development of the seed industry.

However, private institutions are limited because the perceptions of the parties to a contract about circumstances may conflict and parties to a contract may disagree on what can be done and the effectiveness of alternative courses of action. Kreps (1990) developed multiperiod Prisoners' Dilemma game theoretic models for analyzing repeated contracting between an unchanging buyer and a seller; a series of buyers and an unchanging seller; and a series of buyers and a succession of sellers. Kreps showed that reputation can be supported if

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[16] For example, plant breeders or accountants analyze issues, collect data, and propose solutions in characteristic ways which vary with the norms of their professions.

buyers offer to trust sellers from the outset; the game is played repeatedly with high probability; there are low interest rates and high expected returns to induce sellers to maintain reputations for honesty and attract trading partners; and reputations are capitalized in the market values of firms; and the companies' successors buy the capitalized value of reputation. These conditions are met in the developed seed industries in industrialized countries that are characterized by high market competition, knowledgeable farmers, product performance advantages over competitors, and assured market share growth for companies with high value-added products. Therefore, reputation effects are effective in supporting market signaling. But these conditions are not met in the developing seed industries in developing countries that are characterized by low market competition, unsophisticated farmers, limited market potential, and gross product differences over farmer varieties. Hence, reputation is ineffective in supporting market signaling. Therefore, the transition of the seed industry from farmer to farmer seed exchange through various stages of organizational complexity to a mature seed industry requires a sequence of institutional changes beginning with the specification and enforcement of legal rules by the state in the earlier stages leading to enforcement of rules by reputation effects in the later stages of the development of the industry.

Because market institutions arise out of politics, one needs to understand the way political institutions evolve in order to gain insights into how market institutions evolve and shape the performance of the seed industry. There is growing literature on the interplay between economics, law, organizational structure, and politics.

The positive theory of political institutions asserts that political institutions emerge in the way they do because they solve collective-action and commitment problems and facilitate gains from trade.[17] However, Moe (1990a; 1990b; 1991) has argued that political

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[17] Positive political theory has emerged from the literature on social choice theory which focuses on majority-rule voting and the economics of organization which focuses on institutions as a means of enhancing the gains from exchange. The founding fathers of positive political theory include Downs, Tullock, Buchanan, Riker, and Olson.

institutions are not simply solutions to collective-action problems that facilitate gains from trade because in politics people with different interests engage in a struggle to control and exercise public authority. The winners get to use their temporary hold on public authority to shape the organization of the government and create policies that promote their interests and impose them on the polity as a whole, and the losers have to accept what the winners impose even if the rules make the losers worse off. The way political institutions evolve cannot be understood as minimizing the total transaction and transformation costs because the winners can shift the costs of economic change to the losers. Therefore, political institutions are distinctive and need to be understood on their own terms.

One distinctive feature of political institutions is that they are created by winners to provide themselves with economic benefits and at the same time protect the policies and programs from the political uncertainty that their opponents may gain control to authority in the future and undermine what they will have created. The winners can protect the policies they create from future control by separating politics and administration and insulating the administration in government bureaucracies. The bureaucracies reduce the discretion of future bureaucrats and authorities by specifying in detail what the agencies can do through decision criteria, procedures, timetables, and personnel rules and writing the requirements into formal law that is legally binding and enforceable in the courts. But this bureaucratization burdens public agencies with cumbersome and technically inappropriate rules that undermine their capacity to perform their mandated activities well.[18]

A second feature is that political institutions are created through compromise between opposing political groups and interest groups that are opposed to an agency's mandate will press for structures that undermine its performance. Because politics is unavoidably a process

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[18] Moe suggests that the reduced capability of administrative agencies to perform well is often a reasonable price for today's authorities to pay and ensure that policies and administrative agencies they want have the capacity to survive and continue to generate benefits in an uncertain political future.

of compromise, public agencies will be designed in part by their enemies who want them to fail.

A third feature is that bureaucratization creates a principal-agency relationship between political interest groups and constituents who are principals and the politicians and civil servants who are the agents with the right to make and enforce law. But the relationship between the constituents and bureaucrats is different from a market principal-agency relationship because in politics the politicians and civil servants have the effective authority that they can use to pursue their own interests in ways that may be harmful to interest groups and constituents. Because public officials have considerable discretion to use public authority to pursue their own interests, interest groups and constituents fear the state and fear the president and the governing party who have the most autonomy to act in ways contrary to their interests.

Because political uncertainty, political compromise, and the fear of the state work against effective organization, they create credible commitment difficulties and different political systems generate different institutions to constrain the arbitrary power of the state and allow for the security of property rights necessary for investment in productive assets (Moe and Caldwell, 1994). In a separation of powers system, the authority is divided and checked and groups can protect their interests and solve commitment problems by disabling the discretion of public officials through *ex ante* structures embedded in the law because the multiple vetoes guarantee the durability of deals that are enacted into law. But this results in a government that is buried in bureaucracy.

In a parliamentary system, the power is concentrated in a majority party that has the authority to pass whatever laws it wants. Therefore, formalization into law does not work to protect political interests and solve commitment problems because the governing party has the authority to renege on any political deals it makes and cannot credibly commit future

governments to whatever deals that are struck today. Commitment problems are resolved in informal ways by tying the party's hands to prevent subversion of agreements and guard the performance and accountability of the government. One means of tying the party's hands to help solve the commitment problem is for the party to develop a good reputation that it can faithfully keep its promises. Because the uncertainty in the world generates opportunities for reneging and makes monitoring difficult, reputation needs bolstering. A second means is to design agencies and programs in a way that makes major changes in past political deals costly. This can be achieved to provide short-term protection by fontloading the benefits so that clients will immediately have much to lose if subversion occurs and long-term protection by organizing the clients into groups and distributing benefits as widely distributed so that many people have a material stake (Moe and Caldwell, 1994). The third means is cooptation that incorporates political interest groups in the decision-making and implementation of the government agencies and the ruling party. The groups can protect their interests by directly shaping government action and by investing in specific assets such as experience and knowledge that promote mutual dependence and protect them from the government and its successors reneging on deals made today.

Moe theorizes that the development of political institutions are path dependent because the present and future choices of institutions are shaped by institutions created in the past that structure the roles and powers of the participants. Because political institutions are path dependent, government activities in the seed industry such as plant breeding, trials of new varieties, seed certification and quality control which are aimed at ensuring that farmers obtain high-quality seed depend on the history of the struggle to control and exercise public authority by different interests. Also, the public activities depend on the evolution of protective structures crafted into the political process to guard against political uncertainty due to opposing social groups and the fear of the state due to the autonomy of public officials.

To characterize the dynamic relationships between transaction costs and institutional and technological development and the performance of the seed industry during economic development and generate propositions for empirical analysis, the next section discuses a life cycle model of seed industry development. The model draws on the work by Sah and Stiglitz (1989; 1990), Abernathy and Utterback (1978) and Williamson (1991a; 1991b).

2.2.4 A Life Cycle Model of Seed Industry Development

Consider a market for differentiated maize seed products with M seed suppliers and N farmers. Suppose that farmers are imperfectly informed about the quality of a set of seed products and the identity of the sellers but sellers are well-informed about their products. Furthermore, suppose that there are only two types of seed: high-quality seed with a constant marginal value to the farmer q_1, and low-quality seed with a constant marginal value to the farmer q_2 where $q_2<q_1$. The high-quality seed sellers have incentives to engage in activities that inform farmers about the existence and characteristics of their seed. Suppose that the marginal cost of certifying seed so that farmers credibly believe its attributes and sending a message about the certified seed quality is $c(q_i)$, for $i = 1, 2$ and the proportion of high-quality seed is α. Suppose that the proportion of high-quality seed that is certified is β. Because uncertified seed cannot be distinguished, it is priced according to the average

$$p(\alpha,\beta,q_1,q_2) = \frac{[(1-\beta)\alpha p_1(q_1) + (1-\alpha)p_2(q_2)]}{[(1-\beta)\alpha + (1-\alpha)]},$$ where $p_1(q_1)$ and $p_2(q_2)$ are the pricing

functions of high-quality and low-quality seed respectively which will be equal to the marginal value of the seed to farmers under perfect competition and marked upwards if suppliers have market power.

Should a supplier of high-quality seed certify his seed? If a high-quality seed seller certifies his seed then the marginal return is $p_1(q_1) - c(q_1)$. If a high-quality seed seller does not certify his seed then the return is $p(\alpha,\beta,q_1,q_2)$. Therefore, a high-quality seed seller will certify seed if $p_1(q_1) - c(q_1) > p(\alpha,\beta,q_1,q_2)$. The equilibrium condition is characterized by $p_1(q_1) - p(\alpha,\beta,q_1,q_2) = c(q_1)$. There may exist multiple equilibria and the equilibrium at $\beta = 0$ is a pooling equilibrium in which no seed is certified while the equilibrium at $\beta = 1$ is a separating equilibrium in which all high-quality seed is certified and low-quality is not certified (Figure 2.1).

To allow for differences in signaling costs among seed suppliers, assume that there is a distribution of costs of seed certification $F(c(q_1))$. Then sellers with the lowest certification costs will certify their seed. As more suppliers certify their seed, the price of the uncertified seed is reduced so that the return to certification is increased but the marginal costs of seed certification also increase. The equilibrium is characterized by $F[p_1 - p(\alpha,\beta,q_1,q_2)] = \beta$, where $F^{-1}(\beta)$ is the cost of seed certification at the βth percentile. Thus, there may be a multiplicity of equilibria (Figure 2.2).

As noted by Wilson (1980) the equilibria can be Pareto-ranked. Because one of the multiple equilibria is more socially desirable than the other and the seed industry can get locked in a Pareto-inferior equilibrium, the development of a productive seed industry requires the crafting of a set of political and market institutions to support credible commitments to make investments in specific assets in order to move the system from low level to high level equilibria. For example, seed laws specifying minimum quality standards for certified seed, certification procedures,and a judicial system to detect and punish violators are required to prevent the mimicking of high-quality by low-quality seed suppliers and the quality degeneration that was noted by Akerlof.

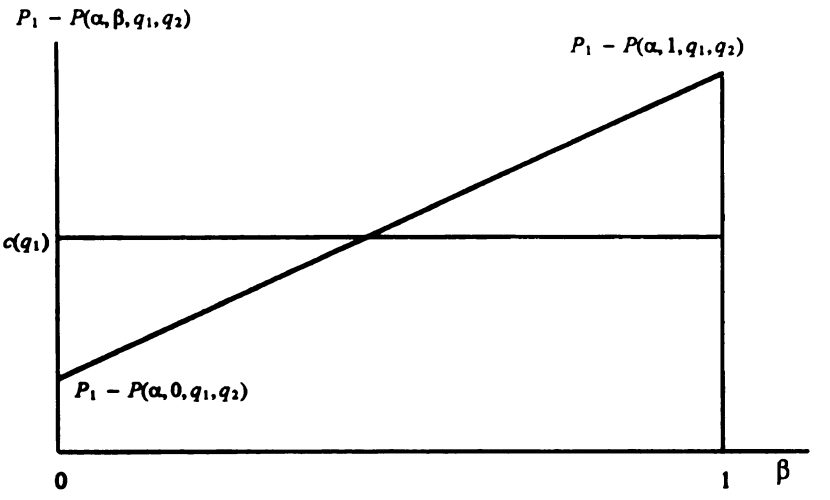

Figure 2.1: Multiple Equilibria with Corner Solutions in a Signaling Model

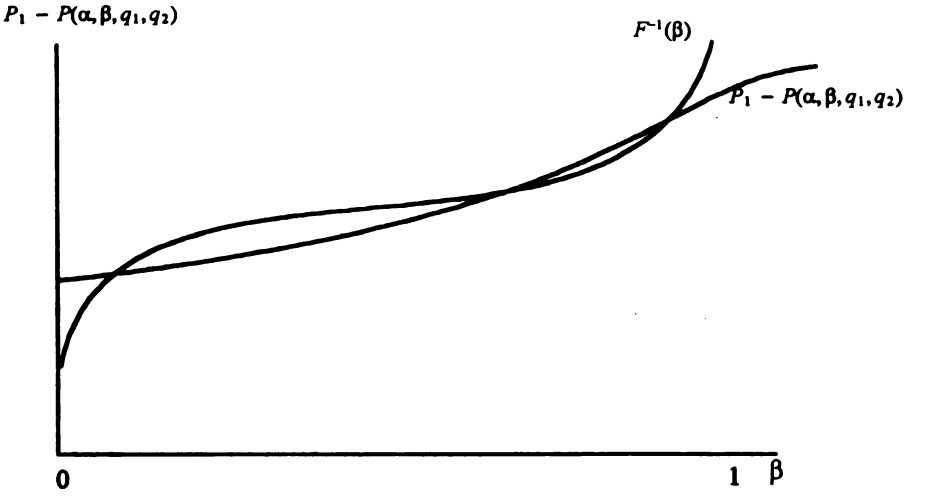

Figure 2-2: Multiple Equilibria With Seed Suppliers Differing in Certification Costs

The effectiveness of the legal system and penalty structure in reducing infractions and lowering transaction costs depends on the kinds of institutions put in place. Indeed, underdeveloped seed industries can be thought of as instances of institutional failure to achieve credible commitments that require restructuring to jump-start seed industry development and move to higher equilibria.

Sah and Stiglitz (1989) have shown that the dynamics which describe the evolution of a market with signaling over time and which determine whether any particular equilibrium is stable or unstable depend on the expectations formation processes. Assuming that different suppliers have different costs of seed certification, suppliers base their decisions about whether or not to certify their seed on expectations about the prices they will receive if they certify or do not certify seed, and expectations are based on current prices of certified and uncertified seed, then the dynamics are given by $F[p_1(q_{1t}) - p(\alpha_t,\beta_t,q_{1t},q_{2t})] = \beta_{t+1}$, where q_{1t} and q_{2t} are the marginal values of different qualities of seed to farmers and α_t and β_t are the proportions of high-quality and certified seed at time t while β_{t+1} is the proportion of seed that is certified at time $t+1$.

Although the market signaling model provides some insights into how seed industries develop over time it is limited for identifying policy interventions to move a seed industry from one equilibrium to a Pareto-superior equilibrium when there is strategic behavior. In most real-life situations, seed suppliers base their decisions on several factors, including the market potential and profitability of producing different qualities of seed, capital requirements, interest rates, input availabilities, competitors' plans, trade barriers, pests and diseases, credit, agricultural policy and political stability. Moreover, seed suppliers are imperfectly informed about the values of these parameters in a given economy. The literature on organizations shows that organizations obtain decision-making information, and make and

implement decisions using standard operating procedures and organizational routines which they learn over time (Nelson and Winter, 1982).[19] Therefore, the dynamics of the evolution of the seed industry are driven by the way organizations learn the routines involved in the development, screening, and adoption of technological and institutional innovations and responding to unforeseen changes in economic, social and political conditions (Schumpeter, 1942; Hayek, 1945).[20]

To better understand the inherently uncertain process by which organizations generate, borrow, adopt, adapt and diffuse new innovations, it is necessary to introduce some strategic management concepts. Several business school analysts have suggested that the evolution of a science-based industry over time follows a life cycle that is driven by three underlying factors: technological innovation, diffusion, and growth of effective demand (Grant, 1991). The life cycle comprises four evolutionary stages that are common to different industries: introduction, growth, maturity, and decline (Figure 2.3). In the introduction stage, new knowledge in the form of product innovation leads to the development of a specialized industry. Because there are a few pioneering firms and customers are not knowledgeable about the products, market penetration is initially slow. During the growth stage, the information about the industry's products diffuses, customers become knowledgeable and experienced, production technology advances, and there is increased market penetration and demand growth. In the mature stage there is widespread diffusion of experience-based information, most customers are knowledgeable and influenced by suppliers' reputations, production technology is sophisticated, and the market becomes saturated and demand growth declines. The industry

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[19] The routines can be of several kinds. Static routines embody the capacity to replicate certain previously performed tasks. Dynamic routines are directed at research and development and new product and process innovations (Teece *et al*, 1994).

[20] According to Schumpeter and Hayek, the problem of economic organization is how to respond to the challenge and opportunity of innovation and unforeseen changes in demand and supply conditions.

may enter a declining phase if it is challenged by new industries that produce technologically-superior substitute products. Grant (1991) has argued that industries which supply basic necessities such as seed, food processing and residential construction are unlikely to enter a declining phase.

Turning to the seed industry, Douglas (1980) has identified four stages of the development of a seed program. During the first stage production practices are traditional, most farmers grow their own seed and exchange seed with a few other farmers. As a result, transaction costs are low in this stage. In the second stage, agricultural research and development emerge and improved varieties of basic food crops begin to replace traditional varieties. A few farmers specialize in seed growing and marketing and transaction costs increase. During the third stage, private seed companies emerge and specialize in the production and marketing of seed. In the fourth stage, commercial seed production and marketing are highly organized. Because seed industries evolve from seed programs, the evolution of the seed industry follows related stages of development: farmer to farmer exchange of seed, emergence, growth, and maturity (Figure 2.4). Thus the evolution of the seed industry follows the standard industry life cycle.

Abernathy and Utterback (1978) have theorized that the pattern of technological innovations depends on where the industry is in its life cycle. They have posited that in the introduction stage product innovations are frequent because firms use a wide variety of strategies to develop technological innovation and employ small-scale general purpose equipment and nonstandardized production processes because demand is not yet sufficient to justify upfront fixed costs in research and development and specialized production plant and equipment. In the introduction stage competition is based on functional product performance among different designs.[21]

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[21] Arthur (1988) shows that the market can lock in on the design that is not the best of available alternatives through small chance events.

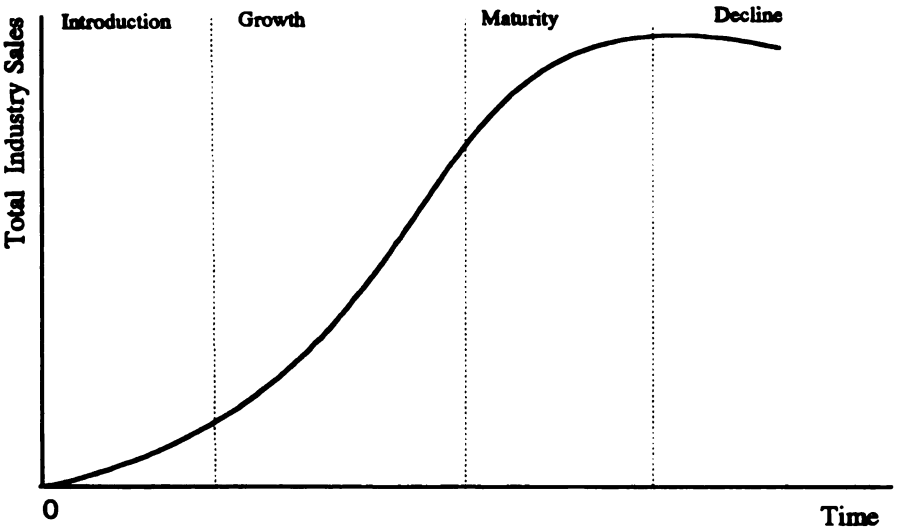

Figure 2.3: The Stages in the Industry Life Cycle

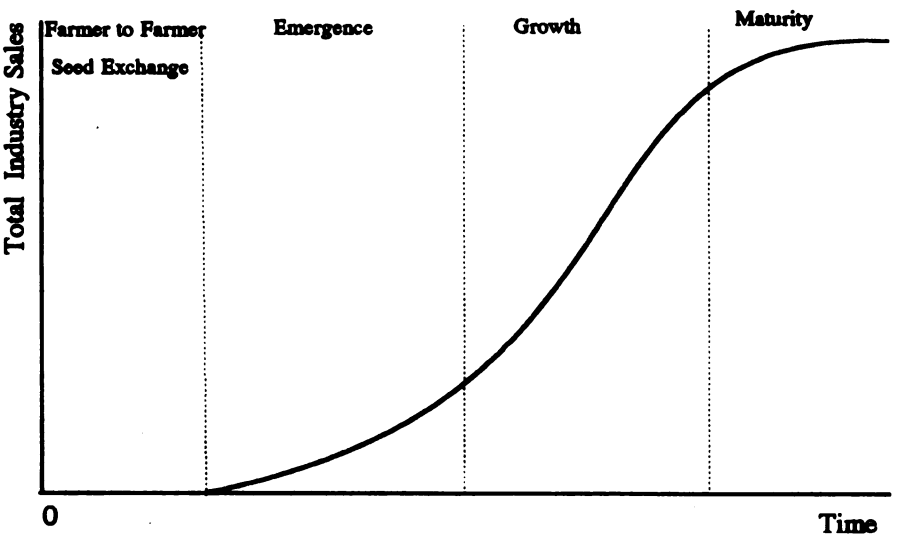

Figure 2.4: The Stages in the Life Cycle of the Seed Industry

As the industry moves into the growth phase, a dominant design emerges after considerable trial and error in the marketplace and there is an increase in process innovations to expand the volume of production and meet the rising demand. The uncertainties in product design and market demand decrease and firms use specialized materials and large-scale special purpose production plant and equipment because they can amortize commitments in investment costs. In the growth phase competition shifts to product differentiation. As the industry enters the mature phase, products and production processes are both standardized to reduce costs and improve quality through exploiting economies of scale and scope and this reduces product and process innovations. Firms use large-scale standardized capital-intensive plant and equipment and production processes. Competition shifts to cost reduction and quality improvement. Figure 2.5 illustrates the pattern of product and process innovations in the industry life cycle posited by Abernathy and Utterback.

In transaction costs terms, there is little to be gained in deploying specialized assets during the early emergence stage because there are frequent product changes, low production volumes, lack of economies of scale, and subordination of price as a competitive factor. However, as a dominant design emerges, market demand grows, production volume increases and opportunities for economies of scale expand, there is a need for specialized research and development facilities, universities, scientists, physical infrastructure, and special purpose production and marketing facilities. Therefore, the transition to growth requires investments in specific assets. Because of the substantial time lags between initial investments in research and development and physical infrastructure and the generation of scientific and technological applications, the specific assets need to be deployed early during the emergence phase. Hence the emergence stage is characterized by increasing levels of asset specificity.

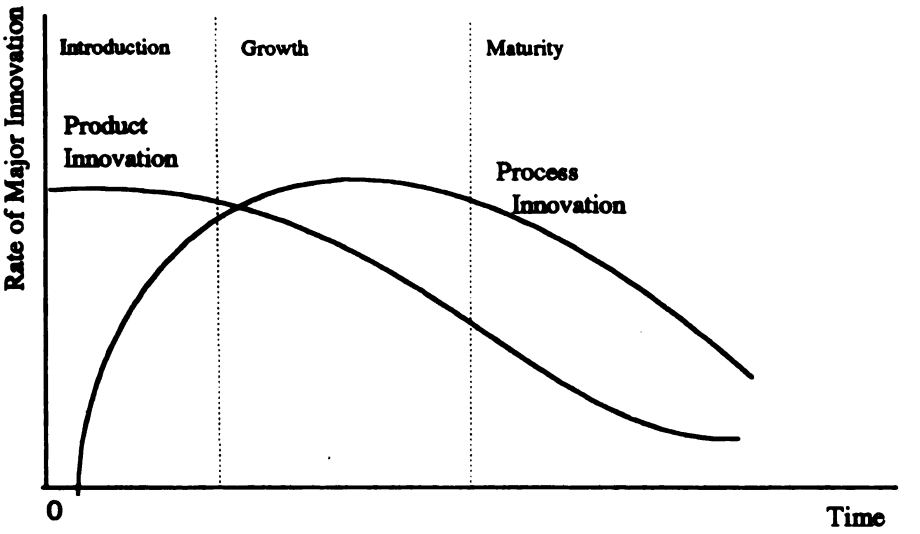

Figure 2.5: Product and Process Innovation in the Industry Life Cycle

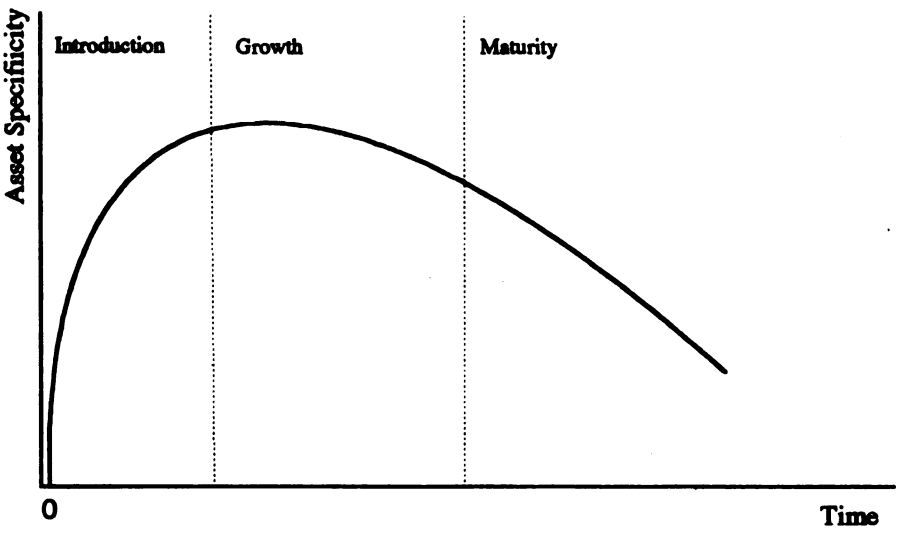

Figure 2.6: The Time Path of Asset Specificity in a Science-Based Industry

As the industry moves from emergence to the growth phase, there is an accumulation of scientific and technological knowledge that reduces technological, market, and financial uncertainties surrounding product innovations. Although firms continue to commit investments in specific assets during the growth stage, the reduction in technological, market, and financial uncertainties reduce the loss in the value of assets incurred to redeploy them to other uses and users. Hence asset specificity declines during the scale-up phase. As the industry matures, market requirements and technological opportunities are well understood and financial uncertainties are further reduced through standardization of products and production processes. Although firms have committed investments in special purpose assets, asset specificity continues to decline because the standardization of products and processes further reduces the difference between acquisition cost and salvage value for idiosyncratic assets since alternative purchase and supply arrangements are easy to work out. Figure 2.6 shows the changing level of asset specificity across an industry life cycle.

Williamson (1991a; 1991b) has demonstrated that the need for transaction-specific assets in an industry generates particular requirements with respect to its pattern of organization. Let $M = M(k)$, $X = X(k)$, $H = H(k)$, and $B = B(k)$ be the reduced form expressions that denote market, hybrid, hierarchy, and government bureau governance costs as a function of asset specificity k. Because governance costs vary inversely with incentive intensity and the intercept for market governance is lower than the intercept for hybrid which in turn is lower than the intercept for hierarchy, $M(0) < X(0) < H(0) < B(0)$. Because markets and hybrids have greater marginal disabilities compared with hierarchies and bureaus in cooperative adaptability respects which increasingly become important as asset specificity increases, $M' > X' > H' > B' > 0$. Transaction costs are kept as low as possible by

operating on the envelope which requires using government bureaus for $k > k_3$, hierarchies for $k_2 < k < k_3$, hybrids for $k_1 < k < k_2$ and markets for $k < k_1$ (Figure 2.7).

Williamson argues that political and legal rules can be treated as a set of parameters, changes in which shift the comparative costs of governance and induce changes between the different forms of organization. Four kinds of parameter changes can be distinguished: uncertainty, security of property rights, contract law, and reputation effects. An increase in uncertainty combined with high asset specificity results in the clustering of transactions under government bureaus because coordinated responses are required to adapt to frequent and highly consequential disturbances and bureaus and hierarchies can use fiat to achieve coordinated responses. By contrast, a reduction in uncertainty results in the clustering of transactions under hybrids and markets because autonomous responses are required to adapt to the infrequent and inconsequential disturbances and hybrids and markets achieve autonomous responses by mutual consent or unilateral action. If property rights can be efficiently assigned and protected from expropriation by the government, rivals, suppliers and customers, then transactions are clustered under private sector governances because private firms and individuals can confidently invest in specific assets and private sector governances provide high-powered incentives for specialized investments in the form of residual profits. By contrast if property rights cannot be efficiently assigned or are arbitrarily reassigned without compensation, then transactions are clustered under government bureaus because the lack of credible government commitment increases the transaction costs of private sector governances. Also, if investments in specialized knowledge cannot be legally protected or if the legal protection is ineffective, then transactions are clustered under hierarchies because hierarchies internalize learning and reduce the risk of leakage of information to suppliers, buyers, rivals and potential entrants.

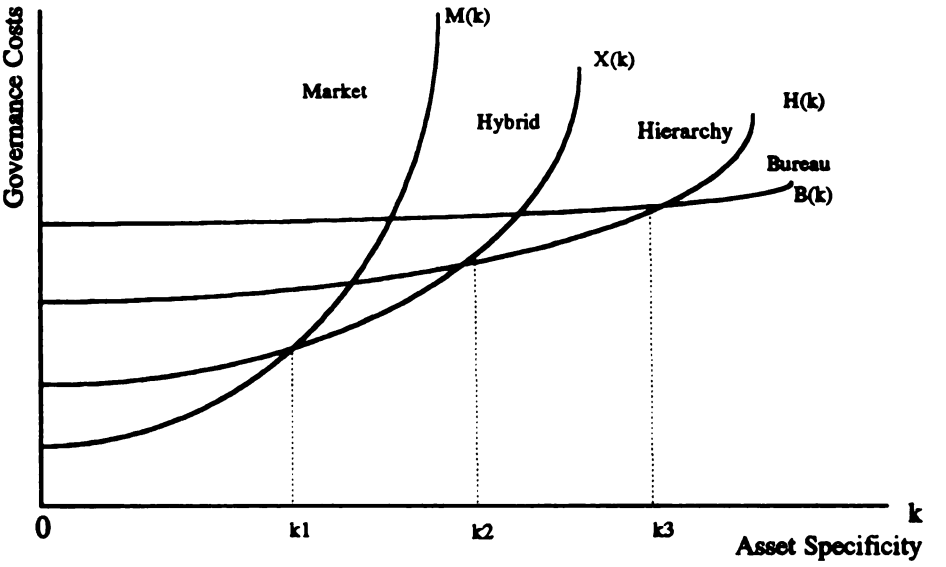

Figure 2.7: Governance Costs as A Function of Asset Specificity

An improvement in a contract law regime such as excuse doctrine reduces the cost of hybrid contracting and increases the use of hybrids compared to hierarchies and markets. By contrast an improvement in forbearance doctrine reduces the costs of hierarchies and increases the use of hierarchies in relation to hybrids and bureaus. Improved reputation effects reduce the incentives to behave opportunistically in trade and lower the costs of hybrid contracting because the hazards of opportunism are greatest for hybrid transactions. Hybrids will therefore increase compared with hierarchies and markets in regimes where reputation effects are important. Because institutional innovations are complementary and different institutional changes are undertaken simultaneously, different parameter shifts often occur together and therefore need to be treated as clusters of organization.

Williamson's framework implies that poor performance of the seed industry largely results from inferior organization and maladapted operations. As technology becomes more complex and as markets increase in size, the best way of organizing the seed industry changes from an informal organization of the farmer to farmer seed exchange stage to predominantly government bureaus in the emergence stage. The transition from farmer to farmer seed exchange to emergence requires institutional preconditions to hold down the costs of obtaining information, negotiating contracts, and enforcing contracts that have been negotiated. The necessary institutional preconditions are a coherent political legislative, administrative and judicial system for resolving the question of whose interests count and how these interests will be articulated through the political system, property ownership rights, laws and regulations. In addition, the transition to emergence requires genetic preconditions, including an elementary science base, the testing, selection, and diffusion of improved varieties. In the growth stage, hybrids and hierarchies are the most cost effective modes of organization because of decreasing technological, market, and financial uncertainties and intermediate asset specificity. The transition from emergence to growth requires the creation of business and

commercial contract law to provide the legal foundations for seed businesses and safeguard commercial seed transactions from trading hazards. In addition, the transition from emergence to growth requires the establishment maize breeding research, testing of varieties from outside the country for possible introduction, generic technologies for commercialization into seed products and infratechnologies to reduce buyer uncertainties and achieve rapid market penetration.[22] Because of low technological, market, and financial uncertainties and moderating asset specificity in the maturity stage, the transaction and transformation cost minimizing modes of organization are hierarchies and hybrids moving towards markets. The institutional preconditions for the transition to maturity require the creation of laws governing intellectual property rights and reputation effect mechanisms to support the legal system of the state. The genetic preconditions for the transition to maturity are proprietary germplasm and technologies.

Table 2.1 summarizes the key problems and innovations during the life cycle of the seed industry. The life cycle model implies that unless special attention is given to creating institutional and genetic preconditions of a specialized, science-based seed industry during the design of structural adjustment programs, economic reforms that focus exclusively on macroeconomic factors such as exchange rates, savings, investment, trade balances, domestic and foreign debt may hinder rather than improve the performance of the seed industry. The life cycle model of the seed industry will be validated by case studies from various maize-producing countries.

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[22] Generic technologies are product concepts that have been shown to work in a laboratory environment. Infratechnologies consist of measurement methods, quality standards, and quality assurance procedures that reduce buyer uncertainty and facilitate rapid market penetration.

Table 2.1: Key Market Problems and Innovations During the Life Cycle of the Maize Seed Industry

	Stage of the Life Cycle			
	Farmer seed exchange	Emergence	Growth	Maturity
Key market problem	Uncertainty of seed quality	Technological uncertainty	Demand and financial uncertainty	Logistics and Intellectual property rights uncertainty
Technological innovations	Testing and selection of varieties	Crop breeding research, Testing of foreign varieties	Generic technologies, Infratechnologies	Proprietary technologies
Organizational innovations	Farmer organizations	Government bureaus predominate	Government bureaus moving towards hierarchies and hybrids	Hierarchies and hybrids moving towards markets
Institutional innovations	Informal habits and customary law	Political legislative, administrative, and judicial structures, Property ownership rights, Laws and regulations	Business and commercial contract law, Trade secrets law	Plant Breeders' Rights, Plant utility patent law, Trademark law, Reputation effect mechanisms

2.3 Theoretical Propositions and Research Methods

Two theoretical propositions about the relationship between technological and institutional change and economic performance flow from this life cycle model of seed industry development for empirical analysis. The first proposition is that the transition of the maize seed industry from farmer to farmer seed exchange through stages of increasing organizational complexity to a specialized seed industry requires market signaling which, in turn, is influenced by a path dependent evolution of institutions that support credible commitments to make investments in specific assets. This path dependence proposition is tested in Chapter 3 by examining anecdotal information, episodic evidence and descriptive statistics of the historical development of the seed industry in two industrial and six developing countries to see whether the results support or refute the proposition. The path dependence proposition is also tested in Chapter 4 by examining anecdotal information, episodic evidence and descriptive statistics of the historical development of the seed industry in South Africa, Zimbabwe, Zambia, and Malawi from 1900 to 1980 and assessing whether the results support or refute the hypothesis.

The second proposition is that structural adjustment programs in Southern Africa have created incentives to shift the public-sector dominated maize seed industry to hybrid organizational arrangements that have a potential to facilitate market signaling and improve the performance of the seed industry. This proposition is tested in Chapter 5 by case studies of the impact of structural adjustment programs on the performance of the seed industry in South Africa, Zimbabwe, Zambia, and Malawi.

2.4 Data Sources

The historical data used for the historical analysis of the maize seed industry in the United States, France, Mexico, Brazil, India, Thailand, Kenya, and Tanzania were obtained from

books, reports, articles, CIMMYT, the Food and Agriculture Organization (FAO), and the United States Department of Agriculture (USDA). The data used for the historical analysis of the maize seed industry in South Africa, Zimbabwe, Zambia, and Malawi from 1900 to 1980 were assembled from archival records, annual reports of the departments of agriculture, research stations, government budget statements, ministries of agriculture, central statistical offices, and personal interviews. The case studies use data that were collected through field interviews between February and November 1993 with representatives of seed companies, seed industry association, and donor agencies, maize breeders, seed technologists, and government policy makers in South Africa, Zimbabwe, Zambia, and Malawi. In addition, secondary data were collected from the annual reports and brochures of seed companies and government organizations.

CHAPTER THREE

THE GLOBALIZATION OF THE MAIZE SEED INDUSTRY

3.1 Introduction

The conceptual framework has portrayed the development of the seed industry as a process of crafting institutions over time that facilitate market signaling and investments in specific assets in the seed industry. This chapter analyzes how eight selected countries have pieced together institutions for the development of seed markets with low transaction costs. Historical information from two industrial and six developing countries will be used to investigate the proposition that the transition of the maize seed industry from farmer to farmer exchange of seed to a mature seed industry requires market signaling which, in turn, is influenced by a path dependent evolution of institutions that support credible commitments to make investments in specific assets in the industry.

The chapter analyzes how different countries have assembled the components of a specialized seed industry into a coherent pattern of organization. The focus is on how various countries developed the political commitment to support agricultural research, legal foundations for specifying and enforcing seed quality standards and contracts in commercial seed transactions, capabilities for high-quality seed production and marketing, and the adoption of improved varietal and hybrid seed by farmers. Each of the case studies has a high proportion of total cereal area planted to maize: the United States, France, Mexico, Brazil, India, Thailand, Kenya and Tanzania.[1]

[1] Although India and Thailand have only 6 and 14 percent respectively of cereal area planted to maize, they are included because they have jump-started seed industries in just two decades.

3.2 United States

Maize was domesticated in Mexico and Central America about seven thousand years ago and introduced into the United States and Canada by Native Americans (Mangelsdorf, 1974). The Native Americans improved maize by mass selection for centuries and developed numerous varieties adapted to the varying agroclimatic conditions in North America. When the European colonists settled in Virginia and Massachusetts and started to cultivate maize in 1608, they inherited varieties and cultural practices that had been developed by Native Americans (Jenkins, 1936).[2]

The watershed event in the development of a seed industry was the establishment of an experimental farm in 1699 by settlers in South Carolina to introduce new varieties and select superior cultivars (Klose, 1950). The first organized effort to use public authority to facilitate agricultural development was the formation of the Philadelphia Society for Promoting Agriculture in 1785 by a group of eminent persons who were mostly engaged in non-agricultural occupations (True, 1895).[3] The founding of the Society was inspired by agricultural societies in Europe and, in turn, stimulated the formation of several agricultural societies in other parts of the United States.[4] About the same time, the first commercial seed company, David Landreth and Son, was founded in Philadelphia (Gilstrap, 1961).

During the early 1800s, agricultural societies began to foster agricultural research and the development of the seed industry. In 1812, John Lorain crossed early-maturing Northern

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[2] Jenkins (1936) cites a 1623 document which reported the efforts of European settlers to improve maize through breeding and improved cultural practices.

[3] The members of the Philadelphia Society included Benjamin Franklin, George Washington, Thomas Jefferson, Robert Livingston, and Noah Webster (McCoy, 1971).

[4] Beginning in 1794, the Philadelphia Society urged the Pennsylvania legislature to incorporate a state society to promote agriculture and set up colleges to teach agricultural science. Two years later, President George Washington urged Congress to establish a federal agency devoted to agriculture. But the Congress failed to take legislative action because of the indifference of farmers and constitutional objections.

flints with high-yielding Southern gourdseed dents and selected superior crosses within the resulting progenies (Wallace and Brown, 1988). The method of crossing different varieties and progeny selection that Lorain and others developed opened up innovative approaches to maize improvement through breeding that were used by successive generations of farmer-breeders to develop the high-yielding varieties of the Corn Belt which provided inbred lines that were used to develop the first hybrids in the United States and other parts of the world.[5]

Although farmer-breeders and agricultural societies made significant progress in developing maize varieties that gradually increased maize yields in the United States, it became clear that plant breeding required considerable time and effort and that it was too costly and risky to be undertaken by individuals. Consequently, agricultural societies and farm leaders began to make demands to the government to create and administer specialized public agencies for carrying out agricultural research, seed distribution, and agricultural education. The lobbying eventually resulted in legislation that created the United States Department of Agriculture and the land grant college system in 1862. In 1883, 35 seed companies established the American Seed Trade Association (ASTA) to lobby on their behalf and promote the interests of the seed industry. In 1887 the government passed the Hatch Act which provided federal support for an agricultural experiment station in each state to carry out agricultural research.

The enactment of legislation authorizing the government to spend money on transaction-specific assets such as universities, experiment stations, seed laboratories, and scientists provided political commitment and continuity and induced researchers to develop public breeding standard operating procedures and generate scientific and technological knowledge which eventually led to the invention and application of hybridization to maize.

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[5] The varieties included Leaming, Reid's Yellow Dent, Lancaster Surecrop, Iowa Silver Mine, Boone County White, Golden Eagle, Hickory King, Champion White Pearl, and Horsetooth. These varieties were transferred to Southern Africa in the early 1900s.

During the 1860s, Charles Darwin began to conduct experiments on cross-fertilization and self-fertilization in plants from which he observed hybridization in maize. While Darwin was investigating breeding in plants, Gregor Mendel carried out experiments on heredity in peas that were brought to the attention of the scientific community in 1900 and inspired the science of genetics which made possible the application of hybridization to maize improvement and seed production. Darwin inspired William Beal to experiment with inbreeding and crossbreeding in maize at the Michigan Agricultural College (Wallace and Brown, 1988). The results of these experiments stimulated scientists at other experiment stations to initiate experiments with hybrids. In 1896 Cyril Hopkins developed the ear-to-row method of breeding pure lines at the Illinois Agricultural Experiment Station that laid down the groundwork for the development of a revolutionary approach of improving maize by developing inbred lines and crossing them into hybrids (Fitzgerald, 1990).

In 1900, researchers at the Illinois Experiment Station helped a group of farmers establish the first maize seed growers' association in the United States, the Illinois Seed Corn Breeders' Association. The goal of the Association was to multiply and distribute breeders' seed developed and released by the station and provide field inspection services to prevent the loss of improved varieties through genetic contamination. The Association encouraged its members to adopt methods for growing varietally pure seed and make demands to the state government to enact legislation to protect pure-bred seed growers and establish a seed inspection bureau with authority to give certificates of seed quality. This spawned the formation of several maize seed breeders' associations and seed-certifying agencies which eventually led to the development of state seed certification programs throughout the United States. The development of seed certifying-agencies was spurred in 1904 when the Congress appropriated funds to the Department of Agriculture to obtain samples of seed offered for sale

to farmers and test them for adulteration and misbranding and publish the names of the seed traders selling adulterated and misbranded seed (Rollin and Johnston, 1961).

