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TRANSFER OF TECHNOLOGY:

A CASE STUDY OF JAPAN AND MEXICO

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CHAPTER I

INTRODUCTION

The importance of the role of technology in economic development has recently been receiving more attention in the literature. Problems of semantics and agreement over definitional terms still exist, but there is a broad consensus that technology can no longer be assigned a backstage role as a parameter in development models. The transfer and diffusion of technology from the developed to the less developed countries is a complex process involving the people and institutions of both the sending and recipient countries. Knowledge of the cultural setting and institutional arrangements of the recipient country is a necessary prerequisite to an understanding of the transfer process. Some cultural traits and institutional arrangements are conducive to the assimilation of foreign technology while others impede the acceptance of new technologies. Mere invention in a developed country does not necessarily lead to innovation in that country. Similarly the delivery of a new technology to a less developed country does not ensure the transfer and diffusion of that technology. Since most of the technological research and development as well as the bulk of the existing fund of technology is found in the developed countries, it is useful to examine their role concurrently with the role of the less developed countries in the transfer process. However, the basic focus of this study is concentrated on the attributes of the recipient countries which permit or impede technological transfer and diffusion.

The transfer of technology from one region to another is not a recent phenomenon. The cross-fertilization of ideas resulting from exposure to different cultures is an old phenomenon. Marco Polo's exploration and the Crusades are typical examples of one culture gaining new techniques from exposure to different societies. Technological change has been occurring since prerecorded history in an irresistible and methodical manner. The pace of technological change increased during the Industrial Revolution and accelerated during World War II as science and technology became inextricably linked together. Thus the problems of transferring technology today are different from those in the past due to both the rapid pace of technological change and the concomitant change in social institutions. The accelerated rate of technological change in the developed countries exerts great pressure on the less developed countries to speedily accept new technology or to be left in a technological backwash. This appears to have been the case in the 1960s as the economic gap between the developed and less developed countries widened.

It is the purpose of this study to investigate the transfer of technology to the less developed countries and its impact on economic development. Two countries, Japan and Mexico, are selected for a case study. These two countries have achieved well above average economic growth rates since World War II. They represent bright spots on what has turned out to be a rather dismal picture for the less developed countries. Japan is the only country to change from a less developed to a developed country status since World War II. Mexico's progress in economic development has been good enough to earn the label, "The Mexican miracle." Technological transfer and diffusion played a crucial role in the economic development of both these countries, although Japan and Mexico have very different histories and contrasting cultures.

It is hoped that the rather detailed examination of the processes of technological transfer and diffusion in Japan and Mexico may reveal certain commonalities useful to the less developed countries who are attempting to employ modern technology in their development. In addition to the basic purpose, this study attempts to test the hypothesis that the quality of human resources is a key force in the process of development. In this connection the role of education and other forces bearing on the quality of human resources in the cases of Japan and Mexico will be examined.

The major sources for this study are English publications of books and journals. Some reliance has been placed upon unpublished Ph.D. dissertations and United Nations and government publications. The literature on technology is vast, and the literature on technological transfer, while less abundant, is plentiful and growing. The bibliography listed in this study testifies to this point.

The methodology employed consists of historical and comparative analyses. Technological transfer, diffusion and adaptation for both Japan and Mexico are examined in the context of each country's history, culture and unique geographical position. The development of both countries is analyzed in the rather distinct periods of development which correspond to revolution, stability and rapid economic growth. Differences and similarities in the acquisition of technology are brought forth in order to bring the transfer process into clearer focus.

This study is divided into eight chapters including the introduction. Chapter II reviews some basic technological concepts and establishes definitions to clarify the use of terms throughout this work. The different channels of technological transfer are delineated with the focus on factors most crucial to the less developed countries. The role of technological transfer and Western economic theory in economic development is analyzed with an emphasis on barriers to the acquisition of new technologies.

Chapters III and IV develop the role of technological transfer and diffusion in Mexico. First the early history, cultural milieu and land patterns are introduced. Then the role of technological transfer in agriculture and industry is examined in the relevant periods, beginning with the Porfirian era, followed by the period of revolution and reform, and concluded with the period of steady growth.

Chapters V and VI develop the role of technological transfer and diffusion in Japan in a format similar to that of Mexico. Background material on history, cultural milieu and land patterns is presented first. Then the influence of technological transfer is developed by periods in the agricultural and industrial sectors. The analysis proceeds from the Meiji period to the era of accelerated growth and concludes with Japan's war and postwar experiences culminating in explosive growth.

Chapter VII brings together the Mexican and Japanese experiences for comparison and analysis. Differences and commonalities in history, cultural heritage and land patterns are discussed. The adaptation of technology to each country's unique requirements and the corresponding institutional adjustment are evaluated. Chapter VIII presents a summary and the conclusions of the study.

CHAPTER II

TECHNOLOGY AND TECHNOLOGICAL TRANSFER

Concepts of Science and Technology

The phrase "science and technology" is often discussed as if those using the term felt they were conveying a common-sense statement understood by everyone. This is not always the case. The phrase "science and technology" can be used as an ambiguous parameter by economic model builders to simplify their task. The same phrase can also be used as a weapon by institutionalists and Marxists to attack the relevance of orthodox economic models. The purpose of this chapter is to clarify the use of the term technology and to reduce the amount of ambiguity associated with such an all-encompassing word. Further, the role of technological transfer in the process of economic development and its relationship to Western economic theory is examined.

