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Lin Sun

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Joseph D. Straubhaar
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DIVERSIFIED FINANCING AND TELECOMMUNICATIONS DEVELOPMENT IN CHINA: ITS IMPLICATIONS IN COMPETITION, DEMAND, AND TECHNOLOGY

By

Lin Sun

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ABSTRACT

DIVERSIFIED FINANCING AND TELECOMMUNICATIONS DEVELOPMENT IN CHINA: ITS IMPLICATIONS IN COMPETITION, DEMAND, AND TECHNOLOGY

By

Lin Sun

Telecommunications is a capital-intensive and technology-driven industry. Capital and technology are also the most critical obstacles to industry growth in developing countries. Underinvestment delays the development of the communications infrastructure and undermines the potential benefits of telecommunications services.

The dissertation uses China as a case study to examine the effects of diversified financing on industry growth. Four relationships are investigated: financing and growth; financing and competition; financing and demand; and financing and technology transfer. Strong correlations were resulted between financing and growth index variables: revenue, switching capacity, and number of telephone sets.

The study also found that diversified financing has not only effectively alleviated investment constraints, but also created new market dynamics, including decentralization in

production and technology transfer, by encouraging sector competition, stimulating demand, and accelerating technological advancements. The study concluded that diversified financing made significant contributions to the growth of Chinese telecommunications during the 1980s and will likely continue as an effective investment alternative.

China's experience also provides a unique perspective for research on industry financing in developing countries, as many are suffering from severe investment constraints. Finally, by constructing two forecasting models, the study concluded that diversified financing is essential for sustained growth of China's telecommunications in the 1990s.

To Mother,

for her love and spirit,
for ever.

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Mr. Hao Weimin and Mr. Liu Shen, both with the Directorate General of Telecommunications (DGT), spent many hours with me discussing policy issues and future prospects, many of them became the foundation for the research hypotheses and analyses. Ms. Ji Shuqin and other colleagues at World Telecommunications magazine provided voluminous data for the statistical tests and forecasting models. Without their help, this study would have been impaired in theoretical and methodological validity.

The research on telecommunications financing and development has opened a new horizon in my life rather than an end. I will never forget those who have helped me during my study at Michigan State. Now I can leave the hard times behind and move forward to take new challenges that should be more exciting and rewarding.

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CHAPTER 1

INTRODUCTION

Systematic research on telecommunications in developing countries began in the late 1960s, and it soon showed great importance and urgency. Since the 1970s, two concurrent movements have emerged in some developing countries, especially in Southeast Asia and Latin America. First, newly industrialized countries (NICs) have achieved substantial economic and social developments, thus changing the geopolitical dichotomy of international trade and commerce. Second, technology has become a fundamental force for change, altering the international technology market from one-way exploitation to active seeking and infrastructure development. Although stagnation is not uncommon in many parts of the world, more countries realize that telecommunications not only improves social integrity and domestic productivity, but also facilitates participation in international communication in a more

competitive and open global marketplace.[1]

These emerging trends are gradually but steadily changing the landscape of telecommunications in the world. The principles and practices established during the colonial era are quickly becoming obsolete, and new perspectives and policies must be sought. The more cooperative and interdependent telecommunications market provides new opportunities for growth. The changing markets provide new opportunities for developing countries to acquire technical expertise, advanced products, and investment, while they have much to offer, such as inexpensive labor, resources, and desirable consumers. Some are even becoming aggressive competitors of advanced countries in many technological and service arenas.

The changing environment also challenges the research community. New perspectives and methods need to be developed and applied, such as the roles of telephony in economic development and social change; relationships between telecommunications and other economic sectors; demand and pricing for public good; industry financing; technology transfer and management. Research on

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[1] The term "developing countries" is often used loosely to include many countries that are very different in a wide political and economic spectrum. To avoid gross generalization, this study makes distinction of "developing countries" between "less developed countries" and "newly industrialized countries" (NICs). The distinction is essentially based on the economic development levels, not political ideology or social systems.

telecommunications in developing countries has exhibited more difficulties and ambiguities than that in developed countries, for the industry's complex dimensions and dynamic functions compounded with limited understanding of the country in question. Generalization often fails to provide accurate insights and viable guidance since each country is unique in its own context, development and policy. Nonetheless, the increasing magnitude of research strongly contends that telecommunications in developing countries must be studied thoroughly so that it contributes to the world telecommunications development.[2]

The People's Republic of China (China hereafter) presents an interesting case in this rapidly changing context.

(1) Telecommunications development is a formidable undertaking in China, a country with a huge population and tremendous demand for communication.) There are about 75 percent of 1.1 billion people living in the vast rural areas, whereas cities and coastal regions consuming more than 70 percent of telecommunications services. The breadth of providing telecommunications services far exceeds any other developing country. In spite of these incredible

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[2] Pitroda (1976) provides a comprehensive overview on telecommunications in developing countries, including regional distribution of telephone growth, demand, organization, policy and technological status, although some of his conclusions may be outdated by the rapid growth in recent years.

difficulties, China seems firmly committed to the goal that by 2000, its telecommunications capability and business volume will have grown by threefold from 1980.[3] Needless to say, the goal entails many difficulties, but is not impossible. To win the campaign, industry financing must be thoroughly addressed and viable solutions sought.

2) China has recognized that telecommunications is a fundamental driving force for its ambitious economic goals. Telecommunications is a top government priority and exhibited strong growth during the 1980s, especially in production, switching and transmission capacity, telephone sets, and basic services, despite a still small base in absolute terms. The government commitment to telecommunications development and mobilizing the market to increase financing has been pivotal for continuing growth; It has also encouraged competition and stimulated demand. These consequences must be studied in the context of policy making to maximize industry growth and its economic contribution.

3) Telecommunications must be bolstered by advanced technologies. China has successfully made technology transfer a leverage to develop its own infrastructure, instead of becoming an exploited market for foreign products, as witnessed in some developing countries.

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[3] In a recent article, Yang Taifang, the Minister of Posts & Telecommunications, expresses strong confidence in achieving the goal by 2000 (Yang, 1991).

Technology transfer in China is also executed as an investment source and acquisition of technical expertise and management. The impacts of communications technologies are becoming more important for growth as new standards and applications have accelerated since the 1980s.

Finally, changes in China's telecommunications industry do not seem to embrace deregulation or privatization, despite the fact that it has become increasingly popular in some developing countries, particularly the NICs. Although deregulation/privatization can be an effective means for increasing investment and competitiveness, the China experience indicates there are other alternatives to achieving this objective. For countries like China where the economic development is very uneven and territorial autonomy is traditionally strong, a state monopoly can coexist with competition especially at local levels. This, however, does not suggest that a central regime is efficient or tenacious; changes are inevitable, but the speed and extent may be much more gradual, depending on the economic development, political reform and influence by the international telecommunications community.

From these perspectives, financing has been identified as the most critical factor for telecommunications growth in China. This dissertation studies the forms of financing and how they affect other variables such as competition, demand and technological change. Central government financing is

no longer capable of accommodating the growth rate and increasing demand, and centralized industry administration has become less effective in controlling local authorities and markets. Diversified financing emerged in the 1980s with great promises in relieving investment constraints by providing multiple sources; its potential and implications in economic and social development are yet to be fully understood. Diversified financing has fostered decentralization by allowing greater local autonomy in production, technology and service. Diversified financing has not only increased investment scale, but also brought about new market dynamics such as competition and technological change. The changing market, in turn, has also reinforced diversified financing.

It is hoped that this study will contribute to the understanding of telecommunications industry in China: the internal mechanisms of a relatively unknown market, industry structure and policies, and the relationships of key variables that have exerted significant and far-reaching impacts on the industry and its future course. Last but not least, since there are similar issues and problems in other developing countries, a study on the policy and practice of diversified financing in China can provide valuable insights in seeking investment alternatives. It is hoped that one country's experience can become an asset for others in their struggle to develop the telecommunications infrastructure.

CHAPTER 2

A REVIEW OF RESEARCH LITERATURE

Large-scale research on telecommunications in developing countries was initiated by the International Telecommunication Union (ITU) in the 1960s, an era of many former colonies seeking independence from Western countries. The Specialized Autonomous Group No.5 (GAS-5), set up within the CCITT, an executive branch of the ITU, conducted a series of macroeconomic studies on telecommunications. The GAS-5 studies established the basic research paradigm for telecommunications in developing countries that has continued till today (ITU, 1986).

The research has quickly expanded since the 1980s. By one account, more than 1,100 studies were reported by the late 1980s (Hudson, 1988). The approaches have also diversified, including correlation analysis, input/output analysis, urban planning models, and cost-benefit analysis (Wellenius, 1984a). While most studies focus on the economic aspects of telecommunications, other related disciplines have also been explored, such as communication and development (Schramm, 1964; Rogers, 1982), political

economy (Jayaweera, 1986), sociology (Cherry, 1977), policy and planning (Cleevely & Walsham, 1980), and technology acquisition and utilization (Schweitzer, 1972; Stover, 1984; Goulet, 1989; Pool, 1990). To make the voluminous literature pertinent to the current subject, this chapter intends to review the following content: roles of telecommunications; investment; demand; and finally technology transfer in developing countries.

2.1 Roles of Telecommunications

The roles of telecommunications are often undermined by the industry's status quo in many developing countries. And as testified by many researchers, the situation has barely been improved. The Missing Link (the Maitland Report), the first comprehensive survey of telecommunications in developing countries, shows that most countries suffer from poor telephone service, lack of access, and unequal distribution between urban and rural users (ITU, 1984).[4] According to the Report, by the early 1980s, nearly 75 percent of the world's population had a telephone density of 10 or fewer for every 100 people; more than half the world population had a density of one per 100 people, as in

[4] According to the principal author of the Maitland Report, Donald Maitland (1986), the status of telecommunications in many developing countries has not improved significantly and should be given more attention by the international community.

contrast to about 50 percent penetration in developed countries (ITU, 1984).[5]

The devastating consequence of poor telecommunications systems is the low contribution to the economic development. A positive relationship between the two has been confirmed in numerous studies.

One common approach is to correlate telephone density to the gross national product (GNP) or the gross domestic product (GDP) per capita.[6] Hardy (1980) in his cross-sectional (37 developing countries and 15 developed countries), time-series (1960-73) study, used GDP per capita as aggregate index of economic development and telephones per 100 people. A strong correlation is found between the two variables in both developing and developed countries, which confirms the findings in the GAS-5 studies. More significantly, the Hardy study found the correlation in selected developing countries is stronger than that in

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[5] It should be reminded that aggregate statistics do not provide sufficient information on change in individual countries, which, in many cases, represent the primary telecommunications market in a particular region. Furthermore, telecommunications has been one of the fastest growing industries in many developing countries in recent years; historical aggregate statistics, therefore, should be read as a "time snapshot" rather than a reference to the present situation.

[6] The GDP excludes revenue from goods produced and exchanged outside the domestic market, which usually accounts for a small fraction in most developing countries, thus GNP and GDP are often used interchangeably as an index to national wealth in developing countries.

developed countries, which seems to suggest that the lower a country's level of economic development, the greater the potential contribution of its telecommunications. Another interesting finding is that in developing countries, residential telephones seem to contribute more to economic development, as compared to business telephones. These conclusions are important because they first systematically explicated that telecommunications has much greater roles in promoting a country's economic development, rather than a mere outcome of the latter.

Later studies have confirmed the correlation established in the Hardy study, indicating strong economic and social benefits in developing countries.[7] A study on telephone use in India (Kaul, 1981) found the benefits telephone in rural India exceeds the cost of using it by the scale of ten or higher to one. An ITU-OECD case study on the Philippines found the benefits as 44 times higher than the cost to the user (Communications Studies and Planning International Ltd., 1986). Telephone is pervasively used for emergency calls, communication with other people and for business. The study also found the regions where telephone service is profitable (better use) have more modern agriculture. Another case study on telecommunications and

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[7] For other cross-sectional and case studies on the roles of telecommunications in developing countries, see reviews in Jussawalla & Lamberton (1982); Hudson, et al. (1983); Hudson, 1984; Pierce & Jéquier (1983); Saunders, et al., Parts II and III (1983); and ITU (1986).

economic development in Egypt (Kamal, 1981) found that telephone renders multiple benefits including money savings between using telephone and other means of communication; time savings in travel and meetings; and indirect benefits such as emergency services. The benefits usually increase when communication takes place over long distances.

/The economic and social benefits seem to increase significantly when new telecommunications technologies are adopted./ In India, Brazil and rural Alaska where population is scattered across vast areas, satellites have become effective communication vehicles for information, education, entertainment, as well as government participation and business activities (Hudson, 1983; 1990). These studies strongly indicate that government commitment to implementing new technologies and acquiring technical expertise to use and maintain the system are the critical institutional factor for success. The studies also show new technologies, when properly applied, reinforce social integration, encourage new applications, and promote national economy.

Benefits as cost savings are also confirmed by research on China. A study by the Ministry of Posts & Telecommunications (MPT), for example, found 75 percent of business travel can be replaced by ~~long-distance calls;~~ and 92 percent of intra-city transport can be substituted by telephone communications. More important, the study found that telecommunications would yield higher returns if

investment could achieve an optimal scale of 2.6 percent of the total national investment, which is twice as high as the current level (MPT, 1988). Another cost-benefit study conducted recently in China found that about 35 percent of transportation can be replaced by communications means; thus savings in transportation can be as 13 times more than that cost in telecommunications (China Science & Technology Association, 1991).

Although high correlations between telecommunications and economy have been widely confirmed, two apparent deficiencies should be noted.

First, the conclusion that telecommunications is the cause of economic development cannot be readily justified in most research. Significant mutual causation was found in the Hardy study between telephony and economic development, which may be the true reflection of the reality: not only do adequate telephone systems promote economic activities, they are also affected by the latter. In addition, multicollinearity was also detected between variables (e.g., GDP per capita and energy consumption per capita) in the study (Hardy, 1980). Similar ambiguity in causal relationship is also found in other correlation studies (Hudson, et al., 1983).

At least two approaches have been proposed to remedy the ambiguity in causation. One is the use of "lag-time" intervals as first applied by Hardy. However, as warned by

Hudson et al. (1983), the result may still be spurious since time lag cannot preclude other variables at previous time (t-1) that may be the cause for the present time (t).

The second approach is non-linear analysis. Gille (1986) showed that instead of direct linear causality, three non-linear stages may be involved between telecommunications and economic growth, 1) Original development phase during which telecommunications grows faster than the economy; 2) Industrialization during which the growth of telecommunications is slower than other economic sectors such as manufacturing and energy. However, industrialization generates high demand and usage of telecommunications, which result in 3) High growth of telecommunications. Instead of drawing a direct causal relationship, Gille's study implies that telecommunications in developing countries should try to accommodate other economic sectors which, in turn, will generate revenues and thus advance communications infrastructure. Although it is a more thoughtful approach, Gille's study does not solve the complexity of causality.

The second problem in most research is the use of aggregate data as conveniently established in many studies. As criticized by Hudson et al. (1983), Pierce & Jéquier (1983) and others, aggregate data provides little information about how the category is distributed or used in different contexts, and it's almost meaningless in devising

policy.

The latter criticism is especially relevant in developing countries. For example, it is not uncommon that telephone penetration in the rural area is .1 per 100 people or lower in developing countries, whereas telephone in cities can be as high as 30 per 100 people. Since the rural population constitutes the majority in developing countries, the aggregate telephone density often fails to present the reality, causing misleading perceptions and even worse, false policies in network implementation, service and tariff. Bebee & Gilling (1976), in a cross-sectional study on 29 countries, used more specific indices such as literacy, education, health, urbanization and population growth. These "development support factors" were tested against the effects of number of telephones among literate population, business use of telephone, and number of calls per year. The study found that the use and availability of telephones has significant effects on development support factors. It also found that the former variable is dependent on the level of latter not vice versa. The Bebee-Gilling study attempts to establish a more realistic correlation than the aggregate data analysis; the results appear to carry higher validity for policy making.

Finally, many studies try to formulate some framework for measuring the benefits of telecommunications. Although in some cases the benefits can be measured in monetary

units, such as substituting travel and other means of communications; most likely, however, the benefits are deemed very high by the user in intangible terms. Such indirect and difficult to measure benefits can be addressed by externality, such as a study on Senegal by Nordlinger (1986). Nordlinger found that telephone users receive additional benefits simply by expansion of the network which likely increases the extent of communication. In fact, telecommunications externality is one of the primary considerations to justify the cost, especially in developing countries where in many cases telephone is the only means of communication. It is apparent that externality as indirect benefits accrue to the economy as a whole when most people are interconnected and services fully utilized. As suggested by Saunders, et al. (1983), indirect benefits can be measured by the highest price the user is willing to pay for the access and service, despite the fact that in many developing countries telecommunications service is heavily subsidized by governments so that the price is far below the accumulated costs.

Benefit is an important subject in studying the roles of telecommunications in economic development. Although benefits often exceed the cost of telecommunications services, they generally positively correlate investment. Conceivably, for telecommunications services to deliver greater benefits (direct and indirect), higher investment is

required, which, unfortunately, is often the reason for delay or cancellation in developing countries. One primary objective embedded in the cost-benefit studies (e.g., the GAS-5 series, the Maitland Report, and others) is to convince governments of developing countries to increase investment, so that greater benefits can be received. Such effort, however, has not been very effective due to the fact that most countries are badly strained by fund shortages and investment is usually allocated to those economic sectors that generate higher revenue quickly or accommodate basic needs in society.

2.2 Underinvestment

Telecommunications development is severely impaired by underinvestment in most developing countries. Although some developing countries have achieved an adequate investment scale, the situation in most countries has not improved significantly (Saunders, et al., 1983; Wellenius, 1984b; Hills, 1990).

According to the Maitland Report (ITU, 1984), developing countries as a whole spent only 1.8 percent of their GDP on telephones construction and services. To make significant improvement in telecommunications systems, the Report urged a substantial increase be made, or by 50 percent to about $12 billion a year. Although some have

attained a much higher investment level, for most developing countries underinvestment remains as a serious bottleneck in telecommunications growth.[8]

The financial benefits of telecommunications investment are often studied in the economies of scale. Research on highly developed telecommunications systems found that one percent increase in input can result in much higher output, and this often attributes to financial returns on investment (Saunders, et al., 1983). Interestingly, studies on developing countries have discovered much higher returns on telecommunications investment despite severe financial constraints in most countries. A study by the North-South Institute of Canada (1989) found that the typical return on capital investment in telecommunications services is between 10 and 20 percent in most developing countries. A much higher rate of 30 percent is reported by the World Bank (Wellenius, 1984b). The main reason for higher benefits is most telephone services are used by government and businesses in developing countries compared to residential use in developed countries. Wellenius, et al. (1989), for example, found that in Thailand, as high as 90 percent of

[8] A recent report shows that telecommunications investment as a share of GDP in developing countries has increased in recent years. For example, in 1986, Brazil had a share of 2.6%, Korea 2.4%, Singapore .8%, as compared to the U.S. (.5%), U.K. (.6%), and W. Germany (.8%) (UNESCO, 1989). Similar results are also found in an ITU report (Development Research Center, 1991). The investment is much higher when calculated with the total investment, which is about 25% to 30% of the country's GDP.

telephone calls are related to economic activities, as compared to about 40 percent in developed countries. Ideally, the high return from telecommunications services can be used to finance other economic sectors that usually have lower and slower returns (Saunders, et al., 1983; Wellenius, et al., 1989).

The following have been identified in research as the essential reasons for underinvestment.

1) Misconceptions. Many point out that despite great financial potential, telecommunications is a low priority in many developing countries, usually after agriculture, health, transportation and energy, for its indirect and seemingly unaccountable contribution to development (ITU, 1984; Ouko, 1987). In addition, telecommunications requires long-term investment and yields low immediate returns; many countries cannot afford such substantial capital drain with little profit in the short run. Telecommunications as a low priority indicates it is still conceived as a less important utility, although in recent years more countries are embracing the concept that telecommunications is an "advance agent" of national economy and an indispensable infrastructure for strategic competitiveness (Morgan, 1991).

2) Shortage of foreign exchange (FE). Telecommunications is a technology-driven industry, which translates to large amounts of foreign exchange for imports in developing countries. Although procurement of

telecommunications equipment takes only about .5-3 percent of FE for a country's total imports (Saunders, et al., 1983), 50 to as high as 80 percent of FE is required, compared to about 25 percent for agricultural products (North-South Institute, 1989; Hills, 1990). Cross-financing has been adopted by some developing countries as a means of raising FE for telecommunications, but many of them are dominated by agriculture, their non-essential products are sold in foreign markets at very low prices that can ill afford the intensity of FE requirements.

3) Tariff policy. Tariff is controversial in many developing countries in terms of how it is perceived and implemented. The conventional recommendation follows the marginal cost pricing principle which may be a viable policy if the volume of access is high but with serious capital constraints (Cleevely & Walsham, 1980). Others (Artle & Averous, 1973; Hudson, 1984; Hills, 1990) contend that telecommunications service is essentially a public good, the benefits of investment contribute little to individual users, but accrue to society in general; therefore its pricing should be based on the benefits or externality rather than the cost, especially in rural areas where the investment is usually higher than urban systems and profit is much less. Therefore, tariffs can be cross-subsidized or even waived to encourage access. As a result, they argue, the economic and social development may justify the

investment, even though direct returns on capital will be low.

It is worth pointing out that one of the assertions widely held in the early research (e.g., Pitroda, 1976) that few people in the Third World can afford high prices may not be accurate, as revealed by studies in the 1980s. Saunders, et al. (1983) argue tariff should be used for increasing financial viability so that higher revenues can be generated for reinvestment or financing other economic sectors. This rationale seems to be supported by the reality in most developing countries that people are willing to pay a high price to obtain access to telephone services. Strong demand with heavily subsidized tariff is one of the reasons for low revenue, thus causing diseconomies of scale in developing countries (Wellenius, 1984b).

Underinvestment presents a serious dilemma for developing countries: high financial returns cannot be attained which further aggravates reinvestment. The shortage of foreign exchange exacerbates the dilemma since telecommunications systems in most countries are dependent on Western technology and products (to be discussed later in the chapter).

The issue of underinvestment has drawn considerable attention from the research and policy making community. Recommendations on investment strategies have been abundant since 1980. A typical approach is cost-benefit analysis.

Saunders (1983), for example, proposes a three-step process to establish a sound pricing scheme: identifying demand; determining the least-cost solution; and assessing benefits on costs. However, all three steps seem very difficult to implement, one reason being that telecommunications demand in many countries is not well recorded especially in rural areas. Saunders also suggests using quality of service as an additional index for determining demand.

Telecommunications finance is mixed with promises and shortfalls. International and multilateral loans have been used pervasively for telecommunications projects, and the results are positive. For example, between the 1960s and early '80s, the World Bank provided 92 loans for telecommunications projects in 42 countries, totaling $2.6 billion (Saunders, et al., 1983). Other important funding sources include ITU through United Nations Development Program (UNDP), International Telecommunications Satellite Organization (INTELSAT), international and regional banks and consortia (North-South Institute, 1989). However, the scale of international lending has not increased since the 1980s. For instance, it has been the World Bank's policy that its loans are provided on the basis that only after other financial and technical assistance are exhausted (Saunders, et al., 1983).

In fact, the World Bank has deemphasized its involvement in telecommunications funding, from about five

percent in the 1970s to less than one percent by the mid-1980s (Goldschmidt, 1984). Amid concerns are political stability, management styles and debt repaying ability of developing countries (Williamson, 1987). The World Bank has provided some loans to telecommunications projects in China, but the scale is low. By comparison, bilateral credits and loans have increased in favor over international lending, but they are contingent on political conditions and profit potentials in recipient countries and tend to create technology dependency in standards, products, and training. In fact, statistics indicate that the primary financing in developing countries is still internal sources (Hills, 1990).

Strategies on self-financing have been debated as alternative solutions in developing countries. Bande (1986), Lerner (1987a) and case studies in Wellenius, et al. (1989) point to privatization of developing country PTTs as a means of generating higher investment and attracting foreign investors. The economic benefits of deregulation in the U.S. and other developed countries are often cited as successful models. The trend of deregulation is growing as an increasing number of developing countries have liberalized their domestic telecommunications market. As a result of a competitive market, production and services have increased, prices have stabilized, and demand is better served. However, deregulation is not without potential

risks, such as system integrity and information security, as well as optimal use of national resources and maximizing benefits, that are of particular concerns for developing countries. Saunders (1983) points out that a government monopoly operating in excess demand can expand services quickly and generate high financial surplus. The negative aspect, however, is the inefficiency in operating such large-scale networks. Parker (1985) believes that institutional/structural change can stimulate some form of investment without dismantling PTT monopoly, such as mixed government and public financing. Nonetheless, telecommunications deregulation is likely to have "ripple effects" as its promises of economic benefits are accepted by more developing countries.