As a result of the testing of commercial seed samples that was started in 1904 and the passing of the Adams Act in 1906, which doubled the level of funding for research, the government fostered collaboration between state agricultural experiment stations and seed-certifying agencies. In 1912 the government passed the Seed Importation Act which restricted the importation of low-quality seed of forage plants. In 1914 the government passed the Smith-Lever Act that authorized the United States Department of Agriculture (USDA) to provide agricultural extension through land-grant colleges and establish a framework for collaboration between seed-certifying agencies and the Extension Service. By 1915, more than 26 states had passed seed laws regulating the labelling and sale of seeds and set up official agencies for certifying seed quality based on trueness to type and field inspections and approved methods for harvesting, cleaning, testing, and labelling of each seed lot. In 1919 the different seed-certifying agencies in the United States and Canada formed the International Crop Improvement Association (ICIA) that later shaped the development of uniform standards in North America and other parts of the world.[6]

The development of a national system of agricultural research, teaching, extension, and seed certification spurred the development of the seed industry. Because seed certification embodied cultivar adaptability, varietal and physical purity standards which signaled seed quality to farmers and, at the same time, protected breeders and seed companies

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[6] In 1968 the International Crop Improvement Association was replaced by the Association of Official Seed Certifying Agencies (AOSCA). AOSCA developed minimum standards that provided the foundation for developing a certified international seed industry. The standards governed the definition of classes of seed used in seed certification; eligibility for the certification of varieties; number of generations of seed multiplications; establishment of parent seed sources; prescription of detasselling work; examination of harvested ears; supervision of seed processing; drawing of bagging samples; testing for germination; freedom from obnoxious weed seeds, inert matter; health and vigor testing; and grow-out testing. These are now used in many countries around the world.

from unscrupulous traders selling contaminated varieties as pure seed or under different names, farmers began to buy seed with official seed certification labels exclusively from the members of the maize breeders' associations. As the demand for high-quality seed increased, seed companies were compelled to invest in seed cleaning and testing equipment in order to assure that the seed they bought and sold was of high-quality (Brown, 1916). A few seed companies began to use brand names to signal the quality of their seed products and expand market share. These activities established the foundation for developing a competitive hybrid maize seed industry that was important in turning scientific research findings during the first two decades of this century into commercially successful hybrids.

Around 1900, three scientists, Hugo de Vries, Carl Correns, and Erich von Tschemark, independently rediscovered Mendel's experiments and laid the foundation for the science of genetics. This inspired George Shull in 1905 to initiate experiments on maize genetics at the Carnegie Institution Cold Spring Harbor Experiment Station, New York, which led him to invent a revolutionary method of improving maize by developing and crossing inbred lines into hybrids in 1908. About the same time, Edward East conducted similar experiments at the Connecticut Experiment Station and invented similar techniques for improving maize in 1909. But the inbred lines that were available in the early 1900s were unproductive and the inbred line-crossing methods invented by Shull and East were impractical for commercial seed production. In 1917 Donald Jones working at Connecticut Agricultural Experiment Station invented the double-cross method that made it commercially feasible to produce hybrid seed. But the possibilities of hybrids were untried and uncertain and their acceptance by farmers was unknown.

Because farmers were unaware of the advantages of hybrids, the United States Department of Agriculture, state experiment stations and private breeders launched a vast hybrid breeding program in the early 1920s. In 1921 the first commercial double-cross

hybrid, Burr-Leaming, was released by the Connecticut Experiment Station and turned over to George Carter for multiplication and sale (Crabb, 1947). In 1922 Frederick Richey was put in charge of maize investigations in the Department of Agriculture and began to coordinate the research of different experiment stations into a national program and shift the emphasis of the Department's maize program from open-pollinated varieties to hybrids. The program fostered the development of an informal partnership between public and private organizations engaged in maize breeding that enabled breeders to make more rapid progress in developing high-performing hybrids. Because farmers were unaware of the possibilities of hybrid maize, the experiment stations conducted hybrid maize schools to familiarize them with the new technology (Sprague, 1980).[7]

In the 1920s several entrepreneurs began to experiment with prototype hybrid seed production techniques and facilities for large-scale production of hybrids (Crabb, 1947). The entrepreneurs included Henry Wallace in Des Moines, Iowa; Charlie Gunn, in DeKalb, Illinois; George Allee, in Newell, Iowa; and Lester Pfister, El Paso, Illinois (Hayes, 1963). In 1926 Henry Wallace organized a hybrid seed venture company, the Hi-bred Corn Company that later became the Pioneer Hi-bred Corn Company, to develop, produce, and market hybrids (Crabb, 1947). The formation of Pioneer Hi-Bred inspired several established seed companies, including the DeKalb Agricultural Association, Funk Brothers Seed Company, Pfister, and Northrup King Company, to expand their operations to include hybrids. The experiment stations' breeders assisted seed companies to start hybrid maize seed businesses by making publicly-developed inbred lines available to them without charge.

As hybrid maize was being commercialized in the 1920s, a new legal system of intellectual property rights evolved to govern the ownership of new plant varieties and seed

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[7] In the 1920s the future of hybrid maize was largely speculative because it was uncertain whether hybrids could be developed for the different maturity and ecological zones and whether farmers would give up their age-old custom of saving seed (Sprague, 1980).

sale. The establishment of seed certification programs during the first two decades of this century provided protection for specialized intellectual property investments in new varieties against appropriation by competitors. However, the maize varieties were open-pollinated and farmers could reproduce and sell their seed without compensating the innovators. The emergence of hybrids allowed for the protection of new cultivars by trade secrets laws because plant breeders could keep secret the information about the parents used to produce the inbred lines and the secrecy of the information was protected against appropriation by others.[8] This stimulated seed companies to make investments in transaction-specific research stations, scientists, and seed dealers and develop private breeding standard operating procedures. In 1930, the government passed the Plant Patent Act that extended the framework for the protection of new plant varieties to asexually-propagated varieties other than tuber-propagated plants. But the Plant Patent Act did not include the patenting of sexually-reproduced varieties and hybrids because it was assumed that seed-reproduced cultivars were not uniform and stable across generations (Lerch, 1989).

Although hybrids were first introduced to farmers in 1921, less than one percent of the maize area in the Corn Belt was planted to hybrids in 1931 (Crabb, 1947). The new hybrid maize seed companies faced the difficulty of convincing farmers of the value of hybrids while simultaneously developing prototype production methods and scaling up facilities to commercial levels. During the 1930s, both DeKalb and Pioneer invested heavily in research and development, production, management, and distribution and created unique farmer-dealer contract arrangements that enabled the two companies to quickly dominate the seed industry.[9] Because the farmer-salesman system facilitated field demonstrations of the

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[8] There are 50 trade secrecy laws in the United States and the precautions and circumstances that protect a trade secret are different in different states because there is no federal law on trade secrecy (Schlosser, 1989).

[9] Pioneer Hi-Bred and DeKalb continue to dominate the global seed industry today.

benefits of hybrids to farmers, the demand for hybrid seed increased rapidly. As the demand for hybrids increased, DeKalb and Pioneer developed trademarks and logos and capabilities to exploit economies of scale and scope and quickly expanded into new geographical markets.[10] By 1944, the area planted with seed hybrids had risen to more than 88 percent and by 1964 virtually all the maize area in the United States was planted with hybrids. Four factors coalesced in the 1940s and 1950s to generate the dramatic expansion in the demand for hybrids and the growth of hybrid seed companies (Duvick, 1990a). First, hybrids were profitable to farmers because of the value added by plant breeders. Farmers purchased hybrid seed annually at premium prices sufficient to generate competitive profits after financing research programs and seed production facilities but low enough to allow farmers to receive a satisfactory return in the form of added yield on their investment in the higher seed prices. Second, seed companies were able to protect their specialized assets and superior genetics by keeping secret the inbred parent lines of hybrids. Third, the large domestic market enabled seed companies to cover the overhead costs of setting up and running large-scale operations. The fourth factor was that farmers were forced to purchase new hybrid seed each year, enabling seed companies to generate the cash flow necessary for financing specialized investments in plant and equipment and research and development that in turn allowed companies to develop better-performing hybrids.

Because of the rapid growth of the demand for hybrids during the 1930s and 1940s, there was little price and non-price competition among seed companies. But as the United States market matured in the 1950s, the seed companies began to compete for market share through research and development, better capacity utilization, product differentiation,

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[10] For example, when De Kalb released its first commercial hybrids in 1934, the Association did not have farms for bulking seed and produced its first 8 tons on a farm owned by Tom Roberts, the De Kalb County Farm Bureau adviser. But by 1940, the Association had established farmer-dealers and production and processing centers throughout the Corn Belt and Canada which produced more than 12,700 tons that were planted on more than 10 percent of the total Corn Belt maize area (Crabb, 1947).

packaging, advertizing, and after sales services (Sprague, 1980). The increasing competition and high risk of leaking valued knowhow to competitors led seed companies to integrate upstream into research and development and downstream into seed distribution and sale. The vertical integration, in turn, led to the displacement of many family businesses by hierarchical companies that were more capably organized to exploit economies of scale and scope. Following the discovery of cytoplasmic male sterility in sorghum, DeKalb established a sorghum hybrid breeding program in 1949 and introduced the first sorghum hybrids in 1956. Pioneer similarly established a hybrid sorghum program in the early 1960s and expanded into hybrid sorghum. By the 1970s, DeKalb and Pioneer dominated the hybrid maize and sorghum markets and began to expand hybridization to wheat, sugar beets, and sunflowers.[11]

During the mid-1960s, higher-yielding single and modified single cross hybrids began to replace double crosses in the Corn Belt and seed companies developed higher-yielding inbreds for the production of single and modified crosses (Wallace and Brown, 1988). In 1970 the government enacted the Plant Variety Protection Act (PVPA) in 1970 which exerted four major influences on the development of the seed industry. First, the Act protected transaction-specific assets against appropriation by competitors and stimulated multinational pesticide, pharmaceutical, oil, and food-manufacturing firms to enter the seed industry by acquiring and merging seed companies with strong reputation and brand names (Butler and Marion, 1985).[12] This process increased the horizontal integration in the seed industry and put pressure on companies to raise their profit margins and generate large cash flows for

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[11] Duvick (1990a) reports that although the hybridization of wheat was genetically feasible, the commercialization of the hybrid wheat seed failed because the cost of hybrid seed production was too high and the seed could not be profitably sold.

[12] The entry of multinationals into the seed industry was also driven by the world food shortage in the early 1970s; opportunities for marketing seed on a worldwide basis; emerging genetic-engineering technologies; synergism in the research and marketing for seeds, agricultural chemicals, and fertilizers; and the desire to secure future distribution channels for biotechnology products (Teweles, 1976).

servicing the interest on debt.[13] Second, the Act expanded private breeding to include several self-fertilized crops that were not amenable to large-scale hybridization such as soybeans, cotton, sunflower, and alfalfa. Many new varieties were brought to the marketplace in the late 1970s and early 1980s and promoted by aggressive sales teams and the quality of germplasm improved faster than anytime during the United States history (Studebaker, 1991). Third, the Act stimulated the USDA and state agricultural experiment station to shift from the development of inbred lines and hybrid testing to breeding methodology, population improvement, and basic genetics. By contrast, private breeding programs shifted to varietal and hybrid development and seed detasseling, drying, shelling and processing (Sprague, 1980). As the private breeding programs grew and improved the quality of seed hybrids marketed in the 1960s and 1970s, many states reduced their official certification of hybrid maize seed while seed companies developed private certification programs with higher standards than the official standards (Copeland, 1985). Finally, the Act stimulated the flow of financial and human resources into the seed industry for the development of biotechnology, seed enhancement processes, microbiology, and specialized information and computer technology.[14]

DeKalb and Pioneer and several other United States seed companies entered seed markets in Europe in the 1950s and expanded to Latin America, Asia, and South Africa in the 1960s. This globalization, in turn, induced the development of international uniformity in legal safeguards to protect specialized intellectual property investments in new plant varieties against opportunism around the world and facilitate the international marketing of seed. The

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[13] Multinationals entered the seed industry through acquisitions and mergers because it was cheaper to acquire businesses with strong market positions than engaging in competitive battles to achieve market entry and internal growth. Also, it is difficult for firms to internally develop strategic assets such as brand image, distribution channels, germplasm, trademarks and experienced management (Kent, 1989).

[14] In the late 1970s, private companies greatly expanded investments in biotechnology research and this trend is still continuing (Duvick, 1992c).

developments led to the Convention of Paris in 1961 where seed officials from twelve nations resolved to introduce plant breeders' laws in their countries.[15]

During the 1980s three key events influenced the globalization of the seed industry. The first was the decision by the Supreme Court in 1980 in the *Diamond v. Chakrabarty* case that ruled that micro-organisms were patentable under the utility patent law. The extension of patenting to micro-organisms promoted biotechnology research and development because biotechnological innovations are better protected with utility patents than with plant variety rights.[16] Second, the court decision in the *ex parte Hibberd* court case in 1985 that ruled that plants, plant varieties and hybrids, seeds, tissue cultures, novel genes, traits, and plant transformation processes were patentable under the Plant Patent Law.[17] This decision increased the complexity and the cost of producing and marketing products developed through genetic engineering because new plant varieties could be protected by multiple intellectual property rights owned by different partners. Before transgenic varieties could be commercialized, the participating parties needed to come together and resolve the allocation of the variety's eventual profits (Sehgal and Van Rompaey, 1992). Third, the Federal Technology Transfer Act in 1986 that granted exclusive licensing of publicly-developed plant technologies to private companies and facilitated the formation of formal partnerships between government research agencies, universities and private companies to speed up the flow of

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[15] Later the Paris Convention was formalized as an international treaty, the International Union for the Protection of New Plant Varieties (UPOV), which provided for the protection in member states of new plant varieties that met internationally uniform standards of distinctiveness, uniformity, stability and novelty.

[16] Because farmers cannot legally reproduce and sell seed of patented genes and varieties, seed companies can insist on selling unique, high-value products to farmers through contracts which are specific about the future use of the germplasm.

[17] The United States utility patent law provides broad protection for most agricultural research products: agrichemicals; transgenic plants; cells; genes; DNA sequences; tissue cultures; transgenic seeds; varieties; and host-vector organisms. Moreover, one patent can cover several varieties and their parts and methods for producing them (Duffey, 1992).

research findings from the laboratory to the marketplace.[18] The United States Department of Agriculture has formed research consortia and entered into numerous cooperative research and development agreements with private companies (Tallent, 1993).[19] In addition, most state agricultural experiment stations have established royalty-sharing agreements with their breeders to motivate and retain scientists (Stallman, 1990).

The United States average maize yield began to rise in the 1930s when farmers started to adopt hybrids and has been increasing since that period (Figure 3.1). National maize production also began to rise in the 1930s and continued to trend upwards accompanied by a decline in the aggregate maize area. The close association between the rate of hybrid adoption and the trends in maize yield and production indicates that hybrids had a significant impact on maize yields and total production. A study of comparative yield trials of open-pollinated varieties and hybrids that were widely cultivated in Iowa between 1934 and 1989 revealed that 56 percent of the yield increase was directly attributable to breeding (Duvick, 1992a). The plant breeding improvements of the 1930s spurred the increased use of complementary inputs such as machinery, fertilizers and agrichemicals because farmers were assured that the new cultivars would respond reliably with higher yields (Duvick, 1990b). Griliches (1957; 1960) estimated that the average annual rate of return to public and private investments in maize research in the United States was 35 to 40 percent over the 1940 to 1955 period.

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[18] The Federal Technology Transfer Act also allowed government scientists to protect their inventions with patents and receive royalties and motivated researchers to commercialize research findings.

[19] Several universities have developed portfolios of patents using public funds and are now receiving royalties that they are using to supplement their declining research budgets. The public and private research collaboration provide several benefits, including the sharing of technology equipment, proprietary materials, information for refinement of research that might not have come into the public laboratory, increased employment to society of having new products on the market, and benefits to consumers.

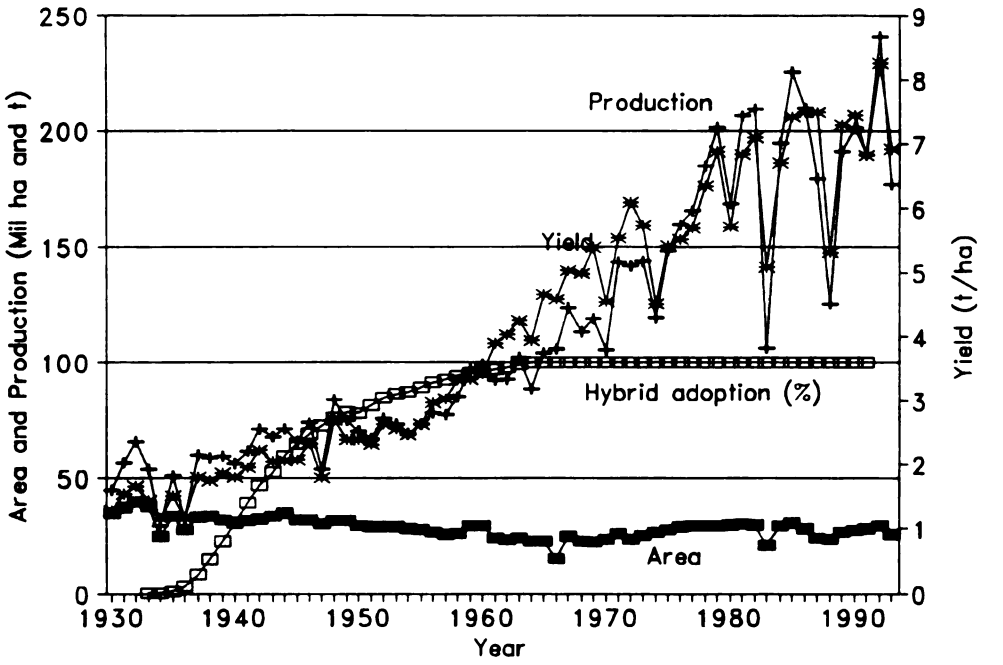

Figure 3.1: Maize Area, Yield, Production and Hybrid Adoption in the United States, 1930-1993
Source: USDA

Today the United States has the world's second largest maize seed industry after China. The industry is in the mature phase of its life cycle and generates more than 550,800 tons in annual seed sales. The major firms in the industry include Pioneer Hi-Bred International which commands a market share of 43 percent, DeKalb Genetics Corporation with a market share of 8 percent, and Garst-Super Crost, Northrup King (ICI Seeds), Cargill Hybrid Seeds, and Asgrow with a combined market share of 17 percent (Pioneer Hi-Bred, 1994). These companies have developed sophisticated and mature maize breeding programs capable of supplying the genetic improvements needed by farmers. Because the seed firms have demonstrated their willingness and commitment to sustain breeding programs and capabilities to supply farmers' needs, they have become accepted as reliable sources of new cultivars. Although private seed companies have assumed most of the responsibilities for maize breeding, seed production and marketing of hybrid and a few varietal crops,

commercial breeding cannot supply the needed genetic improvements of all crops (Duvick, 1990a; 1992b). In response to federal and state budgetary cuts for agricultural research and development, the public research organizations are beginning to charge royalties on publicly-developed germplasm to finance research. Major seed companies are investing in specialized information and computer technology to reduce the costs of coordination and communication.[20] Seed companies are also investing in specialized seed enhancement processes to help farmers better protect and improve the value added to seed, particularly transgenic seed.

The United States had uniquely favorable maize genetic materials and natural resource endowments, a large domestic market, and a strong science and technology base generated in earlier periods in both America and Europe. The political institutions facilitated collective action by farmers that pressured the government to commit investments in agricultural research and development and education which generated new knowledge. Seed-certifying agencies and procedures facilitated the signaling and trade of seed of known quality which, in turn, supported the development of private hybrid maize seed companies in the 1920s. The United States seed companies established world technological leadership in the development and employment of leading edge technologies and scientific management that permitted them to capture the largest share of the world seed trade and dominate seed industries in countries where they established seed businesses. Indeed, seed industry observers predict that by the year 2000, only 12 to 15 mostly United States multinationals and plant biotechnology companies will dominate the most profitable segments of the global seed industry because

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[20] For example, Pioneer Hi-Bred International has invested in a research information system that tracks the performance of more some 70,000 experimental hybrids that the company tests each year at 90 research stations around the world (Freedman, 1993). Pioneer has another information system that tracks some 600,000 farmers in the United States and Canada, including who runs which farms, how many acres they grow of which crop, which company's seed they buy, whether they buy it from a friend or relative, and the yields of Pioneer seed versus the yields of its competitors' seeds.

only multinationals will be in a position to generate the large cash flow that is required to support internationally competitive research programs in classical genetics, microbiology and genetic engineering (Coakley, 1992).[21] With the seed industry becoming more global, multinationals need to market products in as many market as possible and require small companies to carry out the various trade functions, including seed production and marketing.

3.3 France

Maize was first introduced into Europe by Christopher Columbus in 1493 when he returned from his voyage to America. In France, farmers improved maize by mass selection until the beginning of the 19th century when aristocrats and landowners formed agricultural societies to test new crop varieties and disseminate information through agricultural shows and competitions (Cleary, 1989).[22] The first agricultural school was founded privately in 1826 and placed under government control in 1849 (Smith, 1901). In 1876 the National Agronomic Institute was established to train agriculturists, professors of agricultural schools, research administrators, and agricultural engineers. The agricultural societies began to make demands to the government to create a separate public agency to deal with agricultural interests and in 1881 the government established the Department of Agriculture. Because maize was a minor crop and the legislature did not enact legislation authorizing the government to spend money on maize breeding, trials of new varieties and the distribution of

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[21] According to Kent (1989) by the year 2000, global seed companies will typically invest US$ 15 million in plant biotechnology facilities, $10-15 million annually on plant biotechnology research, and more than $15 million annually in classical breeding. Therefore, a seed company will need a minimum revenue of US$ 300-500 million in order to be globally competitive.

[22] For example, in Aveyron the departmental society of agriculture was founded in 1792 by a local aristocrat, Rodat d'Olemps. The society was instrumental in the improvement of pastoral production and introduction of labor-saving machinery.

improved varieties seed to farmers until the 1950s, the Department of Agriculture had little impact on the development of the maize seed industry during the first half of this century.

The watershed event that influenced the transition from farmer to farmer exchange of seed to stages of increasing organizational complexity was the enactment of a seed law in 1905 that prevented fraudulent practices in the trading of foodstuffs and agricultural produce (Organization for European Economic Cooperation, 1954).[23] In 1927 the government passed a specific Seed Act that required mandatory staining of imported clover and lucerne seed which paved the way for compulsory seed testing. In 1932 an Act was passed to regulate the importation of grass seed and a decree that provided for the establishment of an official "Catalogue of Species and Varieties of Cultivated Plants". The seed laws cumulatively influenced the transition to an organizationally complex seed industry by formalizing into law the standards of cultivar adaptability and the production and sale of seed of known quality. This infused trading confidence into seed transactions and increased farmers' awareness of the importance of planting high-quality seed. As a result, farmers began to demand improved varieties seed and the rising demand for high-quality seed stimulated private seed companies such as Vilmorin, Clause, and Deprez and landowners to invest in research stations and scientific personnel for developing superior varieties (Kelly, 1989). The companies multiplied the seed of improved varieties on contract with surrounding farms. Also, breeding syndicates and agricultural cooperatives established contract seed growing among members under the supervision of government plant breeders. Because of the strong development of multipurpose agricultural cooperatives in France, seed growers did not form associations. Hence, the practice of farmers' saving their own seed lasted longer in France than in the United States.

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[23] In 1908 the government passed an Act which prohibited the import of Cuscuta seed and fodder crop seeds with admixtures of Cuscuta.

A turning point occurred in 1942 when the government organized the Permanent Technical Committee for Plant Breeding that developed the regulations governing the entry of new crop varieties into the official catalogue and the seed trade (OEEC, 1954). In 1949 the Committee issued a decree requiring cereal varieties to be recorded in the official catalogue before they could be sold in the country. Also, the Committee required that cereal varieties needed to demonstrate superior characteristics in field trials by the National Institute for Agronomic Research (INRA) for two successive years.[24] In addition, the Committee established compulsory minimum standards for varietal and physical purity, germination capacity, phytosanitary condition, packaging, and labelling of seed lots offered for sale to farmers.

After the Second World War, both public and private maize inbreds and seed hybrids from the United States were introduced in France under the auspices of the United Nations Rural Rehabilitation Administration (UNRRA) under the Marshall Plan from 1948 to 1951 (Moseman, 1970).[25] About the same time INRA scientists launched a hybrid maize breeding program and relied heavily on the techniques and genetic materials that had been developed in the United States in the 1920s.[26] The INRA researchers developed two elite inbreds from locally-adapted varieties that provided half the parentage of most commercial hybrids developed in the country. In the 1950s, several United States agribusinesses, including Pioneer, DeKalb Genetics Corporation, Funk Seed, and Northrup King established research and production agreements and joint ventures with agricultural cooperatives in France. The

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[24] INRA identified the varieties to be tested, the experimental equipment to be used, the location of the variety performance tests and published the results.

[25] Moseman (1970) reports that in 1948 M.T. Jenkins of the USDA coordinated a project supported by the FAO for the first extensive cooperative trials with United states Maize hybrids in Europe. Several maize breeders followed Jenkins in providing technical leadership for hybrid maize adaptive research programs in Europe.

[26] Expenditure by the Ministry of Agriculture rose tenfold in real terms between 1950 and 1979 (Cleary, 1989).

United States hybrids quickly dominated the seed market, particularly in Southern France because the temperate zone agroclimatic condition were similar to those of the maize-growing areas of the United States (Moseman, 1970). In 1958, INRA researchers released a hybrid INRA 258 that helped extend maize production to the northern part of France. During the 1960s, INRA scientists released several early-maturing hybrids that recaptured most of the market from American hybrids. By 1970 INRA hybrids controlled 78 percent of the market (Busch *et al*, 1995).

The enactment of a Plant Breeders' Rights law in 1971 provided protection for novel, distinct, uniform, and stable varieties and hybrids (Pray, 1992). The law facilitated the entry of multinational pesticide, pharmaceutical, oil, and food-manufacturing corporations into the seed industry by acquiring and merging seed companies.[27] Groupe Limagrain expanded through a series of acquisitions and became the third largest seed company in the world after Pioneer Hi-Bred International and Sandoz (Tixier, 1991).[28] In 1973 INRA started to grant exclusive marketing rights to selected seed companies for royalties to expand the French market share of the world seed trade (Busch *et al*, 1995). In 1983 INRA established a foundation seed company, Agri-Obstentions, to sell its products to private seed companies. Recently, GNIS has started to transfer seed certification and control services to the private

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[27] Tixier (1991) reports that two rival agricultural co-operative unions UNCA and UGCAF merged to form SIGMA which formed a joint venture with the seed companies SERASEM and RINGOT. Verneuil formed a strategic alliance with the United States-based company, Dow Elanco-United Seeds, to conduct research focusing on Europe. RAGT, a joint venture with the United States-based DeKalb expanded into the European maize market by acquiring Gruel-Fayer. The Elf-Rustica Sanofi Group acquired equity in Barberet Blanc, Caussade Semences, and Prograin Genetique. Also, the Elf-Rustica Sanofi Group expanded into Spain by acquiring equity in ARLESA; Canada by controlling King Agro; the United States by taking over Dahlgren; and the former Soviet Union by forming the SOVFRANCE HYBRIDES joint venture.

[28] With seed sales of US $ 511 million in 1992, Limagrain was the third largest company in the global seed industry after Pioneer Hi-Bred (US) and Sandoz (Switzerland), which had sales revenues of US $ 1, 200 million and US$ 700 million, respectively (Seed World, 1993).

sector and now employs seed inspectors from the private sector for only three months during the year instead of maintaining permanent staff.

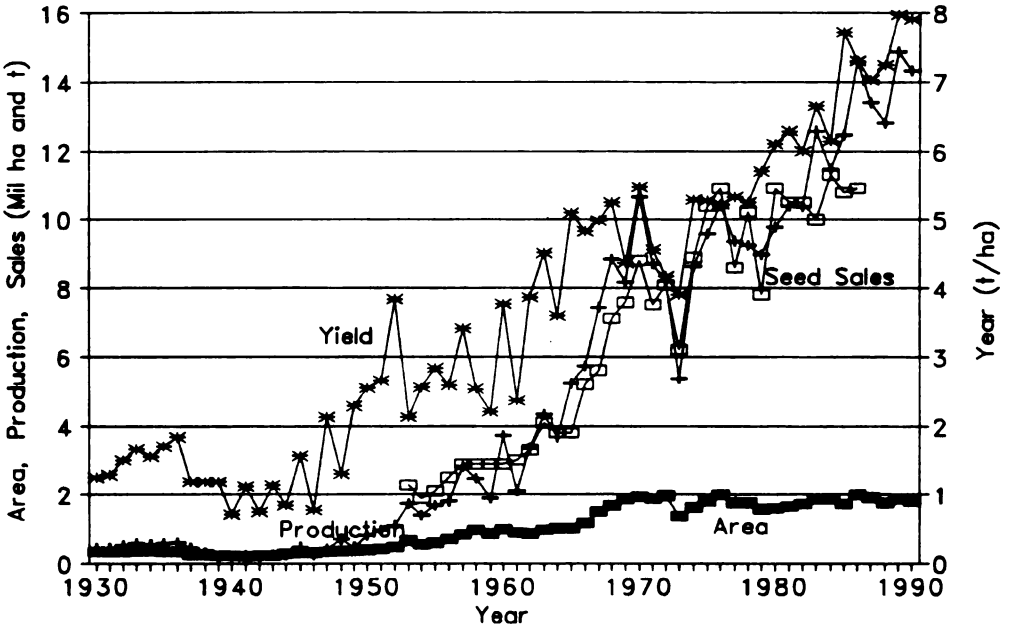

Figure 3.2: Maize Area, Production, Yield and Hybrid Seed Sales in France, 1930-1993
Source: USDA, FAO and Eurostat

The French average maize yield began to rise in the 1950s when farmers started switching to hybrids and achieved the United States' yield level in the early 1980s (Figure 3.2). National maize production also began to rise in the 1950s and it has continuously trended upwards along with a small increase in aggregate maize area. The close association between the trends in hybrid maize seed sales, maize yield, and production indicates that hybrids have had a considerable impact on maize yield and total production in France.

Today France's maize seed market of 110,000 tons per annum is the largest in Europe. As in the United States, the seed industry is in the mature phase of development and dominated by private companies that have become accepted as reliable sources of genetic improvements for maize. Vilmorin-Groupe Limagrain is the largest seed company with a market share of around 38 percent, followed by Pioneer Hi-Bred International with 32

percent. Other key players include Coop de Pau, RAGT-DeKalb, Ringot-UNCAC, Elf Acquitaine, Desprez, CACBA, and Benoist (Busch *et al*, 1995).[29] International seed companies are forming strategic alliances to compete in a common seed market in the European Community.[30] Member states are harmonizing their cultivar determination and release procedures, seed production, and trade rules and plant quarantine legislation in order to facilitate trade in seed (Obst, 1992).

The history of maize seed industry in France provides some evidence that substantiates the path dependence proposition. Over the last 200 years farmers and farm organizations have been mobilized to demand specialized public investments in research stations, scientists, breeding programs, extension services, and seed certification programs that induced private investments in seed growing, conditioning and marketing facilities, research and development, proprietary germplasm, trademarks and reputation. The initiation of government seed quality control in 1905 started a chain of events that infused confidence into seed transactions which gradually increased the scope of institutional arrangements to support technically complex and transaction-specific assets. The successful international transfer and adaptation of United States maize hybrids to France was of great benefit to France but it created an impression among American foreign aid officials that United States varieties and hybrids could be directly transferred to developing countries without strengthening their national research programs (Moseman, 1970).

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[29] In 1994 several French chemical companies withdrew from the seed industry because the return on investment in seeds was lower than in the chemical industry. For example, Elf-Sanofi sold its maize and sunflower investments in 1993. Rhone-Poulenc created a strategic alliance with Groupe Limagrain and withdrew from agronomic seed activities.

[30] Beginning in January 1993, Belgium, France, Germany, Great Britain, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain created a common market which removed checks and controls on persons and goods moving between their borders.

3.4 Mexico

Maize originated in Mexico and it spread throughout Latin America (Mangelsdorf, 1974). The government established an agricultural experiment station in 1906, a Department of Agriculture in 1908, and a maize breeding program in 1943 with assistance from the Rockefeller Foundation (Pardey, Roseboom, and Anderson, 1991; Wellhausen, 1950). The Mexican-Rockefeller cooperative maize improvement program focused on the collection and identification of native maize varieties and strains in Mexico. A milestone was achieved in 1947 when the government created the Institute of Agricultural Research to coordinate public agricultural research and set up the Maize Commission to produce and distribute seed of improved cultivars to farmers in Central Mexico (Lopez-Pereira and Garcia, 1993).

During the 1950s, Mexican and Rockefeller scientists developed several improved composite varieties, including Rocamex V-7, Rocamex V-21, and Rocamex VS-101. In 1961 a new seed law converted the National Maize Commission into a state-owned enterprise, the National Producer of Seeds (PRONASE), with a mission of producing and distributing seed of improved varieties developed by INIA and promoting seed production by farmers' organizations.[31] The government also restricted the activities of multinationals and the importation of seed of staple crops such as maize and beans and created the National Inspection and Certificate Service (SNICS) in a path dependent manner based on the pattern that developed in the United States. SNICS was charged with enforcing compulsory trials of new varieties by the government before their release to farmers, seed certification and testing (Pray, 1990).

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[31] In 1960, the government merged the Institute of Agricultural Research and the Office of Special Studies and formed the National Institute of Agricultural Research along the lines of the agricultural research institutes which were being set up in other Latin American countries with support from United State Agency for International Development (USAID) and private foundations (Pardey, Roseboom, and Anderson, 1991).

After substantial government and Rockefeller Foundation investment in the development of specialized experiment stations, extension agencies, seed inspection and certification agencies, several private seed companies and cooperatives entered the maize seed industry in the 1970s. In 1983, Mexican researchers began to test CIMMYT's maize germplasm throughout the country and subsequently several improved varieties and hybrids were released for the diverse conditions in the country. The diffusion of these cultivars was facilitated by the deregulation policies that government implemented to remove restrictions on foreign seed companies distributing maize and bean seed. The policies stimulated domestic seed companies and multinationals such as Pioneer Hi-bred, DeKalb Genetics Corporation, Northrup King, and Asgrow to expand their research, production and distribution capabilities.

In 1991 the Mexican government aggressively implemented market-oriented political and economic reforms that encouraged privatization and enacted a new seed law that allowed commercial production of improved cultivars without official certification (Lopez-Pereira and Garcia, 1993). The law also authorized private companies to certify their own seed and provide truth in labelling, and removed restrictions on private sector breeding and seed exports and imports. In addition, the government authorized INIA to establish contractual agreements with private seed companies giving exclusive rights to publicly-developed inbreds in return for royalties. The Mexican government is introducing plant breeders rights legislation along the lines of the path dependence proposition by following the UPOV system to expand private sector investments in the seed industry and permit public organizations to generate additional funds to support research.

The impact of improved maize varieties and hybrids was delayed for a decade from the release of the first improved varieties in 1947 because of the time it took to convince farmers of the importance of using high-quality seed of adapted cultivars. The national average maize yield began to rise in the 1960s when farmers started to adopt improved maize

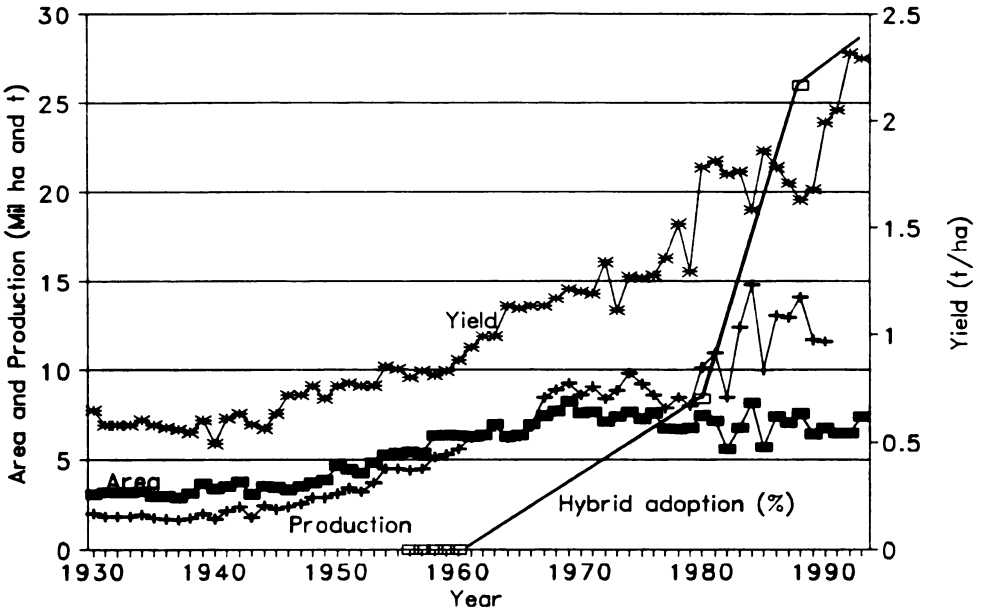

Figure 3.3: Maize Area, Production, Yield and Hybrid Adoption in Mexico, 1930-1993
Source: USDA, FAO and CIMMYT

cultivars. National maize production also began to rise in the 1960s along with a small increase in the aggregate maize area (Figure 3.3).

Today the Mexican maize seed industry is in the early growth phase of its life cycle and generates about 42,460 tons in annual seed sales (Lopez-Pereira and Garcia, 1993). The industry consists of six multinational seed companies, 15 domestic seed companies, and five cooperatives. The four leading seed companies have a combined market share of 83 percent. As a result of the recent political and economic reforms, the state-owned seed company (PRONASE) market share is less than 10 percent of the market, down from 80 percent in 1980. The seed industry is going through the same type of changes that occurred in the seed industry in the United States during the 1940s. The private sector is expanding hybrid maize breeding, seed production, conditioning and marketing while the public sector is focusing on breeding methodology, population improvement and varietal development.

The Rockefeller Foundation drew on its experience in Mexico to develop cooperative maize improvement programs with the governments of Colombia and Peru in 1950 followed by the Central American Corn Improvement Project in 1954, covering Mexico, Colombia, Cuba, Venezuela, Brazil, and Argentina. The Central American Project evolved into the Inter-American Corn Program for Latin America in 1960. The Foundation also began a cooperative program in India in 1957 that evolved into the Inter-Asian Corn Program in 1964 covering 16 Asian countries from Afghanistan to South Korea. The Foundation also established cooperative maize improvement projects in Kenya, Nigeria and Egypt. The Inter-American and Inter-Asian Corn Programs and cooperative programs in Africa were the forerunners of the International Maize and Wheat Improvement Center (CIMMYT) that was established in 1966 (CIMMYT, 1992a).

3.5 Brazil

Soon after Brazil became independent in 1822, the government established several state agricultural experiment stations along the lines of the path dependence proposition modelled after agricultural experiment stations in Europe (Busch *et al*, 1995). A major experiment station, the *Instituto Agronomico de Campinas* (IAC), was established in Sao Paulo in 1887. During the 1920s, the IAC initiated maize research and, in the 1930s, breeders tested varieties from the United States and several Latin American countries. These varieties were combined with local *Cateto* and *Paulista* dent varieties and used to develop superior cultivars such as *Cateto* and *Azteca* that were released in the late 1930s and early 1940s (Sorj and Wilkinson, 1990). Also in the 1930s, the *Universidade Federal de Vicosa* started a hybrid maize breeding program using genetic materials from United States (Lopez-Pereira and Garcia, 1993). Since the United States inbreds were poorly adapted to the local conditions, Brazilian breeders crossed American and Mexican materials. The *Vicosa* program had a profound

impact on the development of the seed industry in Brazil because two of its maize breeders resigned in 1945 and formed a private company, Agroceres, that is currently the largest research-based seed company in Brazil (Jacobs and Gutierrez, 1986).

The turning point in the seed industry occurred in 1946 when the IAC breeders released a double cross hybrid H-3531 from *Cateto* inbreds. In 1953 the breeders developed H-4624, a double cross hybrid by crossing inbred lines from *Tuxpeno* germplasm with *Paulista* Dent and *Cateto* (Wellhausen, 1978). During the 1950s, several new seed companies multiplied and distributed cultivars developed by the National Agricultural Research System (NARS) (Lopez-Pereira and Garcia, 1993).

However, the rate of adoption of improved varieties and hybrids by farmers was slow in the 1950s because of the lack of a seed law and appropriate government seed policies. In 1965, the government passed seed legislation along the lines of the path dependence proposition by following internationally recognized seed certification and testing procedures and establishing seed-certifying agencies and testing laboratories throughout the country to enforce the seed law.[32] The government implemented a National Seed Plan that supported the development of an integrated seed industry by promoting seed certification and market signaling. These activities dramatically increased the adoption of improved seed from 19 percent in 1967 to 55 percent by 1980. The rapid increase in the demand for high-quality seed of superior cultivars stimulated several multinationals to enter the seed industry by establishing production agreements with Brazilian producers and developing and introducing new hybrids. Cargill Hybrid Seeds entered the Brazilian market in the early 1960s with hybrids that it had developed in Argentina during the 1950s (Stahl, 1991). Cargill Hybrid

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[32] The government also established the National Committee of Seeds and Seedlings which provided technical support to the National Seed Policy of the Ministry of Agriculture (Vechi *et al*, 1975).

Seeds was followed by Northrup King in the late 1960s and by Pioneer Hi-Bred International, Ciba-Geigy, Asgrow and ICI in the 1970s.

During the 1970s three events influenced the development of the seed industry. The first was the strengthening of the public agricultural research through the creation of the National Agricultural Research Enterprise (EMBRAPA) in 1972 (Busch *et al*, 1995). Second, the National Center for Maize and Sorghum Research (CNPMS) was established in 1975 to develop improved varieties for smallholders and for marginal areas (Lopez-Pereira and Garcia, 1993). CNPMS tested a broad range of CIMMYT pools and populations and released numerous varieties and hybrids, including BR-201, the most widely planted hybrid in Brazil today. The third event was an attempt to introduce Plant Breeders' Rights legislation in Brazil in 1977. However, a bill to introduce plant variety protection in Brazil was defeated in Parliament because it was opposed on constitutional grounds by some scientists at the IAC, the Sao Paulo's House of Representatives, and the *Association dos Engenheiros Agronomos de Sao Paulo* (Busch *et al*, 1995).

During the 1980s, the government implemented a program to improve seed multiplication capabilities, provided credit and technical assistance to seed producers, and promoted the use of improved seed in the northeast, the poorest region in the country. The government also implemented liberalization policies that removed price controls, lowered tariff barriers, floated the currency, reduced subsidies and privatized state assets (Stahl, 1991). As a result of these policies, the investment and contractual credibility features of the Brazilian economy improved and other multinational seed companies, including Agrigenetics and Groupe Limagrain entered the Brazilian seed industry.

Following the release of BR-201 in 1987, EMBARAPA and CNPMS established an informal partnership with 17 small domestic seed companies for multiplying and marketing hybrids released by CNPMS in the Cerrados region of Brazil, a region neglected by private

seed companies (CIMMYT, 1994). The partnership evolved into a public-private sector alliance under which the seed companies organized the UNIMILHO association for the production and marketing of high-quality hybrid seed. In 1993 the UNIMILHO group of companies had 17 percent of the Brazilian hybrid seed market. The Brazilian National Center for Genetic Resources (CENARGEN) created a system for the registry of cultivars that set the stage for the introduction of plant breeders' rights legislation because it permitted public and private organizations to make legal appeal (Busch *et al*, 1995).