Technology is sometimes described as know-how, while science is associated with know-why. Hence technology aids in producing wealth, while science increases the fund of knowledge.[1] This simplistic distinction is sometimes replaced by a more sophisticated version which holds that there is a symbiotic relationship between science and technology. Science has few direct links to society, while technology serves as the intermediary linking science to society.[2] Technology is seen as more than applying knowledge to practical problems; it is a creative process that is independent of social needs.[3]

An opposing theory, stemming from the works of C. E. Ayres, suggests that there is no difference between science and technology. Both are viewed as results of the union of previously existing combinations of tools and skills.[4] This approach integrally connects human values and needs with technology. The valuing process becomes an instrumental tool-defined conception of truth. Technological values are deemed to be consistent with the life process as

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[1]Graham Jones, The Role of Science and Technology in Developing Countries (London: Oxford University Press, 1971), p. 5.

[2]Albert H. Teich, ed., Technology and Man's Future (New York: St. Martin's Press, 1972), p. 3.

[3]Ibid.

[4]C. E. Ayres, The Theory of Economic Progress: A Study of the Fundamentals of Economic Development and Cultural Change (2nd ed.; New York: Schocken Books, 1962), p. 113.

interpreted from the continuum of an on-going process.[1]

The approach used in the study is an eclectic one which combines some aspects of the Ayresian technological continuum and some aspects of the sophisticated dichotomized version of science and technology. It is recognized that science and technology may be essentially part of the same process, but they will be spoken of separately for pedagogical purposes. The value problem, though crucial, will not play a central role in this definition of technology. Technology has a tremendous impact on value systems, but it seems wise to avoid Mill's mistake of concluding that the value problem has been resolved now with a scientific framework of values.

Technology is defined as the combination of human skills (linguistic, intellectual and physical) with tools.[2] It is the new combination of tools and human skills that advances the state of technology.[3] Technology involves then not only changes in artifacts, but also incorporates

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[1]For a different view see Jaques Ellul, The Technological Society, trans. by John Wilkinson (New York: Vintage Books, 1964).

[2]Ayres, The Theory of Economic Progress, p. 129. Also see W. Paul Strassmann, Technological Change and Economic Development: The Manufacturing Experience of Mexico and Puerto Rico (Ithaca, New York: Cornell University Press, 1968), p. 2.

[3]For a different view see Edwin Mansfield, Technological Change (New York: W. W. Norton and Company, Inc., 1971), pp. 9-10.

cultural, social and psychological processes.[1]

The inconsistent and ambiguous use of the word technology has affected the use of the term "technological transfer." Social scientists have sometimes used the term too loosely. Spencer and Woroniak suggest economists are not exempt from this criticism.

> Economists, too, with some notable exceptions, have been content to deal with technology as if it had somehow arrived as a datum for incorporation via market adjustments in general equilibrium theory, or a "residual factor" -- a shift in the production function. When the specific idea of transfer technology does appear, it is often entwined with industrialization, social and revolutionary change, and other such sweeping ideas.[2]

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[1]John Joseph Murphy, "Retrospect and Prospect," in The Transfer of Technology to Developing Countries, ed. by Daniel L. Spencer and Alexander Woroniak (New York: Praeger Publishers, Inc., 1967), p. 6.

[2]Daniel L. Spencer and Alexander Woroniak, ed., The Transfer of Technology to Developing Countries (New York: Praeger Publishers, Inc., 1967), p. 2. See Strassmann, Technological Change and Economic Development, pp. 5-12 for a capsulization of past views of technology and development. A review of recent Ph.D. dissertations on technological transfer demonstrates the increased awareness of economists of the need to clarify their use of the term technology. See James Edward Annable, "The Transfer of Technology, Industrialization and the Urban Employment Problem in Low-Income Countries" (unpublished Ph.D. dissertation, Princeton University, 1971), p. 10 or Moonsong Oh, "The Role of International Corporations in the Transfer to Developing Countries" (unpublished Ph.D. dissertation, University of Pennsylvania, 1970), p. 10 for their careful use of the term. It should be noted that institutional arrangements have received much the same treatment as technology has from economists. Institutional arrangements are often relegated to the role of a parameter. See Gayle D. Ness, The Sociology of Economic Development: A Reader (New York: Harper and Row, Publishers, 1970), pp. 126-27.

In this study technological transfer will be considered as one aspect of innovation, ". . . meaning by the word 'innovation' the whole process from scientific discovery or invention to the final emergence of a marketable product, or a social service."[1] Technological transfer, in this context, is the conveyance of a tool-using behavior from one group or person to another group or person. The particular channels of transfer will be explored in some depth later in this chapter.

Research and development increases the fund of technological knowledge. This is the first step in the innovative process. Most research and development occurs in the developed countries and may or may not lead to innovation, depending on the type of research and development.[2] Military research and development is not necessarily useful in producing marketable products in the innovative process. Markets may not exist for resultant products, or the research and development expenditures may be used ineffi-

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[1]Introduction by Lord Blackett in Jones, The Role of Science and Technology, p. ix.