Innovative or incentive financing can be an effective source of internal funding. de Got (1987) proposes using foreign trade to finance telecommunications. Foreign trade is a lucrative economic sector in some developing countries, where skilled labor and inexpensive material are available; however, allocation of foreign exchange has to compete with other economic sectors, such as manufacturing, energy and transportation. Other alternatives include subscriber financing. Gellerman (1986) reports successful experiments of subscriber financing in Japan and Brazil. Since the 1950s, Japan's NTT has been issuing subscriber bonds. By the end of 1960s, its funding increased substantially

compared to direct investment from NTT. In Brazil, on the other hand, every new telephone subscriber is required to buy shares of telephone company stocks, providing almost half of the total investment.

Since telecommunications in most developing countries is a government monopoly, research on investment usually concentrates on the central source and overlooks contribution from local sources. In fact, although many projects are PTT initiatives, significant amounts of funding often comes from local sources where the project is located or the service is intended. The construction of satellite earth stations in India is such an example (Hudson, 1990). Experience in China also indicates local financing takes a significant proportion of total investment (see Chapter 5). Local financing can be a substantial source for telecommunications growth if incentives are provided by the government through taxation, profit sharing and retention of foreign exchange.

2.3 High Demand

To a great extent, the excess telecommunications demand in developing countries is aggravated by underinvestment. Studies by Saunders et al. (1983) and Wellenius, et al. (1989) found there is high unmet demand in most developing

countries, ranging from 10 to 70 percent.[9] Requests for telephone service can wait for years to obtain access.

The demand may be further divided into two categories, demand for access and demand for service, both are typical in developing countries. Demand for access cannot be easily measured by given price for the reasons that a large proportion of demand is not recorded, resulting in false perception that level of access in increasing (Saunders, 1983). Moreover, price for access is often heavily subsidized by the government, so it tends to be stable regardless of demand level for the reasons addressed in the section on tariff policy. In developing countries, satisfaction of demand for access does not guarantee service since increased access often exceeds network capacity. Repeated calls further aggravates line congestion, causing more calls unconnected. Therefore, data on fulfilled demand for access must be read with caution because it may in effect have increased demand for services rather than alleviated it. Moreover, the call completion ratio in many developing countries is low, typically about 50 percent, which seems to indicate that forgone benefits and operating revenues, wasted user time, and inefficient use of switching capacity all have diminished the potential contributions postulated in theory (Wellenius, 1984b).

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[9] The "demand" usually means reported request, which can only be used as a relative indicator for the actual uncovered demand, especially in vast rural areas.

The demand in developing countries may be better understood with the concept of public good, which in many cases is also the rationale for pricing policy-making. In general, a public good market contains the following characteristics pertinent to the current discussion. 1) As first stated by Samuelson (1954) and studied by others such as Buchanan (1968) and Head (1974), the individual consumption of public good equals to the total consumption supplied to a market. This can be compared to "private good" in that total consumption is the summation of individual consumption. 2) This fundamental characteristic entails the externality of a public good, namely, individual gains do not inhibit or reduce others' benefit from using the same good, since each person's gain equals the total consumption. 3) The externality denotes that the benefits of public good do not diminish with the increase of number of consumers. On the contrary, the more people use the good, the greater externality is created by their participation, and the greater the benefits.

The theoretical properties of public good is tested in the domain of telephone use by Artle and Averous (1973). Using mathematical inference, the authors prove that telephone systems are essentially a public good. For instance, as marginal use is added (connected) to the network, time for travel and face-to-face conversation is saved (i.e., substitution), and it accrues to the summation

of the benefits in networks which can be received by all users in the network. More interestingly, the study suggests that the recognized benefits such as substitution and time saving will likely stimulate demand for public good if income and other social conditions permit. The study concludes that the welfare gains from the externality of telephone systems as a public good are significantly greater than the costs.

Despite insightful analysis, the Artle-Averous study does show certain limitations when applying telephone use to developing countries. The first limitation is the assumption that access to telephone is a function of income distribution. As discussed earlier, people in developing countries are willing to pay disproportionally high prices for the benefits of telephone services. From the present assumption, however, one may conclude prematurely that since income in developing countries is low and uneven, the demand for the service will be low and, consequently, the benefits will be poor since the externality is limited. Another limitation is the assumption that access to telephone networks is automatic once a user's decision is made, then demand is satisfied. This is not the case in most developing countries where demand for access can be delayed for years, this may frustrate demand despite the willingness to pay, and ultimately undermines the benefits of telephone services.

The public good characteristics of telephone systems have direct implications in policy making on access and pricing. Citing findings from other studies, Hudson (1984) contends that a flat-rate pricing structure (such as the U.S. postal service) will promote rural use of telephone, which, as discussed previously on the roles of telecommunications, yields equitable, if not greater, benefits. Following the same rationale, one may elicit that a centralized industry structure is the most efficient supplier of public goods, or telecommunications services, since the provision and pricing can be made from the entire market (i.e., a country or a region) for specified demand, communication traffic and types of services.

Finally, the claimed benefits of telephony as a public good can only be attained after the system has achieved the switching and transmission capability required by communication needs in society. The relationship between the high unmet demand and other aspects identified in this study can be described as mutual causality: while it is the consequence of underinvestment and inadequate technologies, it is also the cause of traffic congestion in developing countries; heavy price subsidization further depresses incentives to investment which results in poor service and slow growth. Discussions of the positive aspects and limitations of telephone systems as a public good provide insights for and implications in policy making in developing

countries. Further studies and new evidence are needed in analysis of the demand, and solutions to alleviating the demand and maximizing the benefits of telecommunications.

2.4 Complexity of Technology Transfer

Investment scale has direct effects on technology transfer in telecommunications. In many respects, underinvestment in developing countries is a severe hindrance to technological improvements. But technology transfer often contains dimensions beyond just the hardware; Chasia (1976) contends that technology transfer is essentially a "social process" whereby the choice of technology is made vis-à-vis domestic resources, financial feasibility, systems functions/benefits, and social change. These factors will determine the outcome of technology transfer. The political and economic content of technology transfer has been studied from various aspects including history (Eze, 1986), international context and policy (McIntyre & Papp, 1986; Goulet, 1989), legislation and protection (Goossen, 1987), and management strategies (Leuenberger, 1990). The consensus seems to be centered on the fundamental role of technology as the resource and agent, prompting changes in socioeconomic structures in recipient countries. While it can be utilized as effective leverage to improve domestic technological status and

services, it is also accused as being used by the West to exploit excessive profits.

One such aspect is technology dependency. Wellenius (1976) points out that since telecommunications technologies change rapidly, systems designed based on long-term least cost will likely become short-term least cost since they soon have to be replaced by new technologies. Proprietary standards, training and maintenance offer few alternatives but to continue purchasing from the same supplier, creating high dependence on technology exporting countries. As argued by Eze (1986), the technology dependency has in effect widened the gap with the West; developing countries are taking the risk of becoming new colonies in the information age.

As widely agreed, technology transfer contains two levels. First is technology that produces or helps produce end products that may provide little systematic knowledge about the technology and its full potential. Another level is transfer of science as systematic knowledge that controls the outcome and actual gain of the production (McIntyre, 1986). Although the second level is the ultimate source for development, most technology transfer takes place only at the hardware level. For example, technology is often exported in package or assembly lines without delivering relevant knowledge to, or lack of training in recipient countries. Such "asymmetrical" technology transfer has been

criticized to bring about little changes in the domestic technological status quo but mostly negative consequences (Eze, 1986). The perplexity of technology transfer strongly suggests that developing countries cannot afford not to have a prudent technology policy.

There is another critical aspect in studying technology transfer: the effects of transfer do not end at importation of hardware, but are also contingent on a country's ability to absorb, utilize and merge technology with existing structure and resources (Eze, 1986). Among others, transfer of appropriate technologies should be taken as prominent priority to reach technical and economic objectives (Goulet, 1989). In order for technology transfer to be effective, Schweitzer (1972) contends that a country's own scientific and technical infrastructure is crucial for better utilizing foreign technology and products, which includes technology assessment and technical know-how, among others. Without them, as observed by Stover (1984), imported technology will unlikely deliver potential benefits or even largely wasted. However, the predominant opinion is still centered on the accusations of profit-driven motives of Western countries as the primary reason for the worse-off technological status in developing countries.

Telecommunications technology transfer in China provides some insights for the current discussion. The massive technology transfer in China did not take place

until the late 1970s, much later than many developing countries. There has been rapid growth both in investment scale and technology acquisition. A recent study on technology transfer in China has correctly identified the key to successful utilization of foreign technology, i.e., technology transfer must be managed to interweave with domestic research resources so that "efficient production and a gradual increase in domestic technological capabilities" can be accomplished (Conroy, 1990, p.16). This experience can be extended to other developing countries as well.

Despite its remarkable progress, technology transfer in China is faced with other barriers. Since telecommunications is considered as a high-tech industry and China is categorically a communist country, the transfer is subject to international trade regulations from General Agreement on Tariffs and Trade (GATT) and Coordinating Committee on Multilateral Export Controls (COCOM), that impose close scrutiny and vigorous control of technology transfer (Simon, 1986). In addition, China presents an ambiguous case for American policy makers and companies. The U.S. Commerce Department in its market study on telecommunications equipment in China (1985) painted a rather grim and cautious scenario. Two years later, the Office of Technology Assessment (OTA) of U.S. Congress gives a much more positive tone on the prospects of technology

transfer between the two countries (OTA, 1987). In the study, China is conceived less of an enemy, but a player with "a more constructive international role, and many areas of common interest have been found." (p.3) Thus, technology transfer to China is proposed as lever for cooperation and modernization. It is interesting to note that the attitude of U.S. government toward China has been inconsistent for the most time due to political conflicts and trade frictions in both countries. This has significantly influenced U.S. technology transfer and investment in China, for example, the U.S. telecommunications equipment share (in dollar value) in China is much lower as compared to European countries and Japan, although its market potential is well recognized. (See Chapter 8 for a detailed discussion.)

Finally, the review of literature on technology transfer also has exposed certain stereotypical views regarding technological change in developing countries, and they should be reexamined in the changing context of 1980s.

One popular view is that developing countries should acquire only those technologies that have been used in developed countries as a test-bed, often labeled as appropriate technologies (Goulet, 1989). This is a rather passive approach, and it will inevitably affect the pace and scope of technology transfer. Although telecommunications funding in most countries is still a serious constraint, developing countries are much more active in the changing

international technology market to seek state-of-the-art technologies for a reasonable price. It is so because 1) the price for advanced systems has dropped significantly due to the accelerated development pace in recent years, and 2) increasing competition in attracting buyers, particularly the Third World as many countries now possess rather formidable purchasing power. Developing countries can even take the advantage of an international buyer's market by demanding better products and lower price through request for proposal (RFP) and bidding process.

Another view is that given investment constraints, least cost solutions should be sought to maximize returns (Saunders, 1983). It could also be argued that because of limited funding, investing in advanced technologies would be more effective since the normal development cycle would be eliminated and returns much higher. The argument for technological "leapfrogging" is evidenced by an increasing number of countries in Southeast Asia and Latin America. Formation of joint ventures is another leapfrogging strategy to upgrade domestic networks. Many countries' experience, including China's shows that joint ventures not only increase domestic production, but also contribute to domestic infrastructure, such as research and development, management and training. The proactive policy of technology transfer in developing countries has produced very impressive results; in fact, the technological gap with

advanced countries has diminished significantly in newly industrialized countries (NICs), as seen in satellite communications, packet switching, integrated services digital networks (ISDN), and cellular telephone networks. It is evident that technology transfer in developing countries is gradually changing its orientation, content and objectives. It also has raised new issues for the research on international telecommunications cooperation and trade.

CHAPTER 3

TELECOMMUNICATIONS FINANCING IN CHINA

In many respects, telecommunications financing is a ramification of industry structure, policy, and market dynamics. Historically, China's telecommunications was (and basically still is) operated under the central regime by the Ministry of Posts & Telecommunications (MPT). Protected by the government, the MPT is the industry regulator and primary product supplier and service carrier. The vested power has made the MPT a monopoly stronghold. Ironically, the industry seems to be driven by the market away from the MPT's control as a result of rapid growth in the 1980s. The economic reform and the open-door policy since 1979 are the most fundamental forces behind the changes in the industry. Rapid economic development[10] has significantly contributed to the growth of telecommunications: annual investment has increased at an average of 24.7 percent; the industry has attained an annual growth rate of 24 percent in revenue (see Chapter 5). On the other hand, intensifying competition and

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[10] A Business Week symposium (1990) reports that China's GNP increased 150 percent between 1979 and 1988.

persistent demand have reinforced the momentum of growth. It may well be said that China's telecommunications industry has entered an important transition era, as the rigid central regime and awakening market forces are managing to coexist, and they will altogether affect the policy and practice of telecommunications financing. This chapter discusses the fundamental characteristics of China's telecommunications industry and their effects on financing.

3.1 Industry Structure and Administration

The Ministry of Posts & Telecommunications (MPT) is the state protected monopoly in China's communications industry. Established soon after the founding of the People's Republic in 1949, the MPT has become a colossal bureaucracy. It consists of 18 departments and committees overseeing telecommunications construction, research, production, services, and regulations (see Figure 1). In addition, MPT owns about 30 large and jointly owns 90 small-to-medium manufacturing facilities, and 35 research centers nationwide. Altogether, the MPT employs about 900,000 people, with its assets worth at least 50 billion yuan ($11 billion).[11]

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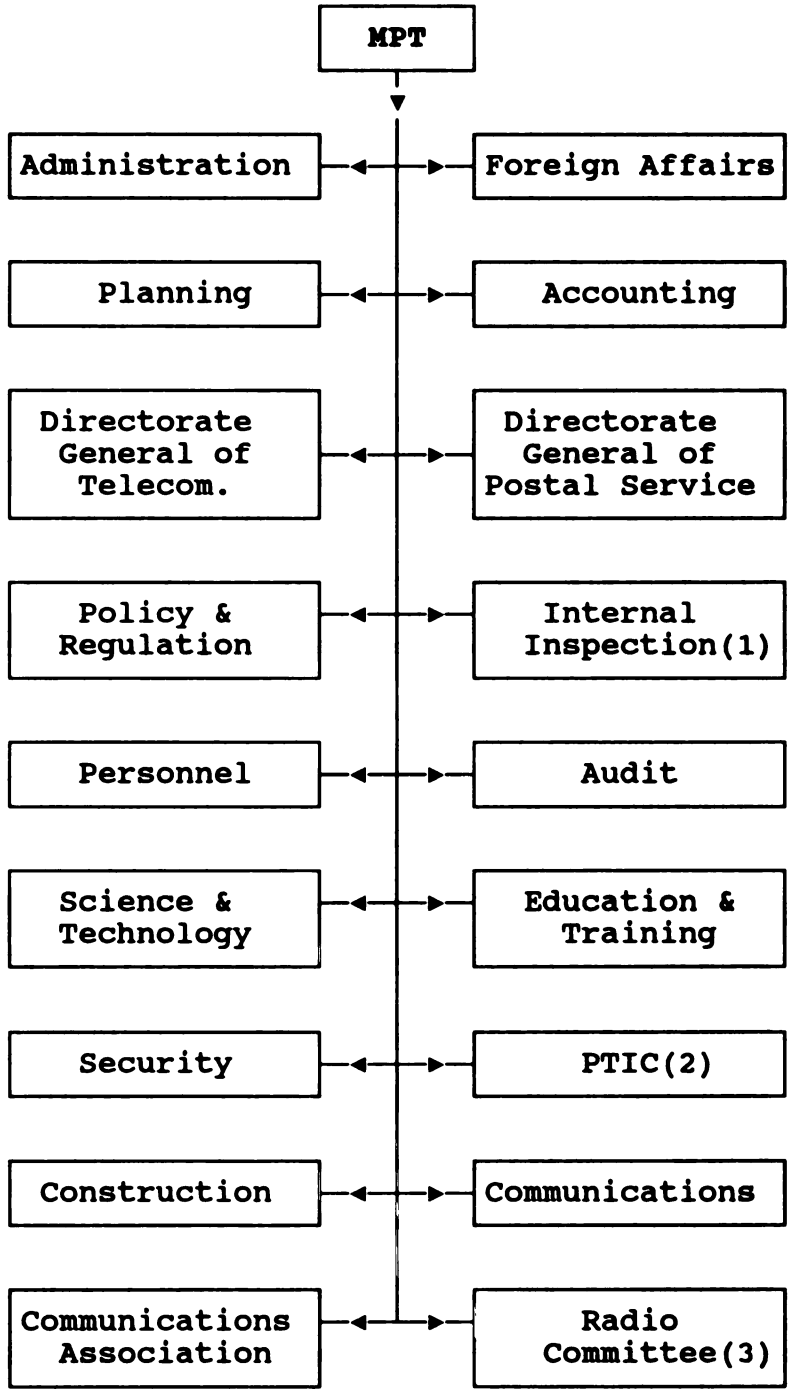
[11] The size of MPT is estimated differently, from 100,000 to one million employees. The number of employees used here include MPT-owned manufacturing and service facilities at all local levels.



Notes: (1) For party discipline and legal violations. Product inspection by Communications Department. (2) National Postal & Telecommunications Industry Corporation. (3) For frequency allocations.

Figure 1 Internal Structure of MPT

The central control of MPT is typically represented in its operating branches in all provinces and cities. Each of MPT departments in Figure 1 has provincial offices, resided in the umbrella organization called telecommunications administration bureau. For example, the Directorate General of Telecommunications (DGT) of MPT controls 30 local DGTs in all provinces.[12] They subsequently command lower affiliates in cities and counties throughout the country. Figure 2 illustrates the administration structure of industry sectors. (Postal administration has a similar structure and is separated from telecommunications at local levels.) As Figure 2 shows, the MPT's control of manufacturing is through its enterprise management branch, the National Posts & Telecommunications Industry Corporation (PTIC). The PTIC is registered as an independent enterprise entity, even though it is still considered an affiliate of MPT. In addition to manufacturing, PTIC contains ten industry groups, specializing from microwave and fiber optics, to video technology and mobile communications. The emergence of independent industry entities is the result of restructuring and horizontal consolidation which will be discussed in details in Chapter 6. Although a structure does not necessarily completely determine market activity, the central regime is to ensure MPT's supremacy to be

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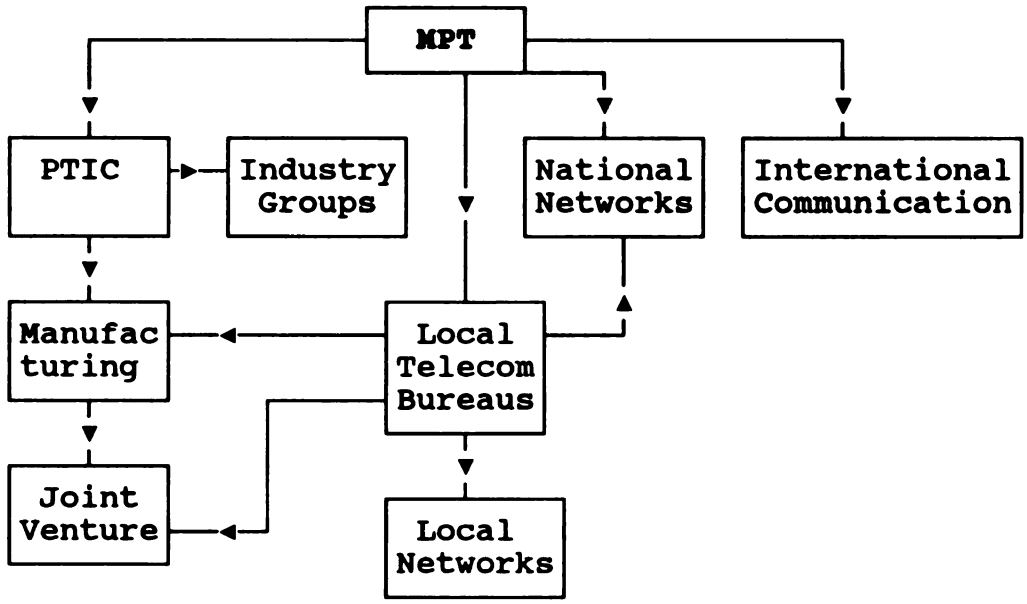
[12] China has 30 provinces, more than 460 cities, 12,000 counties, and about 70,000 townships.

respected and executed throughout the country.



Notes: National networks consist of inter-provincial networks. Local networks include intra-provincial, inter-city and rural networks.

Figure 2 Structure of China's Telecommunications Administration

Like other government agencies, the MPT monopoly is endorsed and protected by state legislation. The protection, at least in form, is formidable. For instance, in response to increasing competition against MPT, the State Council in its 1990 decision dismissed the growing sentiments about diluting MPT's monopoly, reiterating that MPT "is the supreme national telecommunications administrator;" besides running public networks, the MPT should also "provide professional and technical management"

for private networks (World Telecommunications, 4:1, 1991). In such a closely watched environment, China's telecommunications market had become rather monolithic, centered on MPT's control; new initiatives in research, products and services were suffered from bureaucratic procedures, long delays in obtaining approval, and restraints in fund allocations.

Specifically, the MPT's monopolistic power concentrates in the following industry sectors.

1) Central office (CO) exchange market. The current national output is about 1.2 million circuits a year (including crossbar and program controlled exchanges but excluding PBXs), of which MPT has the lion's share of more than 90 percent. The MPT's dominance in CO switch manufacturing provides it with great advantages in new technologies that require intensive capital and technical expertise. Such advantages are also seen in PBX manufacturing. An MPT report shows that by 1989, of 99 TDM (time-division multiplexing) and SDM (space-division multiplexing) SPC PBXs (stored-program controlled), 54 were made by MPT affiliated companies, or 55 percent (Marketing Department of World Telecommunications, 1989a). The MPT also dominates manufacturing of step-by-step switches, used primarily in rural networks.

2) Public long-haul transmission networks. Since the early 1950s, the MPT has been the sole carrier in trans-

national networks through its affiliates throughout the country.

The term "network" entails two types of coverage in China: domestic and international. All international voice communications is handled by MPT-owned and operated exchanges and ports in major cities such as Beijing, Shanghai and Guangzhou (Canton). The structure of domestic network is more complex, containing three components: long-distance, local (urban) and rural.

The long-distance networks consist of five tiers: inter-province; provincial centers; inter-county; county centers; and terminal exchange (customer premises) (Liang & Zhu, 1988). There are six inter-provincial centers in the country, located in major communications hubs. Calls are switched at the center and then to the intended province, and finally transmitted to the destinations. Interestingly, such a transmission configuration is parallel to the hierarchical structure described earlier. For instance, the first tier, inter-province routes all national voice and data traffic, therefore a higher control from MPT is imposed. If the traffic is essentially within a locality, the local telecommunications administration is responsible for operation and service. The MPT control is also executed through budget allocation. Prior to the 1980s, local production was exclusively funded by the MPT. In such an environment, although telecommunications networks in general

were expanding, the growth had to comply with MPT's central planning and funding availability, rather than the industry's mechanisms and local requirements and needs.

3) Service (voice and non-voice). Like most developing countries, the MPT is the only carrier for domestic and international services. As a result, its revenue from service sector has increased dramatically in recent years. (See later in this chapter for discussion of financing.) To a great extent, service revenue has strengthened MPT's monopoly; for instance, service charge can be much higher for private networks routing through MPT facilities, forcing them to use MPT services. The service monopoly also gives MPT a great advantage to engage in new services that will generate higher revenue. While the basic telephone service still has a long way to reach majority of the population, especially those living in hinterland and vast rural areas, it does not prohibit intention for new services. Since the 1970s, MPT has engaged in research beyond plain telephone service, such as videotex, intelligent networks, and non-voice services (data, video, etc.). "CHINAPAC," the first public packet switching network, has been in service since 1989 providing a prototype of video, electronic mail and telephone directory services, all using Chinese characters (Sun, 1991a). Implementation plans for integrated services such as ISDN (integrated services digital network) have also been made at the MPT.