The yield-takeoff of maize was delayed for more than four decades from the release of the first improved cultivars in the 1930s until the 1970s because of the time it took to convince farmers of the importance of buying and planting high-quality seed and developing

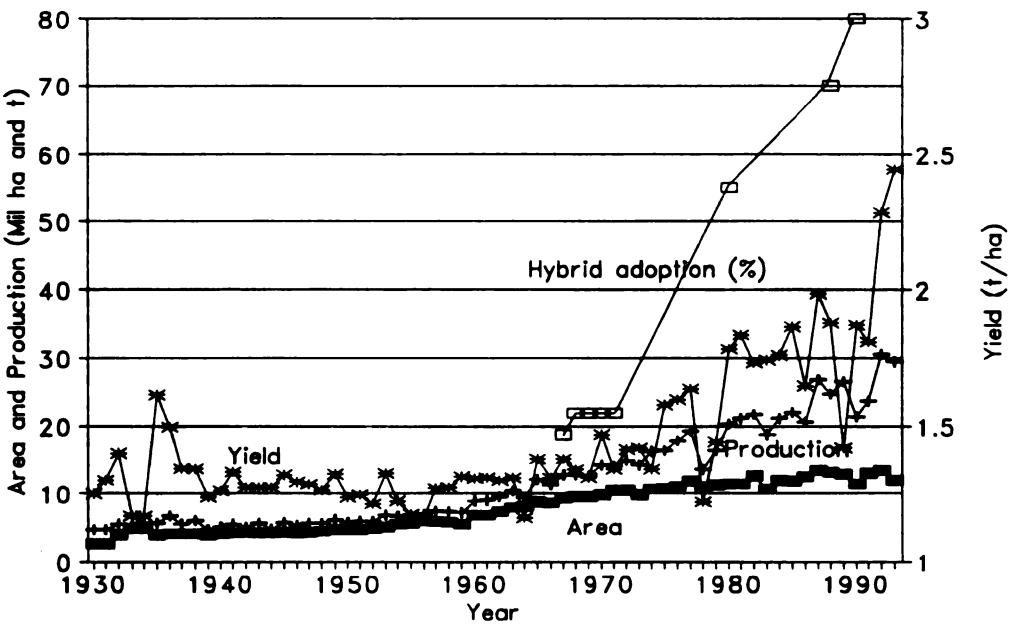

Figure 3.4: Maize Area, Production, Yield and Hybrid Adoption in Brazil, 1930-1993

Source: USDA, FAO and CIMMYT

institutional arrangements for seed certification and seed testing and extension that facilitated signaling and the seed trade of known quality. The national average maize yield began to rise

in 1970 when farmers rapidly switched to improved varieties and hybrids (Figure 3.4). National maize production also began to rise in 1970 as a result of hybrid adoption and higher yields. The correlation between improved varieties and hybrid adoption, maize yield, and production indicates that improved cultivars are having a major impact on maize yield and production in Brazil.

Today Brazil has the world's third largest maize seed industry after the United States and China. The maize seed industry is in the late growth phase of the life cycle and generates over 150,000 tons in annual seed sales (Seed World, 1994). The industry consists of 10 public sector companies, 4 multinationals, 43 domestic seed companies, 10 cooperatives and 35 family-owned businesses. Twenty-six companies have breeding programs and employ about 70 researchers. Although there are more than 100 seed companies and cooperatives, the industry is dominated by Agroceres with more than 50 percent of the market. The private sector now dominates hybrid maize seed research and development, production and marketing and supplies about 85 percent of all hybrids grown in Brazil. The public sector is focused on the basic breeding of hybrid crops, the research and development, seed production, and marketing of varietal crops. The Brazilian government is introducing plant breeders rights in a path dependent manner modelled after the UPOV system to expand private sector investments in the seed industry and permit public organizations to generate additional funds to support research.

3.6 India

In India the British colonial government established a model farm at Saidapet in 1868 that evolved into an agricultural college and research institute (Pardey, Roseboom, and Anderson, 1991). In 1905, the Indian Agricultural Institute was established and in 1929 it was placed under the Imperial Council of Agricultural Research.

In 1945 the government initiated a maize breeding program. Between 1950 and 1955, several commercial double-cross maize hybrids were introduced from the United States, Canada, Australia and other countries and tested throughout the country (Joshi, 1975). The researchers found that although some of the dent hybrids were high yielding, Indian consumers preferred local flints. Also, the imported hybrids were late-maturing and the inbred lines were proprietary hybrids. In 1954 the government sought the assistance of the Rockefeller Foundation to import hybrids from Mexico because India wanted to launch commercial maize seed production without a period of adaptive research. However, two Foundation experts, Wellhausen and Grant, recommended setting up a coordinated national program to introduce and test a wider range of germplasm under Indian conditions (Lele and Goldsmith, 1989). The recommendation was accepted by the Indian government and, in 1957, the Indian Council of Agricultural Research, in cooperation with the various state governments and the Rockefeller Foundation, initiated the All-India Coordinated Maize Breeding Scheme. Research stations were established in the major agro-climatic zones and researchers launched a maize breeding program for developing flint-type hybrids. The researchers identified Cuban and New England flints as the most useful germplasm (Brown *et al*, 1984; Rao, 1983). A few years later in 1961, the researchers released several composites and four double cross hybrids for commercial production: *Ganga* 1, *Ganga* 101, *Ranjit*, and *Deccan* (Timothy, Harvey and Dowswell, 1988). The breeders developed several higher-yielding hybrids, including *Ganga Safed* 2, *Ganga* 3, *Ganga* 5, and *Him*-123. The success of the Indian researchers was followed by requests from several neighboring countries for germplasm and research assistance from the Indian Agricultural Research Program. In 1964 the Rockefeller Foundation established the Inter-Asian Corn Program with headquarters in India.

In 1961 the government took the first step towards the public control of seed quality when it established a seed testing laboratory in every state (Tunwar, 1987). In 1963 the government established the National Seeds Corporation (NSC) with assistance from the Rockefeller Foundation and USAID to produce foundation seed of the newly released maize hybrids, encourage the development of private seed companies and institute seed quality control programs, and train seed technologists. The creation of the NSC induced several states to establish State Farms and State Seeds Corporations to produce breeder, foundation, and certified seed. In 1965 the government expanded the mandate of the National Seeds Corporation to include seed production and distribution, maintaining buffer seed stocks, and leasing seed processing equipment to private seed companies.

In 1966 the government passed the Seeds Act which established minimum seed quality standards and certified seed procedures along the lines of the path dependence proposition based on the pattern developed in America.[33] To enforce the Seed Law, government seed inspectors were directed to collect samples from certified seed lots offered for sale to farmers, submit them to seed laboratories for testing and prosecute seed dealers that sold sub-standard as certified seed (Katyal, 1987).

The institutional innovations embodied in the Seed Act of 1966 increased the farmers' awareness of the importance of high-quality seed of improved cultivars and created a large

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[33] The Seed Act provided for the creation of a Seed Development Section in the Ministry of Agriculture to administer the NSC and State Seed Corporations and implement the Seed Act; a Central Seed Committee to consider the notification and release of new varieties and the specification of minimum standards of variety trueness and purity, germination, and labelling of certified seed; a Central Seed Certification Board to lay down the procedures and standards for the 18 state seed-certifying agencies; a Central Seed Testing Laboratory and 21 state seed laboratories to carry out seed testing; and State Seed-Certifying Agencies to verify seed sources, organize field inspection, provide supervision of processing, sampling and issuing of certificates.

demand for certified seed that, in turn, encouraged entrepreneurs to form seed companies.[34] In the 1970s, the seed industry underwent a hiatus when the Rockefeller Foundation and USAID terminated support to the seed industry projects. The government responded by shifting from private to public seed companies with assistance from the World Bank, restricted seed exports and imports, and created barriers to entry for private firms.

Despite these problems, some Indian companies and a Pioneer-Indian joint venture began to breed and market proprietary seed products and to contract their production with farmers. As agricultural productivity increased and resources became available for buying technological inputs, farmers increased their demand for proprietary hybrids, despite the higher costs of such seed. In 1988, the government implemented the *New Seed Policy on Seed Industry Development* that expanded access of private firms to public inbreds and breeding lines; allowed Indian and foreign private companies to sell seed; and removed restrictions on importing seeds (Pray, 1990). As a result of these policies, many new domestic and multinational companies entered the seed industry, including Southern Petro Industrial Corporation, Bejo, Hindustan Lever, Harrisons Malayalam, JK, Hoechst, ICI, Cargill Hybrid Seeds, Ciba-Geigy, Shell, and Sandoz (Sehgal, 1992).

The spread of improved maize varieties and hybrids in India was delayed for a decade from the time of the release of the first improved cultivars in 1961 because of the time it took to disseminate improved cultivars and hybrids and put in place institutional arrangements for seed production, and regulations for seed certification and testing for promoting the signaling of high-quality seed. The national average maize yield began to rise around 1970 when farmers rapidly adopted improved varieties and hybrids and has been increasing at the same

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[34] For example, the Maharashtra Hybrid Seed company was started in 1963 with only 2.4 hectares of hybrid seed production. By 1973 it was producing more than 1,500 hectares of hybrid maize, sorghum, millet and cotton seed by 1973. The Tarai Development Corporation was started in 1969 with a World Bank loan and, by 1975, it was producing 18,800 hectares of seed (Douglas, 1975).

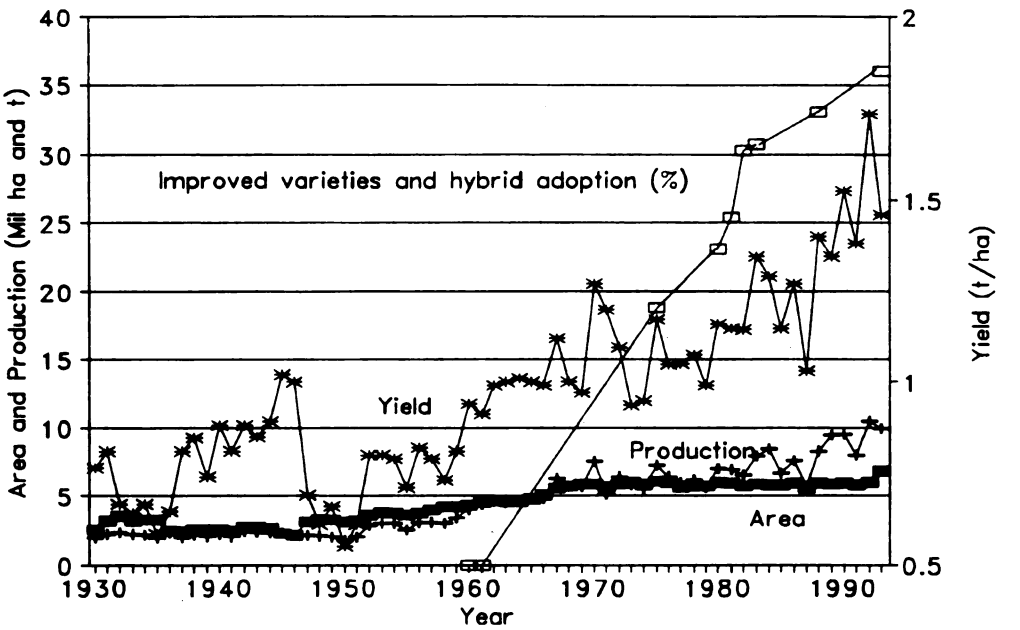

Figure 3.5: Maize Area, Production, Yield and Hybrid Adoption in India, 1930-1993

Source: USDA, FAO, and CIMMYT

rate as improved varieties and hybrid adoption (Figure 3.5). Maize production began to rise around 1970 despite a constant aggregate maize area, indicating that improved cultivars are beginning to make an impact on maize production in India.

Today the Indian seed industry is in the early growth phase of the development of the seed industry and generates 32,000 tons in annual seed sales. The industry is going through the same type of changes that occurred in the seed industry in the United States during the 1940s and in Europe during the 1960s (Burris, 1991). The public sector continues to dominate the supply of genetic improvements of varietal crops while the private sector is slowly taking over a larger responsibility for supplying the genetic improvements of hybrid crops. The Indian government is introducing plant breeders rights in a path dependent manner modelled after the UPOV system to expand private sector investments in the seed industry and permit public organizations to generate additional funds to support research.

3.7 Thailand

In Thailand, farmers conducted maize improvement experiments until the early 1950s when the Department of Agriculture and Kasetsart University initiated independent maize improvement programs (USAID, 1985a). The government breeders introduced hybrids from the United States but they were susceptible to the downy mildew disease. In 1953, researchers obtained a maize variety from the United States Agency for International Development in Indonesia that had been developed by I.E. Melhus in Guatemala from a composite of Caribbean collections (Sriwatanapongse *et al*, 1993). A turning point occurred in 1960 when the government and the USAID sent Thai researchers to visit the Indian maize program (Sprague, 1964). As a result of exchange visits by Indian and Thai scientists, a coordinated maize improvement program was introduced and the headquarters of the Inter-Asian Corn Program was moved from India to Thailand. In 1966 the program released several improved derivatives of the Guatemala variety, including PB5, PB8, and PB9 that dominated maize production in Thailand for nearly two decades (Boonsue, 1987). However in 1972, the new varieties became susceptible to sorghum downy mildew and breeders quickly introduced downey mildew resistant varieties such as *Bogor Syn* 2 and *Tainan*-10. Two years later, breeders achieved a major breakthrough when they released a high-yielding and downy mildew resistant variety, the Thai Composite - 1 DMR.[35] The breeders further improved the Thai Composite variety through recurrent selection and released the *Suwan* - 1 and *Suwan* - 2 varieties in the late 1970s that revolutionized maize production in Thailand and Indonesia.

Since *Suwan* - 1 was high-yielding and resistant to downy mildew, it increased the demand for quality seed by farmers and stimulated farmers and grain traders to engage in seed production and sale. Again, in a path dependent manner of more advanced nations, the

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[35] The Composite was synthesized from maize germplasm from the Caribbean Island, Mexico, South America, India, the United States, and the Philippines (Boonsue, 1987).

Thai government passed "truth-in-labelling" seed legislation in 1975 that required new varieties to undergo standard farm yield trials before they could be sold to farmers. The seed law also established a Cultivar Release Committee to review new applications, and government seed testing laboratories (Senanarong, 1987). However, the Agricultural Regulatory Division was underfunded and unable to enforce the seed law. As a result, the *Suwan* varieties became genetically contaminated, the yield deteriorated, and the rate of adoption slowed down.

In 1978 the government introduced policy reforms that provided tax exemptions on imported seed equipment and tax holidays for private investors in the seed industry. The policies stimulated numerous family-owned businesses and multinational companies to invest in developing and marketing proprietary hybrids. The policies greatly expanded improved cultivar adoption and by 1990 virtually all the maize in Thailand was planted to improved varieties and hybrids.

The improved maize varieties and hybrids began to make a significant contribution to maize production in the 1960s after public breeders introduced the Guatemala variety from Indonesia and disseminated it to farmers. The annual average maize yield began to rise in 1960 but lost its momentum in the 1970s because of the outbreak of the sorghum downy mildew and the deterioration of improved cultivars that resulted from the lack of enforcement of the seed law. In the 1980s, the maize yield began to rise again as farmers rapidly adopted improved cultivars because the availability of elite germplasm following the 1978 policy reforms (Figure 3.6). Maize production rose steadily in the 1960s and 1970s because of increases in both the yield and area. Increasing yields were the main source of increased maize production in the 1980s.

Today the Thai maize seed industry is entering the mature phase of the life cycle and generating around 26,050 tons in annual seed sales. The multinational seed companies in

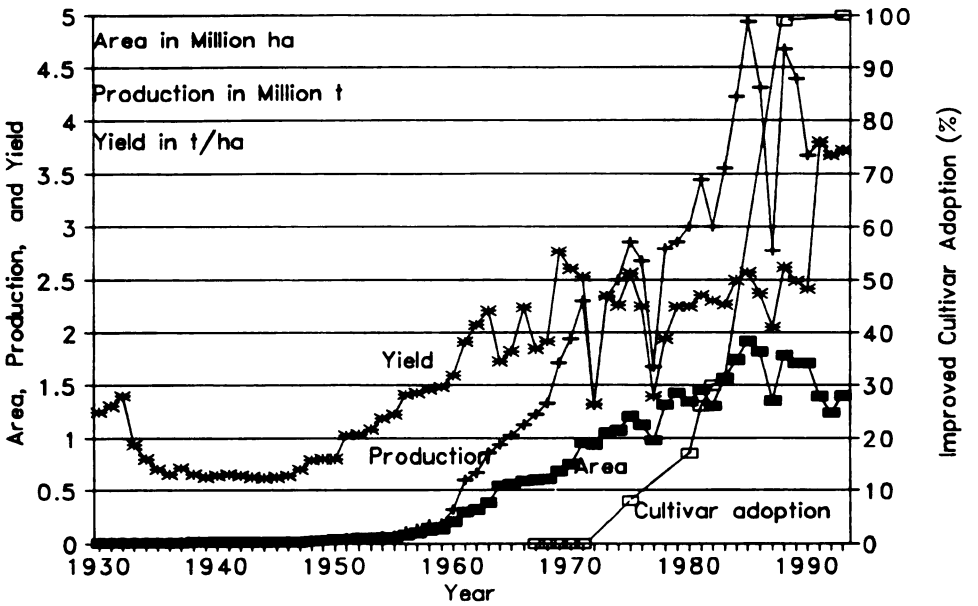

Figure 3.6: Maize Area, Production, Yield and Hybrid Adoption in Thailand, 1930-1993

Source: USDA, FAO, and CIMMYT

Thailand include Pioneer Hi-Bred International, DeKalb Genetics Corporation, Cargill Hybrid Seeds, Continental-Pacific Seeds (ICI Seeds), and Ciba-Geigy (Suwantaradon, 1989). The seed industry is going through the same type of changes that occurred in the seed industry in the United States during the 1950s. The public sector dominates the supply of advanced genetics of open-pollinated crops while the private sector is taking over more responsibility for providing proprietary germplasm. The economic history of the maize seed industry in Thailand illustrates how a latecomer can import technological and organizational innovations from advanced countries and leapfrog one stage of seed industry development.

3.8 Kenya

Portuguese traders introduced flint maize varieties into Kenya in the 1700s (Brown *et al*, 1984). At the turn of this century, European settlers and missionaries introduced the Kenya Flat White maize variety from the United States via South Africa (Rundquist, 1984). In 1930

the government initiated a maize improvement program at the Njoro Plant Breeding Station but the efforts had little impact on maize improvement (Johnston, 1989). The turning point occurred in the early 1950s when large-scale farmers pressured the government to initiate a hybrid maize breeding program and emulate the United States success story. In 1954 the government hired its first full-time maize researcher, Michael Harrison, and launched a maize breeding program at the Kitale Agricultural Research Station (USAID, 1980). Assistance from the Rockefeller Foundation, the British government, USAID, and CIMMYT helped develop an agronomic research program parallel to the breeding program (Wortman and Cummings, 1978). The maize breeding team began by developing inbred lines from the Kenya Flat White variety. Because of the inability of inbreeding and crossing of local varieties to produce superior hybrids, Harrison visited the Rockefeller maize program in Mexico in 1959 and collected 80 varieties of Colombian and Mexican germplasm that were preselected for altitude and day length (Gerhart, 1975). In 1961 breeders made a remarkable advance when they combined the inbred lines from the Kenya Flat White maize variety and formed a synthetic variety, Kitale Synthetic II, which was higher-yielding than the best local open-pollinated variety (Ogada, 1971). The breeders tested different crosses between the introduced lines with local inbreds and found that the hybrid produced by crossing the Ecuadorian line, EC573, and Kitale Synthetic II yielded 40 percent more than the synthetics. In 1964 the breeders released their first two hybrids, H611 and H622, for commercial seed production. A year later, the breeders released two additional hybrids, H622 and H632, which fueled Kenya's maize-based Green Revolution (USAID, 1980).

In 1956 the government launched a maize improvement program coincided that with the founding of the Kenya Seed Company (KSC) in 1956 by European farmers (Hazelden, 1982). In 1963 the KSC signed an agreement with the government that gave the company a monopoly over maize seed production, conditioning, and marketing in Kenya (Ndambuki,

1987). The KSC began by multiplying publicly-developed breeder seeds on its farms and distributing hybrid seeds to mostly large-scale farmers through trading companies such as the West Marketing Board and Dalgerty and cooperative societies (Gerhart, 1975). In 1972 the government enacted a seed law that required new cultivars to demonstrate superior agronomic characteristics and distinctiveness, uniformity, and stability in government-run variety trials for two successive years and to be included in the Official Index before they could be sold to farmers. Also, the government established a Cultivar Release Committee that examined new applications and made recommendations to the National Cultivar Release Committee for inclusion in the Index. Again, in a path dependent manner of more advanced nations, the government introduced compulsory seed certification and created the National Seed Quality Control Service to carry out the registration of new cultivars, field inspection of seed crops, certification, and seed testing using internationally recognized seed certification standards of the Organization for Economic Cooperation and Development (OECD) and seed testing standards of the International Seed Testing Association (ISTA).

The enforcement of the seed law compelled the KSC to certify its hybrids at high standards that reduced adverse selection and increased the demand for seed hybrids, particularly among smallholders. Kenyan farmers adopted hybrids faster than United States farmers during the 1930s and 1940s and as the demand for hybrids increased, KSC contracted with farmers to grow seed (Gerhart, 1975). In 1966 KSC, expanded operations and developed new distribution channels through the Kenya Farmers Association, co-operative unions and societies, and small-scale traders to serve smallholders (Rundquist, 1984). Between 1963 and 1992, the KSC increased hybrid maize seed production from 300 to more than 29,000 tons.

During the 1970s, the Kenya Seed Company exported maize seed to Uganda, Tanzania, Ethiopia, Zambia, Malawi, Somalia, and the Sudan and launched maize breeding

and seed production research. In 1977 the KSC set up strategic business units to provide technical knowledge, field inspection, and machinery services to contract growers (Lynch and Tasch, 1989). In 1980 the government acquired 51 percent of KSC stock and the remaining shares were split between the Kenya Farmers Association (27 percent) and private investors (22 percent) (Ndegwa *et al*, 1985). The government control of the KSC was instrumental in its expansion into wheat, sunflower, sorghum, pasture and horticultural seeds.

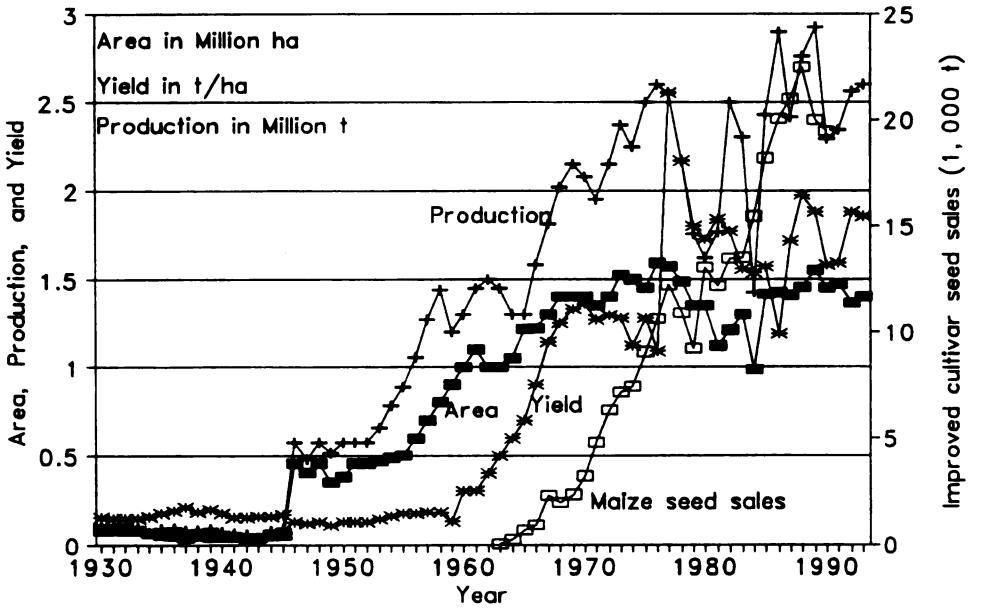

Figure 3.7: Maize Area, Production, Yield and Seed Sales in Kenya, 1930-1993

Source: USDA, FAO and Ndambuki (1987)

The experiences of both Kenya and Thailand demonstrate how a latecomer can leapfrog some stages of seed industry development and catch up with the leaders. Kenya took only nine years (1955 to 1964) from the date that the first full-time maize breeder was hired until the development of two high-yielding hybrids (H611 and H622). Also, the speed of hybrid adoption in Kenya was faster than that of the United States. However, the impact of improved maize varieties and hybrids in Kenya is difficult to establish because farmers adopted the cultivars as a package with some complementary technologies such as early

planting, plant population, fertilizer use and weeding (Gerhart, 1975). The average maize yield increased sharply in the 1960s when farmers first started to adopt the Kitale Synthetic II varieties and continued to increase when farmers switched to hybrids until about 1985 (Figure 3.7). Although, maize yield and production have been fluctuating since the late 1980s, there is little doubt that hybrids contributed to increased production. The average annual rate of return to investment in maize improvement over the 1955 to 1988 period was 68 percent (Karanja, 1990).

Today the seed industry in Kenya is in the late growth phase of its life cycle. KSC, the monopolistic seed company, generates 21,608 tons in annual maize seed sales. The KSC is shielded from globalization and the restructuring that is occurring in the seed industries in many countries. Some analysts contend that Kenya will soon be forced to open the maize seed industry to international competition because the Kenyan breeding program has been based on the Kitale Synthetic germplasm which is becoming exhausted. A South African seed company, Pannar, and a United States seed company, Cargill Hybrid Seeds, are testing their proprietary maize hybrids in Kenya and positioning themselves to enter the market once legal barriers are removed. The Kenya Agricultural Research Institute (KARI) is under stress resulting from budgetary cuts for research and plans to introduce competitive grants to improve the effectiveness of research projects and joint public-private sector programs to speed up the bringing of promising technologies from the research station to the marketplace. In addition, KARI is introducing plant breeders rights to motivate scientists and charge royalties to raise money to supplement the declining government research funds. The history of the maize seed industry in Kenya illustrates how the failure to progressively shift the institutional underpinnings of the maize seed industry from the public to the private sector during the growth stage can retard its development.

3.9 Tanzania

The German government started scientific maize experiments when it colonized Tanzania before the First World War (Experience Incorporated, 1969). But the experiments were terminated when the British government took over the country in 1924. During the 1950s, the colonial government organized research stations to introduce and evaluate new varieties. However, the work conducted at the stations had little impact on the development of the seed industry because of the failure of the government to establish seed laws, regulatory services, seed certification programs, and distribution systems. Large-scale farmers set up a farmers' organization, the Tanganyika Farmers Association (TFA), to import and produce the seed of superior varieties. But the TFA only served a few large-scale farmers.

During the early 1970s, the government and USAID implemented a Seed Multiplication and Distribution Project to improve the quality and increase the quantity of improved seed by establishing farms to produce foundation seed and constructing conditioning plants and seed-testing laboratories (USAID, 1985b). The project included the development of a seed law and the setting up of the Tanzania Official Seed Certification Agency (TOSCA) to control seed quality and enforce the seed regulations. In 1973 a state-owned firm, the Tanzania Seed Company (TanSeed), was established to produce and distribute seed. Another state-owned company, the National Agricultural and Food Corporation (NAFCO) held 62.5 shares of TanSeed's equity while the Commonwealth Development Corporation (CDC) held 37.5 percent shares (Lujuo, 1992). Another state-owned company, TanWatt, was established with CDC support to produce foundation seed.

However, the Seed Multiplication and Distribution Project failed to develop a productive seed industry because the government pursued socialist policies that gave priority to establishing state-owned companies throughout the country. During the 1980s, TanSeed experienced problems in distributing seed to farmers because of the lack of reliable

transportation and poor communication. Also, the company was poorly managed and lacked trained staff for producing high-quality seed (Danagro, 1987). Because of a failure to develop quality seed production and marketing capabilities, TanSeed supplied less than 10 percent of the maize seed annually demanded by farmers from 1972 to 1992 (Lujuo, 1992). In 1982 the USAID-funded Seed Multiplication and Distribution Project was phased out. In 1989, with funding from the FAO and the United Nations Development Program (UNDP), the government implemented a project to rehabilitate foundation seed farms and the Tanzania Official Seed Certification Agency and train seed technologists and certification specialists (Lujuo, 1992). However, the project was hampered by inadequate funding and a shortage of transportation.

In 1990 the government implemented economic reforms that decontrolled maize seed and commercial grain prices, privatized the state-owned shares in TanSeed, and encouraged multinational seed companies to enter the seed business. Cargill Hybrid Seeds started operations in 1991 with South-African bred hybrids that it had introduced in Malawi in the 1980s. Because of the availability of Cargill's high-quality seed of superior hybrids, the area planted with improved varieties and hybrid seed jumped from less than 20 to 26 percent from 1990 to 1993. Pioneer and Pannar began testing hybrids in official variety performance trials in 1993.

Because of unfavorable government policies and Tanseed's failure to develop quality seed production and marketing capabilities, the national average maize yield has been erratic from independence in 1963 to 1993. Most of the increase in maize production has come from area expansion (Figure 3.8). Today the seed industry is still in the emergence phase of the life cycle. The industry is unable to supply sufficient quantities of high-quality seed of adapted varieties and hybrids to farmers (Global 2000, 1993). During 1992, the maize seed sales of 2,667 tons fell short of the estimated requirement of 9,000 tons. To provide

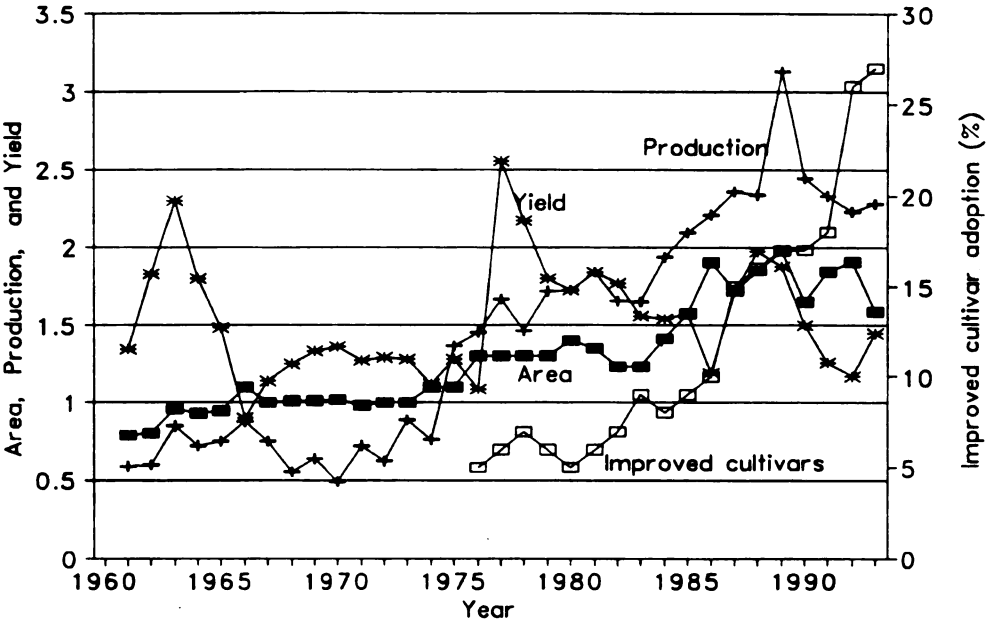

Figure 3.8: Maize Area, production, Yield and Improved Cultivar Adoption in Tanzania, 1961-1993
Source: FAO, CIMMYT

incentives for private investments in the seed industry, the government is introducing Plant Breeders' Rights legislation and removing restrictions on seed equipment and germplasm imports and exports (Lujuo, 1992). The government is also transferring responsibilities for maize breeding, seed production, marketing and certification from the public to the private sector. These developments are expected to improve the performance of the industry.

3.10 Summary

This comparative analysis of seed industry development in eight countries has revealed that each country has followed a life cycle pattern of development in a path dependent way. The evolution of the industry in the eight countries is characterized by changing public and private institutional arrangements as science and technology increases in complexity, and the specificity of assets evolves over time. The economic history of the seed industries also reveals that the development and enforcement of acceptable seed quality standards and the use

of government seed certification labels helped reduce dishonest trading practices and facilitated the trade of known seed quality. In turn, the reduction in trading hazards inspired farmers to purchase certified seed each year. This expansion of seed demand induced private investment in innovative breeding programs and seed production, conditioning, and marketing facilities. The histories provide pieces of evidence to substantiate the proposition that seed industry development is a path dependent process where market signaling plays a central role in reducing transaction costs and facilitating the transition from farmer to farmer exchange of seed through stages of increasing organizational complexity to a mature seed industry.

The histories show that the seed industry is at different stages of the

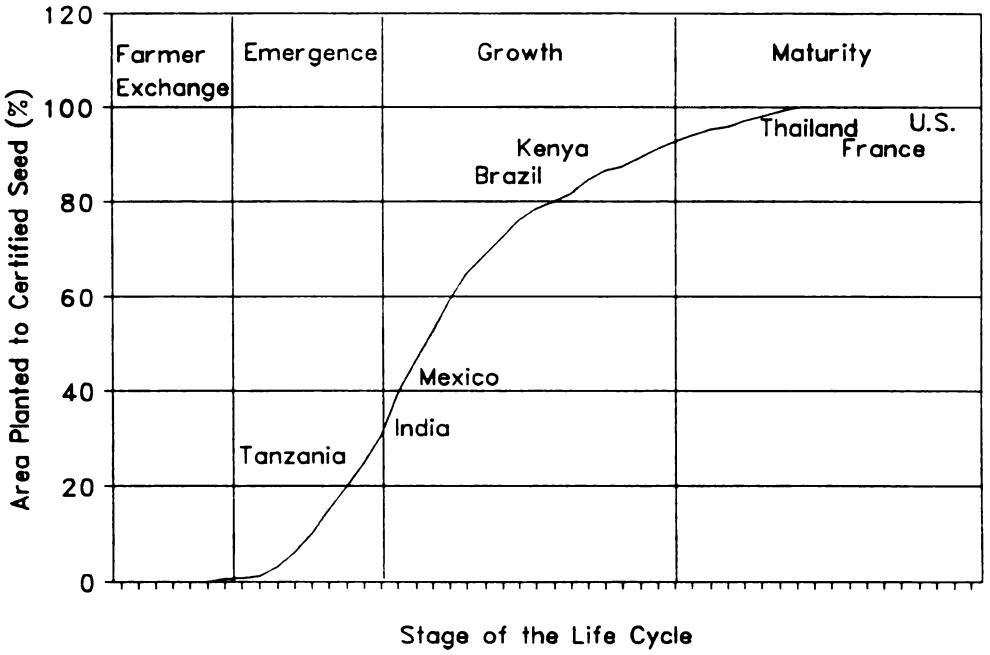

Figure 3.9: The Stages of the Life Cycle of the Seed Industry in Eight Countries

life cycle in the eight countries (Figure 3.9). In Tanzania the seed industry is still in the emergence phase. In the emergence phase, the government is responsible for plant breeding, variety trials, foundation seed production, multiplication, conditioning, certification, and laboratory testing and less than 30 percent of the total maize area is planted to certified seed.

The emergence phase also provides few institutional safeguards for private investments in specialized research stations, seed farms, conditioning and marketing facilities from contractual hazards. The government certification label is the major signal used to inform farmers of the quality of seed offered for sale. Because of government restrictions on private seed companies, there is a narrow portfolio of organizational and technological innovations and limited capacity to supply farmers with needed genetic improvements. The average national maize yield is erratic without an upward trend in the emergence phase because of the limited use of superior varieties and hybrids seed and limited use of complementary inputs.

In India and Mexico the seed industry is in the early growth stage of the life cycle, a phase where 30 to 70 percent of the total maize area is planted to certified seed and the private sector is increasing its role in variety development, seed growing, conditioning, and marketing. Also, in this stage, the emergence of legal codes of conduct for the seed trade, plant breeding and seed certification procedures, and trade secrets laws provide some protection for specialized private sector investments in the seed industry. As private seed companies increase their investments in the seed industry, they begin to certify their seed above the minimum government standards and use a combination of government certification labels and brand names to develop a reputation for product quality. The growth of the private sector increases the array of high-quality seed of superior varieties and hybrids and helps raise the national maize yield.

In Brazil and Kenya, the seed industry is in the late growth phase of the life cycle. In this phase 70 to 90 percent of the total maize area is planted to certified seed and the private sector assumes an increasingly important role in plant breeding, variety development, foundation seed production, seed growing, conditioning, certification, laboratory analysis and marketing. Also public-private sector alliances and attractive seed industry investment laws help provide effective safeguards for private investments in research stations, seed testing

laboratories, brand names and reputation. Seed companies use a mix of government seed certification labels, brand names and reputation to signal the quality of their seed products and develop a loyal customer base.

The seed industry is in the mature stage of the life cycle in the United States and France and is entering this stage in Thailand. Mature seed industries are characterized by 90 to 100 percent of the total maize area planted to certified seed. The private sector plays a dominant role in plant breeding, variety development, foundation seed production, multiplication, conditioning, certification, laboratory testing and marketing while the government dominates the collection, conservation, and evaluation of genetic resources, oversees trials of showcase varieties, and sets and enforces rules governing the industry. Most developing countries with mature seed industries are allowing multinational seed companies to compete in their markets. There is intense competition for market share which leads to a gradual consolidation of the seed industry through mergers, acquisitions, and strategic alliances among seed companies and agrichemical firms. Intellectual property rights are protected through laws such as plant breeders' rights and plant patents. This protection, in turn, stimulates investments in seed enhancement processes, biotechnology and information technology. Private seed companies use a mix of brand names, logos, trademarks, advertising, field demonstration, personal selling and agronomic advice signals to inform farmers about the characteristics of their products. Because of the intense competition among seed companies and the need to gain and retain the loyalty of farmers, there is a continuous flow of superior performing, high-quality genetic products to farmers that fuels an increase in the national average maize yield.

CHAPTER FOUR

THE EVOLUTION OF THE MAIZE SEED INDUSTRY IN SOUTHERN AFRICA: 1900-1980

4.1 Introduction

The analysis of the globalization of the maize seed industry in chapter 3 revealed that the United States provided a path dependent model that has profoundly shaped the development of the seed industries in different countries around the world. This chapter investigates the proposition that the transition from farmer to farmer exchange of seed through stages of increasing organizational complexity requires market signaling which, in turn, is influenced by a path dependent evolution of institutions that support credible commitments to make investments in specialized assets. Special attention will be given to how four countries in Southern Africa assembled the components of a specialized seed industry, including the political commitment to support agricultural research and development, the legal, scientific and technological foundations for seed certification, production, quality control, marketing, and diffusion.

Although maize was introduced into Southern Africa by the Portuguese in the 16th century, the watershed event in the development of the seed industry was the establishment of colonial governments at the beginning of this century in the Cape, Natal, Orange Free State and the Transvaal provinces in South Africa, Zimbabwe (formerly Southern Rhodesia), Zambia (formerly Northern Rhodesia), and Malawi (formerly Nyasaland). The colonial governments also created a dualistic agriculture consisting of commercial and smallholder farming that still exist in Southern Africa today. Each of the colonial governments set up a Department of Agriculture to carry out agricultural research and extension and promote the development of European agriculture in response to political demands by European farmers. The Departments established experiment farms to introduce and test imported maize varieties and produce seed of adapted varieties for distribution to commercial farmers. The

introduction and distribution of improved seed varieties by the government coalesced with the land, technology, financial, labor and agricultural marketing policies that were implemented to develop European agriculture. Although the four countries started at roughly the same point in 1900, South Africa and Zimbabwe have developed technologically-advanced seed industries while Zambia and Malawi have lagged in terms of institutional and technological innovation and the ability to meet the varied needs of smallholders.

4.1 South Africa[1]

The evolution of the seed industry in South Africa was influenced by the United States seed industry in a path dependent way through the transfer of genetic materials and breeding methods, scientific exchanges, the training of South African agricultural researchers in the United States and Europe, and the penetration of United States seed companies into the South African seed market. South Africa honed its capability to borrow and adapt institutional and technological innovations from the United States and Europe. By 1980 South Africa had developed a sophisticated, competitively-organized seed industry that resembled the American and European seed industries of the 1960s.

4.2.1 The Emergence of the Seed Industry Since 1900

Scientific maize breeding was started by the Transvaal Department of Agriculture in 1904 as a result of lobbying by European farmers at the Potchefstroom Experiment Station, which became the cradle of maize breeding in South Africa. Between 1904 and 1920, government researchers introduced and tested several hundred improved maize varieties from the United States, Canada, and Australia (Saunders, 1942). Less than a dozen varieties from the United States that were suitable for the local conditions, including Hickory King, Iowa Silver Mine,

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[1] This section draws from the Annual Reports of the Department of Agriculture, Republic of South Africa from 1911 to 1959; and the Maize Board, from 1948 to 1992.

Champion White Pearl, Eureka, Chester County, Golden Beauty, Reid Yellow, Leaming, and Boone County White (Saunders, 1930). The Department of Agriculture and farmer organizations arranged for the importation of pedigree seed of suitable varieties from the United States for distribution to farmers. However, a local variety, Potchefstroom Pearl, was the anchor of the hybrid maize seed industry and it was widely distributed in the 1920s and 1930s.[2] Several farmer-breeders developed improved strains such as Natal Potchefstroom Pearl and Natal White Horsetooth which they exchanged with other farmers.[3]

As a result of the borrowing and adapting improved seed and agronomic technologies, South Africa evolved from a net maize importer to an exporter to Europe within a decade from 1897 to 1907 (Saunders, 1930). Following demands by farmers for protection against dishonest agricultural trading practices, the government introduced legislation in 1907 in a path dependent manner of the European countries which established minimum standards of purity and prohibited the sale of adulterated fertilizers, seeds, and agricultural remedies. By 1917 European farmers had organized Maize Breeders' Associations and the Seedsmen and Nurserymen's Associations that were co-opted into the decision-making of the Department of Agriculture and cooperated with government researchers in varietal trials and seed distribution. During the 1920s, the government researchers shifted their attention from introducing new varieties to improving the cultivars that were commonly grown in the country. Also, European farmers began to organize maize seed growers' associations for the production of varietally pure seed under the supervision of the Department of Agriculture.

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[2] Potchefstroom Pearl originated from a single ear that resulted from accidental hybridization between Champion White Pearl and either Hickory King or Iowa Silver Mine which was found in a field of Champion White Pearl at the Potchefstroom Experiment Station in 1910 (Saunders, 1930).

[3] Potchefstroom Pearl was modified by farmer selection in 12 seasons from leaf blight susceptible to tolerant strains such as Natal and Pretoria Potchefstroom Pearl. Inbred lines isolated from Natal Potchefstroom Pearl played an important role in the development of the hybrid seed industries in South Africa, Zimbabwe, Zambia, and Malawi.

Because the seed growers' associations certified seed and guaranteed its adaptability, varietal and physical purity, germination capacity, and phytosanitary condition, seed certification facilitated the trade of seed of known quality (Edelman and Hall, 1926).