[2]For instance the United States directs over $27 billion to research and development, of which the government accounts for $15 billion and industry nearly $11 billion. The bulk of the government expenditures is devoted to space and military related projects resulting in relatively few marketable innovations. See Nathan Rosenberg, Technology and American Economic Growth (New York: Harper and Row, 1972), p. 178.

ciently.[1] Figure 1 suggests that since the 1950s both Japan and Germany have made much better use of their research and development in terms of realizing economic gains from their investments than have the United States or Russia. This is probably due to the large percentage of research and development expenditures for military and space projects in the latter two countries. Thus research and development does not automatically lead to innovation or economic growth for the investing country.

The same problem exists from a different perspective when one country wants to transfer the research and development created in another country. Research and development which led to fruitful innovation in a developed country may not necessarily lead to innovation in a less developed country. The innovative process in a developed country is consciously planned and includes market structures and income distribution patterns as well as culturally defined tastes and preferences. It is important to perceive technological transfer as a process package concept and not as something which can be arbitrarily plucked out of one culture and plugged into another. This is especially true when the technology is created in a developed country and transferred to a less developed country. Technological transfer is not limited to the mere imitation of manufacturing techniques;

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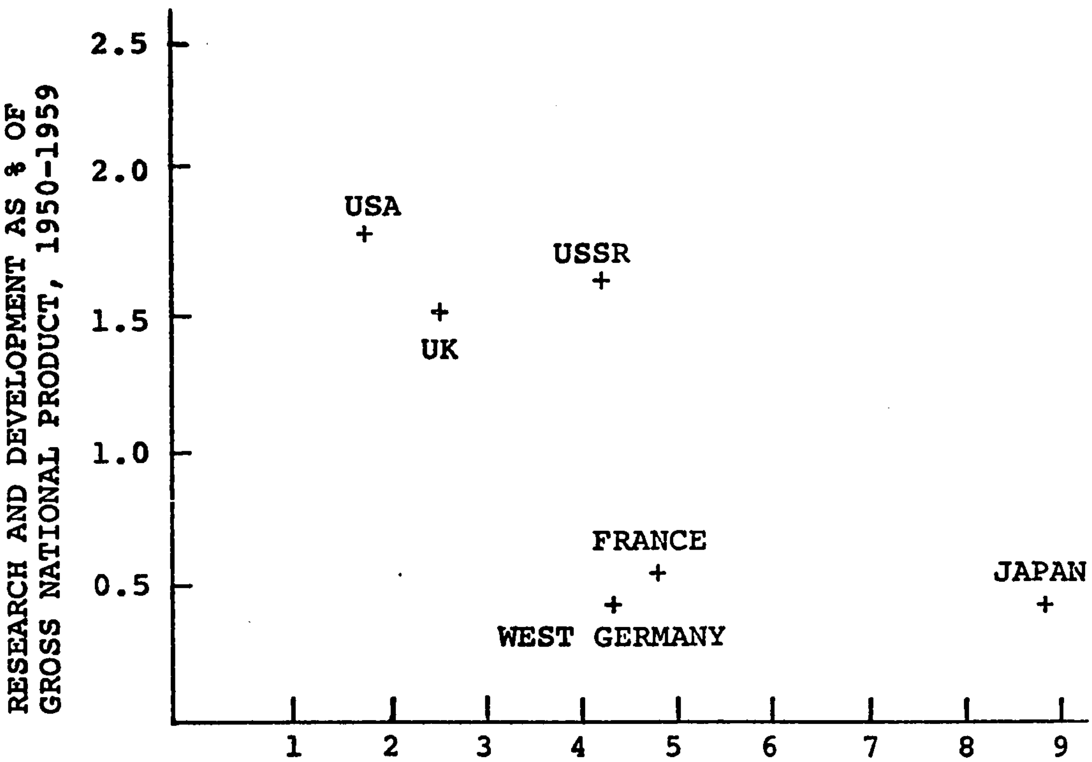
[1] Jones, The Role of Science and Technology, p. 10.

FIGURE 1

THE RELATIONSHIP OF RESEARCH AND DEVELOPMENT TO GROWTH IN PRODUCTIVITY



AVERAGE COMPOUND GROWTH OF OUTPUT PER MAN EMPLOYED, 1955-1964

Source: Bruce Rodda Williams, Technology, Investment, and Growth (London: Chapman and Hall, 1967), p. 57.

it is a cultural-political process.[1] The success of technological transfer is dependent upon adapting the technology to the new environment or changing the inhibiting factors in the receiving country -- or both. If cultural manipulation is necessary, it should be done in a way which utilizes as many existing social patterns as possible.[2] The process package concept is crucial.

> From the wheel to the computer, success has been dependent upon the invention being integrated into a process, and often upon creating a process that demanded a new system of production. Technology, therefore, is embodied not in aggregate capital, nor in particular factors, but in the whole economic process that extends from factor supplies on the one hand to the marketing outlets on the other.[3]

In essence, the transfer of technology involves the transplant of a process package into a new system. Both the process package and the system may need to be adjusted to permit successful technological transfer. When the technology is sophisticated, the concept of a process package becomes a necessity for successful technological transfer, and when the receiver of the sophisticated process package is a less developed country, systems adjustments often be-

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[1] Ibid., p. 21.

[2] Melville J. Herskovits, "The Problem of Adapting Societies to New Tasks," in Development and Society: The Dynamics of Economic Change, ed. by David E. Novack and Robert Lekachman (New York: St. Martin's Press, 1964), p. 291.