4) Terminal equipment (CPE). This is probably the most competitive sector among the four discussed. Terminal market covers a broad range of products, from telephone sets, data terminals, to the equipment used at customer premises, such as PBXs, key telephone systems, teleprinters, fax machines, and so on. In the past, MPT was the dominant CPE supplier and regulations prohibited others from entering this market. Since the mid-1980s, however, the terminal market has gradually opened as the result of following changes: structural reform in MPT creating "horizontal alliances" with non-MPT companies; relaxed regulations in production; surging demand for a wide range of products; and finally, non-MPT and local manufacturers' increasing presence in competition with MPT. As the CPE market has become pluralistic and competitive, MPT's monopoly has diminished quickly. By 1990, for example, MPT's share in telephone set market had declined to less than 10 percent, compared to more than 60 percent by the non-MPT companies (Wang, 1991). It is obvious that increasing competition in the CPE sector has fundamentally changed the characteristics of the market, it has also inspired competition in other sectors.

Despite contextual differences in China's telecommunications, the gradually opening CPE market seems to agree with the deregulation trend in other developing countries notably Brazil, South Korea, Malaysia and

Singapore, who first liberalized terminal market that led to industry privatization. Although the magnitude of change in other sectors is considerably less than the CPE market, it is likely that competition will spread over the entire industry given its strong momentum and MPT's dwindling control of local levels.

3.2 Policy of Industry Financing

For the past 30 years, central government investment was the only source for China's telecommunications financing. As a result, the extent of China's telecommunications market was severely confined to the budget availability. During the early years of development, such sole financing scheme was effective because it secured capital commitment, as evidenced by the remarkable growth during the 1950s. For example, between 1953 and 1957, postal and telecommunications business grew 200 percent a year. Telephone density (sets per 100 people) increased from .05 in 1949 to .13 in 1957, in spite of population growth at about three percent a year during the same period (Liang & Zhu, 1988).

However, the inherent problem of central financing became obvious as the industry was poised for rapid growth in the early 1980s. Telecommunications investment is appropriated from total central budget. Although the

industry investment has increased from .4 percent in 1980 to more than one percent in 1989, its growth rate is far behind the industry growth. The total posts and telecommunications revenue in 1989 was 48 times of that in 1949, but the budget increase was far below this scale. Under the central financing scheme, local telecommunications authorities were restricted from using local financial sources but only funds re-allocated from MPT. The central financing policy had created a vicious cycle effect: the more the industry grew, the more investment had to be allocated to local projects since many projects were not profitable. On the other hand, central financing caused high dependency and low motivation from local bureaus, further aggravating budget drains. This is especially the case in basic construction which typically requires high and long-term investment, and the short-term return is low and always delayed.

Another aspect of central financing is service subsidy. As literature review indicates, service subsidy is used in most developing countries as a means of promoting telephone service. Normally, as more people use telephone service, the benefits increase significantly while additional costs become marginal. In the case of China, however, such cost-benefit rationale is yet to be financially justified after four decades of heavy government subsidization. For example, the combined cost for telephone service using crossbar switching (semi-automatic) was 2,500 yuan ($530 at

then exchange rate) in the mid-1980s, but customer would pay only 200 to 400 yuan for installation and a flat monthly fee of 14 yuan. The costs for SPC (automatic) telephone service was 5,000 yuan ($1,060), but the customer was charged 1,500 yuan ($320), only about a third of total cost (Ji, et al., 1990). Financing constraints and heavy service subsidies had made China's telecommunications a deficit industry for more than 30 years; its growth potential was severely undermined.

Beginning in 1981, China's telecommunications has changed to profitability, thanks to relaxed pricing policies and the expanded consumer base (Zhang, 1986). By 1989, telecommunications revenue (excluding postal services) soared to 7.6 billion yuan ($1.6 billion), in which revenue from telephone services accounted for 83 percent (MPT, 1990a). If China's telecommunications were operated on its own financial terms, sustained growth would lead to significant increase in investment. In reality, however, telecommunications continues to suffer from funding shortages despite potential yields. According to a report collaborated with the World Bank, in order to achieve the claimed goal of 33.6 million telephones (or 2.8 percent in density) by the year 2000, an investment scale of 100 billion yuan is required for the next ten years (Development Research Center, 1991). Interviews with MPT officials reveal that the industry needs at least 5 to 7 billion yuan

a year for construction, research and services, but investment by the central government is at best one-tenth of the amount required (Hao, personal communication, 1990).

It became evident by the early 1980s that the central financing could hardly afford the rapid expansion and growing demand at local levels. With government endorsement, a new financing policy was implemented during the "Sixth Five-Year Economic Plan" period (1981-85).[13] In addition to continuing central investment, the new policy encourages local telecommunications bureaus, enterprises and institutional users to utilize all viable financial sources based on project requirements, location and management responsibility. As a result, the industry financing has diverted from one central source to multiple sources. Table 1 breaks down diversified sources currently engaged in telecommunications financing. As shown in the table, direct investment from MPT has decreased while shares of local sources and foreign investment have increased substantially.

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[13] China's economic planning is based on the "five-year" framework. The first "five-year" period began in 1953. The 1980s had two five-year periods: the sixth (1981-85) and seventh (1986-90). Like other economic sectors, telecommunications investment follows the same time frame, although revenue is calculated annually.

Table 1 Distribution of Financing Sources

Sources	Share(%)
MPT's Direct Investment	32
Local Telecom. Bureaus(1)	14
Self-generated Funding(2)	35
Domestic Loans	5
Foreign Investments(3)	8
Other(4)	6
Total	100

Notes: (1) From local sources, does not include re-allocated central funding from MPT.
(2) Including self financing by company revenue.
(3) Including loans, foreign owned and joint ventures. (4) Including user-raised funding.

Sources: The China Business Review, 1983-91. Department of Commerce, 1985; Liang & Zhu, 1988; Sun, 1990.

In terms of financing responsibility, the diversified financing scheme is parallel to the aforementioned network configuration. Provinces now must provide funding for projects that are located in, or will provide services to, the region. Likewise, cities and counties pay for telephone systems and services serving the locality. The MPT financing is only made for long-haul networks, satellite communications, MPT directly operated services and national facilities. The provision of network structure and financing responsibility is summarized in Table 2.

Table 2 Network Structure and Financing

Types of Network	Financing Sources
Trans-national	MPT
Inter-provincial	Provinces/MPT
Intra-provincial	Provincial Bureaus
Inter-city	City Bureaus

Source: Sun, 1990.

The diversified financing policy contains important implications.

First, entailed in financing responsibility, it has also granted more freedom and flexibility to local telecommunications authorities. Historically, local bureaus are much closer to local governments and enterprises than to the MPT in Beijing, which means they have intimate relationship with local financial sources. Local bureaus receive funding from the MPT, but in the past a large portion of the profit made from local product sales and services was collected by the MPT. Under the new financing policy, local bureaus can independently determine projects and funding scale, and they can retain much higher profit generated within their territories, as long as they fulfill tax requirements and regulations in technical standards, pricing and services.

Second, with greater local autonomy, local financing is now directly linked to profit which in turn promotes more financing. Therefore, local investment has increased

significantly from about five percent in the early 1980s to more than 50 percent in 1990 (cf. Table 1).

Third, as a result of less budget allocation from MPT and greater local financing responsibility, the industry turns to services for higher profitability, which has triggered rampant price increases throughout the country. Since 1989, prices for local telephone services have increased by 30 to 100 percent, as well as in local distance, telegraph and facsimile services (Ji, et al., 1990; Sun, 1990). As discussed previously, heavy government subsidy is one of the reasons for diseconomies of scale in telecommunications, causing diminishing profits and low motivation at local levels. From this perspective, the price hike is widely viewed in China as a healthy measure for growth rather than a disservice to the public. In fact, MPT statistics confirm the price increase is justified by the unrelenting waiting list and consumer's willingness to pay the high price (Marketing Department of World Telecommunications, 1991; MPT, 1991b).

Fourth, the diversified financing policy has encouraged foreign investment. Although foreign investment in China's telecommunications is a recent phenomenon, its growth has been remarkable to becoming an indispensable means for technology transfer (discussed in detail in Chapter 8). Interestingly, a great amount of foreign investments (loans and joint ventures) is designated to local projects, which

in some cases circumvents MPT's intervention. Moreover, because local bureaus now have access to foreign exchange, they can directly purchase foreign products without MPT approval, especially the regions in the south and southeast, where the economic development and foreign trade have been phenomenal.

Nonetheless, increasing service prices is not an ultimate solution to investment constraints. Continual reform of industry structure and improving resource efficiency are the key to long-term growth and profitability. Although diversified financing does not resolve funding shortages, it does create alternative financial sources to bolster growth. The size and diversity of China's telecommunications market may leave little choice for the government but to continue diversified financing as a long-term strategy. The decentralized financing policy has been proven to be an effective means to telecommunications investment; it has made significant contributions to telecommunications growth by bringing about new market forces and reducing central control. The effects of diversified financing will be discussed in great detail in Chapters 5, 6, 7 and 8.

CHAPTER 4

RESEARCH HYPOTHESES AND METHODOLOGY

The literature review and the preliminary analysis of China's industry structure and financing policy has identified four key development aspects: diversified financing, competition, demand and technology. This study attempts to examine the effects of diversified financing on industry growth by addressing the market mechanisms and internal relationships.

It should be first reminded that although these aspects directly influence China's telecommunications industry, they are also influenced in many ways by the environment encompassing the industry, such as political stability, economic development, quality of life, and social change. Although the influences of external environment on telecommunications is beyond the scope of this study, its presence must be taken into account when studying telecommunications financing in China, particularly financing policy. The government suppression of democracy movement in 1989, first taken as a political measure, but it ended with severe economic repercussions when all foreign

loans and sponsored projects were in a halt, including telecommunications. This is a good example of how political stability and continuing economic prosperity are the ultimate conditions which not only bolster diversified industry financing but also provide a much more interesting case for studying the effects of diversified financing.

Although telecommunications financing in China is inevitably influenced by political, economic and social contexts, the industry is essentially driven by its internal forces (to be discussed shortly). The characteristics and relationships of the internal mechanisms determine the direction and speed of industry growth. Study of these industry aspects and relationships will promote a better understanding of China's telecommunications market, its current status and future prospects.

Having established research scope and objectives, this study submits the following research proposition:

> Diversified financing in China contributes significantly to telecommunications growth by creating new market dynamics in competition, network management and technology advancement. Thus diversified financing is thus a viable alternative to industry investment.

The proposition contains several implications that should be verified before research hypotheses can be developed.

First, the relationship between diversified financing

and telecommunications cannot be studied effectively without well defined and measurable contents. In other words, the contribution of diversified financing must be examined through some "intermediate" variables on which the effects of diversified financing can be observed. The variables to be examined include: aggregate growth index, competition, demand and technology transfer. These variables compose the basic criteria of industry growth, they also entail direct effects of industry financing. Therefore, the proposition can be undertaken as studies on changes in relationships between diversified financing and these variables.

Second, from the above research approach, the following working definitions are provided for studying the variables in hypotheses.

1) Diversified financing should significantly supplement central investment in terms of percentage, feasibility, and outcome such as improvements in local infrastructure and services.

2) Telecommunications growth is measured by aggregate variables including revenue, switching capacity, the number of telephone sets, telephone density, and basic and enhanced services that facilitate societal use of telecommunications and contribute to economic and social welfare.

3) Diversified financing exerts profound impacts on industry's internal forces such as competition, demand, and technological change. The relationships between diversified

financing and these variables are essential to industry growth. The study postulates that changes in these variables will significantly affect the industry as a whole.

From these justifications, four working hypotheses are formulated based on the general proposition. They are discussed here with descriptions of research methodology.

Hypothesis 1. Diversified financing significantly relieves constraints of telecommunications investment, that is also the major catalyst for the growth in revenue, switching capacity, and the number of telephone sets.

The postulated relationship is to be tested in three measurements, grouped under the general index of telecommunications growth: investment-revenue, investment-switching capacity, and investment-telephone sets. The independent variable investment contains the actual input scale during the 1980s, which also consists of the growing share of local financing. The most appropriate approach to studying the hypothesis is correlation analysis using a series of linear regression in order to obtain the degree of association between investment and dependent variables. Data analysis is conducted in time series to derive the correlations over a span of eleven years (1980-90). Additional tests on the strength of association and effects of financing are conducted in lag-time intervals (i.e., t-1 and t-2).

Data are collected from secondary sources including the

annual statistics from the Ministry of Posts & Telecommunications (MPT), industry publications, research reports and personal interviews. Research in the United States is also used. The multiple sources not only help verify the accuracy of data, but also provide additional insights. Although reliable data on local financing are not available due to the statistical indexing method in China, its increasing share can be derived from analyzing new financing policies and case studies.

Hypothesis 2. Diversified financing encourages competition within and outside the MPT.

There are essentially two forms of sector competition: MPT versus non-MPT entities (ministries and enterprises), and MPT versus local telecommunications bureaus. Competition stems from industry restructuring in the mid-1980s which has spawned new alliances across different ministries and industry sectors. Competition is also taking place within MPT's territory between the central administration and local operators.

A distinction should be made about local bureaus. Although they are the subsidiary of, and in many cases controlled by, the MPT, they have a certain degree of autonomy usually the regions that have achieved high economic growth enjoy much higher autonomy. Given the extent of network planning and management, competition in production, new application and technology transfer has long

existed in the local and national markets.

The study uses competition as a relative measurement. It analyzes changes in scale between MPT and non-MPT (and local bureaus) rather than absolute values such as production units, because the MPT is still the dominant supplier in many markets; real-value measurements may not best depict the effects of competition. Another reason is that data on specific product sales are not available, especially in the local markets. The qualitative analysis can be an effective approach since information on scales (market share) of certain sectors is obtained, presenting sufficient basis for studying the changing market dynamics with respect to financing scheme. The hypothesis speculates that increased local financing attributes to higher production output; as a result, more products have to compete for sales, creating tension in innovation, marketing and services.

Hypothesis 3. Diversified financing stimulates demand especially among urban customers.

The relationship stated in the hypothesis entails the dimensions contained in the previously hypotheses. Diversified financing apparently does not directly affect customer demand. Diversified financing takes place at the supplier side, its impacts on the recipient (customer) can be studied through the outcome of the new measures, such as changes in production and service availability in society.

Although diversified financing also affects price which in normal circumstances will determine demand, the magnitude of effects of price is questionable in the case of China. Past experience has shown that since demand persistently overrides supply, it has become insensitive to price. The excess demand is persistent even when the price has drastically increased as a result of relaxation of service pricing at local levels.

Despite the indirect relationship, the hypothesis speculates that diversified financing has contributed to the expansion of customer base with more equipment sales and increases in access and service. The possibility of attaining the benefits of telephone services and the glamour of social status (an important reason in developing countries) can inspire more demand, especially among urban residents. Given the disequilibrium between supply and demand in China, most people will still have to wait for years to have access and service, but the progress in expansion will keep the demand strong.

A critical aspect of demand is price. Normally, demand is a function of price, which is the measurement of supply and demand in the market. It is also a reference measure of cost-benefit used by the customer. In China, however, the scarcity of supply and perceived benefits make the demand persistent and inelastic to price. The perceived benefits seem to be the imminent reason since most access requests

come from urban resident. reason. As the economy grows and quality of life improves, people particularly urban residents want to extend their social and personal activities by telecommunications services that are otherwise difficult.

Although diversified financing has caused price increase, the higher price seems to be synonymous with the greater benefits perceived by the society. Nonetheless, the hypothesis does not denote that increasing price is the solution to demand; instead, it postulates that diversified financing has an effect on alleviating demand by promoting competition and decentralization in production and services, which ultimately will drive price down. The hypothesis also contains that the high demand may have dual effects on financing: it exerts tremendous pressure on equipment and service supply, but it also provides a subscriber financing pool essential for a diversified financing marketplace.

Hypothesis 4. Diversified financing promotes technology transfer.

Telecommunications is a technology-driven industry, this is especially critical for China which needs advanced technology to bolster its telecommunications growth. It is also the underpinning for competition and to satisfy demand. It is uneconomical for China to develop its technology infrastructure from scratch which requires huge amounts of capital, proficient technical expertise, and state-of-the-

art research and development facilities. Technology transfer, on the other hand, provides an effective means to taking advantage of modern technologies while avoiding expensive resources.

The hypothesis states that increased local financing facilitates technological change by higher purchasing power and absorbing abilities at local levels.

Essentially two types of technology transfer are observed in China: direct imports and joint ventures. The hypothesis will examine effects of the two approaches, especially their advantages and disadvantages. Because technology transfer in telecommunications requires considerable amount of foreign exchange, the effects of diversified financing may not be as explicit as they are for other variables. It may, however, play an important role in attracting joint ventures by providing local contributions and promising returns.

This perspective may be viable by the fact that a large proportion of joint ventures are established with local bureaus for local production and services. The increasing local orientation of joint ventures suggests the healthy financial environment with viable sources. Therefore, it is embedded in the hypothesis that diversified financing is imperative for foreign investment that affects the scope of technology transfer.

These perspectives and underlying relationships are

addressed by comparing the numbers and categories of products, and domestic market shares by exporting countries. The effects of diversified financing are studied by cases with respect to foreign investment scale and local development. The hypothesis also examines government policy on technology transfer and its implications in maintaining domestic financial viability and a vigorous market for foreign investment.

Finally, for a better understanding of the research subject and statistical and qualitative analyses, a forecasting model is developed based on the results derived from the study. Two development scenarios (linear and exponential) are presented to demonstrate feasibility and conditions for achieving the goal by the year 2000. The purpose of forecasting is not to predict outcome; rather, it is to exemplify the implications of industry's internal forces with the future prospects. The discussion of forecasting serves to achieve the same objective as established in the dissertation: the dimensions and effects of diversified financing in China's telecommunications development.

The study essentially focuses on industry financing and variables crucial to growth. The general roles of telecommunications in economic development will be addressed only in the context of financing. By the same token, discussions of telecommunications services will be

restricted to the domain of supply and demand rather than the social benefits incurred to the user.

CHAPTER 5

DISCUSSION ONE: FINANCING AND GROWTH

This study has identified financing as one of the most critical attributes to telecommunications growth. It is especially relevant for developing countries for the reason that, in many cases, central government's investment is the only source of financing. As the research literature has revealed, the monolithic financing scheme can ill afford the capital and technical requirements of telecommunications, thus becoming a major obstacle to industry growth. Therefore, it may be postulated that the scale of financing can have significant impacts on industry growth.

This chapter examines the relationship between telecommunications financing and growth during the 1980s (1980-90). The hypothesis that diversified financing has made positive contributions to the telecommunications growth is tested using linear regression and correlation coefficients (Pearson's r). The growth index variable consists of three subsets for statistical analyses, namely the relationships between financing and revenue, financing and switching capacity, and financing and the number of

telephone sets. The effects of the independent variable (financing) is further examined with different lag-time intervals followed by discussions of methodology.

5.1 Regression Analyses and Correlations

The 1980s was a remarkable decade for China's telecommunications. Propelled by the economic reform beginning in 1979 and the industry restructuring, China's telecommunications achieved substantial growth in financing, production, service and technology in the 1980s. As shown in the leading indicators, revenue increased at 24 percent a year, switching capacity at 10.9 percent, and telephone sets at 11.8 percent (see Table 4 below). Not coincidentally, the scale of composite investment also increased significantly, at an average rate of 24.7 percent a year. The rapid growth of industry input and output made the 1980s the best period ever in China's entire telecommunications history. It also presents a good case for examination of market dynamics and their relationships that have created the growth momentum.

The independent variable investment is used as an aggregate variable. It contains both central and local financing. The main reason for such treatment is the difficulty in obtaining separate investment data from the current accounting methods in China's telecommunications

administration. Annual industry investment is calculated on the national basis, which always includes some local financing, but it may overlook other sources unaccountable by the current accounting scheme, such as user-raised funding and private sources. Provincial telecommunications bureaus sometimes have information about the scale of local financing, but they are faced with the same problem: lack of viable provision of financing sources. This is because local telecommunications budgets usually do not specify the source between central allocation and local contributions. Furthermore, a significant amount of user-generated financing may never be accurately taken into account since it usually takes place at user's premises, such as investment for PBXs, key telephone systems, telephone sets, and other CPE equipment. In many cases, user financing is drawn from the general and administrative expenses, hence not accounted for as telecommunications budget.

Having defined the variable content, the following variables are compiled for the tests: financing (including central and local investments), and the growth index which includes three variables: industry revenue, switching capacity, and the number of telephone sets. The data collected for each variable between 1980-90 are displayed in Table 3.

Table 3 Variables for Data Analyses[14]
(1980-90)

Year	Investment(1)	Revenue(2)	Switching Capacity(3)	Phone Sets(4)
1980	6.2	13.3	4.4	4.2
1981	5.4	19.5	4.6	4.4
1982	6.8	20.4	4.9	4.6
1983	8.1	22.3	5.2	5.0
1984	10.8	25.0	5.5	5.5
1985	17.2	29.6	6.1	6.3
1986	17.2	28.2	6.7	7.1
1987	21.6	37.7	7.7	8.1
1988	26.6	59.6	8.9	9.4
1989	40.1	75.6	10.4	10.9
1990	49.2	102.4	12.3	12.7

Notes: (1) Including construction, manufacturing and services, in 100 million yuan. (2) In 100 million yuan. (3) Including urban and rural central office switches (automatic and manual); excluding PBXs and key telephone systems; in million lines. (4) In millions.

Sources: Economic Information & Agency, 1986, p.339; Liang & Zhu, 1988, p.13; Liu, 1989, p.56, p.59, p.62; Lou, 1989, p.14; Marketing Department of World Telecommunications, 1989b; MPT, 1990a, 1990b; Marketing Department of World Telecommunications, 1991; MPT, 1991b; Zhang, 1990; Development Research Center, 1991, p.2.

Several observations can be made from Table 3.

First, all four categories achieved double-digit growth during the decade, among which telecommunications investment had an average increase of 24.7 percent, followed closely by revenue, 24 percent. The table also shows that after 1986,

[14] During the 1980s, the exchange rate of Chinese Renminbi yuan with U.S. dollars was depreciated from $1 to 3 yuan to about $1 to 5 yuan. To accurately reflect the actual growth rate, the yuan is used in the study rather than the converted U.S. dollars.

the growth of all the variables becomes more rapid, and their patterns tend to be consistently upward. This is an indication of strong growth momentum.

Table 4 Growth Rate of Variables
(Percentage; 1981-90)

Year	Investment	Revenue	Switching Capacity	Phone Sets
1981	-12.9	46.6	4.5	4.8
1982	25.9	4.6	6.0	4.5
1983	19.1	9.3	5.1	8.7
1984	33.3	12.1	7.4	10.0
1985	59.3	18.4	10.6	14.5
1986	00.0	-4.7	9.6	12.7
1987	25.6	33.7	15.2	14.1
1988	23.1	58.1	14.6	16.0
1989	50.8	26.8	16.7	16.0
1990	22.7	35.4	19.0	16.5
Mean:	24.7	24.0	10.9	11.8

Second, the table shows a discrepancy in growth patterns between the independent variable investment and the growth index variables. For example, investment achieved the highest increase in 1985 over 1984 (59.3 percent), but the highest growth in revenue did not occur until three years later (1988, 58.1 percent), switching capacity four years later (1989, 16.7 percent), and the number of telephones five years later (1990, 16.5 percent). Although not exclusive, this lagged growth pattern seems to suggest a correlation between investment and industry growth (see statistical analyses later in this chapter).

Third, however, the table also indicates that changes in investment do not necessarily affect individual variables in a straightforward fashion. For instance, the flat growth in investment in 1986 has an impact on revenue in the same year (decrease by 4.7 percent), but it does not affect other variables significantly in the same period. Although the independent variable does not appear to have uniform causal effects on the growth variables, a univariate relationship seems to be embedded among three dependent variables. For instance, although not exclusive, a significant increase in revenue over time seems to correspond to the increases in switching capacity and the number of telephone sets, and vice versa. Such discrepancy in causal effects seems to imply the possibility of other variables that independently affect the growth that deserve further investigation. Nonetheless, it is quite evident that investment has the most prominent effects for the proposed variables.

These preliminary observations will help interpret the results of statistical analyses. Two analytical instruments are used running SPSS/PC+ (V3.0): linear regression with stepwise selection and correlation coefficients. Three types of analyses are conducted with investment as the independent variable, and industry revenue, switching capacity, and number of telephone sets as dependent variables. The main results are summarized in Table 5 (see Appendix A for complete testing results).