As the institutional arrangements for seed certification were emerging, public researchers initiated hybrid maize-breeding experiments under the leadership of A.R. Saunders at Potchefstroom in 1925 and Kroonstad in 1928 (Saunders, 1940).[4] Using the American breeding procedures as a blueprint for their work, the researchers selected varieties primarily for resistance to drought, strength of the root system, early maturity, and large size of grain (Saunders, 1940). The scientists focused on synthetics rather than hybrids because they wanted to breed for wide adaptability and drought resistance rather than for yield. Also, the breeders felt that the cost of hybrid seed was too high for farmers because hybrid seed needed to be purchased annually. In addition, there was a lack of commercial organizations with facilities and the trained staff to undertake hybrid maize seed production on a large scale and the Department of Agriculture lacked capabilities to produce and market high-quality seed hybrids. The importation of hybrid seed from international sources was considered unattractive because of the high transaction costs of importing poorly adapted cultivars, introducing unknown maize diseases, and increasing dependency on foreign suppliers. In 1932 government researchers developed Synthetic Potchefstroom Pearl (Saunders, 1942).

A turning point occurred in 1935 when the government established the Maize Control Board to promote the interests of commercial farmers. In 1945 the Maize Board established a single-channel marketing system for maize and was charged to promote maize production. In

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[4] The father of hybrid maize in South Africa is A.R. Saunders who headed the hybrid program from 1925 to 1947. He was succeeded by F.X. Laubscher who directed the program from 1947 to 1951. Laubscher was succeeded by Josephson, Grogan and Bogyo who led the programs at Potchefstroom, Bethlehem, and Pietermaritzburg, respectively from 1951 to 1954. Josephson, Grogan and Bogyo, Stead and Kuhn directed the programs from 1955 to 1960. Helmut Gevers has provided remarkable leadership for the Natal maize program since 1960.

1947 the Maize Board initiated a hybrid maize seed scheme in collaboration with the Department of Agriculture to supply farmers with adapted hybrid maize seed and stimulate private firms to enter the seed industry (Laubscher, 1950). The Maize Board served as an incubator for private seed companies.

In 1944 the government organized a Seed Inspection Service and a Seed Testing Station at Potchefstroom to help farmers learn about the quality of commercial seed and assist seed growers and merchants to improve seed quality. The government breeders started a crash breeding program of importing inbred United States Corn Belt lines in large numbers and crossing selected inbreds into hybrids (Gevers, 1988). American hybrids were poorly adapted to the harsh agroclimatic conditions in the country. In the late 1940s the government maize researchers developed a white dent topcross by crossing Synthetic Potchefstroom Pearl with the inbred line K64 from the United States Department of Agriculture. Because the topcross outyielded all commonly grown open-pollinated varieties by 25 to 30 percent over a wide range of regions, the scientists became convinced that topcrosses performed better across South Africa than conventional hybrids. Hence, researchers modified their selection and breeding methods in the direction of topcrosses (Kuhn and Gevers, 1980).

While researchers were generating the science and technology base for the development of locally-adapted hybrids, the institutional foundation for a specialized seed industry was also emerging. In 1947 the government updated the Fertilizers, Seeds, and Agricultural Remedies Act first introduced in 1907 by establishing more stringent minimum standards of seed quality and intensive enforcement procedures. The government also charged the Seed Inspection Service to administer the part of the Act that dealt with seed. The Seed Inspection Service developed a comprehensive inspection scheme and invested in qualified staff, facilities, plant and equipment to produce government-certified seed. The initiation of the government seed certification reduced adverse selection problems and infused

trading confidence in seed transactions which convinced farmers of the need to buy high-quality seed every year.

A key political development occurred in 1948 when the Nationalist Party came to power and began to implement "Apartheid" policies of racial segregation that led to the creation of black homelands and the removal of black farm households from the white-designated areas. The initiation of the black homelands policies coincided with the release of the first topcrosses in 1949 and shaped the development of the seed industry by increasing the commercial farm area and reducing the area for smallholders. The Maize Board initially carried out all the seed production and marketing functions because of a lack of private organizations with adequate facilities, financial resources and trained staff to produce high-quality seed. Furthermore, government officials felt that farmers would be better served by a non-profit public organization in the early stage because there lacked market competition to discipline private seed companies and prevent dishonest trade practices and fraud (Laubscher, 1950).

4.2.2 The Evolution of Institutions and Technology

During the 1950s, the Maize Board and the Department of Agriculture responded to the rapid increase in the demand for hybrid maize seed by investing in sophisticated breeding and seed production methods to develop hybrids for most of the maize-growing areas.[5] The breeders tried again to import United States Corn Belt inbred lines and combined them with locally-bred inbreds. This strategy was successful and it eventually led to the release of several early white hybrids, including SA4, SA11, SA13 and the yellow hybrid SA200. The Maize Board quickly expanded seed production and the marketing of the new hybrids. A turning point

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[5] The South African hybrid maize program began to advance rapidly after Merle Jenkins of the United States Department of Agriculture, Beltsville, Maryland visited South Africa in 1949 and advised researchers on new hybrid maize breeding strategies (Behrmann, 1994).

occurred in 1954, when the Maize Board began to register farmers, cooperative societies, and seed merchants to produce and market hybrid maize seed to meet the rapidly growing demand for hybrids. In 1958 the government updated the Farm Fertilizers, Seeds and Agricultural Remedies Act by establishing new standards of seed certification and testing and requiring seed sellers to declare the test results of seed lots they sold to farmers by means of labels. The new standards were based in a path dependent manner of the advanced countries on internationally-recognized rules and standard operating procedures developed International Seed Testing Association (ISTA) in order to achieve a favorable reputation for South African seed producers in international trade.

In 1961 the government established a specific Seeds and Foundation Seed Act that laid down legally enforceable rules for the registration of new varieties and varietal trials, seed certification, the approval and registration of seed merchants, and the control of imports and exports to prevent the introduction of seed-borne pests and diseases and weed seeds (Van Wyk, 1961). The Seeds and Foundation Seed Act established the institution of an Official Variety List that required only varieties and hybrids registered on the list to be sold to farmers. To be included in the Varietal List, new varieties and hybrids were required to demonstrate superior characteristics of distinctiveness, uniformity, stability and agricultural and industrial value in government-organized trials of new varieties and hybrids. In addition, the Seeds and Foundation Seed Act required the approval and registration of seed cleaners and sellers and established regular inspections of the facilities of seed merchants and the sampling of seed lots offered for sale by government inspectors to ensure that the seed sold to farmers remained true-to-type and genetically pure. Furthermore, the Seeds Act authorized the Seed Inspection Service to prosecute and punish seed companies that violated the seed quality scheme and misrepresented their products by false advertisements. The Foundation Seed Act created and authorized a Foundation Seed Board to produce parent seed for multiplication

under the seed certification scheme. Finally, the government created the Division of Plant and Seed Control within the Department of Agriculture to enforce the Seeds and Foundation Seed Act and transferred the responsibility for managing the seed certification scheme from the Maize Board to the Division of Seed Control.

Because the Seeds and Foundation Seed Act protected farmers against dishonest trading practices and prevented low-quality seed suppliers from mimicking high-quality seed sellers, it permitted the separation of seed of different qualities which attracted seed companies to enter the seed industry and create new value by improving processing and distribution efficiency, economies of scale and scope, and management capabilities. The early entrants included Sensako, Pannar (formerly Pioneer Seed Company South Africa), and Saffola that still dominate the seed industry today.[6] To safeguard private investments in specialized assets in the seed industry and assure private investors of a reasonable return to their investment, the government passed the Plant Breeders' Rights Act in 1964 which established the rights of inventors of new varieties to exclude others from selling the seed of protected cultivars for five years in a path dependent manner of North American and European countries. The Act enhanced credibility commitments and encouraged Sensako to establish a strategic alliance with DeKalb Genetics Corporation in the 1960s and initiate a breeding program from which it introduced to the South African seed industry the first proprietary sorghum hybrids in 1964 and the first proprietary maize hybrids in 1965.[7]

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[6] Pannar was founded in 1958 by Mr. Bill Wall, a local farmer in the Greytown area of Natal in order to multiply and market hybrid seed released by the Natal program. Sensako is a seed growers' central cooperative that was established in 1959 by three grain cooperatives: the Central Western Agricultural Cooperative, North Western Agricultural Cooperative, and the Eastern Transvaal Cooperative to multiply and distribute hybrids released by the national program on contract with the Maize Board.

[7] Because the cooperatives that had shares in Sensako distributed agricultural credit and acted as agents for the crop marketing boards, they would not give credit to farmers who wanted to buy Pannar seed for many years. Pannar eventually broke the barrier because of the superior performance of its hybrids compared to Sensako's products.

Sensako financed the research and field trials of maize, small grains, dry beans, and oilseeds through foundation seed sales, royalties, grants and research levies collected from cooperative members by the various Marketing Boards. Similarly, Pannar initiated a maize breeding program in 1960, established a research and marketing agreement with Pioneer Hi-Bred International, and registered its first four proprietary maize hybrids in 1968.[8] The Act also attracted several multinationals to enter the South African seed industry, including Asgrow in the 1960s, Ciba Geigy in 1976, and Cargill in the late 1970s. The government facilitated the establishment of private seed companies by fostering informal partnerships between public and private breeders and making publicly developed inbred lines and breeding populations freely available to private breeders. As the private seed companies added breeders to their staff and developed research and production and marketing competencies, the Maize Board began in 1971 to register commercial seed firms that employed maize breeders to undertake the production and financing of foundation seed of the parent lines for their hybrids.

During the late 1960s and 1970s, the private seed companies introduced elite advanced breeding materials and inbreds from the United States, Argentina and other parts of the world and combined them with local publicly-bred inbreds. The strategy of combining local maize material with material from other countries enabled breeders to make rapid progress in developing better-performing seed hybrids. Between 1967 and 1979, the share of local private hybrids in the applications for inclusion in the Varietal List rose from 50 to 80

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[8] Pannar owned the name of the Pioneer Seed Company in South Africa while Pioneer Hi-Bred International owned the name Pioneer in the rest of the world. When Pannar terminated its technical agreement with Pioneer Hi-Bred International in 1985, Pioneer South Africa changed its name to Pannar outside South Africa. When Pioneer Hi-Bred International entered the South African market in 1992 it had to change its name to PHI because Pannar owned the name Pioneer.

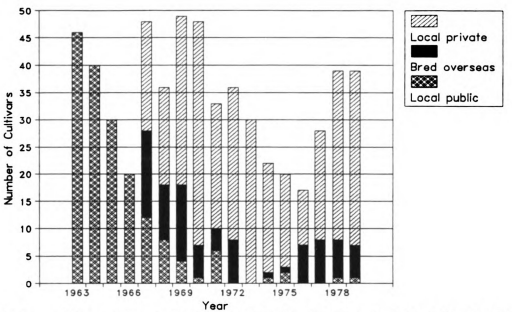

Figure 4.1: Maize cultivar applications for inclusion in the Varietal List in South Africa, 1963-1979

Source: Department of Agriculture, South Africa

percent while the share of public and foreign hybrids declined (Figure 4.1)[9] The government facilitated the rapid growth of private seed companies by intensifying controls on seed production and sale by licensing seed sellers and cleaners, and inspection visits to the premises of seed sellers and cleaners to collect samples for planting out and laboratory analysis. The government also checked to ensure that seed offered for sale satisfied the prescribed requirements of cultivar trueness and purity, germination, physical and phytosanitary condition; carried out field inspections of seed crops during the growing season and laboratory analysis of seed lots during processing; and checked seed advertisements in agricultural journals and newspapers to determine whether advertisers were registered and whether the advertized hybrids appeared on the Varietal List.

[9] The rapid growth of private seed companies was supported by the Natal program which released over 90 percent of the publicly-developed inbreds to the industry following the depletion of staff at Potchefstroom. The inbreds released by the Natal program were also made available to over 20 countries including Zimbabwe, Zambia, Malawi, Zaire, Kenya, Egypt, Japan, Brazil, India, and the United States.

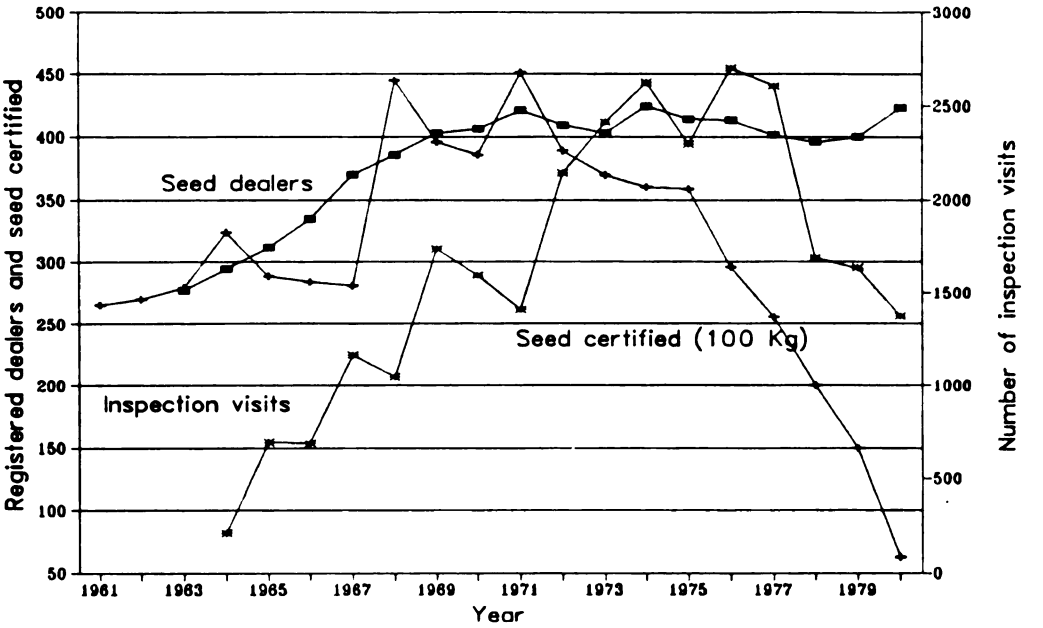

Figure 4.2: Organizations registered as seed dealers, Seed Certified, and Inspection Visits in South Africa, 1961-1979

Source: Department of Agriculture, South Africa

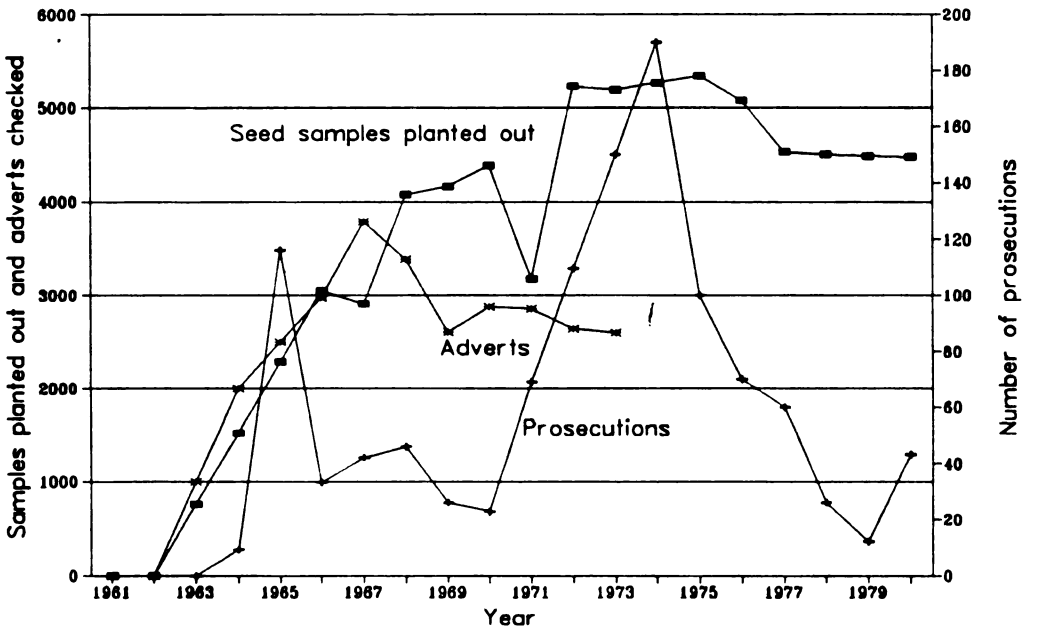

Figure 4.3: Seed Samples Planted out, Advertisements Checked, and Prosecutions under the Seeds Act in South Africa, 1961-1980

Source: Department of Agriculture, South Africa

The number of organizations registered as seed sellers and cleaners rose sharply in

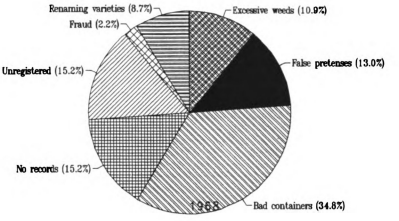

Figure 4.4: Reasons for Prosecutions Against the Seeds Act in South Africa, 1968

Source: Department of Agriculture

1963 when the Division of Plant and Seed Control began implementing the Seeds Act and then remained constant throughout the 1970s (Figure 4.2). The amount of officially certified hybrid maize seed doubled between 1961 and 1971 and then declined because the government handed over the management of field crop inspections and hybrid maize seed certification to private seed companies. The number of inspection visits made by government seed inspectors to the premises of seed sellers and cleaners to collect samples for testing increased tenfold between 1964 and 1974 but then declined because the rate of violations fell as companies became aware of the requirements of the Act and the severity of the penalties imposed by government. The number of seed samples planted out to determine cultivar purity and advertisements checked in agricultural journals and newspapers quadrupled between 1963 and 1969 (Figure 4.3). The number of prosecutions under the Seeds Act rose sharply between 1963 and 1974 but then declined as the high rate of detection and penalties imposed by the government made violating the law unattractive. Figures 4.4 and 4.5 show that within five years after the initiation of seed quality control, there was a reduction in the incidence of seed

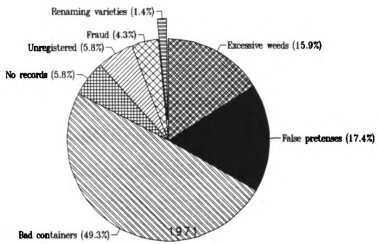

Figure 4.5: Reasons for Prosecutions Against the Seeds Act in South Africa, 1971

Source: Department of Agriculture

sold under names not in the Varietal List, seed sold with incomplete records, and persons not registered as seed sellers but an increase in seed sold in bad containers, seed sold with excessive weed content and under false pretenses.

While South Africa was piecing together the components of a competitively organized seed industry, the government also established collaborative agreements with numerous countries and seed organizations to facilitate international seed trade and gain access to new technology, germplasm, and varieties. In 1954, South Africa was accepted as a member of the International Seed Testing Association. In 1964 South Africa became a member of the Organization for Economic Cooperation and Development (OECD) scheme for the varietal certification of pasture seed. Its membership was extended in 1978 to include maize seed certification. In 1972 South Africa was given equal status under the European Economic Community (EEC) directives for seed and seed certified by the South African Division of Seed Control was treated as equal with the seed in the corresponding category certified in the Community. In 1977 South Africa joined the International Union for the Protection of New

Plant Varieties (UPOV) which provided reciprocal protection of Plant Breeders' Rights between South Africa and other members of the Union. South Africa also entered into a reciprocal agreement on plant breeders' rights with Zimbabwe which provided for the protection for new varieties developed in either country. The Seed Merchants' Association of South Africa also participated in the International Federation of Seedsmen (FIS) which enabled the seed industry organizations to keep abreast of new ideas, problems and policy in international seed business.

4.2.3 The Seed Industry in 1980

By 1980 the South African maize seed industry had developed a sophisticated and competitively-organized seed industry that supplied a variety of innovative seed products to commercial farmers with influence in the Apartheid-controlled government. The industry was dominated by three domestic seed companies that were in partnerships with global seed companies, Pannar, Sensako, and Saffola. Three multinationals had established seed businesses in South Africa: Ciba Geigy, Asgrow, and Cargill. The six dominant companies operated in a competitive environment. The government breeding program focused on areas neglected by private companies such as basic genetics, population and inbred development, physiological breeding criteria, and high lysine maize while breeders in private seed companies focused on hybrid development and testing.

The performance of the South African maize seed industry is impressive. Commercial farmers adopted hybrids at a much faster rate than in the United States by switching from farmer varieties to certified varietal and hybrid seed in 30 years, 1949 to 1979. The number of hybrids available to farmers increased from 18 to 38 from 1966 to 1979 and annual hybrid maize seed sales rose from 1.3 thousand tons in 1949 to more than 54 thousand tons in 1979. The seed to commercial grain price ratio rose from 6 in 1974 to 8 in 1980. The average

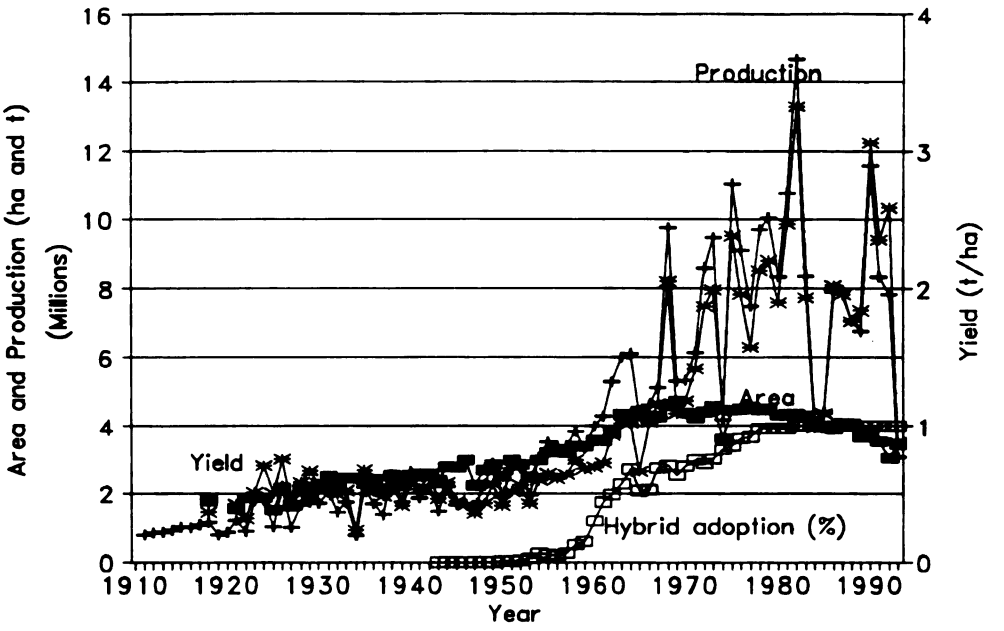

Figure 4.6: Commercial Maize Area, Yield, Production and Hybrid Adoption in South Africa, 1911-1993

Source: Department of Agriculture and Maize Board

yield on commercial farms and production began to rise in the 1950s when farmers started to adopt certified hybrid maize seed (Figure 4.6). A study of comparative yield trials of open-pollinated varieties and hybrids that were widely cultivated between 1950 and 1980 revealed that 39 percent of the yield increase was directly attributable to plant breeding (Gevers, 1988). Without question, hybrids revolutionized commercial maize production in South Africa. Yet the seed industry neglected the needs of smallholders. The proportion of the smallholder area planted to hybrids in 1980 was less than 30 percent and the average smallholder maize yield was 40 percent of the commercial yield partially because of declining soil fertility, small sizes of arable holdings, poor infrastructure, lack of access to improved farming information and technologies, a shortage of draught power and farm equipment, and inability of smallholders to exert political influence (Bembridge, 1987; 1988; 1991).

4.3 Zimbabwe[10]

The evolution of the seed industry in Zimbabwe was influenced by the South African and North American seed industries in a path dependent way since the turn of the century through the transfer of genetic materials and breeding methods, scientific exchanges, the training of scientists and seed technologists in South Africa and Europe, and seed trade between South Africa and Zimbabwe. Zimbabwe also borrowed and adapted institutional and technological innovations from the United States, Europe and South Africa. By 1980, Zimbabwe had developed a sophisticated, monopolistic seed industry that was beginning to make the transition to a competitive pattern of organization.

4.3.1 The Emergence of the Seed Industry Since 1900

Scientific maize breeding was started in Zimbabwe by the Department of Agriculture at the Harare Research Experiment Station in 1904 following demands by European farmers to organize agriculture along scientific lines (Smith, 1979). Between 1904 and 1910, the Department of Agriculture introduced and tested several maize varieties from the United States and South Africa, including Horsetooth, Hickory King, Golden Ball, Leaming, Golden Eagle, His Excellency, Boone County White, and Silver Mine.[11] Hickory King and Boone County White were selected as the most suitable varieties because of superior yield, uniform grain quality, early maturity, and disease resistance. Beginning in 1906, the Department of Agriculture and farmer associations imported pedigree maize seed of adapted varieties from the best growers in the United States for sale to farmers. But the basic germplasm used to

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[10] This section draws from the Annual Reports of the Department of Agriculture from 1902 to 1953; and the Research and Specialist Services, Ministry of Agriculture, from 1949 to 1985.

[11] The introduction of improved varieties from South Africa and the United States was recommended by an American agriculturist, Mr. Odlam, who visited Zimbabwe in the 1900s (Smith, 1979).

launch the seed industry was provided by Salisbury White which was developed by farmers by varietal hybridization between Hickory King and either Horsetooth or Boone County (Weinmann, 1972; Smith, 1979).

The adoption of better seed and improved cultural methods increased maize production and enabled Zimbabwe to export 1,100 tons of maize to the United Kingdom in 1909.[12] Although the Zimbabwean maize was well received on the London Corn Exchange, there were some irregularities in grain size and variety and growers were urged to ensure uniformity in order to establish a secure market for their maize. This prompted European farmers to request the government in 1913 to control the seed trade because they believed that much of the seed offered for sale was of low quality (Mundy, 1914). The government established a voluntary certification scheme in response to the demand under which farmers and seed merchants could submit seed samples to the Department of Agriculture for examination, including information about the variety's name, origin, breeding history, the quantity available for sale, and selling price.[13] The Department of Agriculture organized the examination of the quality of the seed and on the basis of these tests recommended seed for sowing to farmers.

Following the lead of South Africa, European farmers established a maize breeders' association in 1919 to encourage the production of varietally pure maize seed, assist the Department of Agriculture in devising maize experiments, and award prizes in agricultural

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[12] Maize was Zimbabwe's first significant export crop. Maize exports grew at the phenomenal rate of 18.8 percent between 1909 and 1932, mainly to satisfy the demand for white maize in England's starch industry (Masters, 1993).

[13] The government agriculturist and botanist, Godfrey Mundy, visited Canada in 1913 and was inspired by the role that the Canadian Seed Growers' Association played in advancing the interests of seed growers and farmers and facilitating the trade of high-quality maize seed. Mundy wanted to initiate a similar farmers' association in Zimbabwe but felt that the seed industry had not reached the stage to permit the creation of an autonomous maize seed growers' organization.

shows. The association enabled farmers to become interested in the genetic purity of seed which set the stage for the introduction of hybrids (Mainwaring, 1922).

In 1932, Henry Arnold initiated hybrid maize breeding experiments at the Harare Research Station by selecting and inbreeding 44 outstanding plants of Salisbury White. Arnold followed the techniques and procedures that had been developed by researchers in the United States and aimed to develop double hybrids with higher yields than Hickory King (Rattray, 1988). A local farmer, E.H. South, developed the Southern Cross variety which later produced inbred lines that subsequently played a strategic role in Zimbabwe's seed industry.[14] In 1938, Allan Rattray joined the research team and the breeding program was expanded to include Hickory King and Southern Cross varieties. A year later, the maize team began to cross promising inbred lines and compare the yields with Salisbury White.

As the researchers were generating the scientific and technological knowledge for the development of locally-adapted hybrids, the institutional arrangements were being concurrently developed for a specialized seed industry. In a path dependent manner of the pattern of seed certification programs in North America, the European farmers organized the Southern Rhodesia Seed Maize Association with the aim of producing high-quality, certified seed at guaranteed prices, ensuring the continuity of seed supply, and disseminating state-of-the-art information on seed selection and production among its members (Weinmann, 1975). The Seed Maize Association began by multiplying improved open-pollinated varieties that had been released by the Harare Research Station (Hanssen, 1968b). The seed grown by the members of the association was inspected during the growing season by government-appointed seed inspectors. Seed lots that passed the minimum standard were certified and their quality disclosed to farmers by a Government Certification Label. To encourage farmers to sow

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[14] Southern Cross was developed by varietal hybridization from maize varieties which originated in the Greytown area, South Africa, where they had been introduced from the United States by a local farmer, Mr. Reid.

certified seed, the government controlled seed prices and subsidized the production of certified seed. Following the demand by farmers for protection against inferior foreign varieties and seed-borne diseases, pests and weeds, the government introduced the Plant Protection Act in 1942 which restricted the importation of seed of new varieties unless they were accompanied by a permit.

After the Second World War, government researchers expanded the maize breeding program and began to explore the possibility of producing topcrosses by combining inbreds with improved open-pollinated varieties. Beginning in 1945, government breeders bulked inbreds at the experiment stations and issued the seed to farmers for crossing with their own stock. In 1948 the scientists produced a limited quantity of the first topcross hybrids and distributed the seed to farmers. Because variety trials indicated that hybrids consistently outyielded improved open-pollinated varieties, government researchers decided to make hybrid seed available on a large scale. Because there was a lack of seed companies and the government was poorly equipped to produce hybrid seed on a commercial scale, the government asked the Seed Maize Association to assume responsibility for the production and marketing of hybrid seed so that its staff could concentrate on the breeding and production of foundation seed, seed inspection and the training of seed grower-members of the Association. The Association agreed to undertake the responsibility for maize seed production and marketing provided that it became the exclusive recipient of parent inbred seed released by the Harare Research Station (Rattray, 1988). Because the government wanted only high-quality seed to be produced, it accepted this condition and decided that all hybrid seed should be certified. In 1949 Zimbabwe became the second country in the world after the United States to produce double hybrid seed from locally-developed inbred lines. The Seed Maize

Association produced and marketed the first double hybrid seed, SR1, through the Farmers Co-operative Society.[15]

4.3.2 The Evolution of Institutions and Technology

During the 1950s, the demand for hybrid maize seed increased rapidly and the Seed Maize Association and the Farmers' Co-op increased their investment in human capital, machinery, technology and management in order to increase the supply of hybrid maize seed.[16] Again, following South Africa's pathway, the government established a seed testing station in 1950 and introduced the Farm Feeds, Fertilizers, Seeds and Agricultural Remedies Act in 1952 which laid down minimum standards for the production and sale of agricultural inputs, including seed (Hanssen, 1968a). The Act made the laboratory testing of most agricultural seeds compulsory and prescribed methods of seed sampling, testing, purity and germination that were based on internationally accepted ISTA standards (Hanssen, 1967). The strict enforcement of high standards of discipline in growing maize seed and a high degree of co-operation between the government research stations and the Seed Maize Association infused trading confidence into seed transactions that permitted maize seed growers to produce 1,000 tons for local farmers and 160 tons for export to the United Kingdom in the first two years of operation. Beginning in 1952, the Department of Native Agriculture purchased hybrid maize seed from the Seed Maize Association for distribution to smallholders in five kilogram packs.

The rapid development of the hybrid maize seed industry led the government to expand investments in research stations and experimental farms throughout most maize-

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[15] SR1 stands for Southern Rhodesia hybrid one.

[16] The Seed Maize Association developed stringent rules for membership and seed production. The Association required all new members to serve a probationary period of three years, during which they were required to comply with rules governing hybrid seed production. New members were only allowed to fail once during the probationary period and were given a sales quota in their fourth season if they satisfied the Executive Committee.

growing areas and carry out advanced breeding trials. The establishment of the Federation of Rhodesia and Nyasaland in 1954 greatly increased the demand for hybrid maize seed in the region.[17] During the Federal era from 1953 to 1963, the Seed Maize Association expanded hybrid maize seed exports to Malawi, Zaire, and Mozambique. Seed exports were greatly facilitated when Zimbabwe was accepted as a member of the International Seed Testing Association in 1956 and adopted ISTA's seed quality standards. In the same year, government researchers began a maize breeding program at the Matopos Research Station for the lower and less reliable rainfall areas of the country where, at that time, more than 60 percent of the arable area under commercial crops was planted to maize (Rusike and Donovan, 1994). Throughout the 1950s the hybrid maize program made significant advances which resulted in the release of 12 hybrids with better yield, grain quality, and agronomic characteristics.[18]

A milestone was achieved in 1960 when government researchers released an outstanding hybrid SR52 which was the world's first single hybrid for commercial planting. Although SR52 was initially intended for the higher and more reliable rainfall and better soil areas of Zimbabwe, it was widely adapted to conditions throughout Eastern and Southern Africa, particularly in the Natal region in South Africa. The success of SR52 in international markets made Zimbabwe one of the leaders of maize seed production in Africa. Following the release of SR52, government researchers turned their attention to crossing locally-bred inbreds with inbreds from South Africa, Mexico and Colombia. This led to the development of double cross hybrids SR13 in 1964 and SR14 in 1966. The Matopos maize breeding program produced four synthetic varieties and a topcross, American White Flint x K64R,

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[17] The Federal Government exercised only limited responsibility for agriculture in Malawi.

[18] The first eleven hybrids grown commercially in Zimbabwe all had as parents only lines from Arnold's original material (Rattray, 1988).

known as Matopos Topcross in 1964. The Matopos topcross became the first maize cultivar bred specifically for the country's less reliable rainfall areas. The Matopos topcross was the forerunner of three-way hybrids in the R200 series that replaced it in the 1970s.

Four other events influenced the development of the maize seed industry in the 1960s. The first was the transfer of the responsibility for foundation seed production from the government to the Seed Maize Association and the Farmers' Co-op in 1962.[19] This helped lower the transaction costs of gathering market information and coordinating seed production and distribution because it placed the financing and management of foundation seed production under the Farmers' Co-op which was best suited to estimate the demand for individual hybrids because it marketed the hybrid maize seed. Second, the break-up of the Federation in 1964 resulted in the loss of the Zambian market which represented 20 percent of the Seed Maize Association's annual sales. After the dissolution of the Federation, Zimbabwe's Department of Agriculture began to concern itself for the first time with improving both European and African agriculture. The third event was the Unilateral Declaration of Independence by the Smith government in 1965 which was followed by imposition of mandatory sanctions by the United Nations against Zimbabwe. The imposition of sanctions inhibited the entry of multinational seed companies into the Zimbabwean seed industry. The fourth event was the passing of the Seeds Act in 1965 which updated standards for the registration of seed sellers and seed testing laboratories, use of variety names, maintaining records of sales, seed imports and exports, and certification (Hanssen, 1967). However, the Act did not establish an Official Variety List because the seed trade argued that the government lacked facilities and staff to test seed varieties and hybrids in the different ecological conditions. The Seeds Act designated the Seed Maize Association as the only official seed-certifying agency and reinforced its monopolistic position. The Seeds Act also

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[19] But the Ministry of Agriculture retained the responsibility for the maintenance of breeders' seed of inbred lines in commercial use.

encouraged the Seed Maize Association to form the Seed Maize Co-operative in 1969 to control seed distribution which was considered strategically important under sanctions.

In the late 1960s, maize breeding was consolidated at the Harare Research Station to increase the effectiveness of the breeding program. The maize researchers released three-way hybrids which well-adapted to less reliable rainfall areas because of their superior silk to pollen synchronization and earlier maturity. The first three-way hybrid maize seed was R200 which was released in 1970, followed by R201 in 1975 and R215 in 1976. The R200 series was widely adopted by smallholders throughout Eastern and Southern Africa and enabled Zimbabwe to become the leading exporter of hybrid maize seed in Africa.[20]

Following drought in 1965, Zimbabwe imported hybrid maize seed from South Africa and this led the government to encourage the Seed Maize Association to carry over seed reserves as a safeguard against unfavorable seasons for seed production. In 1970, the Seed Maize Association, the Commercial Farmers' Union, and the government formalized the arrangement by establishing a Tripartite Agreement. Under the Agreement, the Seed Maize Association agreed to produce sufficient maize seed for normal domestic use and maintain a strategic reserve of 20 percent of Zimbabwe's annual maize seed requirements (Tattersfield and Havazvidi, 1993). In exchange, the government agreed to give the Association exclusive marketing rights to the parent lines developed by its breeders. The agreement also included annual review of maize prices for the domestic market and government control over maize seed exports. The Tripartite Agreement served as a barrier to private competition because it denied private companies access to government germplasm. Also, the government delegated

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[20] The three-way hybrids R201 and R215 were developed by S.W. Nelson by combining locally-bred material with material released by the Natal program in South Africa and from the pre-CIMMYT populations *Race Pepitilla* and *Race Celaya* which he isolated when he visited Rockefeller Foundation scientists in Mexico in 1963.

the responsibility for managing seed certification to the Seed Maize Association (Hanssen, 1978).

The Tripartite Agreement conferred property rights to the Seed Association which reduced uncertainty and stimulated a small number of commercial seed farmers to produce seed and reap economies of scale at relatively low profit margins. In exchange, the government was assured a country-wide availability of hybrid maize seed and a seed reserve that could be used by farmers to replant in case of drought. Also, the agreement gave commercial farmers a voice in the system and put the Seed Maize Association at the service of large-scale farmers. The Tripartite Agreement charged the government with regulating the industry and allowed private farmers to pursue seed production and marketing. The net result was a reduction in uncertainty and contractual hazards by eliminating middlemen and enabling the government's Seed Services to deal with one seed organization.

Three other events in the 1970s significantly shaped the seed industry. First, the passage of the Plant Breeders' Rights Act in 1973 granting property rights for 20 years to plant breeders for the discovery of new varieties and hybrids which were distinctive, uniform, stable, and novel. The Act was intended to encourage transaction-specific investments in plant breeding programs but it placed the responsibility of judging the distinctiveness, uniformity, stability, and novelty of new cultivars under the government's Seed Services which was legally bound to the Seed Maize Association by the Tripartite Agreement and therefore potentially biased against potential entrants. The second event was the Seed Maize Association's investment in a private research station outside Harare in 1974. The station was set up to reduce the political uncertainty that a future government might not maintain adequate long-term support for plant breeding to serve commercial farmers.

The government fostered the development of the seed industry by registering and inspecting the premises of persons selling seeds, testing seed, and carrying out field inspection

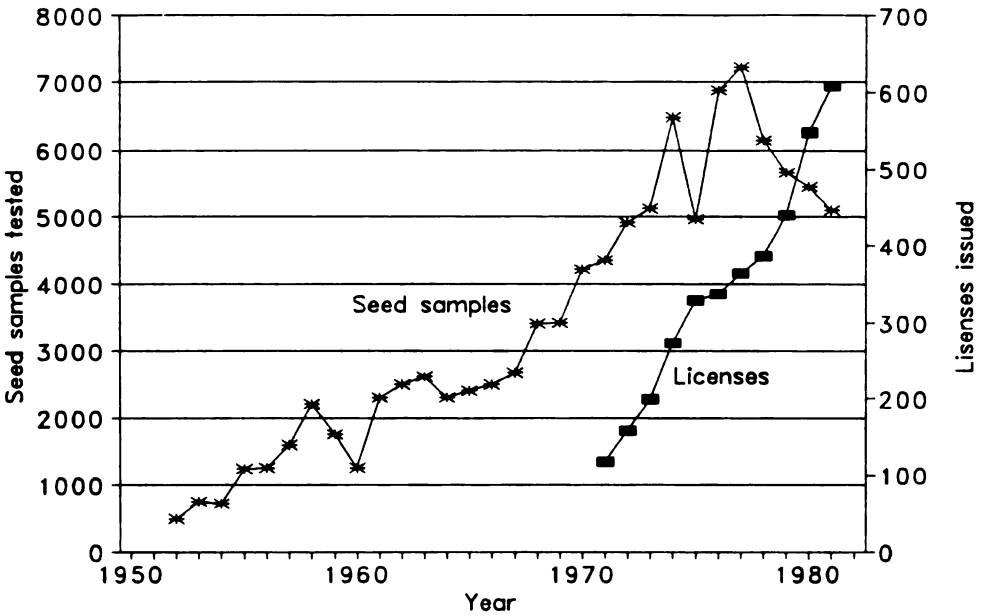

Figure 4.7: Licenses issued to Seed Sellers and Seed Samples tested in Zimbabwe, 1952-1981

Source: Seed Services

of seed crops. The number of licenses to sell seed rose fivefold from 1971 to 1980 while the seed samples tested at the official seed laboratory increased tenfold from 1952 to 1980 (Figure 4.7).

In the late 1970s, the Seed Maize Association began to enter Zimbabwean-bred hybrids in South African maize cultivar trials and establish distributors to market Zimbabwe's hybrids in South Africa.[21] In 1979 the Seed Maize Association was reconstituted as the Seed Co-operative Company of Zimbabwe under the supervision of the Commercial Farmers' Union in order to restrict membership, and limit the quantity of hybrid certified seed placed on the market. The restructuring of the Association as a cooperative was intended to reduce the transaction costs of monitoring and inspecting seed crops which the Association had to bear under the terms of the Tripartite Agreement. Another reason for transforming the Seed

[21] For example, the medium maturity yellow single cross hybrid R70 was released in 1978 solely for sale in South Africa.

Maize Association into a cooperative was that seed growers could obtain tax shelter under the Zimbabwean Company Act.

4.3.3 The Seed Industry in 1980

When Zimbabwe achieved political independence in 1980, it had completed the transition to a specialized seed industry that supplied commercial farmers and a small percentage of smallholders with superior hybrids. The government conducted all maize breeding, including varietal development and hybrid testing, seed certification and laboratory analysis. The Seed Maize Association established a breeding program in the mid-1970s and it increased its commitments to field inspection and seed certification in the 1980s.[22] The Tripartite Agreement was an important institutional innovation and it helped nurture an infant industry and produced the lowest seed to commercial grain price ratios in Southern Africa. However, the Agreement served as a barrier to domestic and foreign firms and the transition to a competitively-organized seed industry.

The development and introduction of hybrid maize has been described as the greatest single contribution of government research to the agricultural industry of Zimbabwe (Weinmann, 1975). The government breeding program released 30 hybrids between 1950 and 1980 that fuelled the country's first Green Revolution by commercial farmers (Eicher, Forthcoming). Because of the seed price control provision of the Tripartite Agreement, the seed to grain price ratio of single cross hybrids was reduced from 10 to 8 and that of three-way hybrids from 8 to 4 between 1966 and 1981. Without question, Zimbabwe's low hybrid maize seed prices were a major cause of the rapid expansion of hybrid maize seed sales to 30,000 tons by 1990, up from 10,000 tons in 1980. Commercial farmers adopted hybrids at

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[22] From 1949, the government and the Seed Maize Association jointly employed seed inspectors. The Seed Maize Association paid about two-thirds of the salaries and the government contributed the remaining one-third of the salaries and travelling expenses.