[3] Murphy, "Retrospect and Prospect," p. 7.

come mandatory. Successful technological transfer results in technological change and economic development. This change does not take place in a vacuum.

> The introduction of a simple material thing, for example, hybrid corn seed, an iron-tipped plow, or a tractor, also means that there will be a corresponding change in the values, behavior, attitudes, and beliefs of the people.[1]

Concomitant with mechanization and urbanization are unemployment and a dislocation of value systems. For orderly change, great care must be taken to seek institutional adjustment rather than ripping apart existing institutional arrangements.[2]

Types of Technological Transfer

The vast variety of types of technological transfer creates a problem of selectivity. Multinational corporations, governments and international organizations are probably the more obvious general modes of transfer.[3] To

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[1]Thomas F. Trail, Education of Development Technicians: A Guide to Training Programs (New York: Praeger Publishers, Inc., 1968), p. 90.

[2]Sidney C. Sufrin, Technical Assistance: Theory and Guidelines (Syracuse, New York: Syracuse University Press, 1966), p. 18.

[3]John Roger Hansen, "The Acquisition of Technology for Development" (unpublished Ph.D. dissertation, University of Colorado, 1970), Chapter VII, "Media of Technological Transfer," pp. 196-267; Chapter VIII, "Channels of Technological Transfer," makes a distinction between channels and media of transfer which makes sense, but which this study lumps together for reasons of simplicity. Channels of

be more specific, means of transfer include radio, television, journals, mass media magazines and books, films, transfer embodied in products and machinery, research institutes, immigration, foreign students, consultants, technicians, salesmen, foreign friends, etc.

The Pearson Report emphasizes the need for multilateral channels of foreign assistance.[1] A multilateral transfer of technology would alleviate the present inadequacies of bilateral transfer which is a part of the assistance strategy. The dependence of the less developed country upon a particular developed country would be lessened by such an approach, allowing a more consistent and continuous flow of technology to the less developed countries. However, multilateral assistance should not be perceived as a panacea to the development problem, but rather as a limited additional and necessary tool for promoting economic development.

A multilateral agency, like public and private agencies, must do more than merely deliver tools and information to the less developed countries. Designs and

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transfer are corporations, government and private research groups. Radio, television, books, etc., are media of transfer.

[1]See Maurice Domergue, Technical Assistance: Theory, Practice, and Policies (New York: Praeger Publishers, Inc., 1968), pp. 83-91 for a discussion of the pros and cons of multilateral aid.

instructions must be accompanied by a continuing program sustaining the relationship between the donor of technology and the receiver. Another limitation is that technological breakthroughs initiated by private enterprises are not going to be given away cheaply. There is a financial constraint. Even when access to sophisticated technologies becomes available, the less developed countries may need huge investments in human capital before these technologies can be exploited.[1]

The local government plays a key role in the successful transfer and diffusion of technology. Japan's successful industrial development is partially due to its government's recognition of the importance of technological flows.[2] Too often the focus is upon capital inflows and the limitation of earnings outflows. Rather than concentrating on negotiating licensing agreements and regulating foreign investment, the Japanese government attempted to select the most appropriate technology and then negotiated commitments of the sender of these technologies to follow up with training and further support programs to insure successful transfer.[3]

As important as the role of government is in the

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[1]Rutherford M. Poats, Technology for Developing Nations: New Directions for U.S. Technical Assistance (Washington, D. C.: The Brookings Institution, 1972), P. 82.

[2]Ibid., p. 70. [3]Ibid., p. 71.

transfer of technology, it is private enterprise which actually produces and transfers the bulk of industrial technology.[1] The multinational corporation is probably the most important of the private agents transferring technology.[2] Given this reality it is necessary to examine the nature of technological transfer through the multinational corporations.

The transfer of industrial technology is accomplished by the,

> sale of their goods; through training for users of their products and establishment of local service facilities; through investment in local production and training of workers and technicians; through technical assistance to local customers and to local suppliers of materials, components, or subassemblies; through introduction in their locally staffed field operations of the methodology of integrated research, development, and engineering innovation, and through influence on or example to local competitors and suppliers.[3]

Thus the multinational corporation functions in such a manner as to connect research and development to the production process to the ultimate marketing of the final product. The multinationals have the advantage of efficient organization

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[1] Ibid., p. 63.

[2] The value of United States production abroad was nearly $110 billion in 1966 compared to United States exports of $43 billion that same year. See Robert Heilbroner, "The Multinational Corporation and the Nation State," The New York Review of Books, XVI, No. 2 (February 11, 1971), 21.

[3] Poats, Technology for Developing Nations, p. 64.

and centralized authority combined with vast research and marketing units capable of finding demand for new products. In essence they have superior technology and the ability to use it.[1]

Many of the less developed countries are understandably concerned about the immense power of the multinational corporations and view technological transfer from them as a mixed blessing. Some scholars suggest that this view is unfair to the multinationals.

> Although some of the charges (exploitation) may have been true in the past, they are no longer applicable to most international corporations today. The international corporation has been unnecessarily hampered by government authorities both at home and abroad largely due to misunderstanding of its true identity.[2]

However, based on past and present experience, it seems that the multinationals warrant a jaundiced eye toward their role in transferring technology. The interests of profit maximizing institutions do not necessarily coincide with the interests of the less developed countries. The sheer concentration of economic power illustrated in Table 1

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[1]James Quinn, "Technology Transfer by Multinational Companies," Harvard Business Review, XLVII (November-December, 1969), 150.