Table 5 Results of Regression Analyses of Investment on Growth Index Variables

	Revenue	Switching Capacity	Phone Sets
R Square	.962	.986	.980
F	230.160	631.709	450.369
T	15.171	25.134	21.222
Standard Error	5.729	.324	.422

One-tail tests. Significant $F \geq 10.56$ at $\alpha = .01$. Significant $T \geq 8.102$ at $p = .00001$.[15]

1) The effects of investment on the growth index variables can be derived from the three regression equations expressed as follows (cf. Appendix A):

$$Y_r = 3.45 + 1.89\ X_i$$

$$Y_s = 3.61 + .18\ X_i$$

$$Y_p = 3.41 + .19\ X_i$$

where X_i is investment variable, Y_r, Y_s, and Y_p are revenue, switching capacity and number of telephone sets, respectively. The slope parameters in all three equations indicate the level of increase in dependent variables as the result of changes in investment. In other words, the growth curve of revenue is much more upward than that of other two

[15] The standard values and references used in this section are drawn from respective tables in An Introduction to Linear Regression and Correlation (Edwards, 1984).

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dependent variables due to the level of investment. The results can be interpreted that if errors are ignored, then the regression equations explain that every yuan invested during the 1980s had about 1.89 times of revenue increase, 18 percent of increase of switching capacity, and 19 percent of increase of telephone sets. The equations also show investment has more direct effects on revenue than other variables in terms of growth scale. Moreover, the effects are partially confirmed by the variance explained in Table 5, 96.2 percent, 98.6 percent and 98 percent, respectively. This is a strong indicator of the crucial effects of financing on the growth index variables. Although a certain degree of mutual causality among dependent variables may well exist, such as revenue may affect network capacity, and switching capacity may contribute to the number of telephone sets, the values of variance explained (R square) should denote exclusively the degree of association with the independent variable since the three tests are conducted separately.

2) The relationships between investment and the growth index variables are significant, as indicated by both the F value and T value. The F values shows a high degree of fitness of regression between financing and the dependent variables. At the probability level of .00001, the correlations of all pairs are significant.

3) The low standard error in all three regressions also

support the existence of strong correlations between independent and dependent variables. This is especially evident in relationships between investment and switching, and between investment and telephone sets, that show low standard errors in contrast to the significant association.

Finally, the degree of association of above variables is further tested using correlation coefficients (Pearson's r). The coefficient matrix is shown in Table 6 (also see Appendix A). The results confirm the strong correlations derived by other statistical instruments discussed earlier. An interesting note is that the correlation between investment and revenue is slightly lower than the others. This may be interpreted that the industry's financial growth is more directly affected by the fluctuation of investment than is technology or "hardware," which depends more on the long-term effects of investment.

Table 6 Correlation Coefficients
Between Investment and Growth Index Variables

	Investment	Revenue	Switching Capacity	Phone Sets
Investment	1.000	.981	.993	.990
Revenue	.981	1.000	.984	.973
Switching Cap.	.993	.984	1.000	.998
Phone Sets	.990	.973	.998	1.000

One-tail tests at p=.001.

5.2 Tests of Lag-Time Intervals

The attribution of industry financing to growth is further tested using lag-time intervals. Regression in lag-time intervals was first used by Hardy in his study on the roles of telephony in economic development (see Chapter 2). The rationale of lag-time interval is to detect the sensitivity or effectiveness of associations by comparing them to the results under normal time series. Two lag-time intervals are used in this study, original time series on investment and t-1 and t-2 on the dependent variables. Then tests of linear regression and correlations are conducted for the new time series.

With t-1 interval, the data for independent variable remain the same as the original set used in the first test, but other variables are re-arranged with delay of one year. For example, the independent variable investment in 1980 is paired with revenue, switching capacity and telephone sets in 1981, investment in 1981 is then grouped with the dependent variables in 1982, and so on. The analytical instruments are the same as in the previous tests. The main results are summarized in Table 7 (also see Appendix B).

Table 7 Regression and Correlations in T-1 Intervals

	Revenue	Switching Capacity	Phone Sets
R Square	.938	.971	.965
F	120.251	263.264	222.752
T	10.966	16.225	14.925
Standard Error	7.440	.469	.559
Pearson's r	.968	.985	.983

One-tail tests. Significant $F \geq 11.26$ at $\alpha = .01$. Significant $T \geq 8.907$ at $p = .00001$. For r, $p = .001$.

The results show a rather uniform pattern of changes compared to the regression without lag-time intervals. The most important finding is that all statistics for significance of association, namely R square, F value, T value, and Pearson's r, are decreased, while the standard error in all relationships is increased. The results indicate that the correlations between financing and growth is decreased when the outcomes of investment are received in the following year instead of the same year. The t-1 time interval statistics also provide a close depiction of reality, where the annual growth should be derived more directly from the investment of the year than the cumulative effects of investments made in previous years. Although investment is usually made in the beginning of the year whereas the growth index is calculated after the year, they are still measured for the same year. Therefore, it may conclude that the closest investment on the time scale bears

the strongest effects on the industry growth.

The preliminary results are also tested in t-2 intervals. It is speculated that the effects of time intervals on independent variable may further decrease as intervals increase. Such speculation is confirmed by a series of regression on intervals of t-2, as shown in Table 8 (also see Appendix C).

Table 8 Regression and Correlations in T-2 Intervals

	Revenue	Switching Capacity	Phone Sets
R Square	.899	.968	.971
F	62.256	211.514	231.666
T	7.890	14.544	15.221
Standard Error	9.714	.488	.511
Pearson's r	.948	.984	.985

One-tail tests. Significant $F \geq 12.25$ at $\alpha = .01$. Significant $T \geq 10.103$ at $p = .00001$; $T \geq 7.885$ at $p = .00005$. For r, $p = .001$.

Some interesting discrepancies are derived from the tests. Except for the number of telephone sets, all dependent variables show a continually declined relationship with investment, particularly revenue, whose F value is decreased by nearly 50 percent, from 120.251 in t-1 test to 62.256 in t-2 test. The drastic decrease confirms the previous finding of a close relationship between revenue and investment. In addition, the T value for revenue is declined significantly, or becomes insignificant at the

probability lower than .00005. Consequently its standard error is increased substantially from previous tests. By contrast, changes in time intervals have opposite effects on the variable of telephone sets. Although not on a significant scale, all correlation values have changed upward, and their standard error is decreased.

The detected discrepancies seem to indicate that the growth of telephone sets contains a gradual and cumulative pattern. In other words, investment may have protracted effects on telephones compared to more immediate effects on revenue and switching capacity. It may further suggest that consistent and increasing investment be required if a continual growth of telephone sets is desired. Finally, switching capacity does not seem to be affected in any significant way by the changes on investment.

Several conclusions can be drawn from the statistical analyses presented in this section.

First, the close association between industry financing and growth clearly indicates continuing investment is the key to sustained growth. However, inference can be made from the statistical tests that such relationship is more contingent on the diversity of financing sources. The industry investment allocated from the central government increased only about five percent a year during the 1980s, much lower than the industry's double-digit growth rate during the same period. It is convincing that the

significant increase of investment must have resulted from increased number of sources instead of central budget allocations. The increase of local financing created a parallel growth pattern of investment contributed to the industry growth, therefore, constraints of central investment is significantly relieved.

Second, the magnitude of changes decreases with increment of lag-time intervals, namely changes in t-2 are smaller than t-1, and t-1 is even smaller than the normal time series. This indicates that industry financing would receive the greatest benefits during the same year when the investment is made. The benefits would gradually decline in different time frames.

Third, the discrepancies between normal and lag-time tests seem to imply that industry financing has distinct effects on different growth variables. For example, revenue seems to depend more on investment than that of telephone sets, while the latter seems to require a more consistent investment over time. This finding is supported by the regression slopes of investment on revenue. In the tests of normal conditions, the regression shows a positive relationship:

$$Y_r = 3.45 + 1.89\ X_i$$

As time series is changed to t-2, the regression becomes

$$Y_{r(t-2)} = -2.84 + 3.56\ X_{i(t-2)}$$ (cf. Appendix C)

The increment of slope values (from 1.89 to 3.56) strongly indicates increasing dependence of revenue on investment. Interestingly, however, such dependency becomes unstable as the time for the variables becomes distant, as shown by a negative intercept in the equation for t-2, indicating the effects of investment on revenue are strong and sensitive.

The finding bears important implications in policy making on investment priority, scales and allocations. For instance, the delayed effects of investment on telephone sets suggest investment priority should be given to increase of switching capacity, which will promote telephone sets to increase as more lines become available. Likewise, an emphasis on switching capacity can also boost transmission capacity, the network backbone whose growth must be equitable to the increase of switching capacity and traffic.

Finally, the variation discrepancies among dependent variables are not sufficient for conclusion that financing has contradictory effects on growth in delayed time series. In fact, the correlation between investment and all dependent variables in the t-2 conditions is still significant, even though not as uniform as in the t-1 tests. Such discrepancies should be considered normal given the characteristics of the industry. In a comparable context, the changes in revenue are usually more direct and less

ambiguous to investment than that in the hardware, which must have basic construction, systems installation, and maintenance before any tangible benefits can be created. Therefore, in a straight sense, the time spent on preparation does not directly reflect the benefits of investment. The results from statistical analyses seem to confirm the protracted growth patterns of hardware in reality.

5.3 Discussion of Methodology

Despite the difficulties in verifying financial sources, the results of statistical analyses in this chapter hold valid, and the contribution of diversified financing to telecommunications growth is well presented. Although accurate figures of local financing cannot be extracted for the time frame under study, the approximate share can be obtained from Table 1 in Chapter 3. And the basic assessment can be made that the share of local (including self-raised) financing in telecommunications investment increased steadily during the 1980s, and its share in the total investment surpassed that of the central source (50 percent vs. 32 percent). As discussed before, central investment is made based on the national annual budget, which remained in the past 15 years at about one percent. This ratio is widely considered too low compared to budgets

allocated to other economic sectors such as manufacturing, transportation, and energy, for an obvious reason that an inadequate communications infrastructure will seriously impair other sectors' growth. Although central investment for telecommunications was accrued as the total budget increased, the increments had been slow and far behind the basic requirements for sustained growth. As disclosed by an MPT official, the minimum investment requirement for basic construction and systems development is about 5 to 6 billion yuan a year, but the budget availability is only about one tenth of what is needed (Hao, personal communication, 1990).

The local telecommunications financing, by contrast, has increased significantly since the mid-1980s. Although it is difficult to quantify local financing as a proportion of total investment, its significant increase can be explicated from several aspects.

First, since the mid-1980s, the number of local projects have increased rapidly. By far, more than 50 percent of total telecommunications projects are carried out at local levels (Pyramid Research, 1988). Meanwhile, according to the new policy, the financing responsibility has shifted from the MPT to local bureaus except for trans-national networks. This has resulted in a drastic increase of local financial sources. In Guangdong (Canton) province, for example, between 1980 and 1987, central allocation from MPT decreased sharply from 60 percent to only three percent;

during the same period, user-raised funding increased from zero percent to 23 percent, and local bureau funding increased more than 30 times (Yang, 1989). The experience in Guangdong is also seen in Shanghai, the largest industrial city in China, where 60 percent of telecommunications budget is from self-raised funds (Wu, 1990). Since the new financing policy also entails transfer of administrative power and direct economic benefits, it has greatly facilitated local telecommunications projects.

Second, the evidence of increased local financing can be inferred from the statistical tests. For example, in the condition of normal time series, the three regression equations

$$Y_r = 3.45 + 1.89\ X_i$$

$$Y_s = 3.61 + .18\ X_i$$

$$Y_p = 3.41 + .19\ X_i$$

indicate that if X_i (investment) became zero, there would be some growth of dependent variables, as indicated by the three intercepts, which can be interpreted to an increase of 345 million yuan, 3.6 million switching lines and 3.4 million telephone sets a year. This finding confirms the existence of other financing sources not shown in current investment data but contributed to the industry growth. It also indicates that the investment information collected in

this study does not include all the sources given the government accounting methods. This confirms the earlier speculation that many user financing sources are often overlooked by the current accounting method. It also indicates that telecommunications investment in China contains a wide array of sources.

For these reasons, it can conclude with strong confidence that China's telecommunications investment contains a significant amount of local/user financing. Therefore, the investment variable used in statistical tests can also be considered as an index of diversified financing, which includes central investment and other domestic financial sources, such as local governments, enterprises, bank loans, and users. This mixed financing scheme contributed to the remarkable industry growth in the 1980s. Statistically, if local financing were extracted from the current data set, similar patterns in regression and correlation should be derived since the share of local financing increases apace with total investment.

Another concern for the methodology is mutual causation. As addressed in other studies (cf. Chapter 2), it is usually difficult to determine exclusive effects of independent variables on dependent variables, given the complexity of industry processes and external forces such as social contexts (Hudson, et al., 1983). Usually, if relative exclusivity in causation cannot be established, the

relationship is considered in low validity.

There seems to exist mutual causation in the current case, namely, not only does diversified financing cause increases in the growth index variables, but the industry growth also drives increases in financing. However, the effects of mutual causation do not present severe damages to the findings when the actual industry process is taken in account. The industry input and output process is usually cyclical, i.e., investment is fueled by industry growth to be able to provide financing for the subsequent growth. If there were one-way causality, the industry process would become disoriented, and its contribution to the economic development would deteriorate over time. Hence, the exclusive causation, if arbitrarily established for the reason of mutual causation, will produce false results since it provides a distorted depiction of the actual process. This argument, however, does not suggest that a leading causality cannot be established. In fact, results from lag-time interval tests point to the existence of leading causality: except for one case, the degree of association between independent and dependent variables is decreased as time series are changed to the intervals of t-1 and t-2. This could conclude that the effects become weaker when the time between variables becomes distant. Therefore, the analyses have well served the research objective, i.e., financing is critical to, and a leading catalyst for the

industry growth.

In conclusion, despite lack of specified data on the investment, diversified financing significantly relieved investment constraints by supplementing central investment. Increased investment contributed to the industry growth, as confirmed by the level of growth and correlations.

CHAPTER 6

DISCUSSION TWO: FINANCING AND COMPETITION

China's telecommunications is a strictly regulated industry with a state-protected monopoly. For a long time, the rationale and policy for such a centralized regime were inherited from the country's political and economic systems established since 1949, that a central system and planned economy could effectively maintain political stability and utilize national resources. From this historical viewpoint, it is apparent that the changes of the current industry regime essentially rely on the general changes in society.

This is exactly what the telecommunications industry experienced in the 1980s. The economic reform and open-door policy since 1979 have altered the country's agenda, from rigid political ideology to appreciation of economic development and market principles. The reform has also facilitated changes in telecommunications by restructuring the industry administration and reforming policies in network management, pricing and financing. The restructuring has created ripple effects in the industry. The financing responsibility has become decentralized and

diversified between central and local sources. Sector competition also has gradually emerged in national and local markets. This chapter will discuss the forces behind competition, forms of competition, and relationships between diversified financing and competition.

6.1 Industry Restructuring

For over 30 years, telecommunications in China was operated by a hierarchical structure. On the top of the hierarchy is the Ministry of Posts & Telecommunications (MPT); its various departments and committees controlled corresponding operational branches in provinces and cities. Such a tightly controlled structure had made the MPT a colossal monopoly in China. Although the centralized regime made commensurate contributions to the early development in the 1950s, it had gradually become unwieldy as the industry quickly expanded and the demand soared. By the early 1980s, the old regime had shown signs of inability to effectively lead the industry, restrained essentially by severe fund shortages (Lerner, 1987b; FCC Week, 1987; China Market,

1988).[16]

Beginning in 1985, the MPT implemented a series of policies restructuring its administration and operations. The restructuring has brought about two important changes that create new dynamics in telecommunications market: the breakdown of the MPT monopoly in technology and manufacturing, and new working relationships between MPT and its local bureaus.

1) Under the new policy, the MPT's primary responsibilities are regulation, research and development (R&D) and administration. The MPT waives its direct control over manufacturing to a newly formed industry group, the China National Posts & Telecommunications Industry Corporation (PTIC) (Jing, 1986). The PTIC is a semi-independent holding company consisted of 27 communications equipment manufacturing companies that were formerly MPT affiliates, and ten communications professional groups, specializing in microwave, fiber optics, telephone systems, video technology, mobile communications, as well as office automation, rural communications, and postal machinery. The

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[16] Exposure of problems in telecommunications is rare in government controlled media, but complaints of the inadequacy of industry structure can still be seen from various sources, such as Wang (1984), Zhang (1986) and the Development Research Center report (1991). A recent article (Chen, 1991) goes so far as to argue that benefit equity among different administrative layers should become incentives for local investment. He also argues that social and economic benefits should override the structural concern for higher efficiency.

PTIC employs more than 40,000 people, 20 percent of whom are technical personnel (World Telecommunications, 3:1, 1990).

These new enterprise groups are virtually detached from MPT's clumsy hierarchy with considerable autonomy in investment, technology and management. More important, a new form of industrial alliance has emerged from industry restructuring, which has further disintegrated the MPT's monopoly.

The MPT is not the only player in China's telecommunications market, there are other ministries that manufacture and operate large-scale private networks. There are two reasons for such divisions. One is historical. Like the MPT, each ministry has established a self-contained hierarchy so that they can protect their territory and do not have to intrude on others' turf. Moreover, a strong ministry has great advantages in negotiating annual budget with the central government, which often is the key to their growth. The other reason is technical. A number of ministries have special operations that require full scale and efficient communications systems. The Ministry of Petroleum Industry, for example, controls 15 satellite earth stations linking on-shore oil and gas production with voice and data transmission (Lerner, 1987b). The Ministry of Defense and Ministry of Railways also require uninterrupted communications with remote sites. Special communications may be jeopardized if managed by public network utilities.

Therefore, over the years these ministries have built immense networks for internal use. They have also attained adequate manufacturing capability and technical expertise. Nonetheless, as the result of territorial autonomy and strict control for public access, much of the capacity of some private networks is underutilized (Zhou, 1990).

One of the goals of the newly formed groups is to streamline manufacturing capability and technical expertise formerly retained by different ministries, or "horizontal alliance," as it is commonly called. For example, the Microwave Communications Group of PTIC has teamed up with Ministries of Water & Power, Coal, Petroleum, and Radio & Television to make microwave equipment and provide technical services (Lu, 1987). The industry restructuring has had manifold consequences. In addition to cross-territorial cooperation, horizontal alliance has been able to create higher investment and promote better applied research. As a result, it has improved industry efficiency, generated greater profits, and obtained a better position in advanced technologies (Lu, 1987).

Ironically, the horizontal alliance was initiated by the MPT to reform the industry structure, but the new industry groups have soon posed serious challenges to the MPT's central control in production, marketing, and technology, and spawned competition in the marketplace. To a certain degree, the horizontal alliance has fundamentally

changed the market dynamics, from one supreme center to many parallel industry groups. Although theoretically the MPT still owns these groups (e.g., through the PTIC), the network management responsibility and decision-making have been shifted downward significantly. The decentralized sector market encourages multiple entries, which inevitably has fostered competition across the MPT and other ministries. The gradually decentralized industry will be the key to many changes in the market in the future.

2) If the horizontal alliances are to break ministerial boundaries, then the vertical overhaul within the telecommunications industry has encouraged competition from local bureaus.

Restructuring within the MPT is driven primarily by lack of central funding for local projects. In the mid-1980s, the industry financing felt a pinch with increasing demand for central budget from other industries, coupled with the rapid sector expansion which needed consistent and long-term investments. With slow increments of central investment, the MPT decided to resort to local financial sources, particularly in provinces where the economy was thriving and had great potential in communications for trans-national and inter-province networks.

China's domestic networks consist of four tiers (Liang & Zhu, 1988). Parallel to Table 2 in Chapter 3, the network configuration is hierarchical. The first tier is inter-

provincial (including trans-national), which handles major voice and data communications across the country. The second tier is provincial centers which switch primarily intra-provincial traffic (inward traffic). The third tier is inter-country/city. And the fourth tier is county/city exchanges to terminals. Both the third and fourth tiers handle local calls (similar to intra-LATA traffic in the U.S.).

The streamlining between the MPT and its local bureaus calls for self financing essentially for the second tier (intra-provincial networks) and downward. These networks are designed for local and long distance traffic taking place within a local area, and in many ways can be considered as "offshoot" networks from the first tier. In the past, all these local networks were funded exclusively by the central investment which had little incentives to local operators and worse still, it caused the slow growth of local communications networks. As explained in the previous chapter, the central investment for local networks has steadily decreased since the mid-1980s, and the share of local financing has increased significantly. In fact, since the late-1980s, the MPT has literally frozen funding for local projects, giving full financing and management responsibilities to the local bureaus (People's Daily, February 10, 1988; Hao, personal communication, 1990).

The diversified financing policy has significantly

changed the market dynamics as a result of increasing competition.

First, MPT's administrative power has been reduced. Under the new policy, MPT is responsible only for the first-tier projects, some second-tier projects (connected to the first tier), major manufacturing facilities, R&D, and technology transfer to its direct affiliates. Although the MPT still has the commanding power over major telecommunications projects, it has gradually transferred day-to-day operation responsibility to local bureaus.

Second, as a result, local bureaus are motivated to take control of local infrastructure. With increased local financing, the quality of local networks and services have been improved and more responsive to local needs, thus making investment more effective and profitable. Moreover, high local motivation has had tremendous impacts on acquiring advanced technologies that used to be strictly controlled by the MPT, such as through imports. Not surprisingly, motivated local bureaus are strongly supported by local governments, many of them, whom local bureaus directly report to, are convinced that an improved communications infrastructure will promote local economic and social developments; such understanding has made local budget allocated to telecommunications far higher in

proportion than that from the central government budget.[17]

Finally, the domestic market has become vigorous and segmented. In the past, there was only one supplier, the MPT, in China's telecommunications market; the decentralized financing policy has encouraged new entries in both national and local markets. For example, a market study found that local bureaus have about 57 percent of China's $720 million telecommunications market, compared to MPT's 14 percent and 12 percent of private (ministerial) networks (Pyramid Research, 1988). The segmented market, in turn, has presented new opportunities for new entries which has further stimulated competition. Although the MPT is trying to impose its influence as the supreme regulator, the trend seems irreversible that China's telecommunications market is being driven and benefitted by competition.

6.2 Intensifying Competition

At present, there are two forms of competition in China's telecommunications market: MPT versus non-MPT and MPT versus MPT affiliates. Ironically, both forms of competition stem from industry restructuring aiming at consolidating marketing forces. The former is the result of the horizontal alliance, and the latter is from increasing

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[17] The strong local commitment can be found in Zu (1989), Zhang (1990), Meng (1991), and has been acknowledged by the MPT (Liu, personal communication, 1990).

local autonomy. Competition concentrates on the most profitable equipment manufacturing sectors, such as PBXs, telephone sets, accessories, and medium capacity transmission equipment.

As mentioned before, ministries that need private communications systems have substantial capacity in research and manufacturing. Horizontal alliance has stimulated rather than subsided their power in an open and competitive market. Their technical and financial strength has made them full-fledged competitors of MPT, even in some highly sophisticated technologies such as high-capacity central office switch, fiber optic cable, and digital microwave systems. In the SPC PBX market, for example, of 99 TDM (time-division multiplexing) and SDM (space-division multiplexing) PBXs registered at MPT between 1986 and 1989, about 45 percent were manufactured by non-MPT companies (excluding direct sales by foreign companies). They include the Ministries of Defense, Machinery and Electronics Industry, Aviation and Space, local companies, and joint ventures (Marketing Department of World Telecommunications, 1989a). A recent report indicates that the PBX market is the strongest sector in China, which provides convenient access for local users, is inexpensive, and easy to install and maintain. The strong demand for PBXs has been the main impetus for competition, despite MPT's protective regulations such as licensing PBX manufacturing and network

entrance (Xu, 1991). This is a good example about confrontation between market forces and central control: market demand stimulates competition, which in effect defies central control.

Competition is fierce in less regulated product categories, such as terminal equipment (including telephone sets, data terminals, other peripherals and components). Because terminal equipment requires less technical sophistication, has high demand, and is very profitable, it is especially attractive to local companies. As a result, the terminal market has been flooded with products made by non-MPT companies. For example, by the end of 1990, there were 75 telephone manufacturers nationwide with an output of 6.5 million sets a year. Among them, the market share by non-MPT companies increased to more than 60 percent, whereas MPT had lost its market almost totally, from nearly 100 percent in the early 1980s to less than 10 percent in 1990 (Wang, 1991). The non-MPT companies (mostly joint ventures) are more innovative in design and aggressive in marketing. They are also more efficient than the MPT-controlled companies with much shorter turnaround time (Marketing Department of World Telecommunications, 1991).

Competition has emerged in other sectors as well, such as cables, switching and connection components, interface circuits, among others. These sectors used to be dominated by the MPT, but now opens to virtually all capable

manufacturers certified by MPT (Sun, 1990). Competition has provided great incentives for many mid- and small-sized companies, since much of the profit can be retained and reinvested by these companies rather than given to the MPT. A competitive market has also stimulated demand in the society (see Chapter 7 for detailed discussions).