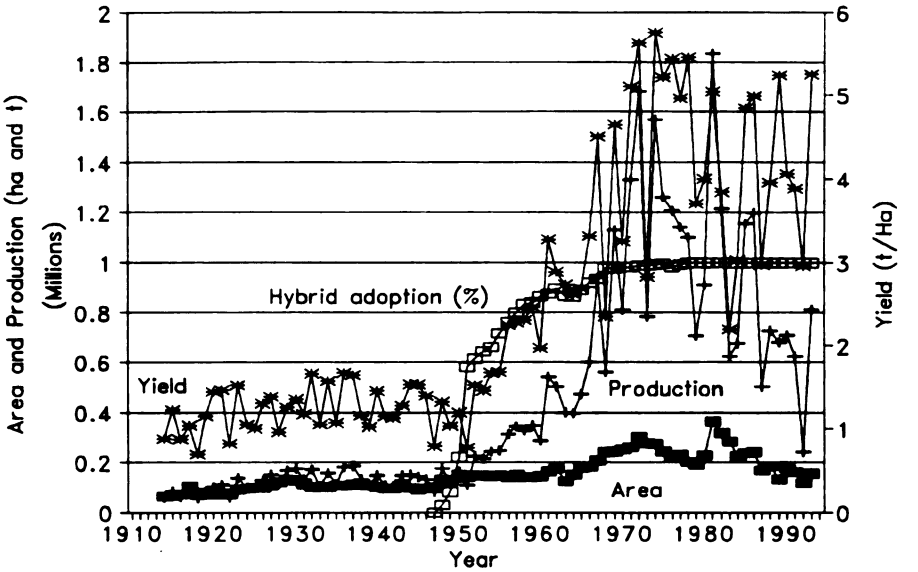

Figure 4.8: Commercial Maize Area, Yield, Production and Hybrid Adoption in Zimbabwe, 1910-1993

Source: Ministry of Agriculture

a rate faster than in the United States and it took only 17 years for farmers to switch from local varieties to 100 percent certified hybrid seed. The commercial maize yield and production began to rise in the 1950s when large-scale farmers started to adopt hybrids and continued to trend upwards until the 1980s (Figure 4.8). Although mechanization, fertilizer and improved agronomic practices contributed to improving the maize yield between 1950 and 1980, more than 45 percent of the yield increase is directly attributable to superior-performing hybrids (Tattersfield, 1982).

The rapid adoption of hybrids by smallholders was stimulated by the agricultural extension service during the 1970s with demonstration plots, field days, and dissemination of research information that convinced smallholders of the benefits of planting seed hybrids (De

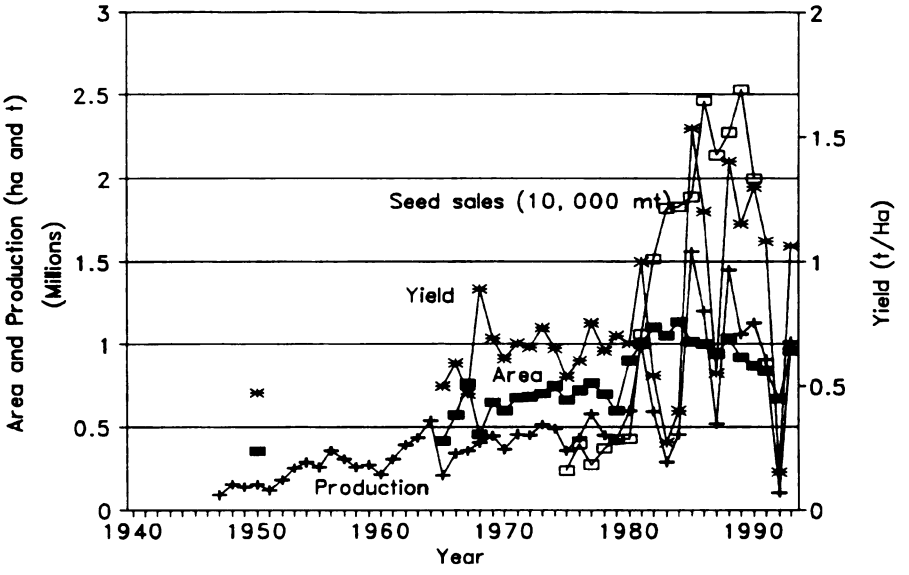

Figure 4.9: Smallholder Maize Area, Yield, Production and Seed Sales in Zimbabwe, 1948-1993
Source: Ministry of Agriculture

Woronin, 1993).[23] The smallholder maize yield and production began to rise in the 1970s with the increased use of hybrid seed (Figure 4.9). Because the government committed resources to infrastructural development in smallholder areas after the breakup of the Federation in 1964, small scale farmers were able to tap the backlog of three-way hybrids at independence in 1980 and spearhead the second Green Revolution in the early 1980s (Eicher, Forthcoming). Hybrid adoption by smallholders rose to about 50 percent by 1975 and 90 percent by 1985 (Rohrbach, 1988; Mashingaidze, 1994).

Although maize breeding and the seed industry in Zimbabwe contributed to high-quality certified seed of adapted hybrids that benefitted both commercial farmers and smallholders, three factors began to press for fundamental change in the industry in the 1980s. First, independence was immediately followed by resignations of experienced staff

[23] Hybrid adoption by smallholders accelerated after the government prohibited the sale of open-pollinated varieties in the domestic market in the early 1970s because research showed that hybrids were superior to open-pollinated varieties under most growing conditions.

from the government maize research program. However, most of the breeders who resigned from the government program joined the Seed Cooperative Company's breeding program, thus minimizing the loss to the country.[24] Second, the government reduced its expenditure on agricultural research in real terms by 25 percent from 1980 to 1990 and allocated most of its dwindling maize research budget to salaries and wages rather to subsistence and travel for field trials (Kupfuma, 1994). Third, the monopoly position of the Seed Cooperative was challenged by domestic and multinational seed companies.

4.4 Zambia[25]

The early development of the maize seed industry in Zambia was shaped by the importation of genetic materials and breeding methods from South Africa and Zimbabwe. However, the development of the seed industry before Independence in 1964 was hampered by inadequate funding for research, a lack of research facilities and professional staff, and rapid staff turnover. Following Independence, the government implemented policies to strengthen agricultural research, teaching and extension and promote domestic hybrid maize seed production. But the government's attempt to transform Zambia into a socialist state failed. The poor performance of the economy forced the government to implement structural adjustment reforms in the 1980s and a reorganization of the maize research with assistance from Yugoslavia, USAID, FAO, and SIDA.

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[24] One remarkable characteristic of maize breeding in Zimbabwe was the continuity of scientific leadership. From 1932 to 1985, the maize program in Zimbabwe was managed by four scientists: Arnold, 1932 to 1948; Rattray, 1937 to 1969; Nelson, 1969 to 1976; and Olver, 1976 to 1985.

[25] This section draws from the Annual Reports of the Department of Agriculture, Northern Rhodesia, from 1912 to 1963; the Ministry of African Agriculture, Northern Rhodesia, from 1954 to 1963; and the Research Branch, Ministry of Agriculture, Zambia, from 1964 to 1990.

4.4.1 The Emergence of the Seed Industry Since 1900

In Zambia scientific maize breeding was started by the Department of Agriculture at Chilanga and Mazabuka experimental gardens in 1913. The Department was concerned with meeting the needs of European farmers along the rail line connecting urban centers and copper mines in Northern Zambia. The government researchers carried out variety performance tests on Hickory King, Hickory Horse-Tooth, Ladysmith, Iowa Silver Mine, Louisiana Hickory, and Potchefstroom Pearl and identified Hickory King as the most suitable variety for commercial farmers.

During the early 1920s, farmers began to adopt seed selection methods and to pay high prices for high-quality seed. Variety trials conducted at the experimental gardens showed that locally selected seed was superior to imported seed in trueness-to-type, quality, and yield.[26] By 1922 most European farmers were using their own selected seed and the Department of Agriculture began to offer selected seed to African farmers and encourage its use. During the late 1920s and early 1930s, the government's attempts to strengthen agricultural research were hampered by the global depression. All long-term experiments, including maize breeding, were suspended in 1939 because of staff shortages connected with the Second World War.

After the War, government researchers resumed long-term experiments but maize breeding was hampered by a shortage of professional breeders and entomologists. In 1949 researchers initiated variety performance trials in different agroclimatic regions to compare Zimbabwean-bred double hybrids with the locally-improved Hickory King variety. The trials showed that double hybrids outyielded Hickory King by some 10 to 30 percent, even under unfavorable conditions. In 1951 the Department set up a Central Research Station at Mount

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[26] In 1919, Joseph Burtt-Davy, a South African maize expert, wrote a letter to the Zambian Department of Agriculture stating that Zambia could produce a better class and better looking seed maize than South Africa which led government researchers to conduct variety trials to compare imported maize seed with locally-selected seed.

Makulu outside Lusaka. However, in 1954 the governments of Zimbabwe, Zambia and Malawi created the Federation of Rhodesia and Nyasaland and transferred most agricultural research functions to the Zimbabwean Department of Research and Specialist services. This severely handicapped the advancement of maize improvement scientific and technological capabilities in Zambia during the Federal era from 1953 to 1963 (Ballantyne, 1966).[27]

But the Federation greatly benefitted European farmers in Zambia by improving extension services, access to advanced agricultural technologies, and the establishment of the Official Seed Testing Laboratory in 1963 (Hoyle, 1967). The major disadvantage of the Federation was the low priority given to agricultural research for African agriculture which was a responsibility of each of the three territories in the Federation. Under the Federation, hybrid maize seed was produced in Zimbabwe by the Seed Maize Producers' Association under Zimbabwean certification rules. In 1956, the Zimbabwean Seed Maize Producers' Association began to admit Zambian farmers to serve probationary periods. However, when the Federation was dissolved in 1963, only three commercial farmers were producing hybrid maize seed in Zambia.

4.4.2 The Evolution of Institutions and Technology

At Independence in 1964, the Zambian government decided to become self-sufficient in hybrid maize seed. To this end, the government expanded the Seed Services to provide inspection services, created the Grain Marketing Board to control maize prices and grain marketing, and set up the Agricultural Rural Marketing Board to supply fertilizers and seed to farmers (Gray, 1975). The maize seed growers formed the Zambia Seed Producers'

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[27] Throughout the Federal era, the territorial Zambian Government financed research for African agriculture. However, the British Government viewed Zambia as a copper-producing country and allocated inadequate staff and funds for agricultural research. There was also a lack of agronomists and entomologists in the maize team which resulted in an unbalanced and ineffective maize program.

Association (ZSPA). A year later, the government established several regional experiment stations and sub-stations and invested in professional staff and equipment to conduct variety performance trials throughout the country.

Because the international community imposed sanctions on Zimbabwe after its Unilateral Declaration of Independence in 1965, Zambia was unable to continue importing hybrid maize seed from Zimbabwe. Hence, the Zambian government faced an immediate crisis of acquiring parental inbreds for producing hybrid maize seed. After negotiations with the Zimbabwean authorities, the Zambian seed officials obtained one kilogram of the male parent and less than two kilograms of the female parent of the hybrid SR52 (McGuire, 1970b). In 1965, the plant breeder, John Abington, and the Seeds Officer, Julian Hoyle, started an accelerated seed multiplication program to bulk up foundation seed, using irrigation to grow two seed crops a year (Hoyle, 1966). A year later the ZSPA maize seed growers began to produce hybrid seed in a path dependent way using the rules of the Zimbabwe Seed Producers' Association which they had inherited during the Federal period (Hoyle, 1967a). In 1967, only three years after the launching of the crash multiplication program, the Zambian seed growers were able to produce a sufficient quantity to meet the country's total SR52 requirements. The ZSPA gave the exclusive marketing rights to a parastatal, the African Farming Equipment Company, and provincial cooperative marketing associations (Griffin, 1968). Once the country's seed requirements had been met, maize researchers initiated experiments to develop three-way hybrids and introduce male sterility into the female inbreds of SR52 to reduce production costs. Also, the maize research team began experiments to develop early maturing varieties and hybrids, high lysine maize, and dwarf maize to facilitate mechanical harvesting.

After the break-up of the Federation in 1963, Zambia lacked a legal framework to establish and enforce seed quality standards and guarantee seed quality. In 1967, the

government passed a minimum standards Seeds Act in a way based on the pattern that developed in Europe and in 1969 it set up a specialized seed laboratory based on ISTA standards (Gray, 1969a). The Seeds Act required all seed sellers, producers, importers and cleaners to be registered with the Permanent Secretary of the Ministry of Agriculture who acted as the Controller of Seeds and delegated administrative responsibility to the Seeds Officer through the Chief Agricultural Research Officer (Gray, 1969b). Producers of certified seed were required to be members of the ZSPA and register their crops with the Seeds Officer. Seed inspectors visited the crops during different stages of growth and took samples of seed lots for laboratory testing to ensure compliance with the regulations which were based on those of the International Seed Testing Association (McGuire, 1970; Gray and Huisman, 1971).

In 1969 the government set up a parastatal, the National Agricultural Marketing Board (NAMBOARD) to take over the functions of the Grain Marketing Board and the Agricultural Rural Marketing Board. Because there was a shortage of staff to enforce the Seeds Act, seed inspectors tended to favor NAMBOARD when issuing licenses to minimize inspection costs (Gray, 1970). Consequently, NAMBOARD and its provincial cooperative agents developed a monopoly in maize seed marketing. Also, NAMBOARD began to carry buffer seed stocks to insure against poor seasons and unanticipated increases in seed demand. To better serve farmers, NAMBOARD established its own warehouses where seed growers delivered seed and retail stores where farmers bought hybrid maize seed. But the parastatal did not set up depots in remote rural areas. Because seed inspectors only issued a few licenses to rural traders, hybrid maize seed was unavailable to most smallholders. For example, in 1969 the seed growers in the Eastern Province packed SR52 seed in nine kilogram packs that were better suited for 0.4 hectare plantings cultivated by smallholders but the packs could not be distributed because of a lack of licensed seed sellers (Gray, 1971c).

Once NAMBOARD had established a monopoly, the parastatal began to control the areas that growers planted to produce certified seed and administer prices in consultation with the Research Branch and ZSPA officials to match production with demand and carry over stocks (Gray, 1971b). Because of the guaranteed market and prices, the seed industry rapidly expanded. As the maize seed industry was expanding, the maize researchers released the first Zambian-bred hybrid, ZH1, and a composite, ZCA, for commercial production in 1970.[28] ZH1 was a three-way cross with the same maturity rating as SR52 but with a five percent lower yield potential. ZH1 had the advantage that its female parent was higher yielding than that of SR52, thus reducing seed production costs. ZCA was an open-pollinated variety that the breeders developed by compositing several inbred lines and allowing them to interbreed by open field pollination for several years. ZCA had a yield potential comparable with that of SR13 but had the advantage that farmers could save its seed after harvest for further planting. By 1970, ZSPA had about 100 members. Most were European farmers. Between 1967 and 1972, hybrid seed production more than doubled from 1,750 to 2,800 tons. The rapid expansion in hybrid seed production enabled Zambia to begin seed exports and in 1971 the country shipped 120 tons of certified SR52 seed to Malawi. As the seed industry expanded, ZSPA began to produce SR11 and SR13 which were better suited to regions with short rainy seasons.

A drought in 1973 reduced seed production, necessitating seed imports from South Africa (ASA 81) and Kenya (H632). Also between 1973 and 1977 the number of seed inspectors did not keep pace with the expansion of seed production (Michanek, 1979). This led to poor incentives and inadequate field inspections and a reduction in seed quality. The maize breeder, John Abington left Zambia in 1974 and his replacement resigned in 1976.

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[28] These varieties were bred by John Abington, the maize breeder at Mount Makulu from 1964 to 1973. They were included in trials throughout the country before being released (Bradwell, 1971; Gibson, 1983).

Finally, a contamination of the parents of SR52 led to reduction in SR52 yields of 15 to 20 percent (Mwale, 1987).

After a shortage of staff in the breeding program in the mid-1970s, a breeder from the Yugoslav Maize Research Institute was hired in 1978. The breeder's first assignment was to clean the contaminated elite parent lines of SR52 and ZH1. With the support of the Food and Agriculture Organization (FAO), the maize team initiated research on developing resistance to cob rots and other diseases. The maize team also started receiving support from the Swedish International Development Agency (SIDA) and USAID to develop hybrids and varieties better suited to different maize producing areas (Howard, 1994).

During the late 1970s, the Research Branch had difficulty in attracting and retaining experienced plant breeders (Olson, 1980). Because of the rapid staff turnover, there was a lack of continuity of breeding and agronomic work to generate technologies relevant to smallholders. Also, the Seed Services was allocated insufficient personnel and finance to operate its certification scheme. These constraints resulted in frequent shortages of foundation seed which reduced hybrid maize seed production. The lack of enforcement of the Seeds Act reduced seed quality. The administered seed prices were too low to attract sufficient farmers to specialize in growing hybrid maize seed. The seed prices were often announced too late during the season for farmers to plant seed crops. NAMBOARD offered the cooperatives financially unattractive discounts and restitutions to compensate them for distributing and selling the seed and the agents were poorly motivated to market hybrid maize seed.

4.4.3 The Seed Industry in 1980

Because of the poor performance of NAMBOARD, the ZSPA farmers formed the Agricultural Seeds Company in the late 1970s to market their seed. But the government's socialist policies hindered the establishment of private seed companies. In 1979, the Ministry

of Agriculture requested SIDA to finance a study of the seeds industry. The study recommended the establishment of a commercial company to produce and market agricultural and horticultural seeds (Muliokela, 1984). The following recommendations were accepted by the government: strengthening the breeding program at Mount Makulu Research Station, reorganizing the Seed Services to form the Seed Control and Certification Institute (SCCI) for enforcing the Seeds Act, and creating a joint venture company, the Zambia Seed Company (ZamSeed), to take over seed production and marketing. The shares of ZamSeed were held by the government which controlled the majority of the equity (40%) through its equity-holding parastatal, the Zambia Industrial and Mining Corporation (ZIMCO), the ZSPA (20%), Zambia Cooperative Federation (20%), Svalof AB (10%), and Swedfund (10%).[29] Although ZamSeed was organized as a private company, the Permanent Secretary of the Ministry of Agriculture was appointed as the Chairman of its Board of Directors[30].

As the 1970s drew to a close, Zambia was piecing together the components of a seed industry in which the Research Branch of the Ministry of Agriculture conducted maize breeding, varietal development and testing, foundation seed production, and seed certification and ZamSeed was responsible for hybrid seed production, marketing, and managing buffer seed stocks, imports and exports. The SCCI was responsible for managing field inspections, seed sampling, testing, labelling, sealing of seed lots, and foundation seed production. A Seeds Advisory Committee was charged with planning of foundation and certified seed production and price setting. The government subsidized seed prices indirectly through subsidies to NAMBOARD and cooperatives.

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[29] Zamseed was organized under a management agreement with Svalof AB, a Swedish multinational seed company, and support from SIDA. It was established with a share capital of US $ 4.4 million (Zambian Kwacha 3.5 million).

[30] Because the Permanent Secretary was also the Comptroller of Seeds under the Seeds Act, this led to a potential conflict of interest and bias against new entrants.

Because of the lack of staff continuity in the breeding program, SR52 was the only major hybrid available to farmers for more than 22 years, 1962 to 1984 (Mwale, 1987). The

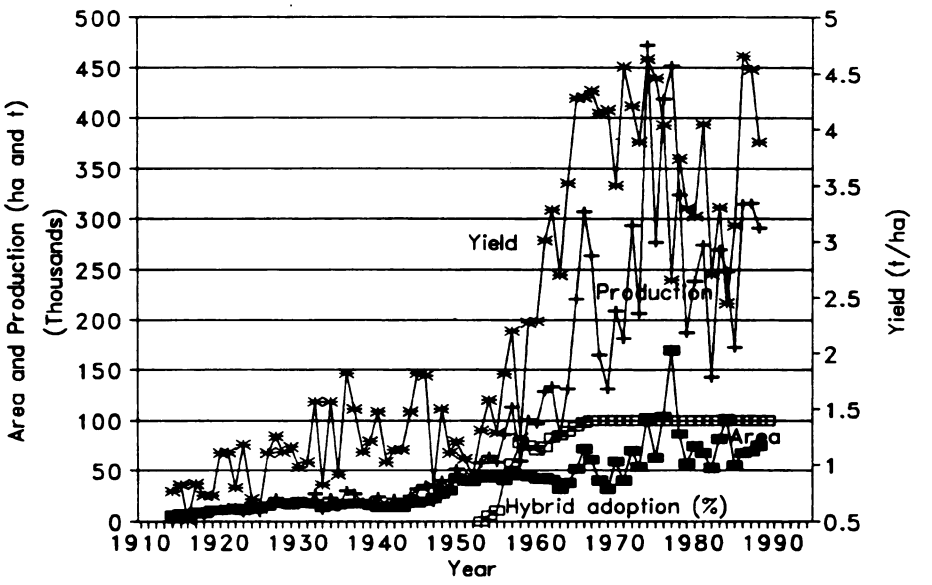

Figure 4.10: Commercial Maize Area, Yield, Production and Hybrid Adoption in Zambia, 1911-1988

Source: Ministry of Agriculture

introduction of SR52 transformed commercial maize production in Zambia in a very short time. Commercial farmers adopted hybrids much faster than in Zimbabwe and took only 12 years to switch from farmer varieties to 100 percent hybrids. The commercial maize yields and production increased in the 1950s when large-scale farmers started to adopt hybrids and continued upwards until the mid-1970s when SR52 became contaminated (Figure 4.10).

Despite the impressive performance of SR52 on commercial farms, the area planted to improved hybrids by smallholders was less than 30 percent of the maize area because of poor infrastructure, unfavorable agroclimatic conditions, and a lack of complementary inputs. Although the government carried out plant breeding, most of the funding for the research was provided by donors. The inadequate research funding by government led to low staff morale

that threatened the viability of the program and stimulated private seed companies whose future is directly connected to the success of breeding programs. Also, it became necessary to reduce the SCCI's work by transferring seed testing to private seed companies in order to reduce delays in receiving the results of tests and sealing of seed lots.

4.5 Malawi[31]

The evolution of the Malawian seed industry was influenced by the South African, Zimbabwean and Zambian seed industries through the importation of genetic materials, breeding methods and communication among scientists and members of the seed trade. The early the development of the seed industry before Independence in 1964 was hampered by inadequate funding for research, research facilities and professional staff, and rapid staff turnover. After Independence, the government implemented several seed projects to strengthen agricultural research and extension and promoted hybrid maize seed production. However, the seed industry was constrained by the lack of supporting legislation to enforce seed quality and erratic government policies.

4.5.1 The Emergence of the Seed Industry Since 1900

In Malawi scientific maize breeding was started by the Department of Agriculture at the Zomba and Nsanje (formerly Port Herald) agricultural experiment stations in 1909. Between 1910 and 1916, researchers tested 18 dent and flint maize varieties from South Africa and the United States. The varieties introduced from South Africa included Iowa Silver Mine, Hickory King, Boone County, Ladysmith, Golden Beauty, Eureka, and Yellow Hogan. The varieties imported directly from the United States were Marlborough Prolific, Williamson,

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[31] This section draws from the Annual Reports of the Department of Agriculture from 1910 to 1974; the Chitedze Agricultural Research Station, from 1975 to 1979; and the Seed Services, Chitedze Research Station, from 1976 to 1989.

Jones Prolific, Hildreth, Leaming, and Clarage. Because exotic varieties performed better than local selections, researchers decided to abandon direct selection and concentrate on new introductions. Another reason for favoring new varietal introductions was that the government wanted to encourage the production of maize to meet the grain quality demanded in Europe. In 1910, Malawi exported its first 2,000 tons of maize to Europe which prompted government researchers to begin distributing seed of high-yielding varieties to farmers in selected locations. However, in 1919 the Department suspended maize experiments and the distribution of seed of new varieties because it experienced staff shortages following the outbreak of the First World War.

In 1927 the Department of Agriculture resumed experiments to introduce new varieties and select locally-adapted cultivars. The government researchers tested the yielding ability of Potchefstroom Pearl against native varieties in different agroclimatic regions and found Potchefstroom Pearl had little advantage over native varieties. Since local varieties were more resistant to weevil damage during storage than the dent Potchefstroom Pearl, farmers preferred local varieties because they could not afford investments in air tight bins and fumigation. These factors led government officers to decide to refrain from distributing exotic varieties and concentrate on the breeding and selection of local varieties. But between 1933 and 1947, government researchers did not conduct experiments on maize. Instead, they concentrated on improving cotton and tobacco which they believed had greater potential to transform smallholders from subsistence to commercial farmers. This neglect of maize research was compounded by a shortage of trained staff throughout the 1930s and 1940s.

Two events in the late 1940s prompted the government to launch a maize breeding program. The first event was the establishment of the Maize Board in 1947 to control maize marketing. During its first year of operation, the Board had to ration grain among consumers because of a shortage of maize. This led the government to consider the production of hybrid

maize seed on state farms. The second event was an unprecedented famine in 1949 following a record drought in 1948. The famine revealed that the country was vulnerable to adverse weather and that the government needed to build a national food reserve.

To expand food production, the government established the Chitedze Agricultural Research Station in 1950 and recruited a plant breeder, pathologist, and agronomist to supervise and coordinate maize research in the country. The breeder, Richard Ellis, started experiments to develop hybrids and variety trials to compare open-pollinated varieties and hybrids from South Africa and Zimbabwe with locally-selected varieties. The 1951 and 1952 variety trials showed that Zimbabwean hybrids gave the highest yields but their cobs were not well covered and the grain was soft which led to heavy weevil infestation during storage. Therefore, researchers adopted a two-pronged strategy of developing hybrids for commercial farmers and high-yielding flint varieties for smallholders.

By the time that Malawi joined the Federation of Rhodesia and Nyasaland in 1953, the maize team had developed an improved locally-selected semi-flint variety, *Namalenga*. In 1954 researchers bulked *Namalenga* seed and distributed it to farmers. The government directed the Agricultural Production and Marketing Board, which had been formed in 1956 to stabilize maize, groundnuts, cotton, and tobacco marketing, to undertake maize seed production and distribution. The Agricultural Production and Marketing Board set up farms to bulk foundation seed produced at Chitedze and distribute it to farmers in exchange for maize grain.

4.5.2 The Evolution of Institutions and Technology

Malawi's research system matured in the 1950s and in 1958 researchers released two flinty synthetics *Mlonda* and *Askari* (SV17) and a dent hybrid *Mthenga* (LH7) that were higher yielding than *Namalenga*. The Agricultural Production and Marketing Board multiplied and

distributed the new synthetic varieties while the government research stations multiplied and distributed hybrids through the extension service. The maize breeding program came under stress in the late 1950s because of a loss of experienced specialists and a shortage of indigenous professionals to take over from the expatriates.[32]

After a hiatus in the maize breeding program for five years, it was revitalized in 1963 when a new plant breeder, P. Kyle, was hired. However, he resigned after a year and another expatriate, H.N.G. Selley, took over the program. Despite the rapid staff turnover in the 1960s, the maize program released a semi-flint synthetic SV28 that replaced *Mlonda* and SV37 that replaced SV17. Also, a semi-flint double cross hybrid LH11 (*Bingo*) replaced LH7. However, because of a lack of variety maintenance, field inspection and seed-testing services, the new varieties and hybrids became contaminated. The genetic contamination of the new varieties and hybrids and their subsequent deterioration hindered adoption (Gausi, 1970). The lack of demand for synthetics and hybrids led government researchers to discontinue the hybrid maize program and initiate a breeding program for composite varieties.

In 1968, the government implemented a Maize and Groundnut Development Project with funding from the United Kingdom (UK) to expand the production of superior seed varieties and increase high-quality seed for farmers.[33] Under the project, the British Ministry of Overseas Development supported a maize breeder, A. Bolton and an agronomist, A.J. Bennett, to set up a composite production and improvement program and country-wide trials to determine the response of different varieties in different agroclimatic areas.[34]

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[32] Ellis whose maize breeding work resulted in the production of a number of improved varieties left the service to join the Malawian Tea Association in 1959 and was not replaced until 1963.

[33] The project was a component of Integrated Rural Development Projects that government launched in 1967 to raise smallholder agricultural productivity.

[34] Selley left the program in 1969 and was replaced by L.C. Brown in 1970 who in turn was replaced by Bolton in 1972.

Between 1971 and 1974, the maize breeders conducted trials in all maize growing areas. The researchers identified Ukiriguru Composite A (UCA) from Tanzania as the most suitable variety in medium and high altitude areas and Chitedze Composite A (CCA) as the most suitable variety in low altitude areas. The researchers also identified SR52 as the highest-yielding hybrid for cash crop production. Because Malawi failed to get the parental inbreds of SR52 from Zimbabwe after the break-up of the Federation, the Agricultural Development and Marketing Corporation (ADMARC) had to import SR52 seed from Zimbabwe.[35] ADMARC also imported the hybrid H632 from Kenya whenever there was a shortage of SR52. The maize project also helped ADMARC expand hybrid maize seed production on its farms and under contract with commercial farmers and marketing seed throughout the country in liaison with the Agricultural Extension Department at government-controlled prices.

After the Maize and Groundnut Development Project was phased out in 1975, the government introduced a seed certification scheme, revived the hybrid maize breeding program, transferred the management of seed production and distribution to a specialized organization, and established arrangements for financing investments in maize breeding and seed production (Overseas Development Administration, 1973).[36] Between 1975 and 1978, the government implemented a Seed Technology Services Project with financial support from the British government to establish a Seed Technology Unit and a seed-testing laboratory at the Chitedze Agricultural Research Station. The Seed Technology Unit was directed to establish and enforce rules for the registration of certified seed growers and carry out field inspection of seed crops, sampling and laboratory analysis of seed lots, and certification based

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[35] ADMARC was established in 1971 to replace the Agricultural Production and Marketing Board.

[36] After the completion of the British-supported Maize Breeding and Agronomy Project in 1974, the maize breeders who had been brought in for the task were phased out. The breeders were replaced by several Malawian breeders, including W.B.C. Chipeta, L.L. Sauti Phiri, B.T. Zambezi, and J.M. Luhanga.

on those of the Association of Official Seed Analysts (AOSA) and the Organization for Economic Cooperation and Development (OECD). The rules required all seed crops grown for certification to be approved by the National Variety Release Committee and accepted for multiplication by the Seed Technology Working Party. Seed growers were required to register crops with the Department of Agriculture and follow approved standards of field isolation, rotation, and agronomic practices. Government seed inspectors visited fields of seed crops at various stages during the growing season and only certified the seed that passed the minimum field, laboratory tests, and labelling standards as high-quality seed.

In 1977 the government directed the maize breeders to revive the hybrid program to meet the demand for hybrid seed by commercial maize growers because the transport costs of importing hybrids increased rapidly after the closure of the border between Mozambique and Zimbabwe in 1976 (Lungu, 1976). The government also wanted tobacco estates to produce maize in rotation with tobacco. Another reason for the revival of the hybrid program was that the National Rural Development Program (NRDP) emphasized the increased use of improved certified seed to expand maize production. This led maize breeders to initiate international variety trials in collaboration with the East Africa Agricultural and Forestry organization, the Food and Agriculture Organization, CIMMYT, and the South African Regional Cooperative Maize Evaluation Introduction Trials (SARMEIT), a sub-committee of the Southern African Regional Commission for the Conservation and Utilization of the Soil (SARCCUS) based in South Africa. The increasing international linkages helped breeders develop and release a white dent hybrid MH12 in 1978 that was developed from the Zambian parental inbred lines of SR52.[37]

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[37] The Zambian SR52 on which MH12 is based had been contaminated in 1976 because of inadequate seed maintenance resulting from a shortage of maize breeders and a cutback in support for field inspection.

To meet the projected requirements of high quality certified hybrid maize seed and achieve national food security, the government envisioned the establishment of a subsidiary company of ADMARC that focused on seed production (McGuire, 1976).[38] In 1978, ADMARC and the Commonwealth Development Corporation (CDC) formed the National Seed Company of Malawi (NSCM) with a start-up investment of US$ 2.3 million (Malawian Kwacha 2.8 million) (McGuire, 1983). ADMARC held 72.5 percent of the shares and CDC held the remaining 27.5 percent. During the 1979-80 season, the company processed and packed its first batch of seed and marketed it through ADMARC. CDC was put in charge of managing the company.

4.5.3 The Seed Industry in 1980

By 1980 Malawi was fitting together the different components of a specialized seed industry. At this time the Department of Agricultural Research carried out maize breeding, varietal development, testing and through the Department of Agricultural Research and controlled the release of locally-bred and imported seed through the Variety Release Committee. The Research Department received germplasm and training support through international links with CIMMYT and IITA and regional links with SARMEIT. The Seed Technology Unit controlled seed quality by inspecting seed crops grown by commercial farmers, testing then for purity and germination, and certifying seed for sale to farmers. NSCM took over seed production, storage and processing from ADMARC and responsibility for foundation seed production from the Seed Technology Unit. ADMARC was marketing seed through its country-wide transport networks, depots and marketing outlets and seed was sold at prices

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[38] The Agricultural Development and Marketing Corporation requested the Commonwealth Development Corporation (CDC) to provide the finance and management of a parastatal seed company (Commonwealth Development Corporation, 1978). After conducting a feasibility study of the Malawian seed industry, the CDC identified the need for a seed company to take over the specialized functions of seed industry including seed production, conditioning, and storage and parent seed maintenance.

controlled by the Ministry of Agriculture. The government subsidized seed marketing by ADMARC and promotion through the Agricultural Extension Department. The industry was coordinated by the Seed Technology Working Party, NSCM and ADMARC. The organizations had sufficient monopoly power to enforce standards.

However, there was a lack of seed legislation to protect farmers from substandard seed and enable the Seed Technology Unit to effectively enforce quality control. In disputes between farmers and seed sellers, the courts applied the prevailing trade legislation but this was inappropriate for the seed trade. In addition, because of insufficient funds to finance

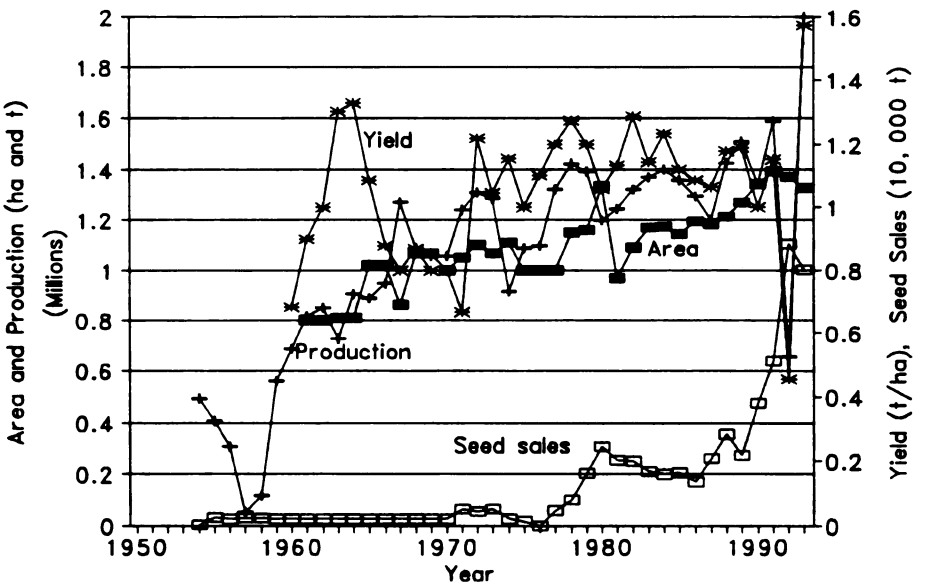

Figure 4.11: Maize Area, Yield, Production and Improved Cultivar Seed Sales in Malawi, 1955-1993

Source: Ministry of Agriculture, and FAO

maize breeding and seed certification, the maize breeding team and the Seed Technology Unit had difficulty in attracting and retaining experienced staff.

Because of the lack of government commitment to provide adequate long-term funding for agricultural research, the absence of seed legislation to support seed certification, the

inadequate funding for seed-certifying agencies, and poor extension and marketing infrastructure, the seed industry made little progress in supplying farmers with innovative varieties and hybrids. Annual seed sales were less than 2,000 tons from 1955 to 1985. In 1980 less than five percent of the total maize area was planted to improved varieties and hybrids. Because of the lack of adoption of improved cultivars and complementary agronomic practices, the national average maize yield and production have been stagnant until the early 1990s (Figure 4.11).

Reviewing the history of maize research in Malawi from 1954 to 1988, Kydd (1989) concluded that the results were disappointing because of the lack of continuity of research and the failure to develop flint high-yielding varieties responsive to local processing and storage requirements. Kydd argued that private seed companies might be more effective than public organizations in assembling the necessary scientists and genetic materials and managing maize research. However, Heisey (1990) argued that although multinationals are likely to play an increasing role in seed production and marketing in Malawi, the small size of the market makes it unprofitable for private firms to make heavy investments in the seed industry. Smale and Heisey (forthcoming) argue that Malawian researchers have incorporated the interests of small farmers into their research objectives and developed hybrids adapted to small farmer conditions in a moderate time by international standards.

4.6 Summary

The evolution of the maize seed industry in South Africa, Zimbabwe, Zambia and Malawi is broadly consistent with the proposition that the transition from farmer to farmer exchange of seed through stages of increasing complexity to a mature seed industry requires market signaling which is influenced by a path dependent evolution of institutions that support credible commitments to specialized investments in the seed industry. The evolution of the

seed industry in each of the four countries was shaped by the experience of the maize seed industry in the United States in a path dependent way. For example, South Africa imported seed from the United States beginning in the early 1900s and replicated many of the American institutions such as agricultural societies and cooperatives and technological innovations such scientific breeding methods, seed production and marketing techniques. Then Zimbabwe followed and imported several American varieties and elite germplasm from the Natal region of South Africa. Later Zambia and Malawi imported American varieties from South Africa and Zimbabwe and South African and Zimbabwean-developed elite inbred lines and hybrids.

Both South Africa and Zimbabwe created specialized government departments of agriculture and relied on local scientists to develop a world class maize research capacity with strong scientific links between the United States, South Africa and Zimbabwe. The governments of South Africa and Zimbabwe helped organize European farmers whose interests counted in the whites only governments into politically-active associations and cooperatives and then responded to their demands by coopting them into government agencies. The farmer associations influenced the government to commit adequate capital and recurrent funding for long-term maize research and the importation of improved maize varieties, breeding procedures and organizational innovations from the United States and Europe. In addition, farmer associations invested in human capital that channeled the benefits of maize breeding to commercial farmers. Because maize did not become an important export crop in Zambia and Malawi, the governments did not systematically invest in maize research, agricultural education and extension, and seed production and marketing until after political independence.

Each of the four countries studied created path dependent rules governing the release of new varieties and hybrids to farmers, seed certification and quality control to facilitate market signaling. Each country followed internationally recognized seed certification and

testing procedures developed in the United States and Europe. However, the four countries differed in their character of the enforcement of the rules. South Africa and Zimbabwe established Official Seed Testing Laboratories and formalized seed certification rules into law before the release of the first locally-adapted hybrids for commercial production and committed significant resources to monitoring and enforcing the rules. Zambia formalized the seed certification rules into law five years after the establishment of the Official Seed Testing Laboratory. Malawi still does not enforce its Seed Act more than forty years after the release of the first improved cultivars. Zambia and Malawi have not committed adequate resources to specifying and enforcing seed quality. As a result, market signaling and the transition to a specialized seed industry have been arrested.

In each of the four countries, the government initially carried out all the business functions of seed production and marketing after breeders released locally-adapted cultivars for commercial production. However, each country has developed different public-private arrangements for managing maize breeding, foundation seed production, seed growing, certification, conditioning, and marketing. In South Africa, the government transferred seed growing, conditioning, and marketing to the private sector after five years, breeding and foundation seed production after 22 years, and seed certification and laboratory testing after 30 years. The government fostered the development of a competitive seed industry by making publicly-bred germplasm freely available to private seed companies, stringently enforcing the Seeds Act, and enacting a Plant Breeders' Rights law. In Zimbabwe, the government transferred seed growing, conditioning, and marketing to a commercial farmers' association after one year, foundation seed production after 17 years, and allowed private breeding only after 36 years. The government fostered the development of a private monopolistic seed industry by establishing a contractual agreement with the commercial farmers' union and the seed growers' association granting exclusive marketing rights of

publicly-bred varieties and hybrids to the seed maize association, designating the seed growers' association as the sole seed-certifying agency, and enacting a Plant Breeders' Rights law and placing its enforcement under the government's Seed Services which was legally bound to the seed growers' association. In Malawi and Zambia and Malawi, the government carried out all the business functions of seed production and marketing until the formation of joint ventures companies, the NSCM and ZamSeed in 1978 and 1980 respectively, when foundation seed production, seed growing, conditioning and marketing were transferred to these government-dominated seed companies.

Commercial farmers in South Africa, Zimbabwe, and Zambia adopted hybrids at a much faster rate than in the United States and compressed the waiting time from first improved cultivar introduction to 100 percent adoption to three decades in South Africa (1949 to 1979), 17 years in Zimbabwe (1948 to 1965) and 12 years in Zambia (1955 to 1967). The reasons for the rapid hybrid adoption include the availability of outstanding locally-adapted hybrids, effective government extension services, seed production and marketing by the seed companies, strict enforcement of seed quality standards by the seed services, and access by farmers to complementary inputs, management and favorable seed to grain price ratio. Zimbabwe was more successful than South Africa and Zambia in promoting hybrid adoption by smallholders because it committed more resources to the development of agricultural extension and infrastructure in smallholder areas after the breakup of the Federation in 1973. In Malawi hybrid diffusion was slow because of the absence of infrastructure and extension services, inappropriate cultivars, lack of organized seed growers, ineffective seed services, and the absence of a seed law to compel the seed trade to supply farmers with seed of known quality.

South Africa responded to the globalization of trade and finance and permitted multinationals to participate in its seed industry in the 1960s. Twenty years later, Zimbabwe

permitted multinationals to enter its seed industry. The Zambian and Malawian seed industries began to globalize in the early 1980s with the formation of ZamSeed and NSCM in which Svalof AB and the CDC provided the management, respectively.

CHAPTER FIVE

THE IMPACT OF STRUCTURAL ADJUSTMENT PROGRAMS ON THE MAIZE SEED INDUSTRY IN SOUTHERN AFRICA SINCE THE EARLY 1980s

5.1 Introduction

The analysis of the economic history of the seed industry in Southern Africa from 1900 to 1980 in chapter 4 revealed that at the advent of structural adjustment programs in the early 1980s, the seed industry was in the emergence stage in Zambia and Malawi, the early growth stage in Zimbabwe, and the late growth stage in South Africa. This chapter investigates the proposition that structural adjustment programs have created incentives to promote the transition from public sector-dominated maize seed industry to new forms of public and private organizational arrangements that have a potential to facilitate market signaling and improve the performance of the seed industry in Southern Africa. The performance of the seed industry is measured by three indicators: changes in the proportion of the total maize area that is planted to certified seed, the average maize yield, and the profitability of seed companies. The structural adjustment proposition is tested by analyzing survey data, government and seed companies' annual reports and literature by the seed trade. Since there is a lack of a dynamic theory of the relationship between institutional and technological development and transaction costs over time that is comparable to general equilibrium theory in precision, it is not possible to test the second proposition by the estimation of regression models. Also, the impact of structural adjustment on maize yields and national food security has not yet occurred to a significant extent and therefore has to be predicted rather than directly quantified. The chapter will proceed by presenting the position of the seed industry in each of the four countries in 1980, analyzing major changes in technology and institutions under structural adjustment, and conclude with a summary of what has happened since 1980.