[2]Oh, "The Role of International Corporations," p. 13. Although Oh's paper tends to place the multinational corporations on a pedastal, it is a very good general source for information on the role of the multinationals in transferring technology to the less developed countries.

TABLE I

DISTRIBUTION OF 500 LARGEST INDUSTRIALS, BY COUNTRY OF ORIGIN, 1963 and 1967

Country	1963	1967
United States	306	300
Britain	53	53[a]
Japan	38	43
Germany	33	25.5[b]
France	25	23
Canada	13	11
Italy	7	8
Sweden	6	5
Switzerland	6	8
Netherlands	4	6[a]
Belgium	3	3.5
Australia	3	2
South Africa	2	2
Luxembourg	1	1
Mexico	1	1
India	1	1
Argentina	--	2
Brazil	--	1
Austria	--	1
Portugal	--	1

[a]Plus two Anglo-Dutch firms.

[b]Including a German-Belgium firm.

Source: Jack N. Behrman, Some Patterns in the Rise of the Multinational Enterprise (Chapel Hill: The Graduate School of Business Administration, University of North Carolina, 1969), p. 161.

justifies careful observation of their operations. Heilbroner projects that 200 United States corporations and 100 foreign corporations will dominate the world economy in the near future.[1]

One explanation for the rise of the multinational corporation is the product cycle theory.[2] This theory suggests that a product goes through stages of development. First, the product is developed by the home country. Then as the product is perfected and production processes are standardized, the product enters the export market. Finally, Figure 2 suggests that as more sophisticated products enter the domestic market (requiring more sophisticated technologies) the product may even be imported.

In general there will be a tendency for the product developed in an industrialized country to be exported to another industrialized country due to similar income levels. Thus the branch plants of one developed country are built in another developed country.

If the product cycle theory is correct in explaining

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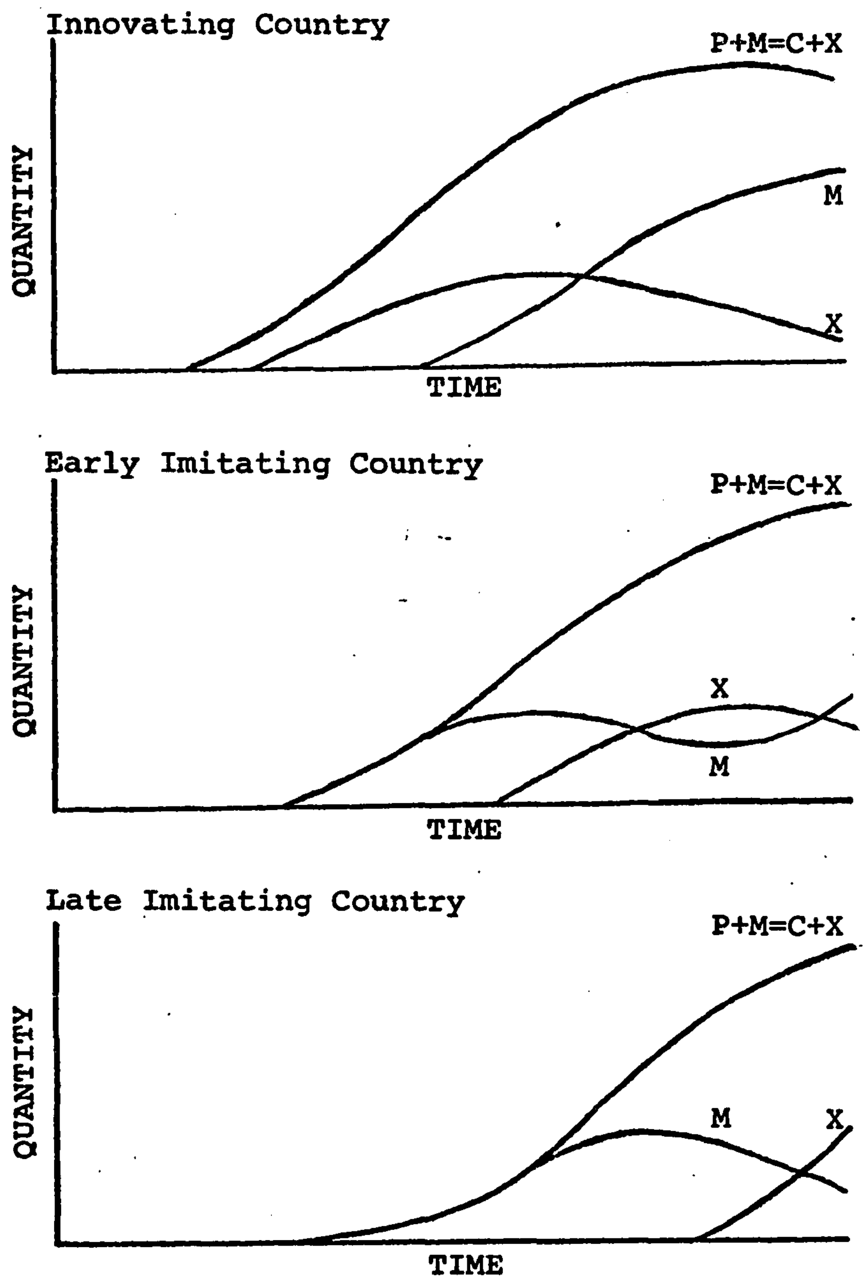
[1]Heilbroner, "The Multinational Corporations," p. 22.