An important aspect for understanding competition with the MPT is the growing autonomy among local telecommunications bureaus. Traditionally, local bureaus are both subsidiaries of the MPT and managed by local governments. In many cases, the latter provide more funding for local projects than the budget distributed from the MPT. Such a dual relationship has made bureaus closer to local governments and somewhat autonomous of MPT in Beijing. The local bureaus, for example, may initiate projects without prior approval by the MPT especially when the project is locally funded and located in a specific area. As the number of local projects expanded rapidly during the 1980s, local autonomy also increased significantly. Two underlying factors have contributed to the increase of local autonomy. First is profitability. The increased local share is driven primarily by higher returns of telecommunications services where a bureau is a monopoly in a locality. The second factor is management. All China's 30 provinces and more than 400 cities have telecommunications bureaus with tens of thousands of operating offices throughout the country; it is

virtually impossible for the MPT to manage these bureaus on a regular basis. Since major local bureaus such as Beijing, Shanghai, Guangzhou (Canton), and Fujian have considerable capability in manufacturing and technology, not only do their products become competitive in quality and price, they are also actively engaged in direct imports and joint ventures. The strong economic growth has increased their foreign currency reserve, and their markets are very attractive to foreign companies. Although all technology transfer must have MPT's approval, many projects are initiated and financed exclusively by local bureaus (see Chapter 8).

However, competition in China's telecommunications market is still a nascent phenomenon, and its scale is small. Compared to telecommunications markets in other countries, competition in China should be understood as a relative concept. In fact, most of MPT's competitors are still state-run enterprises and subject to regulations imposed on state businesses. In addition, although competition has effectively broken down MPT's monopoly in some sector markets, the MPT is still a formidable giant in major product markets that require hefty investment and technical expertise, such as satellites, cellular telephones, and fiber optic networks. Above all, MPT controls all public networks across the country and all communications services that generate most of its revenues.

MPT's dominance in these areas is unlikely to dwindle in the near future.

The MPT's power is also reflected in administration and regulations. Like most developing countries where PTTs are both the carrier and regulator, there is no independent regulatory entity in China like the FCC in the U.S.; the MPT regulates its own activities. This gives MPT tremendous power over almost all aspects of the industry. For example, MPT can set regulations against competition by imposing strict application and inspection procedures, high licensing fees, and designating markets for product sales. In fact, the most competitive markets discussed in this chapter are those where the demand has outgrown the supply, and the MPT can no longer accommodate it alone, therefore it unwillingly relinquished its monopoly to competition.

Although the MPT still dominates many market segments, the scale of competition increased significantly during the 1980s. Given the current industry structure and financing scheme, competition is irreversible and its impacts on the market dynamics will likely continue. The segmented telecommunications market encourages new entries; meanwhile, the market profitability and high demand will continue to attract competition. Finally, if the economy retains its current growth momentum, then the industry regulations will continue to be lenient toward competition since it can significantly promote industry growth.

6.3 Diversified Financing and Competition

Competition is the outcome of new financing policy. As previously mentioned, a single financing source could ill afford the rapid expansion of telecommunications in the mid-1980s. Diversified financing was devised to alleviate the investment constraint of the central government. This has given tremendous incentives to local and non-MPT companies. As the result, the local share of sector market, network construction, and technology advancement has increased significantly. Diversified financing also has opened the market for new entries, particularly in the local market where companies can now sell their products and services for a profit. To a great extent, the decentralized financing scheme has spawned competition with the MPT.

However, it should be remembered that competition in China is in the context of a socialist system which mandates central planning and equal distribution of social wealth. Sector competition in telecommunications will help finance the industry, but its role in the economy should be evaluated carefully as long as central planning and state ownership still prevail in the country. The economic reform is an exploration of alternatives to vitalizing the socialist economy, it is by no means a surrender to the market economy, at least for the current leadership. Therefore, although diversified financing has encouraged

competition, it is premature to predict that sector competition will invoke greater deregulation throughout the industry. In fact, the recent trends show that as the competition has expanded, the resistance from the MPT is escalated by trying to suppress the scale and impact of competition using its political, legal and technological power. The State Council, for instance, has promulgated repeatedly that MPT's supreme administration in China is indisputable, competition must be subjected to MPT's policy, control and coordination (Zhou, 1990; World Telecommunications, 4:1, 1991). It is apparent that the diversified financing has made little impact on diluting the state ownership of China's telecommunications.

Furthermore, given China's scarce telecommunications resource, competition must be able to provide more optimal use rather than dilute it. As noted by Saunders (1983), a government monopoly may generate high profits in excess demand. This seems to imply that competition may not render optimal use of resources that are always in short supply in developing countries. In actuality, however, government bureaucracy, overlapping companies and planning may undermine the claimed potential of government monopoly, especially when faced with financial constraints (Wellenius, 1984b). Although these studies could not foresee the industry privatization in some developing countries soon after, the fundamental principles of optimal scale still

hold. China's experience seems to confirm this assertion. If diversified financing were to lead mixed or multiple ownership, then unruly competition could cause repetitive construction and services. The service cross subsidy would give way to profit-driven price hike. The consumer would have to absorb the cost by competition, aggravating the inequality of telecommunications development (Zhou, 1990). These concerns are reasonable for big countries like China whose priority is to provide universal services for the majority in the society.

Despite these concerns, competition also can promote industry growth, as it explicitly showed in the 1980s. Competition has created a vibrant and progressive market with multiple entries to bolster industry expansion. Competition has provided more opportunities for consumers in an increasing demand. Moreover, sector competition has reduced product prices and improved quality rather than the opposite as speculated. Most of all, competition has generated profits for many small companies, a great incentive for reinvestment. The motivation driven by new opportunities and profitability will continue to expand the local share of industry financing, which in turn will encourage competition. Since the market is now influenced by many financial sources, many of them are strong and far from MPT's reach, competition will become more difficult to quench but continue to grow.

The complex relationships between diversified financing and competition present a true dilemma for China's telecommunications industry. On the one hand, diversified financing is initiated by the MPT to alleviate severe investment constraints. The industry will have to rely on a variety of financial sources in order to maintain an adequate growth rate. Diversified financing will likely continue as the basic financing policy in the 1990s (Yang, 1991). On the other hand, the impacts of decentralized financing have exceeded compensating investment, it also has created new market forces that seem to drive the industry to the direction opposite of government intention. As the experience in the 1980s shows, diversified financing reduced central control in planning, management and pricing, especially at local levels, which led to sector competition. The financing dilemma is also a challenge to the MPT in policy making. If the diversified financing policy remains but is carried out with strict MPT supervision, it will provide lower benefits for the local companies, hence lower incentives for their commitment to industry financing. With reduced local investment, the market growth will become stagnant which will also discourage demand.

The future prospects of diversified financing and competition will continue to be a challenge to the MPT and its roles in the industry. The MPT appears to be in great favor of the current financing scheme, but threatens to

regulate competition for any undesirable consequences. Since there are no viable solutions to the dilemma, it is likely that MPT will try to manage both ends to maximize the benefits of diversified financing while reducing the negative aspects of competition. The effectiveness of such a compromising policy may be questionable as new technologies and services are emerging rapidly, and competition will inevitably take different forms and greater magnitude. It is anticipated by this study that sector competition will continue to grow as the local financial shares increase, but the industry will manage a state of coexistence between competition and MPT's central control. The prospect of complete decentralization caused by competition is unlikely to occur in China, although it has been a successful experience in some developing countries.

CHAPTER 7

DISCUSSION THREE: FINANCING AND DEMAND

Demand for telecommunications service (primarily telephone service) in China is high and largely unmet. As identified by most studies, high telecommunications demand is a prominent characteristic in many developing countries. The main reasons are twofold. Technically, network capacity and telecommunications service are constantly in undersupply, making most demand unfulfilled. On the other hand, increasing awareness of the economic and social benefits from telecommunications services keeps the demand persistent.

The relationship between financing and demand entails a number of dimensions affecting the industry growth. In many respects, the high and unmet demand is persistent to the service supply; on the other hand, it puts tremendous pressure on network capacity, diminishing the potential benefits of telecommunications services. This chapter analyzes the basic characteristics of telecommunications demand in China, and its relationships with industry financing, competition and services. Finally, the chapter

discusses the future prospects of demand.

7.1 Sources of Demand

The high demand for telecommunications services stems directly from the economic reform. Increasing commercial and social activities greatly stimulated communication in the society, particularly among urban businesses and residents. In spite of strong growth of more than one million switching lines every year and about the same number of telephones connected to the public networks,[18] the demand in most urban areas is still soaring at a very fast pace. According to the MPT, there are long waiting lists for telephone services in all major cities. In 1988, there were 480,000 requests for telephone lines nationwide. Despite 770,000 new telephone numbers were issued in 1989, the waiting list was escalated to 520,000 (MPT, 1990b). The similar pattern occurred in 1990: with 980,000 new numbers issued, new requests were doubled to well over one million (Li, 1991). The actual demand can be much higher since most requests in rural areas are unrecorded or ignored. Even for the urban areas, a million requests are considered low for

[18] The growth of telephone sets is much greater if those on local loops are also included. Typically, a PBX or a key system can switch up to 200 access calls in a local area, and route outgoing calls to the public networks.

over 400 cities and about 80 million urban households.[19]

Moreover, the distribution of recorded demand is highly concentrated in the urban areas: the urban population, which is about 25 percent of the total population, constitutes more than 70 percent of demand. The excess demand is so high that the effects of supply diminish quickly despite the growth rate of a million-line per year. The pattern of the high demand is unveiled by a recent World Bank-China joint study. As shown in Table 9, although a significant number of new lines were issued between 1983 and 1989, the service requests remained high.

Table 9 Growth of Excess Demand in Selected Areas

		1989	1982	Change
Beijing	Requests	77,686	23,779	2.27
	New Issues	39,845	6,748	4.90
Shanghai	Requests	98,859	23,297	3.24
	New Issues	65,352	7,016	8.31
Guangdong	Requests	149,983	5,185	27.93
	New Issues	139,647	6,681	19.90

Source: Development Research Center, 1991, p.5.

[19] The waiting list only reflects demand from those who have submitted a request. It does not show, however, the number of households that want the service. Typically, an urban resident may wait for years for a phone line installed. Frustrated by long waiting periods, many simply do not make the request.

The table shows that the urban excess demand remained strong despite the significant growth in telephone service during the 1980s. The table also shows that demand in Guangdong has grown more rapidly and outweighed supply with substantial margins.

According to the same study, during the 1980s, the telecommunications capacity (switching and transmission) could only accommodate about 50 percent of total demand (Development Research Center, 1991). Even by the most optimistic prediction that China will have 33.6 million telephones by the year 2000, the nationwide density will still as low as three percent. This translates to continually high and unmet demand and there seem no effective solutions in the near future.

An interesting trend about the urban demand is the growing number of residential telephone households. In Beijing, for example, requests from residents in 1990 made up more than 60 percent of the total waiting list. Nationwide, residential telephone constitutes more than 25 percent of total telephones in service (Marketing Department of World Telecommunications, 1991).

In addition to demand for telephone services there is also demand for access. To alleviate the demand for access, many business users have installed PBXs for local communication, typically in office complexes or residential areas. The SPC PBXs are very popular among large

organizations because they improve user productivity and reduce reliance on public networks for local communication. As the result of increasing local access, the traffic load on the public networks has increased significantly when a large number of outbound calls are switched onto public networks that are already operated in peak conditions. Repetitive attempts for access further aggravate line congestion, causing the completion ratio (complete/call) for local calls (intra-city) at only 60 percent during business hours (MPT, 1991b). The ratio for long distance calls is even worse, only at 20 percent (Zhou, 1990).

Demand in rural areas is also on the rise. The rural demand comes primarily from mushrooming enterprises in non-agricultural sectors, such as manufacturing, processing industry and exports, as well as from some residents. As more rural population are engaged in trade with urban markets, communication with cities as well as among themselves has increased substantially. Although the rural demand is relatively lower than urban areas, its large population makes the demand a potential financial source for telephone services. At present most rural telephone systems use step-by-step (manual) and crossbar (semi-automatic) switches compared to SPC switches (fully automatic) employed in urban networks. Although voice communication load in most rural areas is still low, such system provision may soon become inadequate as the rural demand is expected to swell.

The high and unmet demand in China has several negative consequences. It keeps high pressure on network capacity, aggravates communications overload; as a result, it undermines the potential benefits of telecommunications services. It also becomes persistent to supply and price, a recurring problem in many developing countries.

7.2 Characteristics of Excess Demand

The drastic increase of residential demand for telephone service is a strong indication of increasing recognition of its economic and social benefits. This confirms the previous studies that telecommunications services yield relatively greater benefits in developing countries than in developed countries (cf. Chapter 2). Although some research found it difficult to establish consistent measurements for the benefits in society (Hudson, et al., 1983, Pierce & Jéquier, 1983), studies by the Chinese suggest the benefits are significant and can be measured by real terms such as money and time.

One of the first studies conducted by the MPT in 1988, for example, found that every 100 million yuan investment in telecommunications could yield 1.4 billion yuan in return in ten years (MPT, 1988). Using computer simulation the study also found that 76 percent of long distance calls could replace business travel, and 92 percent of local calls could

substitute for intra-city transportation.

The benefits of telecommunications are also confirmed by a recent study. Entitled "Report on Development Relations between Transportation Industry and Telecommunications," the study found that about 60 percent of passenger travel is information based (meetings, negotiations, etc.), and 35 percent of it can be replaced by telecommunications. The savings on transportation expenses and time is 12 times when using telecommunications services, or about 20 billion yuan a year (China Science and Technology Association, 1991).

Apparently the economic and social benefits of telecommunications are positively related to the economic development. The Special Economic Zones (SEZs) in Guangdong (adjacent to Hong Kong) and Fujian (across from the Taiwan Straits), for example, have achieved remarkable economic growth and higher quality of life than the most parts of the country. The density of telephones in these regions is also the highest in the country. Shenzhen, one of the SEZs in Guangdong, has a telephone density of 30 percent compared to Beijing, the capital, of about 16 percent. The perceived benefits also prevail among the rural population. By 1987, more than 36,000 farm households installed telephones even though the density is still very low, at .15 percent (Li, 1987).

The perceived benefits are also reflected in an

increasing number of calls. In 1985, there were an average of 65 million calls a day nationwide. By 1989, the daily number had soared to more than 100 million calls. Increased call volume may be a result of increased telephone sets and access; it also shows increasing reliance on telephone for business and personal activities. For example, the author's observations in 1990 found telephones were gradually replacing face-to-face contacts in personal and commercial communication, especially in cities where telephone penetration is relatively higher.

The perceived economic and social benefits often override the costs for obtaining telephone service, making the demand persistent. As revealed by studies on telephone's benefits in developing countries, some people may not have overwhelming needs for telephone communication, but their concerns about emergencies become a compelling motive to obtain the service, even though such occasions may be rare (Pierce & Jéquier, 1983). The benefits of life or property rescue are perceived more than just an extension of personal or community contact. This conclusion can certainly be extended in many developing countries where a telephone is perceived to fulfill very important roles. The cumulative and sometimes indirect benefits seem to surpass telephone's conventional functions as merely a substitute for personal contacts. The overwhelming social perception is the major reason for the excess demand insensitive to

service price.

As discussed in Chapter 3, for more than 30 years, telephone services in China (including installation and access) were heavily subsidized by the government. The price was determined arbitrarily and did not reflect the true costs. Since the early 1980s, central government has gradually reduced its subsidies on services. Meanwhile, the relaxed telecommunications market and diversified financing policy have put financial responsibility on service providers such as local bureaus and carriers. As a result of self financing, the price for telecommunications services has increased significantly. For example, since 1990, the Beijing telecommunications bureau has increased the installation fee from about 500 yuan to 5,000 yuan, and the monthly charge from 14.4 yuan to 20-36 yuan (Yi, 1990). Interestingly, the large-scale price increases do not seem to repress telecommunications demand in China. Wenders (1987) noted that telecommunications demand is determined primarily by the price of usage, under the assumption of cost and benefits. In the case of China, however, the demand seems to be driven more by the perceived benefits than the price charged for receiving such benefits; therefore, despite the price hike the demand continues to rise, as shown in Table 9.

In addition to perceived benefits, improved economic conditions and quality of life also contribute to the

inelasticity of demand. Before the 1980s, few people could afford even the heavily subsidized services. The economic reform has increased income in most households, improved living conditions, and stimulated communications needs.[20] As a result, people have higher purchasing power for expenses other than livelihood items, such as telephone services. Although there are no public opinion data available about the price hike, it is quite obvious from the influx of requests that the majority, particularly urban residents, still believe that having telephone service is a good investment and are able to buy the service.

The willingness to pay high price for telephone service is very common in developing countries (see Chapter 2). In some countries, people are willing to pay the price that is disproportionally higher than their regular income can afford (Hudson, et al., 1983; Saunders, et al., 1983), as compared to developed countries where demand is elastic to price determined by the supply-demand equilibrium. This indicates that perceived benefits from telecommunications are much higher in developing countries, so high that price becomes secondary in many people's decision making, causing the demand persistent.

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[20] During the 1980s, the national per capita income increased from 376 yuan in 1980 to 1,300 yuan in 1990, or 2.5 times. Income for non-agricultural workers in 1990 was 2,150 yuan, agricultural workers 630 yuan. During the decade, the real consumption increased at an average of 5.9 percent per annum (Mackerras & Yorke, p.170, 1991; People's Daily, March 22, 1991; Zou, 1991).

Does the insensitivity of demand mean that the market price is yet to reach the optimal level in the supply-demand equilibrium? Can price for basic telephone service continue to increase? If the price continues to rise until to the level of market acceptance, then the excess demand may decline, and the tension between supply and demand may be reduced. However, decline in demand also means few people will be interested in, or can afford, the telephone service, despite its potential benefits. As the telephone network becomes slow in expansion, its economic benefits will diminish because the latter essentially are based on the externality of the service. As Artle & Averous (1973) have convincingly argued, the more people connected to the network and engaged in communication, the higher benefits the system will deliver. Their study implies that the effective solution lies in expanding access, rather than increasing price, to resolve the persistent demand.

Furthermore, the continual growth relies on the extent of telephone services. Excess and persistent demand translates to a large pool of public funds that can be used for network development. Such user financing sources would likely disappear if the price is set too high in attempts to reach supply-demand balance. Since telephone services in China are gradually decentralized and become self financed by the local carriers, they can hardly maintain if the subscriber base is limited caused by the price hike and

diminishing demand.

7.3 Industry Financing and Demand

The high and unmet demand exerts tremendous pressure on the current network capacity, causing serious traffic congestion and diminishing economic and social benefits. The demand is also pushing the MPT and local service providers to find alternatives to increasing supply, which must go beyond simply raising prices. The ultimate solution seems to lie in new market dynamics that can create a more vibrant supply market.

The discussion of excess telecommunications demand in China confirms the essential argument of this study: financing is the most critical bottleneck of industry growth; it is also the ultimate reason for the high and unmet demand. Since the central government is no longer able to provide sufficient funding, industry financing has been decentralized and diversified. As a result of the new financing scheme, competition has intensified for achieving higher profits.

In many respects, the strong demand is the outcome of an increasingly competitive market. With the local carriers now having financial power and service prices being used as an important financing pool, the service is growing steadily. Despite the growing demand, it is more likely now

than ever before for average households to obtain telephone services. The increasing service availability has greatly stimulated social demand. Higher family income has further reinforced the demand.

Therefore, the key aspect in the relationship between financing and demand is competition which is also directly related to diversified financing. This argument is supported by the following reasons.

First, by far a large portion of industry investment, particularly in local construction and services, comes from the government, collective (enterprises and loans) and private sources. Increased service prices can partially offset costs in switching and drop lines connecting telephone sets at user's premises, which is about 30 percent of the total costs including central office construction and equipment, public network switching and transmission (Ji, et al., 1990). Most people (users and those requesting the service), however, are unaware of such huge investments for even very basic services. Therefore, the cost distribution and financing scheme have limited impact on their demand for service.

Second, however, changes in financing policy have strong implications for the MPT, local bureaus, and other market players. For example, further relaxed financial control will likely encourage more market entries, promoting competition in production and pricing. In fact, the

increase in service price is such an approach local carriers use to increase financial viability. Conversely, restrictions in diversified financing will inhibit potential players and reduce competition scale, thus making the market rigid and less attractive to local service providers. Obviously the consequences of such changes will affect the demand tremendously.

Third, as mentioned in the previous section, the demand in China is driven primarily by perceived benefits which often override costs and the user's purchasing power for the service. Therefore, the demand is affected more by service availability than price or financing policy. The analysis of demand in China seems to show that changes in price or financing do not directly affect service availability when other factors are missing such as effective competition and improvements in network capacity.

For these reasons, it appears that the relationship between industry financing and demand is indirect but significant. The demand is contingent on the outcome of financing, which includes local autonomy which can create better financing and services, competition entailing more opportunities for the consumer, and technological improvements for higher service availability and better communications handling. As China's experience has shown, the joint effects of these factors made direct contributions to the service availability, which reinforced the perception

of benefits, and stimulated demand. This study contends that the implicit and dynamic relationship between industry financing and telecommunications demand is the key to alleviating demand in the long run by encouraging competition and diversifying financial sources.

The pressure of excess demand can prompt further reforms in the MPT to find financing solutions. High and unmet demand in the long run diminishes economic returns of telephone networks because of low access and under-utilized public financing. There are other social repercussions as well. According to the government's plan for the 1990s, telecommunications must grow faster than the general economy in order to accommodate the soaring communications. Added to the already serious situation, the excess demand is also likely to grow as telecommunications services become more accessible and communication more imperative in commercial and social activities. The high and unmet demand will also pressure the MPT to seek alternatives to increasing service supply, this may further open the market for financing, production and services. Decentralized responsibility and increasing local financing shares must be taken as a long-term strategy for alleviating the strong excess demand, which will further encourage and expand sector competition.

CHAPTER 8

DISCUSSION FOUR: FINANCING AND TECHNOLOGY TRANSFER

Technology is a crucial building block of telecommunications development. As discussed in Chapters 2 and 3, telecommunications growth relies on two fundamental conditions: long-term investment and technological advancement. Clearly, there is a close relationship between the two: technology acquisition depends on investment, while to a great extent, sufficient funding comes from revenue generated by higher network efficiency, new services, and large subscriber base. The contingency of telecommunications growth on technology is a distinct characteristic from other industries, both in developed and developing countries.

However, for many developing countries, options in technology transfer are limited. The lack of technical resources and skilled professionals makes many countries rely solely on foreign products. Although the domestic technological conditions may be improved, the drawbacks are also apparent. Many of the issues addressed in the research literature have also been identified by the Chinese

experience. In a recent study on technology transfer in China, the participants seemed to agree that technology transfer must be conducted for the domestic agenda and strategic goals. Based on this understanding, adoption and dissemination of imported technologies become more critical than hardware acquisition; and new technologies must serve for applications and increasing mass production (Lin, 1990). Although many attribute the vulnerable position of developing countries to unfair technology transfer, this study argues that technology transfer must be bolstered by prudent domestic policy and long-term goals rather than blaming exporting countries/companies. If this condition is accomplished (and is not impossible), then developing countries will benefit from technology transfer to improve or even leapfrog their technological status within a short period, as well demonstrated by the newly industrialized countries (NICs).

Technology transfer is essential for China's telecommunications development. Although it is a very costly process, and the country is faced by severe investment constraints, technology transfer in China has accelerated since the early 1980s, particularly in SPC switching technology. To a great extent, the growth of China's telecommunications is fostered by technology transfer. This chapter discusses the context of technology transfer, the market and policy of technology transfer, and

the implications of diversified financing in technology transfer.

8.1 Context of Technology Transfer in China

For 30 years, China's telecommunications market was operated by the self-reliance policy and was closed to foreign investors and products. After the country opened its doors to the outside world in 1979, the Chinese have realized the huge technological gap with the West. Compared to other developing countries, technology transfer is extremely critical for China for two prominent reasons. First, China's vast telecommunications market cannot be easily satisfied by domestic production; outside capital and products are indispensable. Second, state-of-the-art technology can improve switching and transmission networks quickly. Advanced technologies can yield higher financial returns by providing cost-effective communications solutions. It would be slow and uneconomical for China to develop new technologies from scratch.

Despite promising benefits, technology transfer also reveals serious impediments for the Chinese.