5.2 South Africa

In 1980 South Africa was in the late growth stage of the seed industry life cycle, a similar position to the industry in the United States in the 1950s. In 1980 six research-based, private seed companies supplied high-quality certified hybrid maize seed to farmers, down from ten in the 1970s. The six private companies, including Pannar, Sensako, Ciba Geigy, Asgrow, Cargill and Saffola, supplied around 75,000 tons of hybrid seed and 500 tons of improved open-pollinated varieties seed in annual sales to farmers. The government breeding program supplied about six percent of the parent lines used to produce hybrids and all of the germplasm used in improved open-pollinated varieties. Maize seed prices were not controlled by the government and there were no direct subsidies and taxes on maize seed transactions. Hybrid seed prices averaged eight times the price of commercial maize grain. About 95 percent of the total maize area was planted to improved hybrid and open-pollinated varieties, consisting of 4.3 million hectares in commercial farms and 1 million hectares in smallholder areas. Commercial farmers planted all their maize to hybrids while smallholders planted less than 20 percent to certified varieties and hybrid seed (Bembridge, 1987; 1991). Commercial maize yields averaged 2.5 tons per hectare while smallholder maize yields averaged around 0.4 tons per hectare.

5.2.1 The Evolution of Institutions and Technology: 1980-1992

In the early 1980s, the South African seed industry began to undergo a transition from growth to a mature stage of the life cycle by expanding private sector involvement in research and development, seed certification, laboratory testing, and marketing. This transition was driven by changes in the government's fiscal and monetary policies, technology, transaction costs, and legal and constitutional reforms in the early 1980s.

These reforms had a major impact on the seed industry. In 1983 the government abolished the two tier exchange rate system consisting of the commercial rand and financial rand and removed interest rate ceilings on bank credit.[1] This resulted in the depreciation of the rand which forced the South African Reserve Bank to tighten money supply and double its discount rate from 10.1 to 21.8 percent between 1983 and 1984 to protect foreign exchange reserves. As the government was implementing the exchange rate reforms, it initiated agricultural sector reforms to reduce market regulations and encourage privatization. In 1984 the government began to register private seed testing laboratories to take over the laboratory analysis of seed from the official government laboratory. The government also transferred the training of seed analysts and laboratory technicians to the seed trade.

Because the macroeconomic reforms had an immediate adverse effect on the South African economy, the government reintroduced the dual exchange rate system and reduced the discount rate in 1985 to 9.5 percent which was below the rate of inflation. Because of the high cost of subsidizing commercial maize production, the government implemented agricultural sector reforms, including a deregulation of maize producer prices in 1986 and removal of the rights of the Maize Board to carry losses on the maize stabilization fund which were written-off by the state. The change in the maize marketing policy reduced real maize producer prices by 24 percent between 1987 and 1992. Farmers responded by reducing the maize area by 25 percent over the same period. In turn, the reduction in the maize area and three significant droughts in the 1980s sharply reduced the industry's aggregate maize seed sales by 36 percent from 62,300 to 40,000 tons between 1985 and 1992. This cut-back generated fierce competition in the seed industry. To retain their share of the market, seed companies intensified research to develop varieties and hybrids with easily marketable plant

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[1] The reforms were inspired by the deregulation and privatization policies pursued by the Ronald Reagan administration in the United States and the Margaret Thatcher government in the United Kingdom in the 1980s. The deregulation policies gave rise to a presumption in South Africa that free markets were the most effective ways of organizing economic activities.

traits such as disease and insect resistance, length of growth period, stable yields during cyclic droughts, kernel quality and special qualities like protein. In addition, most seed companies diversified their product lines and initiated breeding programs in sunflower, wheat, soybeans, dry beans, lupins, and pastures, forage sorghum and cotton seed which were expected to show increased growth and stability. The advent of biotechnology in the 1980s further spurred investments in genetic engineering and information and computer technology to facilitate the collection and analysis of experimental trials, speed up new product development and introduction to the market. Because maize proved difficult to improve through genetic engineering, most South African seed companies surveyed were using biotechnology techniques such as Restriction Fragment Length Polymorphism (RFLP) to fingerprint their inbreds, hybrids and varieties.

Throughout the 1980s, the evolution of the maize seed industry was shaped by the strategies that Pannar and Sensako pursued, the two companies with over three quarters of the domestic market share of maize seed. Pannar acquired new germplasm, organizational and marketing strategies from Pioneer Hi-Bred International.[2] Since 1980, Pannar has committed around 12 percent of its annual revenue to research, retired 15 new hybrids, and introduced one open-pollinated variety and 15 hybrids.[3] Pannar used a combination of branding, logos, advertising, and field demonstrations to signal the quality of its seed and built an aggressive team of technical assistants, sales representatives and agents to provide full agronomic services and help carry the products out of research into the marketplace. Pannar also streamlined its production and conditioning facilities to deliver superior value products, and

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[2] Seed company representatives interviewed indicated that although the relationship between Pioneer Hi-Bred International and Pannar (Pioneer South Africa) governed the exchange of germplasm, Pioneer Hi-Bred International permitted Pannar to use its brand name, logo, and insignia in South Africa during the 1970s and early 1980s.

[3] For example, Pannar hybrids captured the first eight out of the top ten positions in maize trials conducted by the Department of Agriculture from 1990 to 1992.

established direct sales to farmers instead of selling through dealers to improve marketing margins. By the mid-1980s, Pannar had captured more than 60 percent of the market share, up from four percent in 1972, which it maintained into the 1990s. Pannar also entered seed markets in Lesotho, Swaziland, and Zimbabwe, thereby beginning a new regional approach to conducting seed business in Southern Africa.

Sensako acquired organizational and marketing strategies from DeKalb Genetics Corporation and combined several Corn Belt lines with its own material and publicly-bred inbreds and developed several superior maize and sunflower hybrids. By 1986, Sensako had released a total of 24 yellow and 22 white hybrids since launching its maize breeding program in 1963. However, because Sensako was a cooperative, it faced a greater challenge than Pannar in maintaining its market share because it had to meet the needs of all its farmer-members by handling a broad product line for diverse geographical markets, ranging from favorable to marginal areas. Sensako focused on plant breeding and the production of foundation seed that it sold to five seed-producing member cooperatives which, in turn, bulked the parent material and supplied commercial seed to 21 non-producing member cooperatives for sale to farmers. Because Sensako faced the challenge of synchronizing seed production, conditioning, marketing and timely delivery of seed to farmers, it began to carry out demand forecasts, process seed orders from non-producing members and allocate production quotas among producer members.[4] Sensako launched door-to-door marketing and after-sales services in several areas and started to signal the quality of its products through a combination of strip demonstrations, print, radio and television advertisements, farmers days, training of the member cooperatives' officials, National Maize Producers' organization's Harvest Days, and agricultural shows.

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[4] However, the order processing and clearing of production allocations by Sensako resulted in administrative problems that led the cooperative to reorganize seed production and distribution among the producing member-cooperatives on the basis of territorial responsibilities.

Because the official seed certification scheme was becoming increasingly cumbersome and costly to coordinate as product differentiation increased, the government shifted the responsibility for the certification of maize seed to the private sector in 1988. A year later seed companies formed the South African National Seed Organization (SANSOR) to promote the interests of the industry, take over the management of the seed certification scheme from the government, and distribute publicly-developed cultivars and inbreds among members. Under the seed certification scheme administered by SANSOR, seed inspectors were employed by private seed companies but reported to the seed trade organization. The government was still responsible for conducting spot checks, issuing Plant Breeders' Rights, and enforcement of seed laws. The government also conducted field inspections and issued certificates for the OECD certification because SANSOR was not authorized to certify seed under the European seed scheme. To provide continuity of seed standards, SANSOR conducted training and authorization of private seed inspectors. Although SANSOR was originally established as an interest group for seed companies, it also turned out to be a low transaction cost arrangement for seed certification. Respondents interviewed in this study indicated that the handing over of the certification of seed and training of seed inspectors and analysts to SANSOR had enabled the government to achieve significant cost savings in terms of personnel, administration and overhead expenses. In addition, SANSOR provided relatively faster turnaround that lowered seed companies' transaction and certification costs.

The transition to multiple signaling and market share competition triggered the consolidation of the seed industry around a few research-based seed companies. In 1989, Cargill and Ciba Geigy divested from South Africa and sold their seed businesses to Omnia, a South African fertilizer company, which merged the two companies and formed a new

company called Carnia.[5] In 1991 Omnia acquired Asgrow in South Africa but allowed Asgrow to operate as a separate company with its own brand name and distribution channels. In 1992 Sensako established a research and licensing agreement with the Seed Co-op (Zimbabwe) under which Sensako became the marketing agent for Seed Co-op hybrids in South Africa and the Seed Co-op became the marketing agent for Sensako hybrids in Zimbabwe. The reciprocity resulted from a tripartite agreement between DeKalb, Sensako and Seed Co-op that spelled out geographic marketing arrangements and exchange of breeding material.[6] In 1992 Pannar acquired Saffola from Sentrachem but continued to run the company separately. Pannar also diversified its product line into vegetable seed by acquiring Starke Ayres.

As the seed industry was being reshaped through acquisitions, mergers, and partnerships, Pioneer Hi-Bred International entered the South African market by selling seed hybrids that the company had developed in its maize program in Zimbabwe. In 1992, PHI assembled a management team by hiring experienced managers from already established companies, including Saffola, Sensako, Carnia, Asgrow, established a maize breeding program in South Africa, and imported maize seed from Zimbabwe, Egypt, and Zambia.[7]

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[5] Following the merger of Ciba Geigy and Cargill, Omnia focused on integrating its diverse Swiss, American and Afrikaans cultures by tapping the knowledge and experience of its sales agents and employees to develop a new corporate culture.

[6] The Seed Co-op terminated the agency agreement that it had with National Seeds for the distribution of seed from the Zimbabwean national program in South Africa and paid the National Seeds Company goodwill for the termination of the contract. However, National Seeds continued to market its maize, soybean, and grain sorghum cultivars.

[7] Because of the international sanctions against South Africa, Pioneer started established a breeding program in Zimbabwe in 1985 that was focused on developing hybrids for the South African market and registered its first hybrids in South Africa in the early 1990s. PHI aggressively promoted its entry into the South African seed market in 1992 by mailing introduction letters to around 7,000 farmers, placing corporate advertisements in magazines and newspapers, and exhibiting at farmer days, standing group meetings, farmers' association meetings, and NAMPO harvest days.

A major political development occurred in 1990 when President F.W. de Klerk announced the unbanning of the African National Congress (ANC), the South African Communist Party (SACP), the Pan Africanist Congress (PAC) and followed the announcements by releasing Nelson Mandela and other political detainees from prison. The move initiated constitutional negotiations that eventually led to the first democratically-elected government and a new set of demands on the seed industry. Because of the impending accession to power by the ANC, the government created the Agricultural Research Council (ARC) in 1992 with a mandate to assume the responsibility for all government agricultural research, development and technology transfer. These institutional changes were introduced to reduce the uncertainty that the ANC government might not continue to invest sufficient resources in agricultural research to meet the needs of commercial farmers. Although about 70 percent of the ARC's funding will continue to come from the central government, the ARC is expected to become increasingly dependent on contributions from the private sector and contract research.[8]

The ARC entered into a contractual agreement with SANSOR that provides for the exclusive licensing of its varieties and parent lines to SANSOR which will subsequently sub-license to its members, monitor seed production under certification, and collect royalties. Also, the ARC can directly license its cultivars internationally through specified royalties or through SANSOR or its sub-contractors depending on the advantages and disadvantages of each case. This institutional innovation is expected to reduce contract negotiation, measurement, and enforcement costs and improve the efficiency of research by avoiding unnecessary duplication of projects.

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[8] The ARC was organized to be able to manage its own budget, operate internationally, contract with seed companies, and collect royalties. The change to a market-driven organization structure resulted in some anguish as ARC staff had to cope with severe budgetary cuts and increasing competition with universities and seed companies.

However, the shift to private sector-dominated modes of organization was traumatic because it was accompanied by accelerating inflation and high interest rates that increased uncertainties and risks in competition, demand, price, product, production, and distribution and hence the transaction costs borne by seed companies. The current ratio of a representative seed company indicates that liquidity became squeezed in 1986 because the rise in inflation and interest rates increased the cost of financing inventories and other assets. However, the total asset turnover ratio improved indicating that the company was improving the efficiency with which it utilized its total assets in relation to sales. The trends were accompanied by a declining return on equity because the high inflation and intense competition held down profit margins in the seed industry. Analysis of the profit and cost structure for a representative seed company shows that profitability declined from 1980 to 1989 because of an increase in the cost of goods sold as a percent of sales resulting from the rising input costs, and an increase in field trials and selling expenses resulting from tough competition. Because selling costs were accounting for as much as 15 percent of sales in the late 1980s, seed companies formed mergers, strategic alliances and acquisitions to reduce overlapping infrastructure and lower per unit cost by eliminating redundant expenditures.

5.2.2 The Seed Industry in 1993

By 1993 the South African seed industry was in the mature phase of development, resembling the United States seed industry of the 1970s. The industry generated about 35,000 tons hybrid seed sales and 2,500 tons of open-pollinated varieties seed in 1993 (Figure 5.1). Commercial farmers planted all of their 3.5 million hectares to certified hybrid seed while only about half of one million hectares of smallholder maize was under certified seed. In 1993, there were four dominant research-based seed companies, down from six in 1980 because of mergers, acquisitions and strategic alliances. Pannar-Saffola had a combined

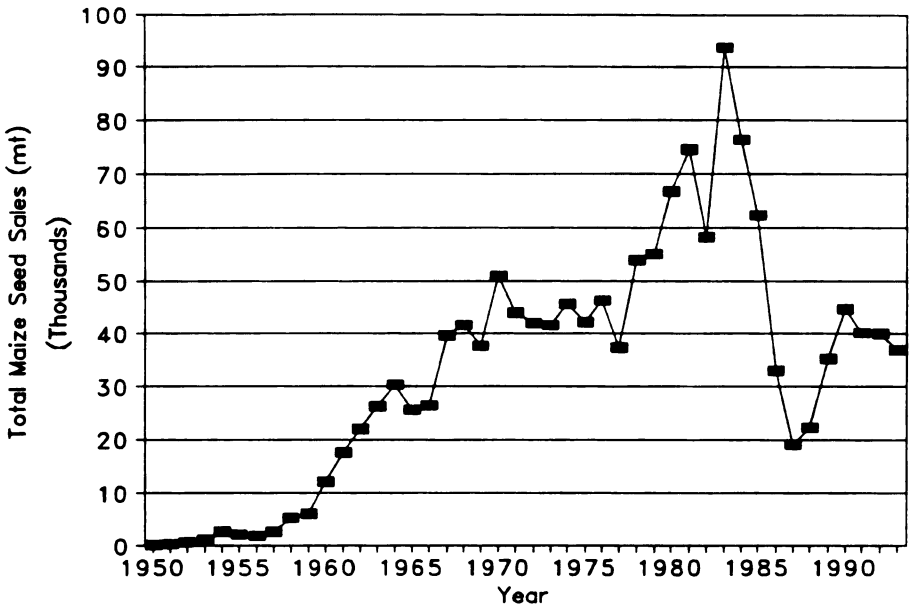

Figure 5.1: Total Maize Seed Sales in South Africa, 1950-1993

Source: Maize Board, South Africa

market share of more than 60 percent, Sensako-Seed Co-op, 30 percent, and Carnia-Asgrow Seed, around 10 percent. PHI (Pioneer Hi-bred International) was strengthening its position in the South African seed market to help increase its Southern African presence. Pannar had a strategic partnership with Holden Foundation Seeds, Sensako with DeKalb and the Seed Co-op, Carnia with Cargill and Funk Seeds International, and PHI with Pioneer Hi-Bred International, wholly owned Pioneer subsidiaries in Zimbabwe and Zambia, and joint ventures in Swaziland and Lesotho. Virtually, all the commercial hybrid seed sales consisted of proprietary hybrids while most of the open-pollinated varieties were publicly-bred materials. Because of escalating research and development and seed production costs, hybrid seed prices had risen to more than 12 times the price of commercial maize grain, up from 8 in 1980. Commercial maize yields averaged 2.6 tons per hectare while smallholder yields averaged about 0.5 tons per hectare, up slightly from levels in 1980.

As the smallholders were becoming the fastest-growing segment of the South African seed market, seed companies tried to capture market shares in this sector through aggressive discounting, demonstration plots, field days, and seed samples for smallholders.[9] Private seed companies employed about 50 percent of all qualified plant breeders and invested about 10 percent of the total public and private expenditure in crop improvement research and development. The seed industry was becoming more service-oriented. Private seed companies employed about 31 agronomists, 89 sales representatives, 25 area managers, and distributed seed through a network of 126 dealers and 182 cooperative branches. Because seed companies focused on technology and customer-driven strategies, the average time of developing and commercializing maize hybrids was nine years, consisting of six years for development, two years for field trials, one year for registration and release and the average life cycle of a maize hybrid was eight years.

The public and private sectors in the South African seed industry were going through the same changes that occurred earlier in North America. The government breeding program started to release publicly-bred germplasm to the highest bidder on an exclusive royalty basis to recover research costs and provide incentives for seed companies to invest in the commercialization of new cultivars. SANSOR emerged as a new public-private organizational arrangement for developing, collecting, and enforcing royalties. The government concentrated on areas that were not commercially viable such as the breeding of drought resistant germplasm to serve the high-risk, low-potential regions of the country, and the development of low margin varietal crops. The government also conducted national variety trials to provide unbiased performance testing of different open-pollinated varieties and hybrids. SANSOR became increasingly involved in the administration of national variety

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[9] Seed companies' representatives interviewed in this study reported that hybrid seed prices can be raised gradually over time as farmers move up the quality ladder and realize the benefits of using sophisticated hybrids.

trials in collaboration with government agencies. The government also registered and protected Plant Breeders Rights along the lines laid out by UPOV. The government had privatized seed testing and transferred all seed certification to SANSOR. However, government agencies continued to issue the final seed certificates, conduct sporadic checks to enforce seed regulations, and inspect seed under the OECD scheme. SANSOR conducted the training and authorization of seed analysts, laboratory technicians, and phytosanitary inspectors. SANSOR was also introducing courses for seed salespersons and developing seed business ethics.

5.2.3 The Future Development of the Seed Industry

The recent accession of the ANC government to power in South Africa has placed new political demands on the seed industry to develop high-quality, superior performing varieties and hybrids to meet the needs of the majority of farmers, black smallholders. The most pressing challenge facing the industry is to develop and market seed products and agronomic services that help raise the proportion of the maize area planted to improved varieties and hybrids and the average maize yield of smallholders to levels being achieved by commercial farmers. Respondents indicated that although hybrids perform better than open-pollinated varieties in smallholder areas, the yield advantage of hybrids is small under smallholder conditions because most of the commercially available hybrids have not been selected for rainfall, soil and farm management regimes on smallholder farms. Also, it is difficult for private seed companies to market certified seed in smallholder areas because there is a lack of infrastructure and distribution channels, the markets are unstable, and seed distribution is dominated by parastatals. The government has introduced market-based reforms in smallholder areas that are creating opportunities for seed companies to develop value added products that perform well under smallholder conditions.

If the South African seed industry continues to follow the life cycle of seed industry development laid out in Chapter 2, then we can expect further consolidation during the latter part of this decade when the major firms introduce biotechnology products to the market. Because biotechnologies such as *Bacillus thuringiensis (Bt)* can be applied to improve maize yields and farmer profitability in South Africa, especially among the smallholders who spend proportionately more on crop protection chemicals than commercial farmers, the commercialization of genetically engineered products in South Africa will revolutionize the seed industry and maize production. Because of the high cost of developing biotechnology products, large companies have a high chance of survival. Small companies have a high chance of survival by focusing on niches that are too small for large companies but big enough to generate profits after financing research programs, seed production and distribution. However, middle-sized companies may be forced out of the seed business or focus on specialty products. The future of most seed companies will depend on whether they can gain access to international financial and scientific capabilities that they lack.

Several respondents reported that SANSOR is initiating institutional changes that have a potential to reduce the transaction costs for seed certification. First, SANSOR is establishing compulsory training for all seed inspectors involving intensive refresher courses on agronomic summer grain crops, dry beans, various grasses, and technical courses for salespersons. Second, SANSOR is introducing mandatory certification for seed inspectors. Inspectors will be authorized on the basis of their work history and performance in courses designed to train skills for doing specific jobs such as seed conditioning and the sealing of bags. SANSOR is setting stringent requirements for passing formal examinations, and issuing certificates of authorization only to persons who meet the minimum grade. Moreover, SANSOR will give provisional authorization to trainees on completion of their courses and monitor their performance as they get hands-on experience until they become fully qualified

seed inspectors. SANSOR will withdraw authorization from persons that consistently issue certificates to seed that show low tolerance in spot checks.[10] Third, SANSOR will collect samples of seed offered for sale to farmers and conduct grow outs of the seed samples. If off-types, varietal mixing, or wrong labelling are picked up in the grow outs, SANSOR will trace the inspector who would have sealed the bag and issued the certificate and prosecute him for violating the Seed law. The fourth is the sampling and checking for trueness-to-type and varietal purity of imported seed. Because SANSOR does not have enforcement powers, it is developing close collaboration with the government to enforce seed standards. Finally, SANSOR is maintaining a register of companies that violate the seed regulations to provide in-house disciplinary checks.

The ANC accession to power led to the removal of political barriers to intraregional seed trade. South African seed companies are well positioned to meet Southern Africa's growing food needs because of their experienced breeders, a knowledge of market requirements, proprietary germplasm built up over 40 years for African conditions and access to a sophisticated national agricultural research system. Because several hybrids are interchangeable within certain ecologies in Southern Africa, several seed company representatives reported that a common market will emerge in the coming decade to serve a dozen countries. The first step towards a common market was taken in 1994 when South Africa became a member of the Southern African Development Community and the Southern African Customs Union (SACU) group of countries became members of SADC.[11] However, the respondents believe that numerous obstacles need to be overcome to facilitate intraregional seed trade, including differing political ideologies, poor communication and marketing

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[10] SANSOR keeps a register of incompetent seed inspectors and threaten to take away their authorization if they fail to improve.

[11] The Southern African Customs Union operates common customs and excise regimes for Botswana, Lesotho, Namibia, South Africa, and Swaziland.

infrastructure in some countries, differing phytosanitary requirements, and lack of standardized seed legislation.

5.3 Zimbabwe

Immediately after Independence in 1980, the government introduced policies that expanded the role of the state in order to transform the country into a socialist state. Inspired by the experience of the Soviet Union and China, the government increased public spending to redress the inequities inherited from colonial governments, imposed controls on foreign exchange, prices, wages, labor and trade, and regulated the remittance of profits and dividends. The government also attempted to reduce foreign ownership and management and expand Zimbabwean businesses. But these policies undermined the investment and contractual confidence in the economy and the socialist rhetoric increased anti-market sentiments which stifled economic growth and development.

At independence in 1980, the seed industry was in the early growth phase of the seed industry life cycle. The seed monopoly, the Seed Maize Co-operative Company, focused on multiplying and distributing parent lines released by government breeders. This was in line with government policy to safeguard the seed supply from international sanctions imposed by the United Nations against Zimbabwe during the UDI period from 1965 to 1980. The Co-operative also conducted research on breeding, production and mechanical handling of seed at the Rattray Arnold Research Station and produced hybrid maize seed on farms of some 140 members. The Seed Maize Co-operative sold 10,500 tons of hybrid maize seed through a network of appointed distributors and agents and achieved a limited geographic distribution. The government prohibited the sale of open-pollinated varieties and controlled maize seed prices which averaged eight times the price of commercial grain for single cross hybrids and four times the price of commercial grain for three-way hybrids. Virtually all 230,000

hectares of commercial maize was planted to government-certified hybrid seed while less than 70 percent of the 900,000 hectares of smallholder maize was planted to hybrids. Commercial yields averaged 4.0 tons per hectare as compared with 2.5 tons in South Africa. Smallholder yields averaged around 0.7 tons per hectare as compared with 0.5 tons in South Africa.

The government implemented market-oriented policies starting in the mid-1980s that improved the investment and contractual credibility of the Zimbabwean economy. In the mid-1980s the Zimbabwean seed industry began to undergo a transition to a competitive form of organization when several multinationals started to challenge the monopoly position of the Seed Co-op. This trend accelerated in 1990 when the government launched a formal IMF-World Bank structural adjustment program to correct persistent internal and external imbalances. Although the impact of structural adjustment has not yet become fully manifest, the foundation is being laid for an expanded private sector role in the future.

5.3.1 The Evolution of Institutions and Technology: 1980-1992

In 1980 the Seed Maize Association Co-operative Company joined forces with the Seeds Co-operative Company Limited and formed the National Seed Company of Zimbabwe which took over the selling functions of the two cooperatives. In 1983 the Seed Maize Co-operative merged with the Seeds Co-operative and formed the Seed Co-operative Company of Zimbabwe.[12] In 1981 as the seed industry was being restructured, Pannar established a seed-producing and marketing company, PNR Enterprises, in Zimbabwe. A year later Ciba Geigy began to introduce hybrids from its South African breeding program. However, both multinationals faced high entry barriers because the Tripartite Agreement granted exclusive marketing rights of government-bred germplasm and inbreds to the Seed Co-op. Additional entry barriers included the lack of an Official Variety List and independent facilities for

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[12] With the merger, the Seed Maize Co-op diversified its product range to included maize, soybeans, sorghum, wheat, groundnuts, sunflower, barley, and oats.

testing private hybrids. Finally, the government extension workers promoted government hybrids, the Agricultural Finance Corporation did not extend loans to farmers who wished to purchase Pannar and Ciba Geigy seed, and government officials did not issue permits to import seed, plant and equipment from South Africa.

The government started to move away from its socialist strategy in the mid-1980s by introducing incentives to encourage private investments, including an export revolving fund to provide foreign exchange for the import of essential inputs and a bonus scheme to allow exporters to retain part of their export earnings for importing raw materials. The government removed restrictions on the utilization of surplus and blocked funds in 1986, established an export revolving fund in 1987, and a promotion program for agriculture in 1988. The government also signed the World Bank Multilateral Investment Guarantee Agency Convention (MIGA) to ensure protection for investors in 1989 and the US Overseas Private Investment Corporation (OPIC) Agreement and several bilateral investment protection agreements in 1990.

Pioneer Hi-bred International established a breeding program in 1985 and introduced hybrids in the early 1990s.[13] In 1987 PNR Enterprises was restructured to form Savanna Seeds and produce hybrid maize seed under the Pannar brand name. In 1991 Savanna Seeds was restructured as Pannar Seed because the company produced maize seed under the trademark Pannar and it wanted to avoid identity problems and legal disputes with Pioneer Hi-Bred International, its competitor in Southern African. In 1988 Ciba Geigy withdrew from the Zimbabwean seed industry and sold its genetics to Cargill. This provided Cargill with an immediate product to sell in Zimbabwe, Malawi, Zambia, and Tanzania. Pioneer Hi-Bred International founded two wholly owned subsidiaries, Pioneer Hybrid (Zimbabwe) which

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[13] Pioneer's research program for Southern Africa which was initially based in Zimbabwe produced hybrids that the company subsequently introduced in South Africa, Zambia, Swaziland, Lesotho, Cameroon, and Cote D'Ivoire in the 1990s.

owned its genetics and functioned as the breeding wing and the Pioneer Seed Company which produced and sold seed hybrids. Because of increasing international competition, the Seed Co-op formed Certseed International in 1989 to handle its seed exports, permit the follow up of end users, and prevent the export of poor quality seed from Zimbabwe. Another significant development affecting the seed industry was the initiation of a comprehensive hybrid testing program to by the Agricultural Research Trust (ART) station which had been established by commercial farmers in 1982. The station provided commercial farmers with unbiased estimates of the performance of maize hybrids of different companies.

Because of continued stagnation of the economy, the government introduced an Economic and Structural Adjustment Program (ESAP) in 1990. The IMF-World Bank supported program included measures to liberalize trade and foreign currency restrictions, devalue the exchange rate, remove controls on prices, wages, labor, investment and repatriation of profits, and reduce the government budget deficit.

The economic reforms stimulated investments in research stations, seed conditioning and marketing facilities and the growing competition among seed companies expanded the number of hybrids from 8 in 1980 to 20 in 1992.[14] The seed companies promoted their products through print, radio, television advertisements, field demonstrations, and seed give-aways which helped reduce the costs of obtaining and evaluating information about different technologies. Since 1980, the Seed Co-op has introduced 12 hybrids of which a third were developed from its proprietary germplasm. A few companies have started to sell their seed on consignment with rural traders and on commission with their sales staff. These innovative distribution strategies have enabled seed companies to remove middlemen, move closer to

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[14] For example, in 1992 Pioneer Seeds invested US$ 5.9 million (Zimbabwe $30 million) in a seed conditioning plant outside Harare with a capacity to handle more than 15 thousand metric tons per annum. Similarly, the Seed Co-op, Cargill, and Pannar invested in modern seed conditioning plant and equipment in 1992 and 1993.

customers and overcome retailer resistance to new products. Also, the strategies have reduced transaction costs for rural dealers by improving the cash flow of rural shop owners, saving on storage expenses and improving the timeliness of seed supply.

During the course of implementing the structural adjustment program, the economy underwent a recession in the early 1990s that increased uncertainties in demand, price, product, production, storage, and distribution risks of seed companies. In addition, there was a record drought in 1992 that led to large maize imports which made it difficult for the government to reduce the budget deficit. The grain imports constrained the availability of foreign exchange which led the government to delay removing import quotas. The devaluation of the Zimbabwe dollar and the deregulation of price controls resulted in a high rate of inflation. The government countered the rising inflation by tightening money supply but this raised interest rates which adversely affected the balance sheets of seed companies.

The current ratio for a representative seed company fell sharply at the onset of the structural adjustment in 1991, indicating that liquidity became squeezed. The decreasing liquidity was accompanied by declining total asset turnover ratio, indicating decreasing efficiency with which the representative company utilized its total assets in relation to sales. However, the return on equity was erratic. The return on equity sharply increased in 1991 because the government subsidized seed purchases by farmers as drought relief which enabled seed companies to move carryover stocks and contain inventory costs.

In 1992 the Seed Coop established a technical and germplasm exchange agreement with DeKalb in 1992 in order to obtain access to biotechnology, information, superior seed production methods, marketing expertise, and access to international distribution channels. Under the agreement, the Seed Co-op will multiply and sell DeKalb's varieties and hybrids in Zimbabwe and DeKalb will sell Seed Co-op's cultivars worldwide and the partners will pay

each other royalties.[15] Because DeKalb had a technical and germplasm exchange agreement with Sensako, the Seed Coop also established a strategic alliance with Sensako under which the Seed Co-op will market Sensako's products in Zimbabwe and Sensako will market the Seed Co-op's products in South Africa.

5.3.2 The Seed Industry in 1993

By 1993 virtually all the maize area was planted to high-quality certified hybrid seed and the Zimbabwean maize seed industry was making a transition to the mature stage of the life cycle, resembling the American seed sector of the early 1960s. The Zimbabwean seed industry generated 35,000 tons in annual seed sales for 155,000 hectares on commercial farms and one million hectares in smallholder areas (Figure 5.2). The private sector was assuming greater responsibility for maize breeding, trials of new varieties and supplied about 20 percent of all maize hybrids. Because of the lifting of seed price controls in 1993 and increasing seed production costs, hybrid seed prices rose to 11 times the price of commercial maize grain for single crosses and five times the price of commercial maize grain for three-way hybrids. Commercial yields averaged 5.3 tons per hectare while smallholder yields averaged about 1.1 tons per hectare.

In 1993 the industry was dominated by four research-based seed companies: the Seed Co-op, Pannar, Pioneer Seeds, and Cargill, up from one firm, the Seed Maize Co-operative in 1980. Two other Zimbabwean seed companies, National Tested Seeds and AgriSeeds, would also have been producing and marketing hybrid maize seed but they failed to gain

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[15] The Seed Co-op pays DeKalb annual fees for tapping into its technology and royalties on DeKalb's products marketed in Zimbabwe. Likewise DeKalb will pay royalties to the Seed Co-op for products that it markets in other parts of the World. But the Seed Co-op cannot exchange material that is proprietary to the government.

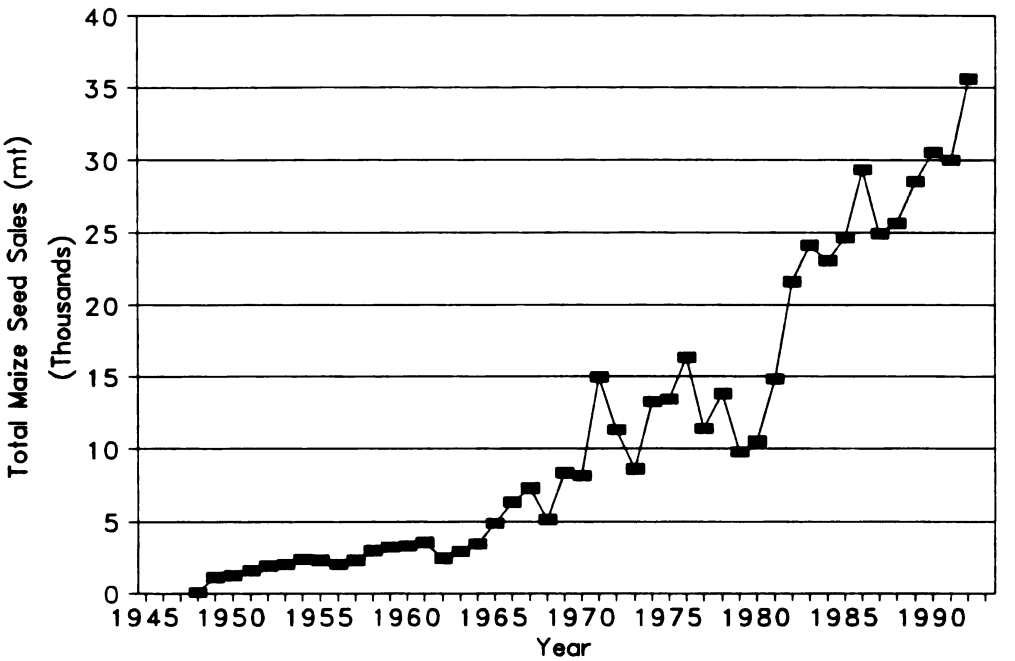

Figure 5.2: Total Maize Seed Sales in Zimbabwe, 1950-1993

access to government-generated elite inbred lines because of the Tripartite Agreement.[16] The Seed Co-op had a market share of around 92 percent and Pannar about 8 percent. Cargill and Pioneer had small market shares because they were establishing their operations. Another multinational seed company, Pacific Seeds (ICI Seeds), was beginning to enter the Zimbabwean seed business. The Seed Coop had a strategic alliance with DeKalb and Sensako, Cargill Hybrid Seeds (Zimbabwe) with Cargill Hybrid Seeds International and Carnia, and Pioneer Seed (Zimbabwe) was linked to Pioneer Hi-Bred International and other Pioneer operating companies within the region. The Seed Co-op also established research and marketing agreements with ZamSeed and Semok (Mozambique) to share germplasm and market each others' products. As a result of the Seed Coop's new regional strategic alliance, the three partners pooled their germplasm resources, breeding programs, and seed production and distribution channels to reduce overlapping infrastructure.

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[16] National Tested Seeds And AgriSeeds focused on producing and marketing vegetable and flower seed in Zimbabwe and multiplying seed of the South African-bred open-pollinated variety Kalahari Early Pearl for export to Mozambique.

Because smallholder purchases constituted more than 80 percent of the total hybrid seed sales in the early 1990s, there was intense competition among seed companies to serve this valuable market. Therefore, seed companies were focusing on breeding widely adaptable, drought tolerant hybrids capable of achieving good yields at low input conditions. Private seed companies employed half of the plant breeders in Zimbabwe and were committing significant investments in conditioning plants, warehouses, retail outlets, and sales representatives to strengthen their positions.

The average time of developing and commercializing maize hybrids from initial test to the market was nine years, consisting of three years for development, five years for yield trials, and one year for registration and release and the average life cycle of a maize hybrid was more than 10 years.[17] Pannar and Cargill were targeting marginal smallholder areas with hybrids developed in South Africa for lower rainfall conditions. In addition, Pannar and Cargill were avoiding going head-to-head with the Seed Co-op by concentrating their marketing program in areas where the Seed Co-op was weak. However, Pioneer was pursuing a different strategy of drawing on its international network of germplasm, human, financial, and marketing resources to develop sophisticated hybrids that are stable under several environments for sale at premium prices. Pioneer was also aggressively promoting its hybrids to farmers through strip tests and educational programs targeted at government extension agents. Because of relatively low wage rates and a well-developed seed grower base, seed companies in Zimbabwe were engaged in exporting seed to neighboring countries.

The public and private sector roles in the Zimbabwean seed industry are changing as witnessed by a reduction in government and an increase in the scope of private research activities. This evolution of public and private arrangements is unfolding in the same manner as it occurred in Europe and America over the past 40 years. Because the government was

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[17] The product life cycles of R201 and R215 were 17 and 19 years, respectively.

cutting its real (inflation-adjusted) budget for agricultural research in the early 1990s, it began to sell new varieties and inbreds to the highest bidders on a royalty basis to recover research costs and help support future breeding work. The government introduced compulsory seed certification to protect smallholders by ensuring that seed companies sell a uniform class of products. The government also decontrolled seed prices and granted seed companies the automatic right to export seed. But Zimbabwe still lacks an Official Variety List and testing facilities to provide farmers with unbiased estimates of the performance of the varieties and hybrids of different companies. The Crop Varieties Release Committee functioned only for government-bred materials. In addition, there was a lack of transparent standard operating procedures in place to govern the release of new private hybrids for commercial production because of the lack of uniform standards of technical performance in variety trials for releasing new varieties and hybrids to farmers.[18] Because of a reduction in funding and staff attrition, the Seed Services lacked the capacity to test and certify large volumes of seed. This explains why the government transferred the responsibility for seed certification and laboratory seed testing to the private sector. The government and seed companies established the Seed Traders Association Inspectorate modelled in a path-dependent manner after SANSOR to implement certification through appointed inspectors that companies can hire to inspect their contract growers' seed crops. The government also began to register private seed testing laboratories to take over seed testing from the official government seed testing laboratory. The Seed Services was focusing on overall supervision, policing and enforcement of quality standards. The Seed Services also carried out ISTA certification for the international of seed and phytosanitary certification because private seed certification was not permitted under ISTA rules. To facilitate international trade in seed and gain access to new

[18] The release of private hybrids was reviewed by the Head of the Crop Breeding Institute, the Assistant Director and the Director of the Department of Research and Specialist Services in the Ministry of Agriculture. The decision whether or not to release a new hybrid was up to the discretion of officials reviewing the information and therefore open to abuse.

genetic technologies, Zimbabwe applied for and was accepted as a member of the OECD seed certification scheme. Also, the government applied for membership in UPOV to provide credibility for its plant variety protection laws.

5.3.3 The Future Development of the Seed Industry

In the coming years the public sector will likely continue to dominate the development of germplasm and breeding populations and the breeding of open-pollinated varieties, but private firms and market forces will play increasingly important roles in generating value-adding activities in the seed industry. The private sector will assume a larger responsibility for providing the genetic improvements needed to sustain and advance maize yields and profitability.

If Zimbabwe continues to follow the life cycle model of seed industry development, then it can be expected that total seed sales will level off and competition will intensify for market share. By 2020 a few research-based seed companies such as the Seed Co-op, Pioneer Seeds, Cargill, and Pannar will likely dominate the seed industry.

Although, the market position of the Seed Co-op Company of Zimbabwe has been weakened through competition from multinational seed companies with strong financial and technological capabilities, it has a strategic role to play in Zimbabwe's future seed industry by developing elite germplasm to serve the majority of farmers. Because of its domestic equity-holding structure, the Seed Co-op will likely continue to gain exclusive marketing rights to government germplasm targeted to the rural majority. Also, because the Seed Maize Association had the foresight two decades ago to establish a private research station and a maize breeding program, the Seed Co-op has proprietary hybrids in the pipeline to help maintain its leadership position. Finally, the Seed Co-op has strengthened its research and seed production and marketing capabilities through its partnership with DeKalb and Sensako

globally and ZamSeed and Semok regionally. These partners will be of major assistance in broadening the genetic base of the products produced and marketed by the Seed Co-op.

As competition increases in the industry, reputation and brand image will become the yardsticks for maintaining seed quality and generate price competition because farmers will choose companies and products that provide superior product performance and consistent quality at lower prices. The companies that succeed will have good products and the private sector investments in brand image, advertising, knowledgeable dealer networks, and sales forces will reduce the transaction costs borne by farmers in searching for suppliers and supply outlets, measuring seed quality, and enforcing legal agreements.

Most seed company managers interviewed in Zimbabwe reported that the future of the seed industry will be largely shaped by the policies that the government implements with respect to the Tripartite Agreement, Plant Breeders' Rights, varietal testing and release, and seed certification. The government will be under pressure to dismantle the Tripartite Agreement because private companies pay taxes and want access to government-generated germplasm which is currently denied to them by the agreement. In the future, the government will likely release publicly-developed germplasm to private firms on a royalty basis to generate additional funds to support research.

Although Zimbabwe has a Plant Breeders Rights law, the plant variety protection legislation is not enforceable in courts. However, the issue of Plant Breeders Rights is being addressed through Zimbabwe's participation in the UPOV Convention. Because Zimbabwe has been accepted as a member of the OECD certification scheme, it is required to keep an Official Variety List. This restricts the sale of new varieties unless they are included on the list. But under the English common law inherited from the colonial past, Zimbabwe cannot issue restricted lists of varieties requiring that only the varieties on the list may be sold. The government is skirting the legal problem of having a restricted list of varieties by issuing a

recommended list of varieties under which the Department of Research and Specialist Services recommends new varieties to farmers on the basis of government-organized trials of new varieties. However, Zimbabwe is introducing the compulsory certification of maize hybrid seed and requiring all the seed marketed to be officially certified before it can sold in order to protect unsophisticated smallholders against unscrupulous seed merchants. Because only recommended hybrids can be certified, respondents recommended that the English common law be modified to permit the establishment of an Official Variety List. They also recommended registering varieties and hybrids based on consequences rather than performance because there was a lack of testing facilities to test the performance of different cultivars in different agronomic and climatic conditions throughout the country. Finally, the introduction of compulsory certification was creating credibility problems for the government and multinational seed companies. The implementation of compulsory certification required seed companies to submit samples of their parent lines to the Seed Services but the multinationals did not trust the government officials because the Seed Services of the Tripartite Agreement with the Seed Co-op. Because the Seed Services did not have technical competencies to conduct morphological characterization of distinctiveness, uniformity, and stability for the certification of hybrids, it relaxed the requirement that private seed companies submit samples to government officials, and concentrated on supervisory and sporadic checks and carrying out seed certification for international seed trade and the OECD scheme.