[2]Frank Shadle Wert, "U.S.-Based Multinationalism: A Conceptual Analysis" (unpublished Ph.D. dissertation, Colorado State University, 1972), Chapter V. Also see Raymond Vernon, "Investment and International Trade in the Product Cycle," Quarterly Journal of Economics, LXXX (May, 1966), 190-207.

FIGURE 2

THE INTERNATIONAL DIFFUSION PROCESS



X = Exports
M = Imports
P = Domestic Production
C = Domestic Consumption

Source: John E. Tilton, International Diffusion of Technology: The Case of Semiconductors (Washington, D. C.: Brookings Institution, 1971), Figure 1-1, p. 21.

the investment behavior of the multinational corporations, then it has implications for the transfer of technology to the less developed countries. First, since the developed countries are the main trading partners, the less developed countries will get a small fraction of the world's technological transfer. Secondly, the transfer which the multinationals create may often be in the less sophisticated technologies, leaving the less developed countries in a technological backwash. This, in fact, seems to be the situation as demonstrated by the growing economic and technological gap between the developed and less developed countries in the 1960s.

The firm located in the less developed country is often an agent of technological transfer, but it is limited in its transfer capacity. A desire to maximize profits is not supplemented with the knowledge of how much of what to purchase.[1] Prices cannot direct information since the bids of firms which are based on inadequate information create the prices of the purchased information. The local entrepreneur does not know the value of the information he bids for, and he cannot just spend until the net marginal gains disappear since the worth of the information is not readily apparent in a continuous flow of gains. It should be noted that the government can subsidize the purchase of informa-

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[1]Strassman, Technological Change and Economic Development, p. 25.

tion in case of market failure, but the government is also faced with the problem of uncertainty. There is no way of forecasting an optimal purchase of information.

The transfer of technology to the firm occurs through a relay system. The relay system is composed of partially educated entrepreneurs and their connections with management consultants, machinery suppliers, trade journals, staff engineers, consulting engineers and license agreements.[1]

The entrepreneur's role as an information seeker is limited since he is interested in improving his business and not concerned with the diffusion of technology per se. He may be secretive and suspicious toward new information. This may result in only partially informing and training workers to reduce their mobility. Expansion is sometimes limited to the family to avoid training an outsider who could become a potential competitor. Greater exposure to new information can make the entrepreneur gradually more receptive and open, or he may change quickly if forced to cope with a modern competitor.

Face to face contact is necessary if the entrepreneur is to become a viable transfer mechanism. This contact often takes the form of his machinery supplier.

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[1]This discussion of the relay system is drawn from Strassman's analysis, Technological Change and Economic Development, pp. 29-42.

Machinery suppliers are more interested in moving goods than in the diffusion of knowledge. Often, due to small markets, most machines are handled by one importer and the demonstrations and transfer of knowledge are less than desirable.

> Failure by Japanese paper machinery builders to provide these services . . . once meant widespread losses by the Japanese of Indian sales to sales of equivalent English and Swedish machinery which was priced over twice as high.[1]

The need for face to face contact and continuing technical assistance is imperative to the local entrepreneur, as further illustrated by the following example:

> I found a Mexican mattress manufacturer who claimed he had paid a 56 percent higher price for a new machine in preference to a one-year-old machine in order to obtain the manufacturer's manuals and technical assistance which went with the new one.[2]

Staff engineers, like machinery suppliers, do not always aid in the diffusion of technology. Often they go strictly by manuals with little effort to improvise or innovate.[3] Foreign textbooks used by engineers may con-

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[1] Ibid., p. 33.

[2] Ibid. Simon Rottenberg notes the great amount of technical information transferred to Latin America by follow-up after the sale of precision control instruments. See Simon Rottenberg, How United States Business Firms Promote Technical Progress (Washington, D. C.: National Planning Association, 1957), p. 65.

[3] Strassman, Technological Change and Economic Development, p. 34.

centrate on mechanization and mass production while ignoring the problems arising in the less developed country. They tend to complain of the lack of funds to buy modern equipment and look with disdain upon makeshift adjustments and old equipment. These attitudes have an impact on the transfer process when the engineers make proposals to bring in management consultants.

Management consultants are often recommended by engineers to justify their desire for large capital expenditures.[1] Owners sometimes agree to such arrangements assuming the engineer knows what he is doing. Consultants may recommend more than increased capital spending, however. They may make suggestions concerning planning inventory control, budget techniques, etc. The problem with such recommendations is that organizational changes are hard to make if they are not forced by the production process itself. Attempts at new record keeping may result in increased costs and inaccurate information due to lack of comprehension of the workers. Problems such as these often are the reason foreign branch plants are not set up in the less developed country.[2]

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[1] Ibid., p. 36.