1) Financial constraints. Technology transfer is an expensive undertaking. Wellenius (1984b) and others (e.g., North-South Institute, 1989) estimate that about 50 to 80 percent of telecommunications investment in developing

countries requires foreign exchange (FE) for importation. This is confirmed in China. For example, by one account, about $800 million worth of technology transfer was made in 1990,[21] well exceeding the estimated total value of $720 million domestic equipment market. (The China Business Review, 1990, 1991).[22]

The high requirement of foreign exchange is aggravated by the fact that domestic production does not generate much foreign exchange since most products are sold in domestic markets. In recent years, China has begun to export some telecommunications products to overseas, such as PBXs and telephone sets, under the agreement of joint ventures and profit sharing. But the FE earned from product exports is a tiny fraction compared to the needs. Other alternatives are also limited. Presumably, FE may be drawn from other industries since telecommunications is a national priority; in reality, however, large-scale technology transfer in all major industries and self-contained territorial power makes

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[21] The expenditure for technology transfer in telecommunications includes importation and foreign government/companies (concessional loans, joint ventures, and direct investments). Usually only the domestic expenditure appears on annual statistics, therefore, it is considerably lower than the actual magnitude of technology transfer by about 10-15 percent.

[22] The size of telecommunications market is estimated differently. If broadcasting systems are included, the market size is at $1.2 billion (Department of Commerce, 1985; China Trade, 1:1, 1986). If only telecommunications equipment is accounted for, the size is about $720 million (Pyramid Research, 1988).

cross-subsidy impossible.

Given the severe constraints in foreign exchange, the only viable source for technology transfer seems to be from foreign investors. And this raises additional difficulties for the Chinese.

2) Foreign financing. After the open-door policy was adopted, China has turned to foreign sources for financial support, but its position in the international investment market has been unstable, coupled with political and economic problems at home.

China faces two obstacles in obtaining foreign capital. The first is political. By definition, China is a communist country, whose international aid is subject to the close scrutiny of international aid regulations, such as General Agreement on Tariffs and Trade (GATT), International Monetary Fund (IMF), the World Bank, and Coordinating Committee on Multilateral Export Controls (COCOM). In addition, technology transfer to China is also subject to regulations imposed by some Western countries on technology exports and bilateral trade, such as the most-favored nation trade status set by the U.S. government. Since the mid-1980s, the world has witnessed the remarkable achievements of China's reform and its commitment to economic development. As a result, international regulations in financial aid and technical assistance have relaxed in favor of China. Such changing context is clearly shown in a U.S.

congressional report on technology transfer to China.

> "China recognizes the need to acquire new technology and new capabilities in its efforts to modernize and expand its economy... U.S. policy toward China for the past 10 years has been predicated on the assumption that closer relations are generally beneficial but that caution must be exercised in the transfer of advanced sensitive technology... some ask whether the United States should make greater efforts to help China modernize through technology transfer." (Office of Technology Assessment, 1987, p.3)

The signs of changing U.S. policy also reflect the increasing awareness that China's improved economy will contribute to the world stability and security, thus should receive financial aid and technical assistance from the West (Ho, 1985; Simon, 1986; Office of Technology Assessment, 1987).

Although China's new economic policy and practice have won considerable respect and support from abroad, its unstable political situation continues to undermine its economic endeavor. The political repercussion of economic reform and demand for democracy have intimidated foreign lending and investment, as proven repeatedly in the 1980s. In China, the Communist Party controls the government and legislation. It is thus understandable that major economic policies must serve the political priority set by the Party. Such a vulnerable relationship often interferes with or even

tarnish economic activities. The most recent evidence is the democracy movement in 1989. The government brutal suppression clearly unmistakably manifested its stance: the country's economic development must sacrifice for the survival of current regime and ideology. All foreign lending and negotiations was halted or canceled immediately after the crackdown, causing economic loss in billions of dollars.

China's political instability and its crucial influence on the economy are the inherent weakness that will continue to undermine the country's economic development. Although China has acquired a number of high technologies previously under strict export control, the heavy political connotation in technology transfer will continue to affect foreign financing, especially in policy consistency and short-term profits.

Another concern that affects foreign investment is China's financial return capability. As discussed in Chapter 2, telecommunications can yield high financial returns on investment relatively quickly; therefore, bank loans (e.g., the World Bank) for telecommunications projects tend to be short, typically between three to four years (Wellenius, 1984b). Studies show that even for such a short period, returns can be substantial, usually double the investment (Saunders, 1983). Although China has received some loans from the World Bank and other banking

institutions (e.g., Asian Development Bank) for its telecommunications projects, usually they are in small amounts and designated to a particular project, or through product sales by foreign manufacturers.

Government concessional loans constitute the major foreign financial source for China's telecommunications. Typically, government loans allow longer lending periods (10-30 years), with low or no interests. During the 1980, China was granted many government loans, especially from Western Europe, Japan, and North America. The loans, estimated at billions of dollars, will gradually enter maturity in the 1990s. Although China's telecommunications has made impressive growth, it is questionable that the industry alone can generate sufficient foreign currency to repay foreign debts. It may have to draw from national foreign currency reserve along with other industries, which is a serious deficiency as many of them will be paying their debts about the same time.[23]

Despite political and economic perplexity, government loans provided great leverage for China's technology transfer during the 1980s, particularly in equipment procurement and upgrading systems. Without government

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[23] By the end of 1990, China's foreign exchange holding was $11 billion, dropped from $17 billion in 1984 (Department of Commerce, 1985; Zou, 1991). The actual payment capability should be much lower since China had incurred much higher debts by 1990. Many debts involved technology transfer and other foreign technical assistance.

loans, it would have been almost impossible to attain the magnitude of technology transfer that has made significant contributions to the industry growth.

8.2 Market of Technology Transfer

A U.S. government report on telecommunications equipment in 1985 described China was "15-20 years behind advanced industrialized countries" in technology (Department of Commerce, p.5, 1985). Switching and transmission technology represents the major gap with the West. Crossbar and step-by-step switches had been used in public networks for decades until China's telecommunications market was opened in the early 1980s.

The first SPC digital switch was imported in 1982 and employed in the public network in southern China. Its 10,000-line switching capacity exceeded any switch then in operation (Zheng, 1989). This is the beginning of a massive influx of technology transfer throughout the 1980s. In 1983, the first joint venture was launched between the MPT and ITT's affiliate Belgian Bell Telephone (BTM) to manufacture SPC analog/digital switches. By mid-1983, about 15 telecommunications joint ventures were established in China (China Trade, 1:1, 1986).

From the very beginning, technology transfer in China has been executed in three basic forms: imports, joint

ventures, and direct investments/sales by foreign companies.

1) Imports. Purchase of Western technology and products was surged by the mid-1980s as the first phase of massive technology transfer. The initiative was driven by three concurring factors. First, the economic growth had accumulated a fair large amount of foreign exchange that made massive purchase possible. Second, China did not have adequate technology and production capacity, and it would be very costly to manufacture themselves while supply was available elsewhere. Third, the government decided that the priority was to improve current networks so that high economic benefits could be attained quickly.

The shopping spree invoked by the economic euphoria also had negative consequences. As a result of lack of strategic planning and technical expertise, many local telecommunications bureaus spent millions of dollars for products that either were dumped by foreign companies or inadequate for domestic needs. Moreover, it created a false perception in the international financial and exporting community that China could spend as much foreign currency as it pleased. To many Western companies, the size of China's market presented great potential that could absorb any imports (Boothroyd, 1985).

In fact, although China's total imports steadily increased during the 1980s, from $20 billion in 1980 to more than $53 billion in 1990 (Zou, 1991), imports of

telecommunications products have been slim, only about three percent (Mackerras & Yorke, 1991)[24].

The market of telecommunications imports is summarized in Tables 10 (by countries) and 11 (by product categories). Both tables cover a time span of 1983-90, since large-scale importation did not take place until 1983. Because telecommunications imports are conducted at all levels, thus

Table 10 China's Telecommunications Imports by Countries (1983-90)(1)

	1983	1984	1985	1986	1987	1988	1989	1990
Belgium	1	1	1	2	0	0	0	0
Canada	0	3	2	7	6	0	0	1
Finland	0	0	2	1	5	1	3	0
France	1	1	10	2	1	3	1	1
Hong Kong	1	2	0	3	5	1	1	4
Italy	1	0	2	5	1	0	2	0
Japan	3	7	12	13	1	1	1	1
Netherlands	0	2	2	2	1	2	0	1
Sweden	1	2	3	3	3	7	4	3
Switzerland	1	0	1	1	1	2	0	0
U.K.	1	5	9	10	5	1	3	1
U.S.	5	6	9	17	8	7	4	3
W. Germany	0	4	4	2	4	1	3	2
Others(2)	1	1	4	2	3	5	3	4
Total	16	34	61	70	44	31	25	21

Notes: (1) Number of transactions; completed or signed.
(2) Including Australia, Czechoslovakia, New Zealand, Norway, South Korea, Spain, Yugoslavia, and INTELSAT.

Source: The China Business Review, 1983-91.

[24] Data on telecommunications imports are aggregate, including broadcasting equipment and electronics. Therefore the actual share of telecommunications imports should be somewhat lower than three percent.

difficult to establish a comprehensive collection, the data may not be complete, but they are sufficient to demonstrate the basic trends in technology transfer in China.

Table 11 China's Telecommunications Imports by Product Categories (1983-90)

	1983	1984	1985	1986	1987	1988	1989	1990
Microwave	1	1	3	13	2	4	4	1
Mobile Comm.	2	5	8	5	4	2	2	3
Satellite(1)	2	5	4	3	7	2	1	0
SPC Switch(2)	7	9	22	26	24	11	10	8
CPE(3)	1	1	1	1	0	2	1	2
Transmission(4)	1	4	17	20	5	12	8	3
Others(5)	3	8	8	11	6	4	1	2
Total	17	33	63	79	48	37	27	19

Notes: (1) Including components and earth stations. (2) Including PBXs. (3) Including telephone sets, terminals, etc. (4) Including coaxial, fiber cables, and other wiring equipment. (5) Including components, radar systems, and non-voice equipment (data, fax, telex, etc.).

Source: The China Business Review, 1983-91.

Several observations on imports can be made from both tables.

First, the distributions of export countries and products show a surprisingly identical curve (Figure 3), indicating a correlated trend between importing countries and products. There are two possible reasons for such a close correlation. One is that China's telecommunications imports market was accelerated before 1986. For example, between 1983 and 1984, telecommunications imports jumped 2.8

times from 692 million yuan to 2.68 billion yuan (Ho, 1985). The overheated imports were coupled with optimistic assessment by Western vendors, until reached its peak in 1986. On the other hand, after four to five years of

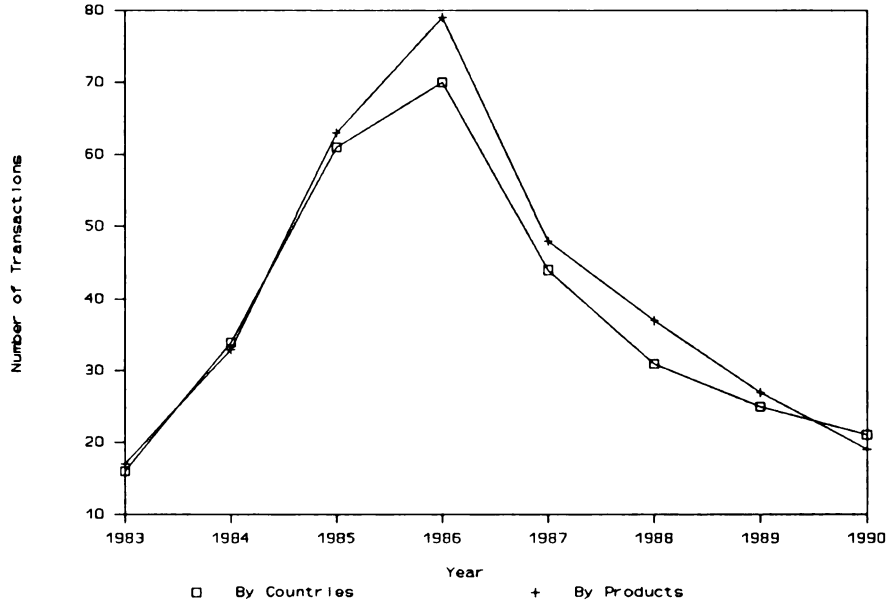

Figure 3 Distribution of Imports (1983-90)

importation, some market segments were gradually saturated. For instance, imports of SPC switch and transmission equipment dropped sharply between 1986 and 1990, reflecting a shift in importation policy, increased domestic production, and lessened demand. As imports in these market segments reached the peak, sales by foreign vendors, notably

Japan, the U.K. and the U.S. were decreased significantly.

Second, Western Europe, North America and Japan were the largest exporting countries in China's telecommunications market; they were also the major supplier for most products listed in Table 11. It is worth mentioning that although the number of sales by U.S. companies are comparable with that by European companies, the size of U.S. imports (in dollar value) is much smaller, typically remaining at about five percent (Department of Commerce, 1985; Ross, 1988). For example, sales of the most lucrative SPC switch were (and still are) dominated by the European and Japanese companies, such as Ericsson of Sweden, Alcatel of France, Siemens of Germany, and Fujitsu of Japan, because the volume purchase from these companies is made possible by their governments' concessional loans which usually require purchase of particular products from government designated companies. As Table 12 shows, as of 1990, American AT&T's market share of SPC switch was less than one percent. Several reasons contribute to weak U.S. imports: the government's regulations on exporting high-tech products to communist countries; no government loans to promote sales; higher prices; and the lack of marketing.

Table 12 Market Share of SPC Switch (1990)

Company/Country	Product	Share(%)
Shanghai Bell(1)	S1240	26.7
Fujitsu/Japan	F150	23.6
NEC/Japan	NEAX61	22.9
Ericsson/Sweden	AXE10	10.7
Alcatel/France	E10B	6.5
Siemens/Germany	EWSD	4.0
Northern Telecom/	DMS100/200	3.5
Canada	DMS10	1.3
AT&T/U.S.	5ESS	0.8

Notes: (1) A joint venture between MPT and Belgian BTM.

Source: Marketing Department of World Telecommunications, 1991, p.46.

Third, the decline of imports after 1986 indicates the changes in product demand and market potential, such as the soaring demand for mobile communications (cellular telephone and paging systems), as well as changes in the supplier such as the increasing sales by Hong Kong companies. In fact, Hong Kong's role in exporting and investment increased tremendously in the late 1980s, particularly in neighboring Guangdong province, despite relatively small dollar value compared to the national market. The Hong Kong's increasing financial and technical involvement in China's telecommunications market is a prelude for 1997, when it will be transferred from the British to China's sovereignty.

Finally, the rising-decline pattern of China's imports during the 1980s clearly illustrate the changing dynamics of

the domestic market. Importation has been used as a convenient solution to easing the high demand and a "shortcut" to reduce technological gaps with the West. Nonetheless, the ultimate goal for encouraging imports was to promote domestic production for reducing reliance on foreign technology and supply. And this policy seemed to take effect (see the following section). If the current trend continues, China's telecommunication imports market will unlikely have the same magnitude as in the 1980s but continue to decrease. In the meantime, the emphasis will be on the domestic production and quality which have been greatly elevated by joint ventures, the type of technology transfer China can benefit for in the long term.

2) Joint ventures. Technology transfer in China has been conducted in a two-prong approach: direct imports and joint ventures. Although importation can improve networks and alleviate some demand in the short run, it often conveys little systematic transfer of knowledge and expertise embedded in the product. Advocates for technology equality such as Eze (1986) argue that the success of technology transfer depends on the skills of recipient country, which is a much more complex and costly process than simply buying foreign goods. Joint ventures, on the other hand, require much more efforts to initiate the transfer of technology, from manufacturing to management, marketing and service the product. The involvement of both foreign and domestic

resources in much longer time duration makes the joint venture a desirable approach to technical expertise (Oshima, 1990).

Furthermore, joint ventures often entail licensing new technologies or production procedures to the recipient countries, that, when well managed, can be very effective in upgrading domestic technology and improving infrastructure in the long run. China's telecommunications strongly prefers licensing in joint ventures to direct imports. As noted by Goossen (1987), licensing not only requires less foreign exchange compared to direct purchase, which often times translates to substantial returns on investment, it also encourages local governments to pursue joint ventures by funding of international sources at lower rates than domestic loans.

The first large-scale telecommunications joint venture is Shanghai Bell Telephone Equipment Manufacturing Company Ltd. Established in 1983, Shanghai Bell is jointly owned by the PTIC of MPT (60 percent), ITT's Belgian Bell Telephone Manufacturing Company (30 percent) and the Belgian government fund (10 percent) (China Trade, 1:1, 1986). By 1988, Shanghai Bell produced a total of 300,000 lines of S1240 analog/digital switch and they were all sold in domestic markets (Marketing Department of World Telecommunications, 1989b). By 1990, more than 970,000 lines of S1240 had been installed, the largest switch base

in China (see Table 12) (Marketing Department of World Telecommunications, 1991).

In addition to Shanghai Bell, major joint ventures in manufacturing SPC switch include Germany's Siemens (with Beijing; EWSD), Japan's NEC (with Tianjin; NEAX61), and Canada's Northern Telecom (with Beijing; MSL1). There are about a dozen self-financed technology transfer companies, joined with about 100 domestic switch companies (Sun, 1991a).

Table 13 lists the number of telecommunications joint ventures/direct investment by participating countries.

Table 13 Joint Ventures and Direct Investments in China (1983-90)

	1983	1984	1985	1986	1987	1988	1989	1990
Canada	0	0	1	2	1	3	1	1
W. Germany	0	1	1	1	2	3	0	0
France	0	0	0	1	0	0	0	1
Hong Kong	0	2	3	4	1	1	1	4
Italy	0	0	0	0	0	1	0	0
Japan	0	0	2	4	2	1	3	4
Netherlands	0	0	0	0	0	1	2	2
Sweden	0	1	0	1	1	1	0	1
U.K.	2	1	3	0	1	2	0	0
U.S.	0	4	4	1	1	1	2	3
Others(1)	1	0	1	1	0	2	1	2
Total	3	9	15	15	9	16	10	18

Notes: (1) Including Australia, Belgium, Brazil, Singapore and Spain.

Source: The China Business Review, 1983-91.

The characteristics of joint venture/direct investment can be detected by plotting it with the distributions of imports, as shown in Figure 4.

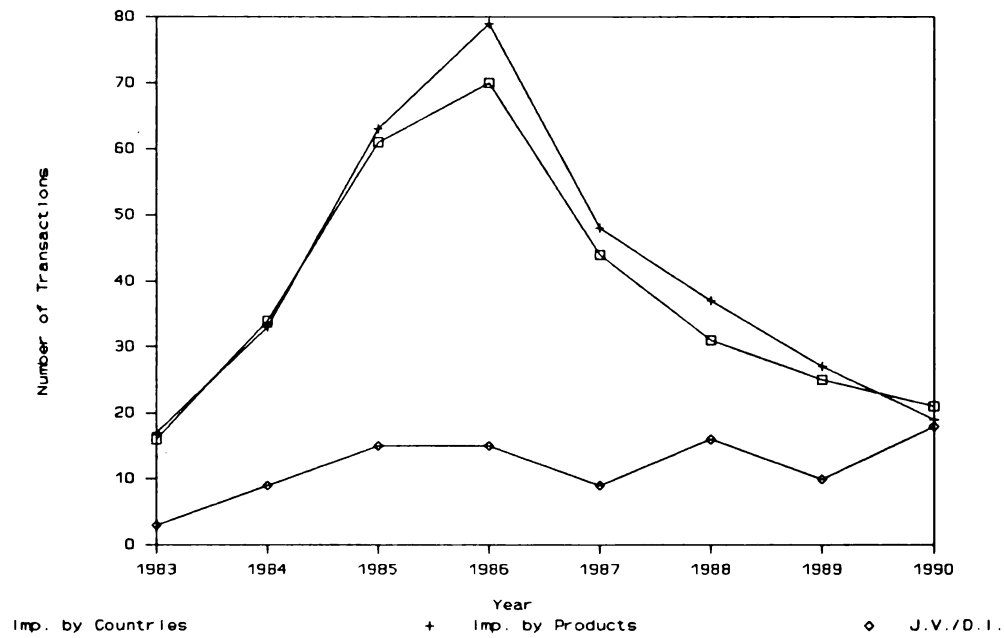

Figure 4 Comparison Between Joint Ventures/ Direct Investments and Imports (1983-90)

First, although the magnitude and kurtosis of the joint venture curve are much smaller compared to that of imports, its distribution also shows an upward pattern before 1986. This is consistent with imports during the same period, indicating a strong trend in technology transfer at that time.

Second, after 1986, however, joint venture/direct investment seems to become unstable with yearly fluctuations. Since the MPT policy is to encourage joint venture, the seeming seasonality may indicate some uncertainty in foreign investment with regard to China's market potential. It may also show the financial strain on the Chinese to conduct capital-intensive joint ventures.

Third, the number of joint ventures/direct investments achieved the highest level in 1990 (18), despite the backlash of the political upheaval in 1989. This is in strong contrast to imports which declined steadily after 1986. The differences between joint ventures and imports strongly indicate that as imports continue to decrease, the market supply will be gradually taken by domestic manufacturers including joint ventures. This applies to primary market segments such as digital switch, transmission equipment, and CPE. Some products requiring high technological sophistication such as fiber optic cable and cellular telephone networks will continue to rely on imports for some time, but the current trend seems evident that domestic production will eventually take the lead.

Finally, although not shown in Table 13, most joint ventures and direct investments are made between foreign companies and local telecommunications authorities, particularly Shanghai, Guangdong (Canton), Fujian (southeast), Jiangsu (south) and Sichuan (southwest), among

others. The local orientation of joint ventures indicates greater financial attraction to foreign investors, bolstered by local autonomy, which strongly reinforces diversified financing.

8.3 Policy of Technology Transfer

China's commitment to acquiring advanced technology seems unyielding. Technology transfer is indispensable for China to develop its telecommunications industry. The question, however, is by what means to approach technology transfer, and how to make imported technology feasible for domestic use.

Technology transfer requires intensive capital and absorption by the market. The former makes technology transfer possible and the latter makes it profitable. Although these requirements present tremendous difficulty, China's research foundation and policy of telecommunications have shown some interesting characteristics that have significantly improved the effects of technology transfer.

China has a strong tradition in basic scientific research: China possesses a commensurate number of scientists and engineers and comprehensive research

facilities.[25] The MPT alone, for example, has more than 30 research centers and two universities. However, the strong emphasis on basic research has also created biased perceptions that applied research is of less importance. As a result, although China made the first digital computer in 1958, and began the research on fiber optics in as early as 1971, most results could not materialize and failed to become viable products (Zhao & Jiang, 1987; Conroy, 1990).

Since the economic reform, China has recognized the importance of market application and profitability, and initiated policies to utilize the existing research facilities for applied research. There are two approaches in applied research. One is create new products. The high-capacity digital switch DS2000, for example, is a sophisticated product made entirely by the domestic R&D capability. Introduced by the MPT's First Research Institute in 1987, its quality is comparable to the equivalent imports (Yan, 1989). The other is upgrade existing products such as crossbar and step-by-step switches. The emphasis on applied research and product commercialization have increased production, improved quality, and expanded services.

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[25] For example, Zhao & Jiang (1987) found that up to the 1980s, the number of scientific results in China showed an exponential growth pattern, doubling in every 15 years, comparable to the world's average growth (doubling in 15.6 years).

Another important characteristic of technology transfer in China is an explicit and well enforced policy. China has reiterated that technology transfer should be used as a leverage to acquire advanced technologies; the ultimate purpose is to increase domestic capability, not to just create a market for foreign products. Therefore, direct importation has been taken as the least preferred solution since it entails limited transfer of technical expertise. Joint ventures, on the other hand, are greatly encouraged because they are located in China, and once in operation, will make much greater technological and financing contributions. Moreover, the Chinese employees are trained in joint ventures whose knowledge and skill about the technology will become a valuable asset for many years to come. Although the joint venture is costly in initial investment and returns may not be immediate, the Chinese seem to be convinced that its long-term benefits are worth the effort.

The policy objective is not without drawbacks. The first and potentially detrimental is management, particularly in network services. China wants to absorb foreign investment as much as possible, but it fears to be controlled by Western companies. In the wake of increasing penetration of foreign influence in joint ventures, the MPT has vehemently rejected that network management and operation must be controlled by China, although foreign

investment in these areas is still encouraged. This policy may be interpreted to preclude any foreign involvement in network services, such as network management and information services through telephone lines.