5.4 Zambia

In 1980 the Zambian seed industry was in the emergence phase of the seed industry life cycle and it was dominated by a newly established state-owned seed company, the Zambia Seed Company (ZamSeed). ZamSeed focused on multiplying and distributing parent lines released by the government maize breeding program. ZamSeed marketed around 6,200 tons of hybrid

seed for some 74,200 hectares of maize cultivated by commercial farmers and around 30 percent of 100,000 hectares grown by smallholders. The government controlled maize seed prices which averaged six times the price of commercial grain for single cross hybrids and four times the price of commercial grain for three-way hybrids and provided subsidies to NAMBOARD and the marketing cooperatives. Because of poor infrastructure and distribution capabilities inherited from NAMBOARD, ZamSeed was unable to ensure timely distribution of certified hybrid seed throughout the country. Commercial farm maize yields averaged 3.2 tons per hectare while smallholder farm maize yields averaged around 1.1 tons per hectare.

In the early 1980s, the government adopted an IMF-World Bank structural adjustment program to reduce the role of the state, restructure the economy and improve economic incentives. However, after the food riots of 1986, the government abandoned the IMF-World Bank structural adjustment program and introduced its own adjustment program. But this program failed to address persistent inflation and a shortage of inputs. The government embarked on another IMF-World Bank structural adjustment program in 1989. Although the impact of the 1989 structural adjustment program is still evolving, the foundations are being laid for an expanded private sector involvement in the future.

5.4.1 The Evolution of Institutions and Technology: 1980-1992

ZamSeed was founded in 1980 under a one party system when the economy was in a severe crisis. Despite a macroeconomic crisis, ZamSeed became well established within its first two years. Svalof AB of Sweden provided a management team for ZamSeed. ZamSeed was granted exclusive marketing rights to parent material released by the government breeding program. ZamSeed was also granted exclusive rights to import, produce and supply a wide range of seed products. ZamSeed began to contract with ZSPA members to produce seed at

negotiated prices under the rules laid down by the Seeds Act (Thole, 1992). The field inspection of seed crops was carried out by both ZamSeed and SCCI inspectors who checked isolation, germination, weeding, top-dressing and detasseling. Technologists employed by the Seed Control and Certification Unit (SCCI) tested samples of seed lots and government inspectors certified and sealed seed pockets.

ZamSeed conditioned, graded, treated and packaged 80 percent of the national seed supply at plants in Lusaka and Kapiri Mposhi and distributed about 70 percent of its seed through the Provincial Cooperative Marketing Unions (PCMUs), 20 percent through private traders, and the remaining 10 percent through its retail shops. In 1982 the seed industry was endangered because the government was unable to pay the subsidies to the Marketing Unions who, in turn, were unable to pay ZamSeed for seed on delivery.

In 1983 the government introduced a structural adjustment program with support from the IMF, World Bank and other donors. Under the program, SIDA supported the maize breeding program and the SCCI developed capabilities for seed inspection, certification and research and organized a Variety Release Committee. As a result of the strengthening of the SCCI, the number of seed samples tested dramatically between 1988 and 1992 (Figure 5.3).

In 1983 the Variety Release Committee released a purified version of SR52 that was redesignated as MM752. In 1984 seven new hybrids were released from infusions of high yielding germplasm from the Maize Research Institute in Yugoslavia and South Africa: MM501, MM502, MM504, MM601, MM603, MM604, and MM606. These hybrids included single, double, and three-way crosses aimed at subsistence, emergent and commercial farmers.[19] The hybrids were quickly taken up by smallholders (Howard, 1994). In 1985 the maize research team released two open-pollinated varieties, MM400 and MM600, which were early maturing, drought tolerant, and hard-kernelled as compared with

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[19] The hybrids were early maturing, drought tolerant, streak and cob rot resistant and adaptable to different environments compared to MM752 and imported varieties.

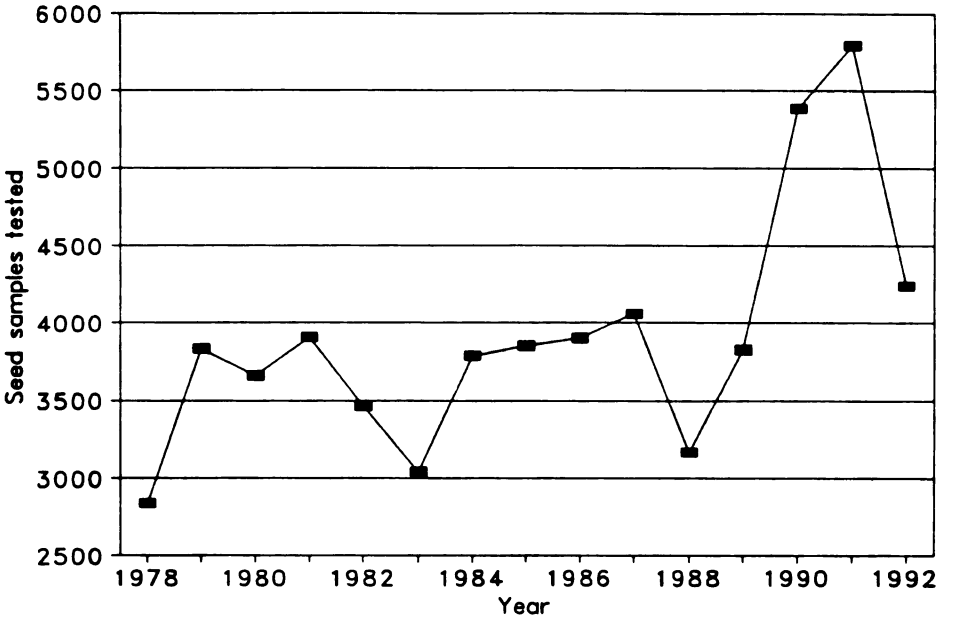

Figure 5.3: Seed Samples tested by the Seed Control and Certification Institute, Zambia, 1978 to 1992

Source: SCCI, Zambia

MM752.[20] The open-pollinated varieties were designed to meet the needs of smallholders in remote areas but the demand for these varieties was low.

In 1985 the government adopted additional reforms to phase out agricultural marketing subsidies and introduced a weekly foreign exchange auction to determine the exchange rate of the Kwacha. This resulted in an immediate 80 percent devaluation of the Kwacha. The government also liberalized import licensing, reduced tariffs, decontrolled interest rates through daily auctions of treasury bills, and increased maize agricultural producer prices to import parity. The devaluation of the Kwacha and weekly auctions increased inflation, uncertainty and business risk. The cash flow problems of the Marketing Unions worsened and the cooperatives were unable to provide seasonal credit to farmers,

[20] MM400 was derived from the CIMMYT variety Pirsbak (2) 7930 and its relatives. MM600 was derived from EV8076 that was developed by maize breeders in Tanzania from Ilonga Composite and CIMMYT Tuxpeno population 21.

thereby reducing seed production and sales.[21] Despite the cash flow problems, Zamseed purchased a seed farm with financial support from SIDA to take over the production of foundation seed from the government's Research Branch. Zamseed also expanded the distribution of the seed of new hybrids and varieties to smallholders and exports to neighboring countries. But the distribution of improved maize seed in smallholder areas was seriously constrained by the lack of knowledgeable salespersons among the Provincial Cooperative Marketing Unions' staff to help ZamSeed process orders, manage inventories and help farmers select appropriate hybrids for their conditions.

In 1986 the government increased the price of maize meal. This sparked food riots in the Copperbelt which forced the government to abandon the IMF and World Bank structural adjustment program and introduce its own adjustment program.[22] The government set an exchange rate of US$ 0.125 per Zambian Kwacha and interest rates below 20 percent and reintroduced price controls and foreign exchange allocation to reduce inflation. However, the government controls increased bureaucratic costs and shortages of transport, spares, and tarpaulins which resulted in the development of parallel markets. Although the shortages of agricultural inputs constrained seed production and marketing, ZamSeed achieved record sales and profits because the investments in hybrids and varieties for smallholders began to pay off.[23] ZamSeed also expanded its product line when the maize team released the hybrid MM612 that was well suited to small-scale farmers in medium and high rainfall areas. By

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[21] Because the Provincial Cooperative Marketing Unions continued to pay Zamseed late, the government subsidized ZamSeed from 1985 to 1989. In 1988, the seed subsidy was US$ 1.2 million (Zambian Kwacha 9.7 million), about 10 percent of the total government spending on crop improvement research.

[22] In 1987, the IMF and the World Bank withdrew from Zambia.

[23] In 1986, more than 70 percent of ZamSeed's seed sales were early maturing and drought tolerant varieties marketed to small-scale farmers.

1987, the eight hybrids released since 1983 represented more than 90 percent of ZamSeed's maize seed sales.

In 1989 the government was forced by persistent inflation and shortages of inputs to discontinue its domestic resources restructuring program and readopt a comprehensive IMF and World Bank structural adjustment program. This involved the removal of price controls, except for maize meal and fertilizers, and restrictions on foreign exchange, imports and exports. The Kwacha was devalued, monetary policies were introduced to restrict the money supply and increase real interest rates, and a start was made to reform the government budget and reduce the deficit. The policies had the immediate impact of accelerating inflation and interest rates which squeezed liquidity and increased seed production and inventory costs. Because of decreased liquidity, late payment to farmers by the government for marketed maize, and insufficient seasonal credit, the Provincial Cooperative Marketing Unions were unable to distribute seed timely in 1990. This reduced ZamSeed's sales to their lowest level in its ten year history and resulted in large carry over stocks. ZamSeed then shifted seed distribution from an exclusive focus on the Provincial Cooperative Marketing Unions to a mix of private dealers and direct sales through company-owned outlets and credit organizations (Kabaghe, 1992). In addition, ZamSeed began to offer cash and bulk sales discounts, price seed freight on board ex-depot, and use print, radio, and television advertisements to aggressively promote its products to farmers.

The government took a significant step towards improving the investment and contractual confidence of the Zambian economy in 1991 by enacting the Investment Act which provided legal protection for private investments and tax incentives for new investments. The Investment Act also established an Investment Center to facilitate the registration of new companies. The passing of the Investment Act encouraged the entry of multinational seed companies, including Pioneer Hi-Bred International in 1991, Cargill and Pannar in 1992, and

Carnia in 1993. Pioneer introduced proprietary hybrids from Zimbabwe, Cargill from Malawi, and Pannar from South Africa. Carnia is introducing hybrids from South Africa.[24]

In 1992 a new government came into power and began to rapidly implement the structural adjustment reforms, including the reduction of subsidies and the removal of import and export restrictions. The government also liberalized foreign exchange regulations, established a bureaux of exchange to allow for the market determination of the exchange rate, and reduced tariffs to 40 percent. The government started to reduce the budget deficit by laying off civil servants and created the Zambian Privatization Agency to sell state-owned companies. The immediate impact of these policies was a rapid increase in inflation which led to strikes and unrest as workers demanded wage compensations. The government approved wage increments but these expanded its expenditure and increased the budget deficit. The government financed the deficit by expanding the money supply but this fuelled inflation to more than 150 percent. In 1993 the government began to sell Treasury Bills to reduce the money supply and the rate of inflation. The respondents interviewed in this study reported that because of the persist budget deficit and an unpleasant monetarist arithmetic, the use of Treasury Bills to reduce money supply was generating hyperinflation.

The high inflation and interest rates adversely affected the balance sheets of seed firms by increasing depreciation charges and the borrowing requirements of seed firms to carry more expensive inventories. The current ratio for the representative seed company has declined since 1983 indicating decreased liquidity. Seed company representatives also pointed out that the high inflation increased business uncertainties and risks which made it difficult for companies to budget, price their products, and determine what their competitors were doing.

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[24] Although Carnia and Cargill have a strategic alliance, the two companies were following different marketing strategies in Zambia.

5.4.2 The Seed Industry in 1993

By 1993 the Zambian seed industry was in the growth phase of the life cycle and undergoing a transition from a public to a private competitive form of organization. The seed industry generated 10,673 tons in annual seed sales for planting some 60,000 hectares of maize by commercial farmers and 417,000 hectares cultivated by smallholders (Figure 5.4). More than 74 percent of the smallholder maize acreage was planted to improved open-pollinated varieties and hybrids, up from less than 30 percent in 1980. Because of the removal of seed subsidies and escalating production costs, hybrid seed prices had increased to more than 16 times the price of commercial maize grain for single crosses and 14 times the price of commercial maize grain for three-way hybrids. Commercial maize yields averaged 6.0 tons per hectare while smallholder maize yields averaged 2.2 tons per hectare.

Because the fastest-growing segment of the industry was the smallholder sector, seed companies were focusing on developing, producing, and marketing high-quality seed capable of achieving good yields under the low input conditions. Although the multinationals had established breeding programs in Zimbabwe and South Africa, they carried out adaptive research and varietal testing in Zambia and introduced 12 new hybrids between 1992 and 1993.[25]

ZamSeed had 96 percent of the market share in Zambia, Pioneer Hi-Bred International had two percent, and Pannar the remaining two percent. However, Pioneer Hi-Bred International withdrew from Zambia in 1993 and established a distributorship with a Zambian company because the SCCI introduced a mandatory certification of seed that required seed companies to submit samples of their inbred lines to government officials in order to get their seed certified even though Zambia did not have a plant variety protection legislation in place. Carnia International entered the Zambian seed market in 1993. Seed companies were

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[25] In 1993, Carnia applied to the SCCI to release in Zambia its three maize hybrids, three sunflower hybrids, and two soybean varieties that had been tested in South Africa.

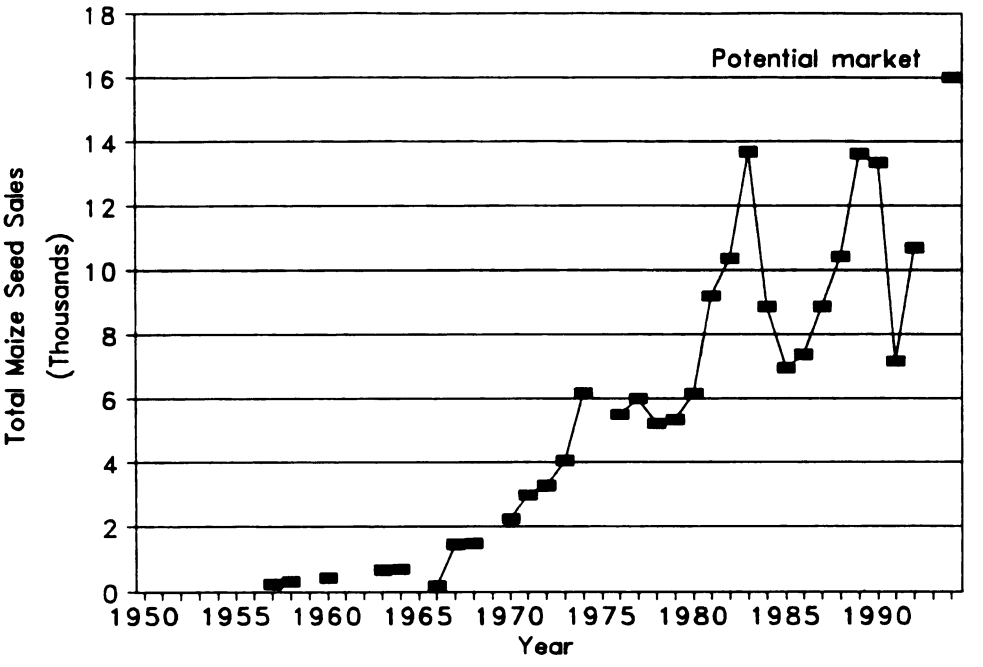

Figure 5.4: Total Maize Seed Sales in Zambia, 1950-1993

Source: Ministry of Agriculture

committing resources to maize development, production and distribution because there was a high awareness among farmers to purchase hybrids every year and hybrids were generating high gross margins. Zamseed was granted ownership rights to all the parent materials released by the government breeding program before 1993 but future materials are to be auctioned and licensed to highest bidders on a royalty basis. Zamseed initiated a maize breeding program and established a research and marketing agreement with the Seed Co-op and Semok to pool technologies, build synergies, and promote the marketing of each others' products in the three countries. Cargill focused on promoting its hybrids in the Eastern Province of Zambia where there were many areas of flint types of maize and introduced flint maize hybrids from Malawi. Pannar established a seed production agreement with a Zambian seed producer, Galaun Holdings, and founded a new seed marketing company called Quick Marketing to distribute hybrid seed from Zimbabwe and South Africa while it set up

production and conditioning facilities. The average time of developing and commercializing maize hybrids was 12 years, consisting of six years for development, four years for yield trials, and two years for registration and release. The average life cycle of a maize hybrid was 10 years.

The public and private sector roles are being redefined along the life cycle patterns followed by mature seed industries over the last 50 years. The government set up arrangements to auction exclusive marketing rights to new publicly-bred inbreds, varieties, and hybrids on a royalty basis to generate additional funding to support crop research. The government was also establishing research programs in millets, sorghum, cassava, sweet potatoes, bambarra nuts and cowpeas to ensure household food security and turning over the responsibility for the breeding of hybrid crops to the private sector. Commercial farmers were establishing a private research station, the Golden Valley Agricultural Research Trust, and hiring indigenous scientists on expatriate salaries in order to evaluate different varieties and hybrids. The government was reforming the Seeds Act to introduce the compulsory certification of seed in order to protect unsophisticated farmers from unscrupulous seed merchants during the transition to a competitively organized seed industry. The government was also establishing an Official Variety List and requiring all new varieties and hybrids to undergo official variety testing and release before they could be sold in Zambia. However, Zambia introduced stringent morphological characterization for distinctiveness, uniformity and stability by the SCCI and breeder to breeder cooperation trials for yield and quality before new cultivars could be included in the list even though the country lacked technical competence and facilities to implement variety characterization. The government also required seed companies to submit samples of all parent lines of hybrids to the SCCI which led Pioneer Hi-Bred international to withdraw from Zambia. The new Seeds Act also permitted seed companies and individuals to form private seed certification agencies and seed

testing laboratories, strengthened the capacity of the SCCI to monitor seed quality and control, and established new rules for the appointment of members of the National Variety Release Committee.[26] The government was also introducing plant variety protection law modelled after UPOV. But the government still lacked independent facilities for testing the genetics of different seed companies. The seed companies formed a Seed Liaison Committee to provide a foundation for a seed trade association that could take over the administration of seed certification from the government in a path-dependent manner along the lines developed by SANSOR in South Africa.

5.4.3 The Future Development of the Seed Industry

In the coming years the public and private sectors within the Zambian seed industry will most likely evolve along the life cycle model followed by the seed industry in North America over the last 50 years. The public sector will continue to dominate the supply of advanced genetics in varietal crops and release materials on exclusive licenses in exchange of royalties while the private sector assumes increasing responsibility for maize and other hybrid crops. The public sector will play mostly a monitoring and policing role while the private sector will have the responsibility for seed certification and laboratory seed testing. Because of the widespread adoption of hybrids by smallholders, seed companies will continue to target small scale farmers in order to wean them onto more sophisticated hybrids as they move up the quality ladder and begin to use more inputs such as fertilizer and irrigation.

If the Zambian seed industry continues to develop along the lines of the life cycle model, then it can be expected that seed sales will level off in the early 2000s and competition

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[26] The National Variety Release Committee comprised the Director, Ministry of Agriculture as the Chairman, the Director of the SCCI as the secretariat, government plant breeders, farming systems specialists, seed specialists, and representatives of the Zambia National Farmers' Union, Zambia Seed Producers' Association, and University of Zambia School of Agriculture.

for market share will be intensified. The market will be most likely include such firms as Zamseed, Cargill, Pannar, and Carnia. The increasing price and service competition will provide farmers with a wide choice of varieties and hybrids and information acquisition costs will be reduced by advertising, strip demonstrations, and agronomic advice provided by the seed companies. Zamseed has gained first-mover advantages and exclusive rights to government-generated elite inbreds that enables it to provide advanced genetic materials if multinational firms withdraw from Zambia.

Government officials reported that if private certification performs well in Zambia, the government will remove compulsory certification because high-quality seed standards will be maintained through competition and reputation effects. The SCCI waived the compulsory seed certification rules for cotton and soybean because the government did not have a breeding program in these crops but did not waive the rules for maize because Zambia had five publicly-bred short season hybrids: MM501, MM502, MM504, MM601, and MM604. The SCCI was developing a low transaction cost seed certification system by licensing seed certification agencies and private seed inspectors separately and requiring seed inspectors to obtain licenses every two years. The seed inspectors are awarded licenses depending on their performance in formal examinations and the quality of seed they certify is sporadically checked. Licenses are withdrawn from inspectors who are found to pass seed that falls below tolerance levels. Zambia will seek membership in UPOV and OECD seed certification scheme.

Seed company representatives interviewed in this study were convinced that Zambia will evolve into a regional center for producing seed for export to Zaire, Tanzania, Angola, Mozambique, Namibia, and Uganda because of its favorable natural resource endowments, knowledgeable and experienced seed growers, and relatively low labor costs. Most respondents contended that expanded seed trade in Southern Africa will benefit both the seed

companies and countries in the region by reducing the strategic seed reserves needed for unfavorable weather.

5.5 Malawi

In 1980 the Malawian seed industry was in the emergence phase of the seed industry life cycle and it was dominated by a newly established state-owned seed company, the National Seed Company (NSCM). NSCM focused on multiplying and distributing parent lines released by the government breeding program. NSCM produced and distributed 2,500 tons of improved varieties and hybrid maize seed through ADMARC which was planted on less than five percent of the 1.3 million hectares of maize that was mostly grown by smallholders for their own consumption. The average maize yield was 1.1 tons per hectare. The government controlled maize seed prices which averaged eight times the price of commercial grain for single cross hybrids and subsidized ADMARC. Because of poor infrastructure, organization and distribution capabilities inherited from ADMARC, NSCM was unable to distribute certified hybrid seed throughout the country on a timely basis. In the early 1980s, the Malawian government adopted an IMF-World Bank structural adjustment program to correct the government budget and balance of payments deficits, improve agricultural pricing policy, and increase the effectiveness of state-owned companies.

5.5.1 The Evolution of Institutions and Technology: 1980-1992

The National Seed Company (NSCM) of Malawi was organized in 1980 under a one party system of government as a production unit of ADMARC for all agricultural and horticultural crop seed. The Commonwealth Development Corporation (CDC) invested in the NSCM and became the management shareholder in charge of managing business functions. NSCM's mission from 1980 to 1982 was to meet ADMARC's needs for agricultural and horticultural

seeds required by farmers in Malawi. Because maize is the staple food, maize seed was the main crop seed supplied by NSCM. The company rapidly developed organizational capabilities for producing high-quality seed which induced farmers to adopt improved varieties and hybrids. NSCM started by multiplying breeders' seed released by the government Research Branch to produce foundation seed which was then bulked by 60 contract seed growers under the supervision of the company's staff and government inspectors. To ensure quality, the company cleaned, graded and treated seed at a central processing plant in Lilongwe. The seed was then packed in different container sizes for distribution to farmers and distributed through its central factory and ADMARC outlets. As the demand for high-quality, certified seed increased, NSCM established a network of sales agents to distribute improved seed throughout the country.

Following the establishment of the Seed Technology Unit and the National Seed Company of Malawi, the Malawian seed industry expanded rapidly. The quantity of maize seed certified by STU, produced by NSCM and marketed by ADMARC doubled from 2,950 to 4,874 tons from 1980 to 1985. The seed samples tested by STU increased fourfold from 1978 to 1981 and then remained steady throughout the 1980s (Figure 5.5).

Turning to hybrid maize seed production, Malawian breeders developed a dent hybrid MH12 in 1978 using the Zambian inbred lines of SR52 which became the dominant hybrid in the early 1980s. However, because MH12 had poor storage qualities, the breeders released another dent hybrid MH15 and a semi-dent MH16 in 1985, using inbreds from local materials and South Africa. But MH15 was phased out because it had poor synchronization and NSC concentrated on producing MH16 which had better storage and pounding characteristics. The breeders also developed two flint composites Chitedze Composite C (CCC) and Chitedze Composite D (CCD) in 1985 by crossing local materials with germplasm from CIMMYT, IITA and South Africa. Because CCC and CCD were early maturing and resistant to lodging,

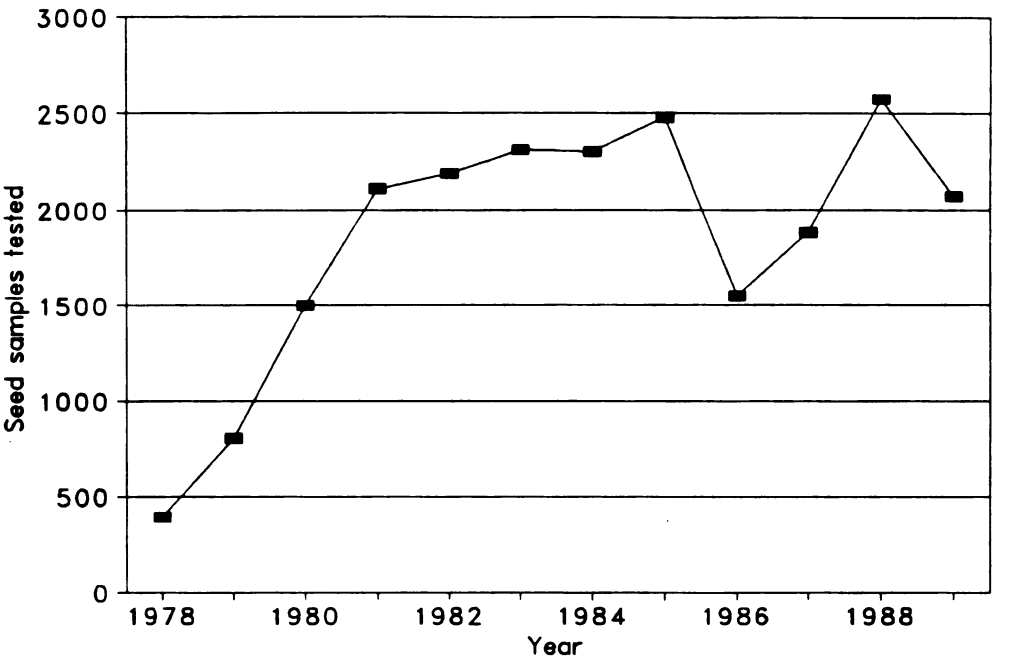

Figure 5.5: Seed Samples Tested by the Seed Technology Unit, Malawi, 1978 to 1989

Source: Seed Technology Unit, Malawi

they eventually replaced CCA and UCA. In 1986 government breeders changed their breeding strategy from developing dent hybrids to breeding flints using germplasm from IITA and CIMMYT. This work led to the release of two high-yielding flint hybrids MH17 and MH18 in 1990 that have good pounding and storage characteristics. MH17 and MH18 have dramatically increased the area under hybrids from 7 to 24 percent from 1988 to 1992 (Smale, Forthcoming).

Turning to the profitability of the seed business, because of the rapid growth of the seed industry the net profit realized by the NSCM increased by 44 percent from US$ 150,470 (MK 122,334) in 1980 to US$ 216,974 (MK 373,000) in 1985. The increase in net profit permitted the company to pay an annual dividend averaging six percent and reduce its outstanding long-term debt by 50 percent from 1980 to 1988. Although data are unavailable to assess profitability when structural adjustment got under way in the late 1980s, interviews

with the managers of seed companies revealed that the seed firms earned competitive return on their investments.

During the late 1980s, NSCM was unable to meet the demand for hybrid maize seed because it failed to secure an adequate number of contract seed growers as estate farmers found it more profitable to grow tobacco.[27] Also, detasselling coincided with tobacco reaping and estate managers tended to ignore detasselling as a result of which government inspectors disqualified their seed crops. Because of the shortage of seed growers, NSCM was forced to contract production with farmers in the remote parts of the country which greatly increased the operation and inspection costs of the Seed Services. To reduce seed certification costs and seed prices, the government implemented three policies in the late 1980s. First, the government launched a Smallholder Seed Multiplication program in 1986 to promote certified seed production by smallholders throughout the country under certification under inspection by the STU. However, the program achieved little success because the fragmented holdings increased supervision and inspection costs, gross margins were unattractive to seed growers, and there was a lack of marketing and storage facilities. Second, the government granted subsidies to ADMARC ranging from 20 to 50 percent of hybrid seed prices depending on the variety and year.[28] Third, the government enacted a Seed Act in 1988 but it has not been implemented because regulations have not been drafted for enforcing the Act.

In 1989 Cargill entered the Malawian seed industry by acquiring 55 percent of NSCM's equity while the balance was split between the CDC and ADMARC. Cargill also became the management shareholder and began to transform NSCM from a seed production unit of ADMARC to a profit-driven company by focusing on hybrid maize seed because of its high gross margins. In addition, NSCM invested in a seed laboratory to ensure that its

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[27] The shortages of hybrid maize seed were met by imports from Zimbabwe.

[28] The seed subsidies exceeded 20 percent of the total government expenditure on crop improvement research in the 1990s.

standards were higher than those of government and hired seed technologists to inspect the premises of wholesalers and stockists to check seed quality and establish a reputation for consistent quality. Furthermore, Cargill initiated an adaptive maize research program that it coordinates from its central breeding program in Zimbabwe.

In 1991 Lever Brothers (Malawi) entered the seed industry and focused initially on hybrid sunflower seed to help meet its requirements for alternative sources of vegetable oil to groundnuts. In 1992 Lever Brothers added hybrid maize seed because it was not commercially viable to operate a seed business with only sunflower seed. Because of the structural adjustment program, the Ministry of Agriculture licensed Lever Brothers to produce and market the newly-released maize hybrids MH17 and MH18 under the brand name *Chokonoka* 17 and 18 which means "poundable". Lever Brothers drew on international links with its sister Unilever company, Plant Breeding Institute (PBI) Cambridge, to acquire plant and equipment, germplasm, and finance to establish a seed business in Malawi. Lever Brothers also entered into a production and marketing agreement with Pannar-Saffola to multiply and distributed their proprietary hybrids in Malawi. Lever Brothers transferred production and distribution strategies which have been successful in its core detergents business to selling seed in Malawi. Lever Brothers distributed seed in smaller packs compared with the NSCM because it used its existing network of rural dealers and retailers who were within walking distance of most farmers. Because of its strong brand image and intensive distribution channels, Lever Brothers is penetrating the Malawian seed market even though the NSCM sells most of its seed to ADMARC at subsidized prices.

5.5.2 The Seed Industry in 1993

In 1993 the Malawian seed industry was undergoing a transition from emergence to the early growth phase of the industry life cycle. The seed industry generated about 8,000 tons in

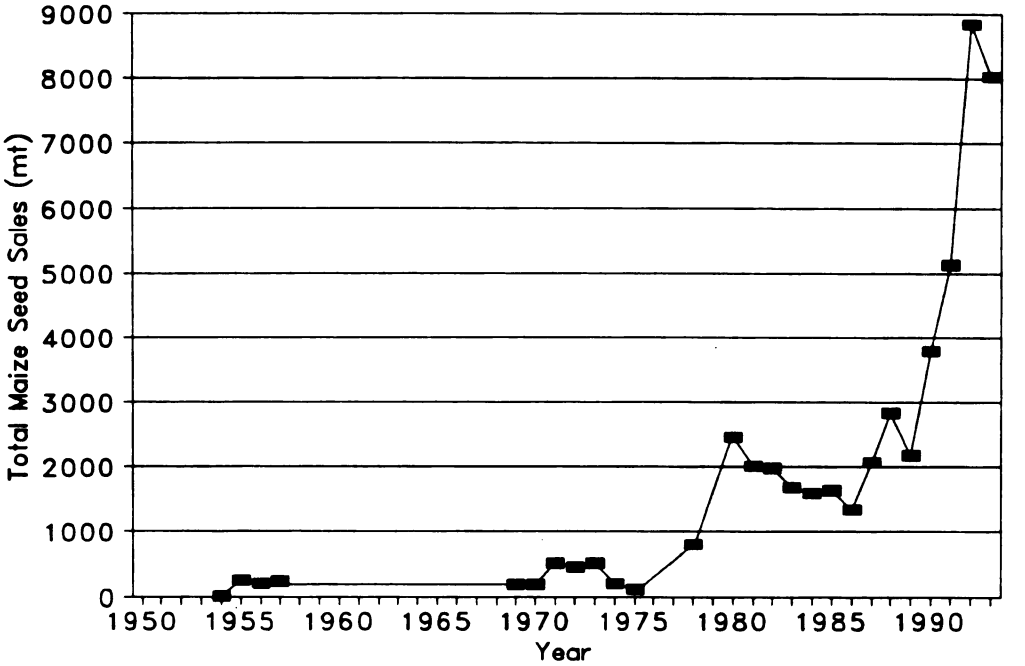

Figure 5.6: Total Maize Seed Sales in Malawi, 1950-1993

Source: Ministry of Agriculture

annual seed sales that was used for planting around 25 percent of the one million hectares of maize (Figure 5.6). The potential market of around 30,000 tons consisted mostly of smallholders who were growing maize for their own consumption and demanded flint hybrids that can perform well under low input conditions and have traditional pounding and storage characteristics. Seed companies were responding by developing, producing and marketing high-quality seed of flint maize hybrids. Because of seed price controls and subsidies to ADMARC, the hybrid maize seed price has remained at eight times the price of commercial maize grain. The average national maize yield was 1.57 tons, up from 1.1 tons per hectare in 1980, largely because of the new hybrids that perform well even under low input and drought conditions (Figure 5.7).

The industry was still dominated by the NSCM although Lever Brother was rapidly building market share. Both companies focused on multiplying and distributing seed

originating from the government breeding program and were competing on seed quality, prices, and services. NSCM was becoming a subsidiary of Cargill Hybrid Seeds. NSCM obtained permission from the government to hire its own breeders and initiate a maize program in Malawi coordinated from Cargill's African regional maize program in Zimbabwe. Lever Brothers established a production and marketing agreement with Pannar and initiated a breeding program linked to Unilever's international breeding program. Both Carnia International and Sensako were testing their hybrids in government trials in 1993 and preparing to enter the seed industry.

The public and private sectors in the Malawian seed industry are undergoing the same type of changes that have occurred in South Africa and Zimbabwe. The government introduced seed policy reforms in 1993 to permit the licensing of new seed companies, remove seed subsidies and provide tax credits for private sector investments in the seed industry. Also, the government was introducing Plant Breeders Rights and royalties for government-bred varieties and hybrids, changing the variety release procedures to allow the release of privately tested hybrids and varieties, and applying for membership in UPOV and the OECD.

5.5.3 The Future Development of the Seed Industry

In the coming years privatization and the evolution of a competitively-organized seed industry will continue to evolve but because of a lack of infrastructure and institutions to provide the legislative and regulatory framework for guaranteeing the supply of high-quality seed to farmers, it will probably take another decade or two for the seed industry to enter the mature phase of its life cycle. Because NSCM and Lever Brothers are marketing the same hybrids, competition will initially center on price, distribution, and promotion. As seed companies introduce proprietary hybrids from their breeding programs, product competition will increasingly become important in establishing niches. If the Malawian seed industry continues

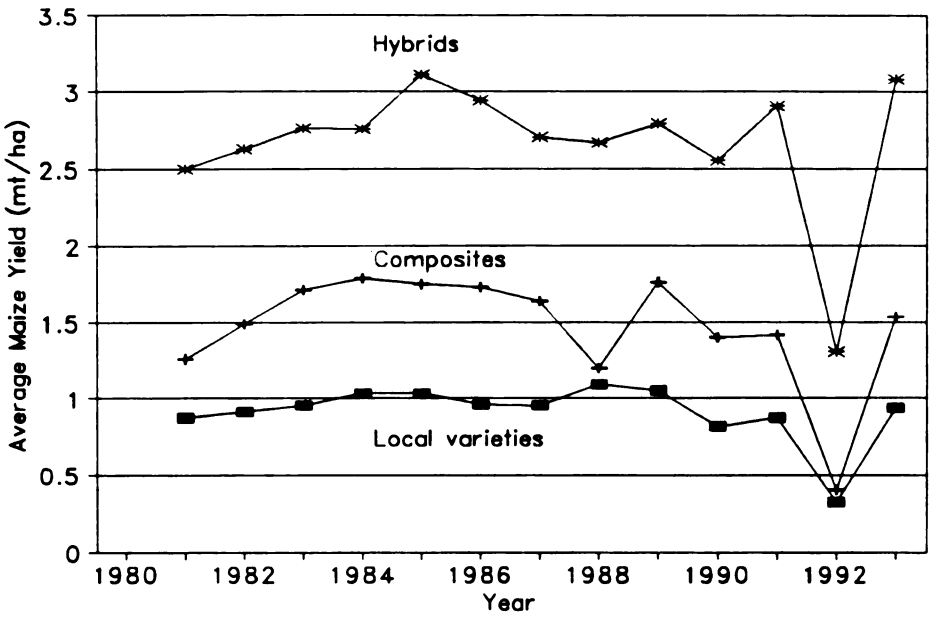

Figure 5.7: Average Maize Yield of Hybrids, Composites, and Local Varieties in Malawi, 1981-1992

Source: Ministry of Agriculture, Malawi

to develop along the lines of the life cycle model, then it can be expected that seed sales will level off in ten to fifteen years and firms will then focus on maintaining market shares. The market will likely be dominated by two to three research-based companies and several smaller companies serving particular niches. Respondents in Malawi indicated that this scenario will benefit farmers in several ways. First, hybrid maize seed prices in Malawi are high because seed producer prices have been tied to tobacco prices as most maize seed growers are tobacco farmers. But now there will be competition for seed growers among seed firms and for seed companies among growers that will compel the adoption of low cost production strategies and reduce seed prices. Second, competition will force seed firms to establish outlets in rural areas within walking distance of farmers. Third, competition is forcing companies to sell seed in small packs that are commensurate with farmers' holdings. Finally, increasing competition will force companies to adopt aggressive advertising which will reduce the

information costs of farmers. In addition as companies develop proprietary products and establish niche markets, seed firms will expand into export markets. It is conceivable that in the future one seed company could produce hybrid maize seed in Zimbabwe, tobacco seed in Malawi, and sunflower seed in Tanzania, and market these products in all three countries.

Because of the government control of the seed industry in the past, respondents reported that government breeders are apprehensive about private companies bringing in inbreds and hybrids from other countries. The seed policy should be changed to enable seed companies to market hybrids other than those released from the government program. Since only government breeders can release material, all testing has to done through government breeders. But as competition evolves there is less need for a Variety Release Committee because competition will reduce the likelihood of seed companies risking their reputation by selling poor quality seed. Yet government officers feel that smallholders are vulnerable and require institutional safeguards for protection against dishonest trading practices and unscrupulous seed merchants during the transition to a competitively-organized seed industry.

5.6 Summary

The case studies provide pieces of evidence that support the proposition that structural adjustment programs in Southern Africa have created incentives to shift the institutional foundations of the public sector-dominated maize seed industry to new forms of hybrid organizational arrangements have facilitated market signaling and improved the performance of the seed industry. These case studies demonstrate that the maize seed industries in South Africa, Zimbabwe, Zambia and Malawi have introduced the following institutional innovations that are reducing adverse selection and facilitating the development of the seed industry: SANSOR in South Africa, the Seed Traders Association Inspectorate in Zimbabwe, and the Seed Liaison Committee in Zambia.

Figure 5.8 reveals that the South African seed industry is in the mature phase of

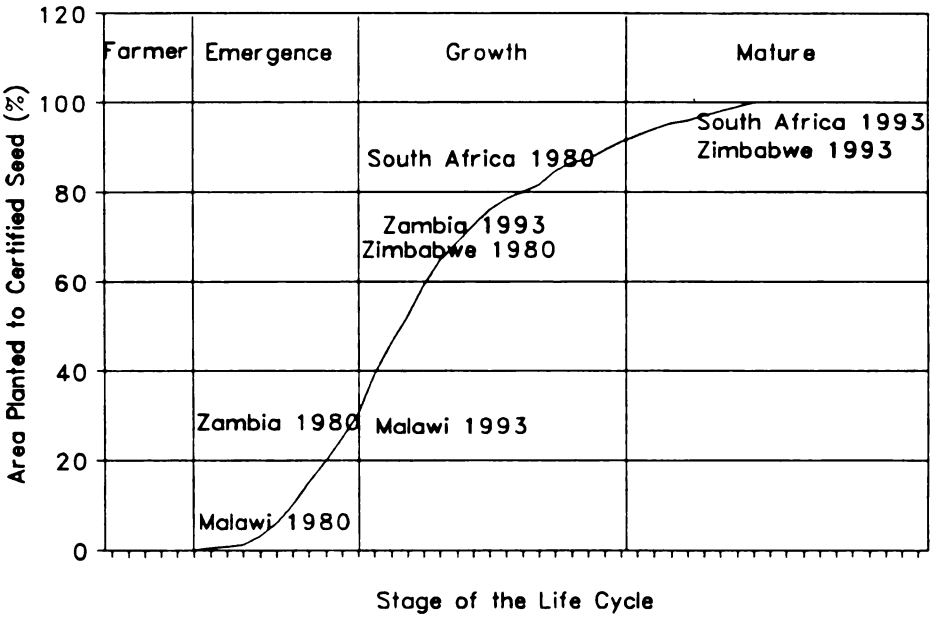

Figure 5.8: The Stages of the Life Cycle of the Seed Industry in Southern Africa

development and the leader in the region in terms of a private-dominated form of organization. The area planted to certified seed increased from 85 to 95 percent from 1980 to 1993. The average commercial maize yield increased four percent while the average smallholder yield increased 25 percent between 1980 and 1993. The profitability of the seed industry declined in the 1980s because of high cost of goods sold and intense competition which reduced profit margins.

South Africa's seed industry is dominated by four private companies that have demonstrated a capability to supply farmers with innovative and superior seed products. Seed companies in South Africa have responded to structural adjustment by diversifying into other crops and selling a wide portfolio of seed products to stabilize sales. Also, the companies are using a mix of brand names, advertising, trademarks and logos, packaging, field demonstrations, personal selling and after-sales services to signal the quality of their seed

products to farmers and capture market shares. In addition, domestic seed companies have formed acquisitions, mergers and partnerships among themselves and with global seed companies to reduce duplication of research effort and overlapping infrastructure, gain access to cutting-edge technology in advanced countries, and prepare themselves for global competition. Because private companies have demonstrated their willingness and capability to sustain breeding programs, seed certification is voluntary, and South Africa is installing a system where seed inspectors are employed by seed companies and report to SANSOR. SANSOR tests and authorizes private seed inspectors and government officials carry out spot checks and certification for ISTA and OECD. SANSOR is reducing transaction costs for licensing seed inspectors and giving them legal exposure and cross-licensing parent lines and collecting royalties. Because of the reduction of transaction costs, commercial farmers and a few smallholders are more reliably served with better quality seed.

The seed industry in Zimbabwe is entering the mature phase of its development. However, more than 90 percent of the seed in Zimbabwe is handled by the Seed Co-op which focuses on multiplying parent lines from its own private research and from the government maize program. Because of the MIGA and OPIC agreements and political commitments to structural adjustment, Pannar, Pioneer Hi-Bred International, and Cargill have entered the seed business over the past decade and invested considerable resources in maize breeding programs, seed production, and distribution. The companies are using a variety of signals, including brand names, logos, trademarks, packaging, advertising, field demonstrations, and sales force to signal the existence, characteristics, and quality of their seed to farmers. Although the private sector has made substantial investments in research stations, conditioning and marketing facilities and proprietary germplasm, private companies have not yet demonstrated their ability to sustain breeding programs and deliver innovative products for widely dispersed smallholders.