[2] In addition, foreign consultants may have problems with the language, appointment dates, etc. See E. T. Hall, The Silent Language (Greenwich, Connecticut: Fawcett, 1959): Fred Tickner, Technical Cooperation (New York: Praeger Pub-

To gain information, the less developed country's firm may enter into licensing agreements with foreign firms. A patent is often used to make the transfer of information. Unfortunately, patents are usually not detailed enough to allow ready application unless the user is highly trained in the particular area -- which is usually not the case.[1] The channel of communication is also a problem. The licensor generally determines the kind of information to be delivered. Supposedly the licensee does have a better knowledge of the indigenous surroundings in which the knowledge will be transferred. The one-way communication flow is obviously inadequate (the licensor has an incentive for success, usually a percent of net sales, but does not share in failure). The Japanese have been particularly successful in acquiring technology through patents. But they have taken great care to get commitments from the sending country to follow through with training and support programs.[3]

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lishers, Inc., 1965), p. 159. See Trail, Education of Development Technicians, pp. 46-74 for a comprehensive list of the needed adjustments for the development technician, e.g., maintaining cultural identity, group interaction, world ideologies, etc.; Yonah Alexander, International Technical Assistance Experts: A Case Study of the U.N. Experience (New York: Praeger Publishers, Inc., 1966), offers the experience of United Nations technicians which are illustrative of the problem.

[1]Poats, Technology for Developing Nations, p. 64.

[2]Strassman, Technological Change and Economic Development, p. 38.

Consulting engineers are responsible for making a new enterprise work, and thus they are generally more motivated than licensors in the adaptive process. Yet they are most familiar with the techniques used in industrialized countries and have difficulty in adjusting to the requirements of the less developed country.[1] Often the industrial process is considered to be set and routine -- only a matter of construction along existing guidelines. The attitude prevails that marginal adjustments can be made later. But where major innovations occur, the concept of adaptation was planned in advance, as demonstrated in Mexico with the development of stabilized tortillia flour; direct reduction of iron ore with natural gas; and paper produced from bagasse, yuccas and tropical hardwoods.[2]

Research institutes in the less developed countries have been typically ineffective in creating technology for development. They often become involved in research more suitable to the needs of developed countries. Scientists throughout the world are interested in breaking through the existing frontiers of knowledge. Unfortunately the desperate needs of the less developed countries are not directly met by esoteric research. As a result, research institutes in the less developed countries become isolated in a cloistered environment with little connection to the immediate

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[1] *Ibid.*, p. 40. [2] *Ibid.*, pp. 242-50.

problem of finding technologies useful for creating economic development.

Research institutes can play a key role in the developing and diffusion of new technology. Priorities need to be set and adhered to while linking the research work to universities, government and agricultural and industrial enterprises.[1] Since a certain minimum effort is necessary which requires scarce resources, international cooperation may be desirable on regional levels. The linking of research institutes in the developed countries and the less developed countries offers further promise for transferring technology.

International research centers such as the Rockefeller Foundation develop new technologies for global distribution and support local research institutes. The new Canadian International Development Research Center plans to focus specifically on the immediate and fundamental development problems of the less developed countries. At times the international research centers can make dramatic technological breakthroughs resulting in successful technological transfer, as with the Rockefeller Foundation's work on new seeds and the ensuing Green Revolution.

The Rockefeller Foundation's first agricultural sciences program was established in the Mexican Ministry of

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[1]Jones, The Role of Science and Technology, p. 28.

Agriculture in 1943.[1] This program has been very successful and greatly aided Mexico in becoming self-sufficient in the production of wheat. Importantly, the program was initiated with only a very few American scientists and no Mexicans holding a Ph.D. in the agricultural sciences. By 1963 Mexico had institutionalized agricultural science into the fabric of society and had begun to produce its own agricultural scientists.

That research institutes in the developed countries can make contributions to the less developed countries has also been demonstrated by Batelle Memorial Institute (Ohio). This institute, supported by an Agency for International Development research contract, was able to develop a hand-operated water pump suitable for use in the less developed countries.[2] Such action reflects the importance of linkage between the research institutes, government and the less developed country.

The vast inflow of human resources of a relatively high quality (in terms of usefulness in initiating the industrialization process) that occurred in the development

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[1]Vernon W. Ruttan, "The International Institute Approach," in Agents of Change: Professionals in Developing Countries, ed. by Guy Benveniste and Warren F. Ilchman (New York: Praeger Publishers, Inc., 1969), p. 221.

[2]Organization for Economic Co-ordination and Development, Development Assistance Review, 1971 (Paris: Organization for Economic Co-operation and Development, 1971), p. 113.

of the United States is not likely to repeat itself in the less developed countries today. However, immigration in the form of scientists, engineers, technicians and managerial talent is still an important channel for transferring technology from the developed countries to the less developed countries. The single most important source of this type occurs through the networks of the multinational corporations. The transfer can be particularly successful when the local branch of the multinational corporation is attuned to the culture, political environment, and economic needs of the less developed country. Foreign skills can be used more efficiently in this context as opposed to a local branch which is isolated from the indigenous surroundings.

In recent years there has been a flood of talented people who have moved from their homes in the less developed countries to the developed countries, largely offsetting the influx of technologists sent to less developed areas. This phenomenon is referred to as the "brain drain." Scientists, engineers, doctors, etc., have moved from the less developed countries to the developed countries to take advantage of higher salaries, better working facilities, and other lures that the developed countries offer. If the "brain drain" can be stopped, or especially if it can be reversed, the rewards to the less developed countries may be considerable. To reverse the flow of human resources will require the cooperation of the developed and less developed countries as well as international organizations. Research grants, higher salaries, better working facilities, and better preparation of foreign students going abroad are necessary to achieve this goal. Foreign students are often not prepared for the cultural shock they experience when the realities of the developed countries do not match their preconceived images of those countries. As a result they may become alienated from the developed countries, or they may reject their own cultural identities.