Such policy can be very difficult to carry out in reality. Its premise of central control may be construed by foreign companies as more rigorous regulations and to deprive profits by joint ventures, thus intimidating rather that encouraging foreign investment.

Another important aspect of policy in technology transfer is standards. Industry standards directly affect network planning, capacity, service and profits. Therefore, standard conformity is the essential criterion for evaluating foreign vendors and products. International standard organizations such as CCITT are the major reference for policy making for China's standard provision. For example, CCITT recommended pulse code modulation method (PCM), often referred to as A-law (such as time-division multiplexing), is also a standard in China for manufacturing SPC digital switch and space-division multiplexing (SDM) for analog switching equipment (Yang, 1989). As a result of standard conformity effort, non-standardized products have tremendous difficulty selling in domestic market regardless of price.

The MPT in 1986 established a series of inspection procedures to ensure standards (Sun, 1991a). Under the new

inspection regulations, all communications products intended for sale must obtain a network entrance permit upon passing the inspection, including imports.

The weak sales of U.S. telecommunications products in China can be partly ascribed to the effects of policy on technical standards (Ho, 1985). Mobile communications systems is a good example. China has adopted the European "total access communication system" (TACS) as the national standard for cellular networks and future expansion (Sun, 1991b). The United States, on the other hand, uses AMPS standard ("advanced mobile phone service"). China imported one AMPS system in 1988, and soon found out that it was difficult to interconnect with other cellular networks using the TACS standard. Therefore, for Motorola, an American cellular systems company, to enter China, it has to modify its products to the TACS standards. This applies to other product categories as well such as transmission and CPE.

As technology transfer gained its momentum, the policy objective has shifted from catching up with technologies and increasing sales to promoting domestic production capability. The changes have caused confusion and complaints among foreign companies.[26] From China's perspective, however, such changes can benefit the domestic

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[26] See the article entitled "China's Trade Status? Most Annoying" in The Wall Street Journal (McGregor, May 3, 1991). It reflects the frustration of U.S. telecommunications companies doing business in China.

market in the long run, therefore should be enforced firmly. If policy were made to depend on imports too much, then domestic production would be severely undermined. In the case of SPC switch, imports and joint ventures were strongly encouraged when the domestic technology was behind and production capability was low. However, the massive importation also caused confusion in standards because many imported products used proprietary standards, that could hardly interconnect each other. In addition, the Chinese soon realized that if all switch assembly lines (including imported) were run in full capacity, the domestic demand could be well served. Meanwhile, propelled by technology transfer, domestic production was upgraded and increased rapidly. The quickly changing market was the major reason for the shifts of policy on technology transfer, from large-scale importation to strict control, standardization, and encouraging domestic production.

The effects of policy change have been seen in three aspects. First, the MPT's inspection and licensing procedure was extended from SPC PBXs to all terminal products, including telephone sets, fax machines, modems, etc., with specific requirements of standards, quality, and functionality (Xu, 1990; MPT, 1991a). The products (domestic and imported) cannot be connected to public networks if they do not meet the requirements. Moreover, by enforcing inspections, the new policy has significant

influence on the product priority by encouraging certain product categories; subsequently, it can affect sales of a particular product. These effects have promoted standards and improved product quality.

Second, the scale of joint ventures in switch manufacturing has been reduced. For example, by the mid-1980s, China imported nine types of central office switches from eight countries. The new policy has designated three as the major production lines: Shanghai Bell's S1240, Siemens-Beijing's EWSD, and NEC-Tianjin's NEAX61 (Marketing Department of World Telecommunications, 1991). Clearly, many imports are discouraged as the result of the streamlining policy. This measure has had tremendous impact on foreign companies whose products do not represent leading-edge technology or do not meet the Chinese expectations, as well as the domestic counterparts because they will have to stop importing certain products or switch to others in the future.

In consequence, the proportion of domestic production has increased significantly. In the SPC PBX market, for example, domestic production had only 26 percent of the total sold in 1986. By 1990, its share soared to 85 percent (Yang, 1991). In the transmission equipment market, the share of domestic production of fiber optic cable increased from 23 percent to 39 percent between 1988 and 1989 (Liang, 1990). The increasing share of domestic products indicates

that after technology transfer, new technologies and production have been gradually adopted by the domestic industry; it is also the outcome of the new policy that fosters domestic products equipped with advanced technologies.

Despite the strong effects, it is expected that the large-scale technology transfer will continue because advanced technology is still the key to China's telecommunications growth for a long time, and the level of domestic technological sophistication and production can hardly satisfy the high demand in the near future. As the pace of innovation is accelerating, China has no choice but to continue relying on importing advanced technologies, especially through joint ventures and direct foreign investments.

Finally, China's experience may provide some insight in technology transfer for developing countries. This study contends that the policy based on domestic goals and needs can create greater benefits because it puts control in the hands of importing countries instead of foreign vendors. More important, such policy can help weld advanced technology with domestic infrastructure to maximize technical and economic benefits. However, the experience should be learned with caution. It may be easier for China to implement such policy than smaller developing countries that do not have a comprehensive research foundation to

facilitate technology transfer, and transform foreign products. Nonetheless, the study stresses the point that developing domestic infrastructure should always be the foremost priority when technology transfer is conducted. Only this way can imported technology make the best contribution to the domestic development, bringing long-term economic and social benefits.

8.4 Diversified Financing and Technology Transfer

Technology transfer is an expensive undertaking, especially in the beginning when huge investments must be made, and the returns will not be feasible until several years later. During this period, the industry has to bear the high costs that may further aggravate financial constraints which is already a serious problem in the developing countries.

Although it may not be the MPT's intention, the diversified financing scheme has made significant contributions to the massive technology transfer in China, so that a large number of imports and joint venture projects were accomplished without delaying other telecommunications sectors.

Although not explicit in the aforementioned tables, about 50 percent of imports and 80 percent of joint ventures in the 1980s were carried out by local telecommunications

bureaus (The China Business Review, 1983-91).[27] The growing tendency of foreign investment in the local market has been promoted by the following factors. First, there exists very strong purchasing power at local levels especially the foreign currency reserves. Second, dealing directly with local markets is much easier than cutting the red tape with the MPT, because many local governments have implemented lenient policies that provide favorable terms for foreign sales and investments.

One of the important findings of this study is that China's telecommunications market has become fragmented with multiple entries. As a result, the share by local participants has increased considerably to more than 50 percent in the total product values (cf. Chapter 6), reflecting the decreasing funding by the MPT for local projects. The analysis also applies to technology transfer projects. Local bureaus have to generate foreign currency to buy imports or conduct joint ventures, most of them are not funded by the MPT. Therefore, the self-financing policy for technology transfer must be viewed as an integral part of the overall diversified financing scheme.

China's experience has proven that the self-financing policy is a great incentive for local engagement in technology transfer to improve the local communications

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[27] See Sun (1991b) for an example of China's cellular market in which almost 100 percent of projects are initiated by local bureaus.

infrastructure (Sun, 1991a). The rapid economic development has provided adequate foreign exchange for technology transfer, particularly in the Special Economic Zones (SEZs) and many coastal cities. Local investment in Guangdong province, for example, increased to 350 million yuan in 1987 from 30 million yuan in 1980, in which more than 50 percent was from foreign and domestic loans (Yang, 1989). The result of increased local investment is remarkable: 96 percent of Guangdong's urban switching networks are automatic, compared to the national level of 67 percent (MPT, 1990a). It is convincing that without diversified financing local telecommunications development would have been much slower given the insufficient central investment.

The policy favoring diversified financing in technology transfer is expected to continue for the following reasons. First, local telecommunications market will continue to grow strongly, requiring a significant amount of capital that will have to draw from local sources instead of from the MPT. Second, local economic growth will continue to reinforce local autonomy and foreign currency spending. Third, improvements of local communications networks will facilitate national network performance, such as digital switching, transmission capacity, and the quality of service. All this can be accomplished without resorting to the central government funding.

Finally, some may argue that since most developing

countries do not have adequate technological infrastructure, technology transfer must be conducted under the central government's control to avoid unnecessary wastes and confusion. This study insists that the role of central regime can serve the best interest of national telecommunications development only by encouraging local motivation and diversifying financing sources, not by controlling or prohibiting them. Furthermore, each country must devise its own technology transfer policy congruent to the national characteristics and development goals. From this viewpoint, the centralized financing scheme in technology transfer may be appropriate for small countries whose demand can be well served by the PTT's capacity, and does not need much local financial contribution and distributed network management. For large developing countries with a huge market, high demand, and relatively established research capability, the diversified financing policy for technology transfer will be more effective, as China's experience has well demonstrated.

CHAPTER 9

FUTURE PROSPECTS FOR CHINA'S TELECOMMUNICATIONS: A FORECASTING MODEL

The diversified financing is also critical for China's telecommunications development in the 1990s. After a decade of experiment, diversified financing has evolved from an expedient measure to an indispensable foundation for a sustained growth in the future. The future prospects are integral to the discussions on diversified financing and growth in the 1980s, since the past experience can be used to detect patterns of future development.

Despite uncertainty ahead, China's telecommunications is poised to an even stronger growth in the 1990s. In the recently published government "Eighth Five-Year Plan (1991-95)" and "Ten-Year Economic & Social Development Plan (1991-2000)," telecommunications is listed as an important infrastructure and deemed a high priority in development, after agriculture, water resources, energy and transportation (People's Daily, April 16, 1991). During 1991-95, the telecommunications industry is expected to generate investment of 35 billion yuan, which translates to 75 percent of increase over the 1986-90 period (Jing, 1991).

The actual investment scale should exceed the government projection when local, enterprise and user financing is included.

Maintaining the industry growth is also a daunting task. The goals by 2000 as recently confirmed by the MPT, include a total number of 33.6 million telephone sets, representing about three percent penetration nationwide. In addition, switching capacity shall increase at 15 percent per year. Transmission networks shall consist primarily of fiber optic, digital microwave and satellite, gradually replacing coaxial trunks. It is expected that by 2000, 98 percent of all cities/counties will have automatic switching in intra-city communications, and 80 percent will have direct dialing in domestic long-distance services (Yang, 1991).[28]

However, the discrepancies found between estimated investment and projected growth suggests that the future prospects will continuously be strained by funding shortages. This conclusion is drawn by performing the following tests. First a forecasting model for investment is constructed, then the estimated investment data are plotted to the regression equations for switching capacity and number of telephone sets for the extended period. Lastly, the outcomes of different scenarios are compared.

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[28] For details of sector developments, see Pyramid Research (1988), Development Research Center (1991), Sun (1991b, 1991c), and Jing (1991).

1) The investment model is constructed using exponential smoothing techniques for time series analysis (SPSS/PC, V3.0). The estimated investment data are extrapolated from the existing growth pattern between 1980 and 1990, particularly the last five years since investment achieved the strongest momentum after 1986. The model does not contain seasonal factors, and the time frame is ten

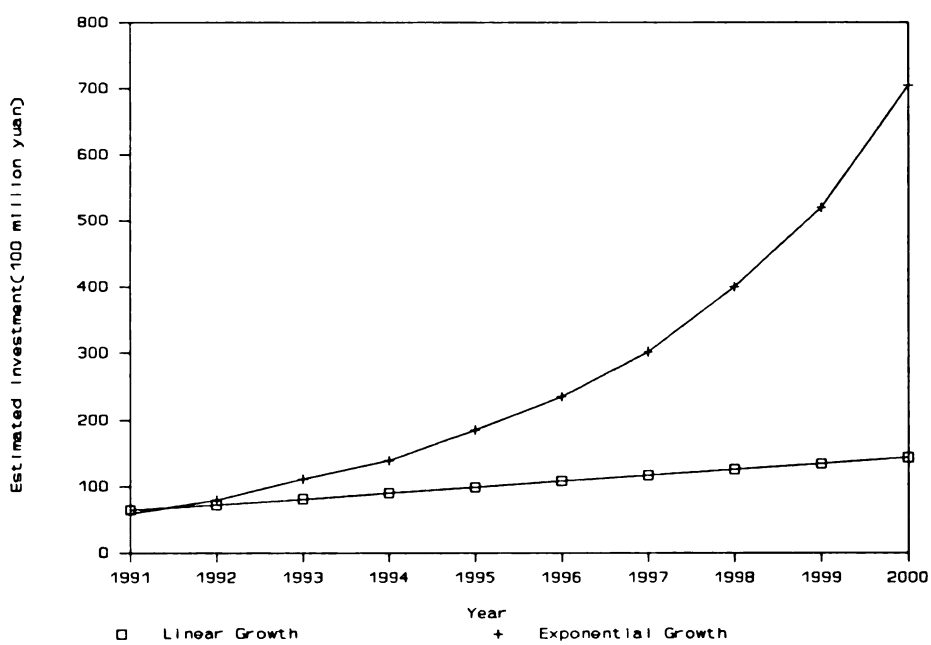


Figure 5 Forecasting Scenarios for Investment (1991-2000)

years (1991-2000). Two scenarios are presented for comparison: linear growth and exponential growth. The results are reproduced in graphical forms as shown in Figure

5 (see Appendix D for parameters and calibration).

The interpretation of the scenarios can be made in reference to the findings derived in this study. As shown in previous analysis, there is a strong correlation between investment and growth during the 1980s. In other words, an average growth rate of 24 percent in investment paralleled with about 11 percent growth in switching capacity and telephone sets (cf. Table 4 in Chapter 5). Such relationships are likely to continue in the 1990s.

Although the linear scenario represents a non-fluctuated growth, from about 6.5 billion yuan in 1991 to 14.4 billion yuan in 2000, its average annual increase is only about 7.9 percent (cf. Figure 5). It is obvious from the past experience that such an investment scale cannot sustain the projected goal. For example, in order to achieve 33.6 million telephone sets (or three percent in density) by 2000, the annual growth must maintain at 15 percent or higher. This translates to an annual increase of investment in 20 to 25 percent. It is estimated that if an upward investment scale of 20 percent a year is adopted, then 12 billion yuan is required by 1995, and 25 billion yuan by 2000 (Marketing Department of World Telecommunications, 1991). Clearly the current linear projection of investment is not sufficient for achieving the intended goals. However, the linear regression scenario assumes that the prices for service and products will remain

constant, which may discount the supply that may otherwise increase faster than projected by the scenario.

The exponential scenario, on the other hand, shows a significant increase, especially after 1995. It indicates an investment scale of 70.5 billion yuan by 2000 from about six billion yuan in 1991, an average increase rate of 31.6 percent for the time frame. The exponential growth, although ideal for projected goals, apparently contains a high unlikelihood given China's general economic growth and persistent fund shortages. When the linear and exponential approaches are combined, then it becomes evident that the optimal investment scale should fall in the cross section covered by the linear and exponential curves. If the current tendency maintains, then the investment scale in the 1990s will likely fall in the lower region, approaching the linear growth; but if more aggressive policy is implemented, or dramatic changes occur, then the scale will likely increase at the rate closer to the upper region. Like the linear growth scenario, the exponential forecast does not take into account of price changes (e.g., decrease) which may affect the growth as the product and service provision will likely increase.

2) Projections of the effects of the estimated investments are made based on the regression equations

derived from earlier analyses.[29] For switching capacity and number of telephone sets, the forecasting scenarios are created with different investment models. The results are compared in Table 14 (only values for 1995 and 2000 are shown for brevity).

Table 14 Regression Forecasts for Switching Capacity and Telephone Sets

	1995	2000
Linear Growth Scenario(1)		
Switching Capacity(2)	21.3	29.1
Telephone Sets	22.9	31.4
Exponential Growth Scenario(3)		
Switching Capacity(2)	36.3	128.4
Telephone Sets	39.4	140.7

Notes: (1) Estimated investment scale: 10 billion yuan for 1995, 14.4 billion for 2000. (2) Not including PBXs and key systems. (3) Estimated investment scale: 18.5 billion yuan for 1995, 70.5 billion yuan for 2000 (cf. Figure 5).

In the linear scenario, growth for both switching capacity and number of telephone sets is somewhat below the projected goals. However, it will be a very impressive achievement if the current trend can be maintained throughout the 1990s. Ironically, although the estimated

[29] The regression for the variable of switching capacity, $Y_s = 3.61 + .18X_i$; for the variable of telephone sets, $Y_p = 3.41 + .19X_i$. X_i is investment variable.

investment during the same period is considered low at an annual growth rate of 7.9 percent, the results are close to the projected goals if the growth pattern in the 1980s is extrapolated. The exponential scenario, on the other hand, shows a significant growth pattern, particularly between 1995 and 2000. However, such a scenario is less likely to occur since it will require much higher investment and will be disproportionate to the general economic development.

The forecasting results and their feasibility derived in this study also concur with projections by the Chinese State Council. In a report on the strategy and policy for telecommunications development by 2000, three scenarios are proposed with respective investment requirements and feasibility levels. They are summarized in Table 15.

Table 15 Investment Requirement and Feasibility

Telephones by 2000(1)	Investment Required(2)	Feasibility
33.6	100	Difficult
67.2	250	Very difficult
134.4	600	Impossible

Notes: (1) In millions. (2) Cumulative investment in ten years; in billion yuan.

Source: Development Research Center, 1991, p.20.

Interestingly, both the number of telephone sets and investment scale in the first scenario is very close to the

linear model discussed earlier (31 million phones and 104 billion yuan by 2000), whereas the third scenario concurs with the projected telephone sets in exponential model (141 million phones and 274 billion yuan).

Despite different results of the forecasting models, they provide strong evidence to the central theme established in the beginning of this study: industry financing is the key to a sustained growth. Both the analyses and forecasting have revealed that the future development of China's telecommunications relies on consistent and accelerating investment. Despite strong commitment of the central government and the development priority, the scale of central investment will likely stabilize and increase slowly. It seems very clear that diversified financing must be preserved as the primary source for increasing industry investment in the future.

During the 1980s, the Chinese government tried to maintain a middle ground between the autocratic regime under socialist ideology and a rapidly changing economy. Such efforts will become increasingly difficult in the 1990s since economic development not only improves quality of life, but also encourages personal freedom and democracy in society. Mounting evidence indicates that the carefully maintained middle ground may soon vanish, and China will have to make a choice from the apparent incongruity (McGregor, September 24, 1991). The change, if taking

place, may be very painful for the communist regime, as shown in the Soviet Union and Eastern Europe.

While further political reform remains largely nebulous at present, the continuing dichotomy of power between the central government and localities is and will continue to be determining the scale of diversified financing throughout the 1990s. The root of local autonomy in China grows out of the lack of policy directives and enforcement, as well as inefficiency in local authorities and enterprises (Leung, 1991). These characteristics are also entrenched in the telecommunications industry, and ironically, they have invoked local motivation in investment and growth. The dichotomy between central government control and growing deviation in local authorities and enterprises will likely remain as a cooperative and sometimes confrontational context which will have significant impact on diversified financing. Although further industry decentralization will depend on many factors including political reform and democracy, it is evident that local autonomy will certainly increase as its contributions to the national economy become indispensable and a risk too costly to suppress, as testified by the democracy movement in 1989.

For diversified financing to grow in the 1990s, the following sources are of particular importance for their potential and the multitude of funds.

1) Enterprise financing, such as telephone companies

and product sales. Profits from telephone services (including installation) will become the major source for enterprise financing, and it is expected to increase significantly as a result of expanded user base and increase of service volume.

2) User financing can be expanded from user premises installations (e.g., PBXs and telephones) to regional exchange, such as in new industrial zones. Agreements can be established between local users and telephone company. For example, the network is operated by the telephone company, while the profits are shared between investors and the carrier.

Other alternatives of user financing can be explored in the future, such as selling enterprise bonds to entice public investment. Although issuing telecommunications securities can create a greater investment pool, the public demand for high returns may undermine the effects since telecommunications industry usually yields low in the short term.

3) Loans. From the past experience, local bureaus prefer government loans (converted from budget allocations) to bank loans, because the former has lower interest rates and the latter has shorter lending period (Wu, 1990). Since telecommunications requires long-term investment, loans with low interest rates and longer time are expected to grow.

4) Foreign investment. Government concessional loans,

commercial loans will be the major sources in the 1990s. Although direct investment by foreign companies is encouraged, strict MPT regulation and government ownership will make direct investment a less possibility, unless the industry is further decentralized to mixed ownership and management.

The success of joint ventures in the 1980s will continue as an effective means for technology transfer and to attract foreign investment. Since joint ventures not only increase production and improve quality, but also adopt new management, training and marketing, their impacts on the future of China's telecommunications industry cannot be underestimated, despite the undertaking of joint ventures will be strictly controlled by the MPT, and the number will not increase substantially from the present level. New forms of foreign investment may emerge in the 1990s such as buying telecommunications stocks, as the Chinese gradually opens its securities market to foreign investors (The Wall Street Journal, September 17, 1991).

The government policy is essential for the effects of diversified financing in the 1990s. In addition to encouraging local investments, policy making must provide greater benefits for local initiatives, such as greater local autonomy, higher profit retention, and pro-active pricing and service regulations. For an essentially centralized industry, prudent government policy can

significantly enhance financial viability and technological advancement.

CHAPTER 10

CONCLUSIONS

This study uses China as a case to examine telecommunications financing and development in developing countries. Despite China's telecommunications industry achieved remarkable growth during the 1980s, it also has exposed serious financial constraints. The financial constraint contains two interlocking dimensions: market dynamics that can generate funding necessary for sustained growth, and the prudent policy that promotes market dynamics. From this perspective, it is quite obvious that while industry efficiency can be measured in common terms, policy making must be contingent upon each individual country's domestic capability, resources, and long-term objectives.

This study provides a research framework by which the critical relationships between China's diversified financing and industry growth can be effectively examined. By so doing, the study wishes to contribute to a better understanding of the fundamental characteristics in financing China's telecommunications industry and their

implications for other developing countries.

Four hypotheses are submitted in the study, and the results indicate that the diversified financing scheme is essential for industry growth. The following is a summary of the main findings from the study.

1) Diversified financing plays an important role in relieving investment constraints. The rapidly growing local financing basically satisfied the growth requirements, as shown by the industry revenue, switching capacity, and number of telephone sets. The study has also found that the technical development requires long-term and cumulative investment, as shown in tests with lag-time intervals. The regression statistics indicate an increasing share of local financing and its contribution to growth is indispensable. The evidence is overwhelming that for telecommunications continues to grow, the current financing policy must be maintained. The close relationships between investment and the growth index variables also confirm previous studies by Saunders, et al. (1983), Wellenius (1984), ITU (1986), and others that telecommunications investment is a major obstacle to growth; the output and financial returns are significant once the "bottleneck" is alleviated.

2) Diversified financing encourages competition. The study found that as the financing responsibility is transferred from the MPT to many local telecommunications operators and users, the network management and decision

making have become decentralized, particularly in the regions whose economic growth is strong and local autonomy is a long tradition. This has led to competition in the market such as CPE and SPC PBXs, and it will likely expand to other sectors. Meanwhile, the industry restructuring and horizontal alliances have stimulated competition between the MPT and other ministries. As a result of competition, the product and service supply has increased tremendously, and the central command power of MPT has been crippled.

The effects of diversified financing on competition in China provides a unique perspective to the research on structural reform and sector competition in developing countries, which has pervasively held that competition is effective only when the central regime is dismantled (Wellenius, et al., 1989). The study found that sector competition can bring about positive results when the policy is consistent and pro-active, and incentives are provided.

3) Diversified financing stimulates demand. The study found that telecommunications demand in China is driven primarily by perceived benefits rather than by supply or price. This confirms the multi-country study by the World Bank in the early 1980s (Saunders, et al., 1983). The study identified two types of demand: demand for access and demand for service, and they often do not equate in developing countries. Evidence has shown the demand is inelastic to price as the waiting list in most urban areas increased

significantly when prices also soared. Moreover, demand for service creates severe line congestion as a result of increased access.

The relationship between diversified financing and demand is dynamic: while demand is surged as greater benefits are perceived and supply is gradually increasing, it also creates a significant subscriber financing pool to enhance the feasibility of local financing. Although the origin of demand in China is identical to many developing countries, this study does not find diminishing effects of demand on telecommunications benefits, as suggested by some studies (e.g., Pitroda, 1976; Wellenius, et al., 1989). On the contrary, the study found that although unmet demand poses tremendous pressure on supply, the benefits incurred by the size of current customer base are not affected by the demand. On the other hand, if all the demand were satisfied, the benefits of telecommunications services would be decreased due to overloaded network capacity. Therefore this study concludes that high unmet demand should be used in policy making to contribute to network growth rather than mere a adversary to supply; for example, demand's inelasticity to price can be used as a leverage for subscriber financing.