Since private companies have not yet been accepted as a reliable source of new cultivars, the government is continuing to support the Tripartite Agreement. Because the government maize breeding program is under stress, the government is commercializing its breeding program and offering new inbreds to all companies in exchange for royalties in order to generate revenue for supplementing its declining research budget. There are also several bureaucratic hurdles that are constraining the performance of the Zimbabwean seed industry. The government is introducing compulsory seed certification but it lacks independent facilities for testing different materials and an Official Variety List. Although it has recently introduced a list of recommended varieties, transparent rules are not available of getting varieties on the list of recommended varieties. Because of the large number of inspectors needed to carry out field inspections of seed crops, the government is transferring the responsibility for seed certification to private companies.

Because of the reduction of information asymmetry and adverse selection in the seed industry over the past decade, the proportion of the maize area planted to hybrids increased from 70 to 100 percent from 1980 to 1993. The average commercial yield increased by 33 percent while the average smallholder yield increased by 57 percent over the same time period. Financial and ratio analysis of income statements of a representative seed company shows that the seed business became marginally profitable in the 1980s because high interest rates increased the depreciation and interest expenses which raised general and administration costs as a percentage of sales.

The seed industry in Zambia is in the middle of the growth phase. Most of the seed in Zambia is distributed by ZamSeed which focuses on multiplying and distributing parent lines from the government breeding program. As a result of the political commitment to structural adjustment, Pioneer Hi-Bred International, Pannar, Cargill and Carnia have entered the Zambian seed market since 1991 and are investing in adaptive research, seed production,

and distribution and expanding the seed industry. Because private companies have not yet been accepted as a reliable source of new cultivars, the government is establishing an Official Variety List and maintaining stringent varietal registration and mandatory seed certification procedures. The government is also requiring seed companies to submit samples of their parent lines to government officials for testing for distinctiveness, uniformity, and stability to get their seed certified. Because Zambia does not have in place a plant variety protection legislation, Pioneer Hi-Bred International refused to comply and withdrew from the Zambian market in 1993. Because of budgetary constraints, the government is commercializing its breeding program to generate revenue for research and transferring the responsibility for seed certification to private companies. Zambia is introducing Plant Breeders Rights modelled after UPOV to encourage seed companies to introduce new varieties. Because the government intends to lift mandatory certification if private certification works well, Pioneer Hi-Bred International plans to return eventually to Zambia. Between 1980 and 1993, the area planted to certified seed increased from 30 to 74 percent and the average yield doubled on both commercial and smallholder farms. The profitability of the seed industry was erratic in the early 1980s but improved slightly in the late 1980s because of seed subsidies and the large growth in hybrid seed sales of the MM500 and MM600 series.

The seed industry in Malawi is in the early growth phase. Most seed is handled by NSCM, which focuses on multiplying and distributing parent lines from the government breeding program. However, since Cargill has become the management shareholder, NSCM is evolving into a subsidiary of Cargill and gaining access to varieties developed by Cargill's international breeding program. As a result of the political commitment to structural adjustment, Lever Brothers has entered the Malawian seed market and is investing in maize breeding, seed production, and distribution. Malawi is slowing putting in place the basic legislative and regulatory framework to lower the transaction costs of purchasing and selling

seed, Plant Breeders' Rights, and promote private sector investments. Between 1980 and 1993, the area planted to certified seed increased from 4 to 25 percent and the average yield increased by 43 percent. Although financial data are unavailable to calculate the profitability of the seed business, the large growth in net profits earned by NSCM from 1980 to 1985 and the competitive annual dividends paid out from 1980 to 1988 indicate that profitability improved because of the rapid growth of hybrid maize seed sales.

CHAPTER SIX

SUMMARY, CONCLUSIONS AND POLICY IMPLICATIONS

This chapter reviews the principal results of the study and discusses the policy implications. In addition, several suggestions are advanced for future research.

6.1 Background

Sub-Saharan Africa is a vast continent of 48 independent nations, seven colonial histories and more than 1,000 different ethnic groups. Africa has the world's fastest rate of growth of population and is facing a severe Ricardian food bottleneck. Moreover, it is the only continent that has not broken the famine cycle. Therefore, the political stability and the future development of Africa are critically dependent on increasing the productivity of the agricultural sector, the sector that employs two thirds of the working population.

When most African countries became independent in the 1960s, Africa was a modest food exporter. However, buffeted by rapid population growth and drought, Africa's food balance sheet changed from exporter to importer status in the early 1970s. In fact, Africa's rate of growth of food production (1.5 percent) was half that of population (3 percent) from 1970 to 1985. Since agriculture is the backbone of most African economies, it follows that "getting agriculture moving" is the central development challenge on the continent.

Both the Economic Commission for Africa (ECA) and the World Bank addressed Africa's economic crisis with the release of landmark reports in the early 1980s. In 1980 the ECA's *Lagos Plan of Action* stressed external variables as the cause of Africa's economic crisis. A year later the World Bank's published *Accelerated Development in Sub-Saharan Africa: An Agenda for Action* and identified inappropriate domestic policies as the major problem and laid out a strategy of economic policy reforms. The Bank's report was followed by recommendations of the International Monetary Fund (IMF) that African nations should

pursue macroeconomic stabilization policies. However, after a few years of IMF assistance in the early 1980s, the Fund realized that it alone could not meet the needs of African governments. Therefore, the World Bank and several bilateral donors agreed to underwrite structural and sectoral adjustment lending programs starting in Ghana in 1983. However, after more than a decade of structural adjustment lending, the influence of the structural adjustment policies on food production and agricultural development is still limited. Africa's collective experience with structural adjustment programs reveals that getting prices right and correcting overvalued exchange rates cannot by themselves increase the aggregate supply response in agriculture and accelerate the rate of economic growth. There is growing awareness that structural adjustment reforms must be supplemented with technological and institutional innovations to reduce contractual hazards. However, there is a general lack of understanding of how institutions should be restructured to support specialized investments in agriculture.

In a recent report to the World Bank, de Capitani and North (1994) pointed out that identical structural adjustment programs are producing different outcomes in different countries. They hypothesize that something is missing in the body of economic theory and the economic models currently employed and that the missing link is an analysis of institutions, organizations and the process of economic growth. They recommend that the Bank devote more resources to preparing country-specific institutional strategies, more resources to research on institutions and place more emphasis on experimentation and pilot projects in an iterative process of tailoring institutions to the needs of a particular country.

Since most of the arable land in Southern Africa is already under cultivation, further increases in agricultural productivity will critically depend on yield-increasing innovations. High-quality seeds of improved locally-adapted varieties and hybrids and higher rates of fertilizer application are critical components of increasing crop yields in this sub-region.

Since maize is the staple food in Southern Africa, it is important to examine the impact of structural adjustment programs on the maize seed industry. Because of the reduction in government spending being imposed under structural adjustment programs and the declining real budgets for agricultural research in many countries in the region, many questions are being raised about the impact of structural adjustment on the institutions underpinning the emerging maize-based Green Revolution in Southern Africa. These institutions safeguard specialized investments in specific asset technologies in plant breeding, seed production and conditioning, credit, fertilizer, and marketing.

The general objective of the study is to analyze the impact of structural adjustment programs on the organization and performance of the maize seed industry in four countries in Southern Africa and identify institutional and organizational innovations that have a potential to improve the performance of the seed industry in the region. The first objective is to develop a conceptual framework for analyzing the performance of the seed industry under changing public and private institutional arrangements. The framework is used to examine the globalization of the maize seed industry in two industrialized and six developing countries. The second objective is to analyze the economic history of the seed industry in Southern Africa from 1900 to 1980. The third objective is to carry out a business strategy analysis of seed firms in South Africa, Zimbabwe, Zambia and Malawi and determine the impact of structural adjustment on the performance of the seed industry in these countries from the early 1980s to the early 1990s.

Chapter 2 presents a life cycle model of the development of the seed industry under different institutional arrangements. This model is used to derive two propositions about the organization and performance of seed industries. The first proposition is that the transition of the maize seed industry from farmer to farmer exchange of seed through stages of increasing organizational complexity to a mature seed industry requires market signaling which, in turn,

is influenced by a path dependent evolution of institutions that induce public and private investments in specific assets. The first proposition is tested in Chapter 3 by analyzing the economic history and the life cycle of the seed industry in selected industrialized and developing countries. The proposition is also tested in Chapter 4 by examining the evolution of the Southern African seed industry from 1900 to 1980. The second proposition is that structural adjustment programs in Southern Africa have created incentives to promote the transition from public sector-dominated maize seed industry to new forms of public and private organizational arrangements that have a potential to facilitate market signaling and improve the performance of the seed industry. The second proposition is tested in Chapter 5 by examining the impact of structural adjustment programs on the performance of the seed industry in South Africa, Zimbabwe, Zambia and Malawi since the early 1980s.

6.2 Summary of Results

The empirical results substantiate the first proposition that the transition of the maize seed industry from farmer to farmer exchange of seed through stages of increasing organizational complexity to a mature seed industry requires market signaling which, in turn, is influenced by a path dependent evolution of institutions that induce investments in specific assets in the seed industry. The empirical analysis validates the second proposition that structural adjustment programs have created incentives to promote the transition from public sector-dominated maize seed industry to new forms of public and private organizational arrangements that have facilitated market signaling and have achieved qualified success in improving the performance of the seed industry in each of the four countries in Southern Africa.

Oliver Williamson, Douglass North and others have argued that legal and political institutions are critically important in hindering or facilitating economic progress. This study

reveals that the seed industry has evolved in a path dependent process where market signaling plays a central role in the creation of seed markets with low transaction costs. This study highlights the critical role that government-enforced seed certification plays in inducing market signaling, reducing the transaction costs of buying and selling seed and protecting specialized investments in maize breeding, seed production, conditioning, and marketing. This reduction in buyer uncertainty has encouraged the planting of high-quality certified seed which induced further institutional and technological innovations through the life cycle.

The first objective is to analyze the economic history of the maize seed industry in the United States, France, Mexico, Brazil, India, Thailand, Kenya, and Tanzania. The analysis in Chapter 3 reveals that the United States was the pioneer in promoting the transition from farmer to farmer seed exchange to more complex organizational stages of the maize seed industry from 1900 to 1965. To be sure, the United States benefitted from a unique set of initial condition, including favorable natural resource endowments, well-developed maize genetic materials, and a large domestic market. But the hybrid maize success story is not based solely on favorable initial conditions. The United States laid the foundation for a science-based agriculture by encouraging farmer organizations who in turn demanded public action that subsequently led to a public varietal introduction and seed distribution scheme, and public schools of agriculture, research, and extension. Around 1900 several American improved open-pollinated and breeding procedures were transferred to South Africa, Zimbabwe, Zambia and Kenya. Later, United States' hybrid maize was transferred to France in the early 1950s as part of foreign aid under the Marshall Plan for the recovery of Europe. Also, American private seed companies facilitated the international exchange of elite germplasm, advanced seed production technologies and marketing.

Five lessons for developing countries flow from this analysis of the economic history of the seed industry in two industrialized and six developing countries. First, government

leadership and investment were essential in launching the seed industry in each of the eight countries studied. Because of market failure and the lack of secure property rights, the private sector was unable by itself to finance the initial research and development and bear the risk to develop improved genetic materials, the engine of seed industry development. Second, the government developed official seed certification labels to protect farmers and reputable seed companies from unscrupulous firms and dishonest trading practices. This "seal of quality" was the key to creating seed markets with low transaction costs and encouraging farmers to plant certified seed. The Tanzanian case study reveals that the failure to develop a code of conduct, workable seed laws, and low cost enforcement of regulations explain why foreign aid technicians and equipment were ineffective in helping improve its government seed agency. Third, private firms will enter the seed industry if there is a public research foundation, rules and regulations, and market incentives. Private participation in the seed industry is also influenced by access to publicly-developed elite germplasm, transparent rules governing trials of new varieties and variety registration, seed import and export controls, intellectual property rights protection laws, and subsidies to state-owned seed companies. Fourth, public-private partnerships are generally more effective than government seed companies in marketing certified seed of improved varieties and hybrids to farmers. The fifth lesson is that because of the increasing globalization of the seed industry, domestic seed companies must acquire managerial, financial and marketing capabilities to compete with multinational seed companies in national, regional and global seed markets.

The second objective is to analyze the economic history of the seed industry in four countries in Southern Africa from 1900 to 1980. The historical analysis in Chapter 4 reveals that the evolution of the seed industry in South Africa, Zimbabwe, Zambia, and Malawi was shaped by the American seed industry in a path dependent way by importing open-pollinated varieties from the United States starting in the early 1900s and by replicating institutions such

as agricultural societies and farmer cooperatives and technological innovations such as breeding methods and seed production and marketing techniques. This analysis reveals that white commercial farmers in South Africa and Zimbabwe developed politically-active agricultural associations and cooperatives that pressured the Department of Agriculture and other government agencies to invest heavily in research and development to meet their particular needs. This political pressure from commercial farmers generated support for government agencies to invest in plant breeding, field trials of new varieties, seed multiplication, seed certification, testing, seed quality control, and extension. Both South Africa and Zimbabwe gradually introduced seed laws and regulations embodying minimum seed quality standards that were enforced through government seed certification labels and the licensing and inspection of seed merchants. This four country comparative study revealed that South Africa and Zimbabwe have been highly successful in developing and financing a specialized seed industry without the use of foreign aid while Zambia and Malawi have depended heavily on foreign aid. However, erratic foreign aid, ineffective domestic economic policies and political resistance to private seed companies have retarded the development of the seed industry in Zambia and Malawi.

Two important institutional innovations facilitated the development of the seed industry in South Africa and Zimbabwe. The Maize Board of South Africa introduced a research levy on maize grain marketed through the cooperatives in the 1960s that was used to support Sensako's research program targeted to farmers in marginal agroecological areas. In Zimbabwe, the government, commercial farmers and seed growers introduced the Tripartite Agreement in 1970 to ensure seed security reserves. Although the Agreement has produced the lowest seed to commercial grain price ratio in Southern Africa, it has served as a barrier to the participation of domestic and foreign private firms in the Zimbabwean seed market and it has retarded the transition to a competitively-organized seed industry. By contrast, Zambia

and Malawi did not commit adequate resources to specifying and enforcing seed quality standards and, as a result, became stuck in the emergence stage until the 1980s.

Commercial farmers in South Africa, Zimbabwe, and Zambia adopted hybrids at a much faster rate than in the United States and compressed the waiting time from the introduction of the first hybrids to 100 percent adoption of certified seed to 30 years in South Africa (1949 to 1979), 17 years in Zimbabwe (1948 to 1965) and 12 years in Zambia (1955 to 1967). This is because public scientists, government organizations, and seed associations in these countries were able to borrow, adapt and adopt more advanced methods of maize breeding, seed production and marketing in use in the United States and their political and legal institutions were sufficiently developed to facilitate the diffusion of hybrids.

The seed industry in Southern Africa is becoming rapidly globalized. South Africa created plant breeders' rights and investment incentives in the 1960s that attracted multinational seed companies to its seed market. Zimbabwe created investment incentives and allowed several multinational seed companies to enter its seed industry in the 1980s. The Zambian seed industry was globalized in the early 1980s with the formation of the Zambia Seed Company in which Svalof AB (Sweden) took an equity position and provided the management. The Malawian seed industry was also globalized in the early 1980s with the formation of the National Seed Company of Malawi in which the Commonwealth Development Corporation (United Kingdom) became the management shareholder.

The third objective is to examine the impact of structural adjustment programs on the performance of seed industries in South Africa, Zimbabwe, Zambia, and Malawi since the early 1980s. The analysis in Chapter 5 reveals that South Africa developed and implemented its own "home-grown" structural adjustment program in the 1980s, while the World Bank, IMF and various bilateral donors have underwritten structural adjustment programs in Zimbabwe, Zambia and Malawi during the 1980s.

At the advent of structural adjustment programs in Southern Africa in 1980, the seed industry was in the emergence stage in Zambia and Malawi, the early growth stage in Zimbabwe, and the late growth stage in South Africa. South Africa's market-based economic reforms starting in 1983 have had a major impact on the seed industry. Seed companies have increased the use of brand names, advertising, trademarks and logos, packaging, field demonstrations, personal selling and after-sales services to signal the quality of their seed to farmers and capture market shares. In addition, private seed companies have formed acquisitions, mergers and partnerships with global seed companies to reduce duplication of research effort and overlapping infrastructure, gain access to cutting-edge technology in advanced countries, and create competitive advantages for competing in global markets. In 1992 the government reorganized its public research system by creating the Agricultural Research Council (ARC), a semi-autonomous organization, in order to reduce the political uncertainty that future governments might not commit adequate long-term investments in agricultural research for the benefit of commercial farmers. The ARC has entered into contractual agreements with private seed companies and it is collecting royalties on its elite germplasm and inbreds.

Although the South African National Seed Organization (SANSOR) was only established in 1988, it is already proving to be an important organization by providing efficient seed certification and testing, training and licensing of seed inspectors, technologists, and salespersons and cross-licensing of elite germplasm and collection of royalties. Private companies are promoting market signaling by the use of brand names, advertising, logos, field demonstrations and personal selling and farmers' needs for genetic improvements in maize are more reliably served. The challenge now facing the seed industry is to develop, produce, condition and market hybrid and varietal seed that meet the specific needs of smallholders in marginal areas consistent with the ANC's political mandate to serve the

majority of the farmers. The area planted to certified seed by smallholders increased from 20 to 50 percent from 1980 to 1993 while the average yield of smallholders increased by 25 percent during the same period.

In Zimbabwe, Pannar, Pioneer Hi-Bred International, and Cargill entered the seed industry at various times in the 1980s and restricted their activities to breeding and varietal testing. However, when structural adjustment policies were introduced in 1990, each of the three companies expanded investments in maize breeding programs, seed production, and distribution. These companies are currently using brand names, trademarks, advertising, and field demonstrations to signal the characteristics, and quality of their seed to farmers. However, even though private investments in research stations, seed farms, conditioning and marketing facilities and proprietary germplasm are rapidly expanding, private companies have not convinced the government they have the capacity to sustain breeding programs. Because the real budget of Zimbabwe's public maize research program declined by 25 percent from 1980 to 1990, the government is offering its new inbreds to all companies on a royalty basis in order to generate revenue for supplementing its maize research.

The Seed Certification Association set up by the Zimbabwe Seed Trade Association is emerging as a new institutional arrangement for reducing the organizational and coordination costs of seed certification and the training of seed technologists. The future development of the seed industry will be shaped by the way the government implements the licensing of publicly-developed elite germplasm, variety trials, restrictions on varieties and hybrids that may be sold, compulsory seed certification, the requirement that samples of all parent lines be deposited with the Seed Services, seed import and export procedures, and Plant Breeders' Rights. Because of the reduction of information asymmetry of seed quality, the proportion of the maize area planted to hybrids increased from 70 to 100 percent from 1980 to 1993. The

average commercial yield increased by 33 percent while the average smallholder yield increased by 57 percent over the same time period.

In Zambia, structural adjustment programs led to the removal of some of the restrictions on private seed companies and as a result, three multinationals, Pannar, Cargill and Carnia, entered the seed industry. However, Pioneer entered the seed market in 1991 but withdrew in 1993 because the government introduced compulsory certification requiring private seed companies to deposit samples of their parent materials with the Seed Control and Certification Institute (SCCI) even though Zambia did not have Plant Breeders' Rights legislation in place. The three remaining companies have introduced proprietary hybrids that they developed in South Africa and Zimbabwe and investing in production, conditioning and marketing facilities. The entry of multinational seed companies into Zambia has generated price and service competition which has compelled the market leader, ZamSeed, to introduce a mix of brand names, logos, advertising, field demonstrations, and services to signal the characteristics and quality of its seed to farmers. Because of the reduction of information asymmetry, the area planted to certified seed jumped from less than 30 to 74 percent from 1980 to 1993 and the average yield doubled on both commercial and smallholder farms. Because of the pressure on Zambia's public research budget, the government is offering new inbreds to private companies on a royalty basis in order to generate revenue for maize research.

The Seed Liaison Committee set up by private seed companies to take over seed certification and testing from the government is emerging as an important institutional innovation that has a potential of reducing the cost of organizing seed certification and the training of seed technologists. The future development of the seed industry will be shaped by numerous factors, including the way the government manages variety trials, restrictions on varieties and hybrids that may be sold, compulsory seed certification, the requirement that

samples of all parent lines be deposited with the SCCI, seed import and export procedures, and Plant Breeders' Rights. The profitability of the seed industry was erratic in the early 1980s but improved slightly in the late 1980s because of the large growth in hybrid seed sales of the MM500 and MM600 series.

The structural adjustment program in Malawi has helped lift the restrictions on private seed companies. As a result, Cargill entered the seed industry in 1989 by acquiring 55 percent of the equity of the government-owned National Seed Company of Malawi. Lever Brothers entered the market in 1991. Both companies are currently competing for market shares on the basis of seed quality, prices, and services which are reducing the transaction costs of purchasing seed by farmers. Because of the reduction of information asymmetry about seed quality and adverse selection, farmers have been more reliably served with seed of known quality. Between 1980 and 1993, the area planted to certified seed increased from 4 to 25 percent and the national average yield increased by 43 percent. To summarize, this analysis of the impact of these structural adjustment programs on the seed industry reveals that the industry is going through a transition involving the privatization of maize breeding, seed certification and testing, the use of royalties to finance public breeding programs, globalization and the restructuring of seed firms through mergers, acquisitions, and strategic alliances. Since 1980, the Malawian seed industry has moved from emergence to the early growth stage, while the Zambian seed industry has moved from emergence to the middle growth phase, the Zimbabwean seed industry from early growth to the mature phase, and the South African seed industry from late growth to the mature phase.

6.3 General Conclusions

Four main conclusions follow from this study. The first conclusion is that the development of the seed industry follows a life cycle pattern of development. Table 6.1 summarizes the

experience of 12 countries in developing a specialized seed industry. The table reveals that the transition from stage to stage is dependent on a number of important market signaling, technological, organizational and institutional innovations that were introduced at each stage of the life cycle to hold down transaction costs. These innovations induced public and private investments in the seed industry and facilitated the mass diffusion of improved varieties and hybrids. For example, the public sector dominated all the value-adding activities of the seed industry during the early stages of the life cycle. However, the private sector gradually assumed increasing responsibility for maize breeding, seed production, conditioning, marketing and certification. The declining role of public breeding and certification programs and increasing role of private investments are driven by new technologies and institutional innovations that provide protection against contractual hazards. In the mature phase of the life cycle, the public sector continues to dominate basic research, population improvement, monitoring of seed quality and certification for exports, phytosanitary inspection, and the preservation of germplasm. Because the seed industries in the region are at different stages of the life cycle, there are opportunities for countries with seed industries at the early phase to learn from countries at more advanced stages of the life cycle.

Second, the government is instrumental in crafting and enforcing seed laws and regulations because it is ultimately the state that determines when standards are broken and whether penalties should be imposed on violators. Because seed laws need to have political legitimacy, the crafting of institutional arrangements that coopt the interest groups of farmers and the seed trade in policy formulation helps provide the credible commitment necessary for the development of low transaction cost seed markets. Since laws and regulations are introduced in an accretionary manner, they become more embracing as technology becomes more complex, the sophistication of farmers increases, and the seed industry is privatized over time.

Table 6.1: Case Study Results: Market Signaling, Technological, Organizational and Institutional Innovations Introduced During the Life Cycle of the Seed Industry[1]

		STAGE OF LIFE CYCLE		
Innovation	Farmer seed exchange	Emergence	Growth	Maturity
Market Signaling	Little information on seed quality	Government seed certification label	Brand names	Logos, Trademarks, Packaging, Advertising, Field demonstrations, Personal selling, Agronomic advice
Technological innovations	Simple mass selection	Scientific maize breeding. Public investments in experiment stations, extension, universities, official seed testing laboratories, scientists, seed inspectors, technologists, extension agents, and market infrastructure. Private investments in seed farms, processing and marketing facilities	Complex seed production and process technologies. Private investments in scientific management, specialized laboratories, product commercialization, and marketing facilities	Knowledge-intensive technologies. Private investments in specialized in central breeding stations and satellite adaptive research locations, seed production and enhancement processes, biotechnologies, and information and computer technologies
Organizational innovations	Agricultural societies, seed associations	Department of Agriculture, Plant Breeding Institutes, Official seed certification agencies	Research Institutes, Seed Services, Family-owned seed businesses, Corporations, Seed growers, Seed dealers and retailers	Public-private research consortia, Public-private seed certification agencies, Joint ventures, Mergers, and Strategic alliances
Institutional innovations	Informal habits and practices surrounding seed exchange	Government legislative, administrative, and judicial structures, Public breeding procedures and seed certification procedures, Licensing of seed traders, Phytosanitary and quarantine laws, Trade secrets law	Private breeding standard operating procedures, Plant Breeders' Rights, Seed industry investment law	Private seed certification procedures, Trademark law, Plant Utility Patents law

[1] The 12 case study countries are the United States, France, Mexico, Brazil, India, Thailand, Kenya, Tanzania, South Africa, Zimbabwe, Zambia, and Malawi. Tanzania is in the emergence stage. Mexico, Brazil, India, Kenya, Zambia, and Malawi are in the growth stage. The United States, France, Thailand, South Africa and Zimbabwe are in the maturity stage.

Third, the development of the seed industry is an evolutionary learning-by-doing process of piecing together a set of interactive and mutually supporting institutions in a path dependent way that holds down transaction and production costs and infuses trading confidence in commercial seed transactions. This interlocking set of institutions includes seed quality standards, codes of conduct and regulations that are embodied in legally enforceable seed laws. Assurances from the legal system induced seed firms to commit investments to supply adapted varietal and hybrid seed of known and guaranteed quality to farmers. The study also shows that legal institutions are needed to provide safeguards for private investments in research, seed production and marketing facilities, brand names and proprietary germplasm. These safeguards enable investors in the seed industry to recoup their research expenses and earn competitive profits.

The fourth conclusion is that although the ultimate effects of the structural adjustment programs on the seed industry in Southern Africa are unknown at this time, the results to date are positive and encouraging. Structural adjustment programs have encouraged multinational seed companies to enter the seed markets of Zimbabwe, Zambia, and Malawi. In response to growing competition, domestic seed companies in each of the four country studies (Sensako in South Africa, the Seed Co-op in Zimbabwe, ZamSeed in Zambia, and NSC in Malawi) have responded by forming strategic alliances to pool germplasm resources, breeding programs, seed production and marketing capabilities. As a result, the leading seed companies in each of the four countries are now engaged in maize breeding and the production and marketing of seed for the regional market of Southern Africa.

6.4 Policy Implications

Several policy implications can be drawn from the results of this study. The implications apply to national governments in Southern Africa, private seed companies, regional

organizations, the International Maize and Wheat Research Center (CIMMYT), and international donors.

6.4.1 Implications for National Governments

The results of this study indicate that the seed industry progresses through different stages of a life cycle through an incremental and path dependent learning process for governments, agribusiness firms, and farmers. This process implies that government policies for improving the performance of the seed industry must be tailored to the life cycle of the seed industry on a country by country basis. This requires country specific research to guide policy makers.

The seed industry in South Africa is now in the mature stage of the life cycle. At this advanced stage of development, there are four roles for the government:

1. The government should continue breeding population improvement programs, breeding and development of varietal crops with low margins, and the enforcement of Plant Breeders' Rights and develop open-pollinated varieties and hybrids for smallholders in agroecologies that are not served by private seed companies;
2. Carrying out variety trials to determine the performance of showcase varieties and hybrids under different agronomic and climatic conditions for inclusion in the Official Variety List and providing unbiased estimates of the performance of different seed products and seed companies;
3. Monitoring and policing seed laws and regulations to ensure that private seed certification and competition serve as effective yardsticks for maintaining field and laboratory seed standards for certified seed; and
4. Certifying seed exports for international trade and issuing phytosanitary permits for seed imports because these activities are characterized by high

exclusion costs and the ISTA and OECD regulations governing international seed trade do not permit private seed certification.

The Zimbabwean seed industry is entering the mature stage of development. There are six roles for the government:

1. Establishing an Official Variety List, uniform procedures for variety evaluation and release and third party facilities for testing the performance of showcase varieties and hybrids under different agronomic and climatic conditions;
2. Upgrading the extension service to provide impartial information to farmers on the relative performance of both public and private varieties and hybrids;
3. Developing elite germplasm for the low-potential regions of the country which are unattractive to commercial seed companies, breeding and developing varietal crops, and enforcing Plant Breeders' Rights according to the UPOV system in order to provide credible security for proprietary germplasm;
4. Phasing out the Tripartite Agreement while devising alternative mechanisms to ensure that private seed companies maintain seed reserves;
5. Promote the development of domestic seed companies by providing access to government-generated elite germplasm, production technology, marketing, and equity finance in order to provide alternatives if multinationals withdraw from the Zimbabwean seed industry; and
6. Strengthening phytosanitary enforcement to prevent the introduction and spread of plant diseases which is becoming more important with the expansion of international seed trade.

The Zambian seed industry is at the middle of the growth phase. At this stage of development, there are seven activities for the government:

1. Developing laws and standard operating procedures to ensure seed quality by licensing seed sellers and testing seed samples to ensure that they meet acceptable purity and germination standards;
2. Establishing an Official Variety List based on results and independent facilities for testing public and private varieties and hybrids for inclusion in the List;
3. Strengthening the capacity of the extension services to disseminate the results of trials of both public and private varieties and hybrids to farmers;
4. Focusing the government breeding program on the breeding, development and production of seed of low margin varietal crops instead of competing with private breeding programs;
5. Introducing and enforcing a Plant breeders' Rights law based on the UPOV system;
6. Promoting the entry of indigenous seed companies into the seed industry by granting them access to government-generated elite germplasm, production technology, and equity financing in order to foster competition and provide alternatives if multinationals withdraw from the seed industry; and
7. Establishing facilities and procedures for the enforcement of phytosanitary regulations.

The Malawian seed industry is entering the early growth phase. At this stage of development, the government should concentrate on seven activities:

1. Incorporating field and laboratory standards for certified seed in workable laws and enforcing the law through the licensing of seed merchants and testing seed samples to ensure that farmers are offered seed that corresponds to purity and germination standards specified by law;

2. Modifying the restricted varietal registration procedures and allow both private and government breeders to present the results of variety trials before the Variety Release Committee and establishing facilities and standard operating procedures for independent third party testing of showcase cultivars;
3. Upgrade extension service to provide farmers with unbiased estimates of the performance of both public and private varieties and hybrids;
4. Introducing a workable Plant Breeders' Rights law based on the UPOV system to promote private investments in superior germplasm;
5. Promoting the entry of indigenous seed companies into the seed industry by expanding their access to publicly-bred elite germplasm, production technology, markets, and equity financing in order to foster competition and provide alternatives if multinationals withdraw from the seed industry;
6. Establishing procedures for transferring seed certification and testing to private companies as reputable seed companies become established and the seed industry becomes competitive that seed firms will not risk their reputation by selling bad seed; and
7. Developing and enforcing phytosanitary regulations to prevent the introduction of new diseases which is becoming more important with expanded international seed trade.

6.4.2 Implications for Private Seed Companies

The research findings indicate that there are significant opportunities for domestic and multinational seed companies to contribute to the maize seed industry in Southern Africa by breeding, producing and marketing maize hybrids. The analysis of financial statements and field interviews reveal that private seed companies are finding that smallholder seed markets

are profitable because of the widespread awareness and appreciation of hybrid seed. Several private seed companies are committing investments to the breeding, production, and marketing of maize hybrids targeted specifically at smallholders in Eastern and Southern Africa because these farmers can still recover their investment in the higher cost of hybrid seed even if they do not apply fertilizer. Even in Malawi where only 25 percent of the total maize area is planted to hybrids and annual seed sales are less than 8,000 tons, private companies are earning competitive profits.

The four countries in Southern Africa have a combined annual market size of 116 thousand metric tons of seed valued at US$ 138 million, about 10 percent of the size of the United States hybrid maize seed business. Each of the four governments is liberalizing its seed industry and encouraging private seed companies to enter the seed market. The governments are also introducing Plant Breeders' Rights based on the UPOV system and crop varietal evaluation and release, seed certification and testing based on ISTA and OECD seed standards in order to encourage private sector investments. These new policies are increasing opportunities for private companies to obtain a competitive return on their investment in the form of gross margins or royalties.

To succeed in the Southern African regional seed markets, multinational firms need to modify business strategies that are commonly used in the United States and in Europe. For example, although each of the four study countries is strengthening Plant Breeders' Rights, only South Africa has the capability to enforce them by using effective techniques such as RFLP fingerprinting techniques. Therefore seed companies are at risk of appropriation of intellectual property rights in most countries in the region. However, they can reduce risk by selling double cross and three-way hybrids rather than single cross hybrids. Also, seed companies must develop the capacity to anticipate and deal with high rates of inflation, poor infrastructure, and the uncertainty about prices, profit margins, availability of credit and seed

demand. Finally, seed companies need to limit their exposure to risks by limiting debt, operating with short-term finances, increasing average collection periods, budgeting more frequently, and diversifying into a wide portfolio of products and markets.

The case studies reveal that some government officials are still reluctant to allow private firms to enter the seed industry in Southern Africa. To overcome this resistance, private companies must commit considerable time and financial resources to establishing local breeding programs and superior varieties and hybrids and developing a loyal base of farmer customers who can pressure government scientists and civil servants to expand their access to the best material, including imported varieties and hybrids. Multinationals should give priority to hiring and training local staff and bringing in expatriates only when local staff are unavailable.

6.4.3 Implications for Regional Organizations

The research findings reveal that structural adjustment programs are encouraging private domestic and multinational investment in the seed industry which, in turn, are expanding regional seed trade and facilitating the development of a common seed market in Southern Africa. However, formidable barriers remain to be overcome. The challenge for regional organizations such as the Southern African Development Community (SADC) and the Southern African Customs Union (SACU) is to harmonize seed laws and regulations among different countries. Because varietal release, seed certification and laboratory testing procedures are increasingly based on ISTA and the OECD standards for certified seed, it is feasible to harmonize seed laws and regulations in Southern Africa. Countries in the region should work through regional organizations to harmonize variety registration trials in order to allow for the testing and registration of varieties throughout the SADC region, a practice used in the European Community. Also, regional organizations need to implement steps to

harmonize phytosanitary regulations among countries and introduce plant health passports to reduce the spread of diseases and parasites which are becoming more important with expanded intraregional seed trade. Because most countries are introducing plant variety protection based on the model of the UPOV convention, regional organizations should move towards making protection automatically valid in all countries. The reciprocal agreement between South Africa and Zimbabwe on Plant Breeders' Rights could serve as a model for reciprocal agreements among Southern African countries.

There are opportunities for countries to improve the performance of their seed industries by participating in regional programs. For example, South Africa has capabilities for training seed inspectors, analysts, and salespersons in technical aspects of seed production and crop management, legal and administrative responsibilities under seed certification, and seed marketing. Regional organizations could strengthen the training of seed certification specialists and technologists by developing a regional accreditation system for inspectors. National seed certification organizations such as SANSOR could expand seed certification programs in Botswana to other countries in the region.

Regional organizations can encourage private seed companies to join international organizations such as the International Federation of the Seed Trade (FIS) by becoming category members of national organizations such as SANSOR. Private seed companies can participate in business meetings and congresses and keep abreast of developments in the international seed industry through membership in SANSOR.

6.4.4 Implications for the International Maize and Wheat Research Center (CIMMYT)

CIMMYT is an internationally funded, nonprofit, scientific research and training organization with a headquarters in Mexico and a mandate to carry out research on the genetic improvement of maize and wheat in developing countries. CIMMYT's maize program

provides elite germplasm and international expertise without charge to public breeding programs in numerous developing countries. Without question, CIMMYT has made a significant contribution to germplasm development in advanced and developing countries. Also, CIMMYT's economics program has pioneered farming systems research in Eastern and Southern Africa and has provided valuable technical assistance to many national agricultural research systems.

South Africa currently has a mature seed industry that is effectively serving the needs of commercial farmers. However, if the government is aggressive in promoting smallholder development and support services, then it will need to step up the development of superior varieties and hybrids for smallholders. CIMMYT may be in a position to assist in breeding and developing varieties and inbred lines that private seed companies can finish, produce, and sell to smallholders. The managers of seed companies interviewed in this study reported that they would like access to CIMMYT lines with special traits such as streak resistance and drought tolerance and that they would pay royalties if CIMMYT were to offer its elite lines to seed companies on exclusive licenses.

In Zimbabwe, CIMMYT provided an infusion of elite germplasm and international expertise in the eighties when the national breeding program and the Seed Co-op had limited international linkages and CIMMYT elite inbred lines have been used by seed companies to produce hybrids that are now being sold to farmers. However, since the Seed Co-op has recently established strategic alliances with global seed companies and three multinationals have entered the Zimbabwean seed industry, there is less need for CIMMYT's international germplasm and technical expertise. CIMMYT can compete with the research-based seed companies in Zimbabwe or it can supplement their programs. Because private seed companies are already investing more than CIMMYT in maize research in Zimbabwe, CIMMYT should focus on niches that commercial breeders are ignoring and develop

germplasm with sources of resistance to streak virus, stalk borer, drought and low fertility tolerance that can be exploited by private breeders. Also, CIMMYT can assist national governments to set up Official Variety Lists and providing third party testing facilities for evaluating the performance of showcase hybrids under different agronomic and climatic conditions. This would require CIMMYT to change its strategy from working exclusively with public research programs to working with both public and private researchers. Some respondents suggested that CIMMYT needs to become market-driven and operate as a foundation seed company that spins off inbreds with beneficial traits while leaving the commercialization to other companies.

In Zambia, although CIMMYT has historically contributed to the breeding of open-pollinated varieties, it was hesitant to promote hybrids in the 1970s. As a result, Zambia sought the assistance of the Yugoslav Maize Research Institute. Respondents indicated that as the private sector assumes a large role in the maize seed industry, CIMMYT will need to shift its focus to developing inbreds with traits that private companies can finish into seed products. Some respondents suggested that CIMMYT can help governments set up independent variety testing facilities, train seed inspectors, technologists, and certification specialists and develop a regional accreditation system for inspectors and analysts.

In Malawi CIMMYT has made substantial contributions to the breeding of both open-pollinated varieties and hybrids. The Malawian hybrid maize breeding program was based on the Zimbabwe's SR52 inbred lines which produce soft dents. CIMMYT introduced flint germplasm into the national breeding program for crossing it with dent material to improve grain hardiness and resistance to insect damage. The respondents reported that as the private breeding programs expand and become accepted as the major source for superior germplasm, the role of CIMMYT will decline. But the respondents stressed the need for CIMMYT to make available inbreds and expertise to private seed companies, particularly start-ups. Some

respondents suggested that CIMMYT and other NGOs could play an important role in the breeding, development, and production of seed of varietal crops because they are not commercially attractive for seed companies.

6.4.5 Implications for International Donors

There are more examples of failed foreign aid-financed seed projects than successes in Africa. The reasons for failure have included a penchant to send seed equipment to Africa and Africans to overseas seed courses instead of helping African nations develop the fundamental political, technical and legal foundations for a specialized seed industry. An important lesson that flows from this study is the need for donors to examine the political, social and legal environment when determining the level and pattern of support for the seed industry on a country by country basis. Unless there is government supervision and enforcement of rules through a legal system enshrined in a political system which will back up the rules, donor support to fill some missing components of the seed industry such as seed cleaning equipment will be unproductive.

Since varietal crops such as wheat, millets, cowpeas, and groundnuts can be reproduce themselves with little genetic variation, it is not profitable for private seed companies to invest in the breeding, production, and marketing of seed of varietal crops because farmers do not have to purchase new seed every year to maintain genetic purity and achieve potential yields. By contrast, this study has focused on maize which is easily hybridized and provides significant opportunities for private seed companies to enter the seed industry, add value to hybrid maize seed through heterosis breeding and seed enhancement, protect the value by keeping secret the parent lines required to produce the hybrid, and recover the value in the form of gross margins or royalties.

The major implication of this study for international donors is the need to develop country specific institutional strategies to assist in seed industry development based on a careful diagnostic assessments rather than developing a standard seed industry model for all of Africa. Donors first need to identify the type of the seed crop and the stage of the life cycle of the seed industry in a particular country. The next step is to tailor interventions to the specific phase of the life cycle. In countries with mature seed industries, donor assistance will not normally be required because the private sector has assumed responsibility for plant breeding, variety development, foundation seed production, multiplication, conditioning, certification, laboratory testing and marketing. Therefore donors need to focus on countries in the farmer to farmer exchange of seed, emergence and growth phases of the seed industry. Donors can assist by promoting experimentation with new types of public and private institutional arrangements for supporting seed industry development.

6.5 Suggestions for Further Research

The results of this study suggests that microlevel studies are needed to identify parties involved in assembling and modifying particular institutions such as politicians, bureaucrats, and interest groups, political structures in which they bargain, what is exchanged, how performance is measured, time horizons involved, and the distribution of benefits and losses. For example, microstudies are required to identify the impact of proposed changes in seed legislation in Zimbabwe, Zambia and Malawi and generate insights into how to move from a government-controlled to a competitively organized seed industry serving a dualistic agricultural sector while protecting unsophisticated farmers and seed firms against contractual hazards.

Research is also required to develop methods for measuring the impact of alternative technological and institutional innovations in the seed industry on the rate of economic

progress and identify which innovations are imitable and, of these, which are worth imitating. One of the potential difficulties with measuring the impact of technological and institutional innovation on the rate of economic progress such as yield improvement is that there are many changes taking place at the same time and there is a lack of objective measures of institutional changes to include in a regression model. Time series historical decomposition statistical techniques can overcome some of these problems by decomposing a yield series into a permanent or random walk component and a temporary or transitory component and the using dummy variables to estimate the effect of institutional changes on the path of the permanent component.

At the macrolevel more attention needs to be paid to the kind of political and legal institutions and organizations that provide incentives for rapid learning in the seed industry during different stages of the life cycle. Research is needed on how administrative agencies, government departments, research institutes, and regulatory systems function at different stages of the seed industry life cycle and the interaction between political and institutional change over time.

Finally, although this study has identified some promising benefits from structural adjustment programs, one cannot generalize from this study to the impact of structural adjustment on other components of input delivery systems such as fertilizer. Similar institutional studies are urgently needed on the impact of structural adjustment programs on fertilizer, pesticides, credit and other input delivery systems.

6.6 Conclusion

This study has developed a transaction cost and market signaling life cycle model of seed industry to generate hypotheses that guide ongoing efforts to rebuild seed industries and agricultural input delivery systems in Sub-Saharan Africa. The study provided evidence that

seed industry development is an evolutionary learning-by-doing process of fitting together a set of interactive and mutually supporting institutions in a path dependent way that hold down transaction and production costs and infuse trading confidence in seed transactions. Since the seed industry is at different stages of the life cycle in different countries in Southern Africa, there are opportunities for countries at an early stage to learn from countries at a more advanced stage.

The findings of the study reveal that although the ultimate effects of the structural adjustment programs on the seed industry in Southern Africa are unknown at this time, the results to date are positive and encouraging. The leading seed companies in each of the four study countries have formed strategic alliances with domestic and international partners and are now engaged in maize breeding and the production and marketing of seed for the regional market of Southern Africa. However, there are country-specific legal and regulatory hurdles that need to be overcome if structural adjustment programs are to achieve their full potential in improving the economic performance of the seed industry.

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