4) Diversified financing promotes technology transfer. The study found that local bureaus have become active in acquiring advanced technologies as a result of their

increasing autonomy in foreign exchange spending. Technology transfer in China serves two purposes: to improve domestic financial viability, and to improve domestic technological infrastructure. The findings confirm most studies (e.g., Schweitzer, 1972; Eze, 1986; Goulet, 1989; Hudson, 1990; Oshima, 1990) that for technology transfer to be effective, it must be integrated to domestic capability, resources and development strategies. Therefore the study found joint venture is much preferred to direct import by the Chinese because it requires less foreign capital and increases domestic production and services; more important, it provides systematic transfer of technical expertise which can significantly facilitate domestic research and development. Clearly, such development agenda must be guided by policies on the scale of transfer, foreign exchange spending, and conversion of commercial products.

The study also found a large number of joint ventures are established with local facilities, this is a strong indication of healthy financial conditions at local levels. The improved technical capability has strengthened local competitiveness, which in turn, has fostered industry decentralization.

These findings confirm the research proposition that diversified financing has made significant contribution to telecommunications growth in China, hence it is a viable alternative to increasing investment.

Although telecommunications can deliver significant benefits to economic and social development, its potential is often hindered in developing countries due to investment constraints. Some solutions have been proposed by the previous research, most concentrate on three aspects: altering financing structure, innovative financing, and subscriber financing. These suggestions bear mixed prospects in the case of China.

Innovative financing such as using foreign trade to provide foreign currency for investment may be less effective in China simply because China's telecommunications scale is immense and foreign exchange is badly needed by every sector of the economy. Subscriber financing is just being recognized as a viable financial source in China. China possesses a huge customer base, slight increase in service charge can translate to a substantial amount of funds for investment. Implications in industry privatization will be discussed later in the chapter.

The following conclusions from the China study are believed to have significant implications in policy making for telecommunications financing in developing countries.

First, it is evident that a centralized industry hierarchy may not render the highest efficiency. As the study shows, at the early stages of development when national resources were limited and the society could not afford a high price, the central regime could collaborate a

national effort and provide heavy subsidy in order to promote telecommunications services quickly at low prices. As the industry grows, however, the centralized structure has shown serious weaknesses. Not only is it not able to provide sufficient funding in pace with the growth, but also its commands ill address local needs and objectives that often are drastically different from each other. In countries whose industry structure is traditionally centralized like China, reform is imperative as the market expands and the excess demand persists.

Second, however, measures of reform can be different from case to case. In China, for example, the structural reform is aimed at resolving financing shortages rather than altering industry ownership from central command to private enterprise. Regardless of policy measures, the consequences are rather similar: the central power has been reduced, replaced by market principles and competition.

Third, diversified financing has proven to be an effective approach for developing countries that have a central industry regime but suffer from investment constraints. The rationale of diversified financing is that it brings economic and social benefits to locality as a result of their share of investment. The more profits local authorities are allowed to keep, the more motivated they become in investment. Once the momentum is achieved, local financing will increase rapidly, even outgrow central

investment in scale; it also can become a catalyst for competition and technology transfer, as revealed in the study.

The final remark is the prospects between diversified financing and central efficiency. Since the late 1980s, an increasing number of developing countries have taken steps in privatizing their telecommunications. Experiences in South Korea, Mexico, Malaysia, Singapore and others indicate that privatization can improve industry financing and hence competitiveness (Wellenius, et al., 1989). Interestingly, those countries that have privatized their telecommunications industry almost all began with sector competition in the CPE market; the similar pattern in China is found by this study as competition first emerged in the CPE market. However, the study recognizes that privatization also poses potential risks in controlling national resources, unruly competition causing price hike and service degradation. One additional observation should be raised that those countries that have privatized their telecommunications industry are generally small, have a well developed economy, and a strong private sector. These characteristics do not exist in China. On the contrary, China is faced with scarce capital and technical resources, and the economic development is very uneven between urban and rural areas.

It seems legitimate to have a centralized industry

regime that can utilize scarce resources more efficiently, providing more access and lower prices (Saunders, 1983). It also seems possible that diversified financing can yield better results if coordinated by the central administration. However, the concept of central efficiency may face tremendous difficulty in countries that have enormous and uneven markets, strong local autonomy, and particularly, an inefficient industry regime that is often perceived as a hurdle to local developments. As argued by Wellenius, et al. (1989), the key to telecommunications development in developing countries is motivation, while most central regimes have failed to create motivation because central planning and financing scheme provide little flexibility and profitability for local businesses. China's experience has also confirmed this rationale.

However, the question remains as whether industry decentralization is totally incompatible with a central efficiency. China's experience indicates that answer seems to lie between the two ends. The coordination and competition between the central control and local diversity serve the best interest of the industry, the consumer and the economy, as shown by the growth in the 1980s.

The debate of industry privatization should be based on the outcome, not on a priori imposition. It may take some time for individual countries to find the most effective approach to telecommunications development, and

privatization is one of such possibilities. As this study insists, a decade of telecommunications growth in China has manifested that vigorous central control is neither efficient nor sufficient for the industry. It has just begun to acknowledge emerging market forces and their contributions.

The study of diversified financing supplements the current research on financing strategies in developing countries. China's experience provides the possibility of creating a hybrid industry structure in which central planning and distributed operations and local autonomy coexist through coordination and competition. The result of diversified financing is remarkable, not only does it offset investment constraints, but it also has facilitated a new dichotomy of market forces, which undoubtedly will have far-reaching impacts in the future.

Therefore, it is premature to elicit that diversified financing will result in privatization in China based only on changes occurring in the telecommunications industry. Further evolution in decentralization will depend on many external factors such as political reform and economic development. Nonetheless, diversified financing has definitely strengthened the trend that cannot stop but continue to move forward, even if this means taking risks including a diminishing central regime. The stake is too high for China's telecommunications to retreat to its old

course.

China's telecommunications industry will face many new challenges in the 1990s, amid drastic political and economic changes both at home and around the world, particularly the Asia-Pacific region. Although investment constraints will be the persistent obstacle for China's telecommunications industry the 1990s, this study believes the industry will manage to advance. Diversified financing made significant contributions to China's telecommunications development in the 1980s, it will likely continue to have fundamental effects on the market growth, competition and technology in the 1990, and ultimately, the Chinese economy and society.

APPENDICES

APPENDIX A

REGRESSION TESTS AND CORRELATIONS OF TELECOMMUNICATIONS INVESTMENT AND GROWTH INDEX

YEAR	INVEST	REVENUE	SWITCH	PHONESET
1980	6.2	13.3	4.4	4.2
1981	5.4	19.5	4.6	4.4
1982	6.8	20.4	4.9	4.6
1983	8.1	22.3	5.2	5.0
1984	10.8	25.0	5.5	5.5
1985	17.2	29.6	6.1	6.3
1986	17.2	28.2	6.7	7.1
1987	21.6	37.7	7.7	8.1
1988	26.6	59.6	8.9	9.4
1989	40.1	75.6	10.4	10.9
1990	49.2	102.4	12.3	12.7

Number of cases read = 11 Number of cases listed = 11

* * * M U L T I P L E R E G R E S S I O N * * *

Equation Number: 1 Dependent Variable: REVENUE Total Revenue(100 million yuan).

Beginning Block Number 1. Method: Stepwise.

Variable(s) Entered on Step Number.
1. INVEST Total Annual Investment(100 million yuan).

Multiple R	.98100
R Square	.96237
Adjusted R Square	.95819
Standard Error	5.72909

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	7554.43374	7554.43374
Residual	9	295.40262	32.82251

F = 230.16012 Signif F = .0000

Variable	B	SE B	Beta	T	Sig T
INVEST	1.89130	.12467	.98100	15.171	.0000
(Constant)	3.44908	2.93344		1.176	.2698

End Block Number 1 POUT = .100 Limits reached.

* * * M U L T I P L E R E G R E S S I O N * * *

Equation Number 2 Dependent Variable: SWITCH Switching Capacity(million lines).

Variable(s) Entered on Step Number.
1. INVEST Total Annual Investment(100 million yuan).

Multiple R	.99295
R Square	.98595
Adjusted R Square	.98439
Standard Error	.32352

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	66.11980	66.11980
Residual	9	.94201	.10467

F = 631.70853 Signif F = .0000

Variable	B	SE B	Beta	T	Sig T
INVEST	.17694	7.03991E-03	.99295	25.134	.0000
(Constant)	3.60766	.16565		21.778	.0000

End Block Number 1 POUT = .100 Limits reached.

* * * M U L T I P L E R E G R E S S I O N * * *

Equation Number 3 Dependent Variable: PHONESET Total Number of Telephone Sets(millions).

Variable(s) Entered on Step Number.
1. INVEST Total Annual Investment(100 million yuan).

Multiple R	.99016
R Square	.98041
Adjusted R Square	.97823
Standard Error	.42159

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	80.04942	80.04942
Residual	9	1.59967	.17774

F = 450.36964 Signif F = .0000

Variable	B	SE B	Beta	T	Sig T
INVEST	.19469	9.17390E-03	.99016	21.222	.0000
(Constant)	3.40648	.21587		15.780	.0000

End Block Number 1 POUT = .100 Limits reached.

CORRELATIONS VARIABLES=Invest Revenue Switch PhoneSet

Variable	Cases	Mean	Std Dev
INVEST	11	19.0182	14.5325
REVENUE	11	39.4182	28.0176
SWITCH	11	6.9727	2.5896
PHONESET	11	7.1091	2.8574

Correlations:	INVEST	REVENUE	SWITCH	PHONESET
INVEST	1.0000	.9810**	.9930**	.9902**
REVENUE	.9810**	1.0000	.9844**	.9728**
SWITCH	.9930**	.9844**	1.0000	.9979**
PHONESET	.9902**	.9728**	.9979**	1.0000

N of cases: 11 1-tailed Signif: * - .01 ** - .001

APPENDIX B

REGRESSION TESTS AND CORRELATIONS IN T-1 INTERVALS

YEAR*	INVEST	REVENUE	SWITCH	PHONESET
1980	6.2	19.5	4.6	4.4
1981	5.4	20.4	4.9	4.6
1982	6.8	22.3	5.2	5.0
1983	8.1	25.0	5.5	5.5
1984	10.8	29.6	6.1	6.3
1985	17.2	28.2	6.7	7.1
1986	17.2	37.7	7.7	8.1
1987	21.6	59.6	8.9	9.4
1988	26.6	75.6	10.4	10.9
1989	40.1	102.4	12.3	12.7

*Year for investment.

Number of cases read = 10 Number of cases listed = 10

* * * M U L T I P L E R E G R E S S I O N * * *

Equation Number 1 Dependent Variable: REVENUE Total Revenue(100 million yuan).

Beginning Block Number 1. Method: Stepwise.

Variable(s) Entered on Step Number.
1. INVEST Total Annual Investment(100 million yuan).

Multiple R	.96831
R Square	.93762
Adjusted R Square	.92983
Standard Error	7.44015

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	6656.61441	6656.61441
Residual	8	442.84659	55.35582

F = 120.25138 Signif F = .0000

Variable	B	SE B	Beta	T	Sig T
INVEST	2.44898	.22333	.96831	10.966	.0000
(Constant)	2.84636	4.27826		.665	.5246

End Block Number 1 POUT = .100 Limits reached.

* * * M U L T I P L E R E G R E S S I O N * * *

Equation Number 2 Dependent Variable: SWITCH Switching Capacity(million lines).

Variable(s) Entered on Step Number
1. INVEST Total Annual Investment(100 million yuan).

Multiple R	.98514
R Square	.97051
Adjusted R Square	.96682
Standard Error	.46945

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	58.01796	58.01796
Residual	8	1.76304	.22038

F = 263.26380 Signif F = .0000

Variable	B	SE B	Beta	T	Sig T
INVEST	.22863	.01409	.98514	16.225	.0000
(Constant)	3.57187	.26994		13.232	.0000

End Block Number 1 POUT = .100 Limits reached.

* * * M U L T I P L E R E G R E S S I O N * * *

Equation Number 3 Dependent Variable: PHONESET Total Number of Telephone Sets(millions).

Variable(s) Entered on Step Number
1. INVEST Total Annual Investment(100 million yuan).

Multiple R	.98251
R Square	.96533
Adjusted R Square	.96100
Standard Error	.55991

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	69.83202	69.83202
Residual	8	2.50798	.31350

F = 222.75152 Signif F = .0000

Variable	B	SE B	Beta	T	Sig T
INVEST	.25083	.01681	.98251	14.925	.0000
(Constant)	3.38667	.32196		10.519	.0000

End Block Number 1 POUT = .100 Limits reached.

CORRELATIONS VARIABLES=Invest Revenue Switch PhoneSet

Variable	Cases	Mean	Std Dev
INVEST	10	16.0000	11.1051
REVENUE	10	42.0300	28.0861
SWITCH	10	7.2300	2.5773
PHONESET	10	7.4000	2.8351

Correlations:	INVEST	REVENUE	SWITCH	PHONESET
INVEST	1.0000	.9683**	.9851**	.9825**
REVENUE	.9683**	1.0000	.9829**	.9702**
SWITCH	.9851**	.9829**	1.0000	.9977**
PHONESET	.9825**	.9702**	.9977**	1.0000

N of cases: 10 1-tailed Signif: * - .01 ** - .001

APPENDIX C

REGRESSION TESTS AND CORRELATIONS IN T-2 INTERVALS

YEAR*	INVEST	REVENUE	SWITCH	PHONESET
1980	6.2	20.4	4.9	4.6
1981	5.4	22.3	5.2	5.0
1982	6.8	25.0	5.5	5.5
1983	8.1	29.6	6.1	6.3
1984	10.8	28.2	6.7	7.1
1985	17.2	37.7	7.7	8.1
1986	17.2	59.6	8.9	9.4
1987	21.6	75.6	10.4	10.9
1988	26.6	102.4	12.3	12.7

*Year for investment.

Number of cases read = 9 Number of cases listed = 9

* * * M U L T I P L E R E G R E S S I O N * * *

Equation Number 1 Dependent Variable: REVENUE Total Revenue(100 million yuan).

Beginning Block Number 1. Method: Stepwise.

Variable(s) Entered on Step Number
1. INVEST Total Annual Investment(100 million yuan).

Multiple R	.94812
R Square	.89893
Adjusted R Square	.88449
Standard Error	9.71425

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	5874.89290	5874.89290
Residual	7	660.56710	94.36673

F = 62.25598 Signif F = .0001

Variable	B	SE B	Beta	T	Sig T
INVEST	3.55616	.45070	.94812	7.890	.0001
(Constant)	-2.84260	6.82185		-.417	.6894

End Block Number 1 POUT = .100 Limits reached.

* * * M U L T I P L E R E G R E S S I O N * * *

Equation Number 2 Dependent Variable: SWITCH Switching Capacity(million lines).

Variable(s) Entered on Step Number
1. INVEST Total Annual Investment(100 million yuan).

Multiple R	.98385
R Square	.96797
Adjusted R Square	.96339
Standard Error	.48827

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	50.42670	50.42670
Residual	7	1.66886	.23841

F = 211.51420 Signif F = .0000

Variable	B	SE B	Beta	T	Sig T
INVEST	.32947	.02265	.98385	14.544	.0000
(Constant)	3.13299	.34289		9.137	.0000

End Block Number 1 POUT = .100 Limits reached.

* * * M U L T I P L E R E G R E S S I O N * * *

Equation Number 3 Dependent Variable: PHONESET Total Number of Telephone Sets(millions).

Variable(s) Entered on Step Number
1. INVEST Total Annual Investment(100 million yuan).

Multiple R	.98523
R Square	.97067
Adjusted R Square	.96648
Standard Error	.51108

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	60.51159	60.51159
Residual	7	1.82841	.26120

F = 231.66583 Signif F = .0000

Variable	B	SE B	Beta	T	Sig T
INVEST	.36091	.02371	.98523	15.221	.0000
(Constant)	2.92519	.35891		8.150	.0001

End Block Number 1 POUT = .100 Limits reached.

CORRELATIONS VARIABLES=Invest Revenue Switch PhoneSet

Variable	Cases	Mean	Std Dev
INVEST	9	13.3222	7.6203
REVENUE	9	44.5333	28.5820
SWITCH	9	7.5222	2.5519
PHONESET	9	7.7333	2.7915

Correlations:	INVEST	REVENUE	SWITCH	PHONESET
INVEST	1.0000	.9481**	.9839**	.9852**
REVENUE	.9481**	1.0000	.9846**	.9716**
SWITCH	.9839**	.9846**	1.0000	.9975**
PHONESET	.9852**	.9716**	.9975**	1.0000

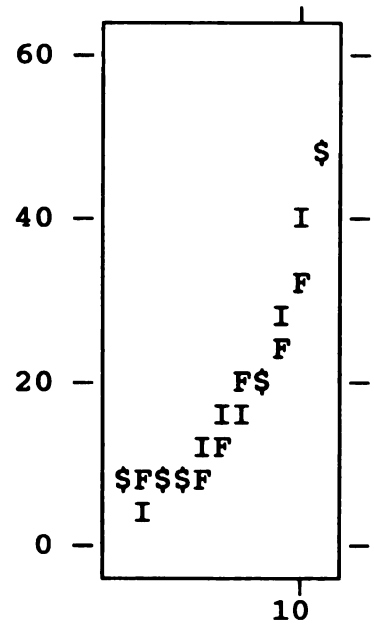
N of cases: 9 1-tailed Signif: * - .01 ** - .001.

APPENDIX D

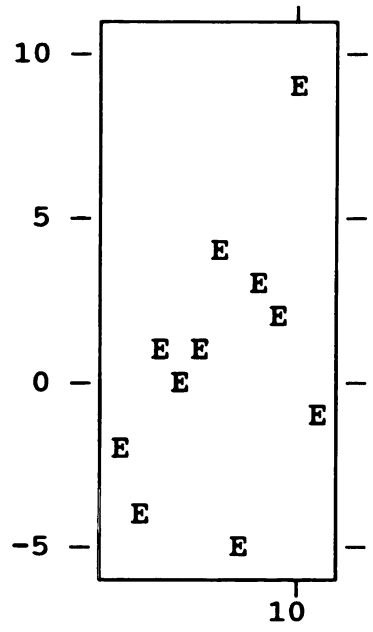
EXPONENTIAL SMOOTHING MODELS FOR INVESTMENT
(Linear & Exponential, 1980-90)

1. Linear Model

```
Results of EXSMOOTH procedure for Variable INVEST.
MODEL= LN (Linear trend, no seasonality).

Initial values:        Series            Trend
                      4.05000          4.30000

Number of cases = 11      DFE = 9.

The SSE is:       Alpha        Gamma              SSE
                1.000000     .6000000        155.25129

FIT_1  Fit for INVEST from EXSMOOTH, MOD_1 LN A1.00 G .60
ERR_1  Error for INVEST from EXSMOOTH, MOD_1 LN A1.00 G .60

TSPLOT Invest Fit_1.
The following plot symbols are used:
    I - Variable INVEST
    F - Variable FIT_1
    M - Missing Data (placed on the horizontal axis)
    $ - Multiple Hits
```

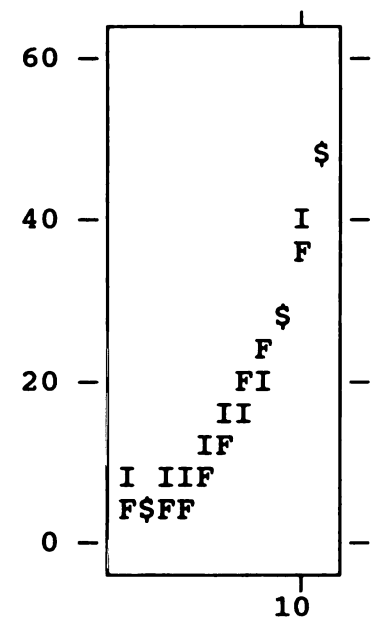


TSPLOT Err_1.
The following plot symbols are used:
E - Variable ERR_1
M - Missing Data (placed on the horizontal axis)

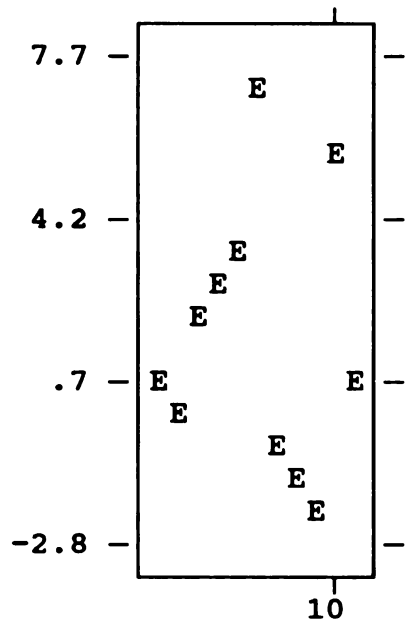


2. Exponential Model

```
Results of EXSMOOTH procedure for Variable INVEST.
MODEL= EN (Exponential trend, no seasonality).

Initial values:        Series            Trend
                       6.64340           .87097

Number of cases = 11      DFE = 9.

The SSE is:       Alpha        Gamma              SSE
                .5000000     .4000000       103.71128

FIT_2    Fit for INVEST from EXSMOOTH, MOD_2 EN A .50 G .40
ERR_2    Error for INVEST from EXSMOOTH, MOD_2 EN A .50 G .40

TSPLOT Invest FIT_2.
The following plot symbols are used:
    I - Variable INVEST
    F - Variable FIT_2
    M - Missing Data (placed on the horizontal axis)
    $ - Multiple Hits
```




```
TSPLOT ERR_2.
The following plot symbols are used:
    E - Variable ERR_2
    M - Missing Data (placed on the horizontal axis)
```


7.7
4.2
.7
-2.8
10

APPENDIX E

FORECASTING MODELS FOR INVESTMENT
(Linear & Exponential, 1991-2000)

1. Linear Forecasting Model

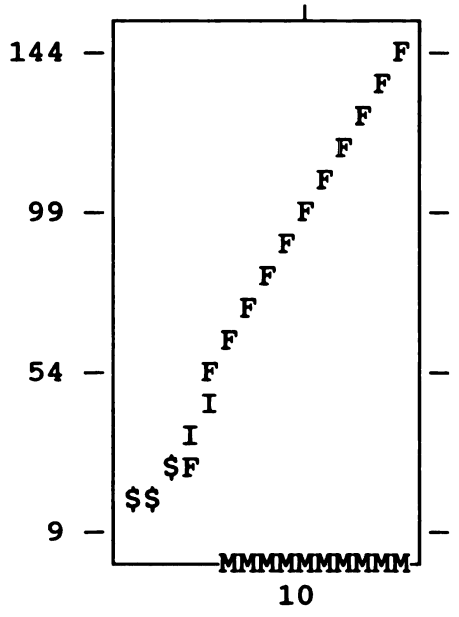
PREDICT Year 1991 THRU 2000.

FIT#1 Fit for INVEST from EXSMOOTH, MOD_1 LN A1.00 G .60

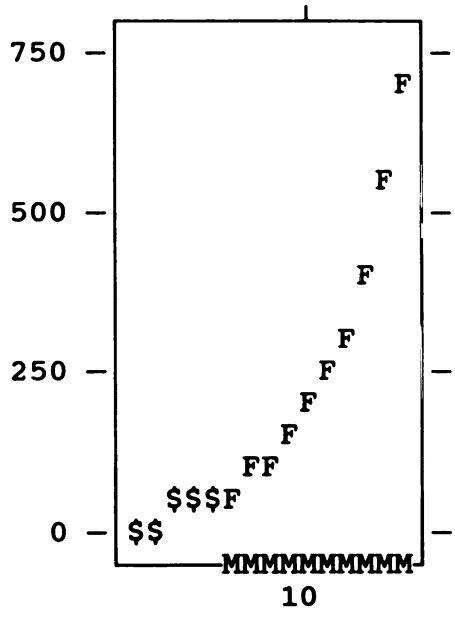
10 new cases have been added.

USE 1986 THRU LAST.

TSPLOT Invest FIT#1.
The following plot symbols are used:
    I - Variable INVEST
    F - Variable FIT#1
    M - Missing Data (placed on the horizontal axis)
    $ - Multiple Hits



```
2. Exponential Forecasting Model

PREDICT Year 1991 THRU 2000.

FIT#2  Fit for INVEST from EXSMOOTH, MOD_2 EN A .50 G .40

10 new cases have been added.

USE 1986 THRU LAST.

TSPLOT Invest FIT#2.
The following plot symbols are used:
    I - Variable INVEST
    F - Variable FIT#2
    M - Missing Data (placed on the horizontal axis)
    $ - Multiple Hits
```



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