The danger of losing valuable human resources through the "brain drain" is a very real and important obstacle to the acceptance of new technologies. If the selected trainees reject their own cultural images in favor of a developed economy's lure, the result may well be either an extended stay in the developed country under the guise of continuing education or a permanent change in citizenship.[1] Plans should be made from the start to prevent potential alienation from the home culture in order to prevent temporary or even permanent loss of these scarce resources. An alienated person, even if he returns to his own country permanently may be more of a burden than a resource for future development. Persons forced to accept employment

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[1]Domergue, Technical Assistance, p. 126.

below their qualifications may even threaten the political stability of a less developed country as in the case of Sudan in 1961.[1] Thus plans for preparing students before going abroad, while abroad, and for their eventual return is essential to creating a human resource base in the less developed countries.

Superficially the problem of the "brain drain" can be solved simply by placing an embargo at the source or by exclusion at the destination.[2] But this approach ignores the fact that the "brain drain" is a symptom of the structural maladjustment prevailing in the less developed countries. Many less developed countries cannot absorb the highly educated people they have trained at home and in foreign countries. Their infrastructure has not developed to the point where the present quantities of professional people can be employed according to their abilities. Further, the developed countries often have inelastic supply curves for professionals such as doctors and engineers. The long period of education contributes to the inelasticity of supply and is reinforced by monopoly power such as the

[1]Walter Adams and Joel B. Dirlam, "An Agenda for Action," in The Brain Drain, ed. by Walter Adams (New York: The Macmillan Company, 1972), p. 250.

[2]This discussion of the brain drain is primarily based upon Adams and Dirlam's article "An Agenda for Action," pp. 246-63.

American Medical Association. Thus there is a tendency for the professionals to be "pushed" out of the less developed countries due to structural maladjustment and "pulled" into the developed countries where there is often a shortage of these highly developed human resources.

Solutions to the "brain drain" problem are not simple, but there are some measures that could be taken to alleviate the present condition. It is probably impossible for the less developed countries to match the salaries offered in the developed countries for key personnel, but apparently only a fractional increase, say 20 percent of base salaries, is often sufficient to keep many professionals in their home countries. There is a strong tendency for people to stay with their cultural heritages, familiar surroundings and families. A revision of salary structures in the less developed countries would also ease the flow of talent from these countries. Financial reward should be made to be more in line with international markets which reflect the worth of technically skilled people in the twentieth century. Scientists, engineers, doctors, etc., must be rewarded according to their relative contributions to the less developed countries. Bureaucratic jobs, often a holdover from colonial heritage, should be less rewarding. Thus the shift in salary structures is basically one from property and position to accommodate the level of human resource.

Such a shift in salary structures requires an increase in the receptivity to change by the leadership of the less developed countries. But often the elites of these countries rely upon the status quo to maintain their positions of social status and wealth. Less developed countries must find ways of breaking this barrier to change by allowing new elites who are more receptive to change to come into power.

The developed countries can help ease the "brain drain" by eliminating monopoly power in the education of their human resources and by better planning of needed manpower requirements. Foreign aid to the less developed countries is especially important to enable them to create an infrastructure capable of absorbing the products of their higher educational institutions. A greater participation of the less developed countries in international trade should be promoted in order to permit these countries to gain the foreign exchange needed to make the necessary structural changes.

Universities in both the developed countries and the less developed countries are important channels of technological transfer due to their position as suppliers of educated manpower. Universities in the less developed countries are too often patterned after the older European universities' study of the classics. To be more effective channels of transfer, the universities in the less developed countries should be closely linked with the research institutes and government agencies concerned with industrial and agricultural problems. As in the case of research institutes, the role of the university should be a pragmatic one, devoting the major thrust of its effort to immediate and fundamental development problems.[1] Less developed countries placing a high priority on economic development should direct the bulk of educated manpower produced by the universities toward an education preparing it to enter industry, agriculture and agricultural extension services. Special attention should be given to support technicians such as nurses, welders, engineering technicians, etc., in order to correct past misallocations of human resources.[2] Given the scarce resources of the less developed countries, they cannot afford to devote more than a minimal effort to basic science.

In connection with the study of the role of the universities, it is useful to examine the relevance of Western economic theory obtained in these institutions. Western economic theory has played an important role in the economic strategies of the less developed countries, and

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[1]Albert E. Gollin, Education for National Development: Effects of U.S. Technical Training Programs (New York: Praeger Publishers, Inc., 1969), p. 184.

[2]Jones, The Role of Science and Technology, p. 32.

consequently it has affected the modes of technological acquisition. The economic theories spun in the Western universities contain implicit, if not explicit, value judgments which may determine the general economic policy of a less developed country. The usefulness of Western economic theory may be greatly reduced if it is not adapted to the particular needs of the less developed countries. Uncritical application may emphasize short-run efficiency at the sacrifice of long-run structural development. For example, less developed countries with dense populations may do much better by utilizing labor-intensive techniques which seem inefficient by Western standards. Western theory is not necessarily inapplicable or useless, but it must be applied with intelligent care to the less developed countries.

The largely nonmonetized economies of the less developed countries greatly limit the use of capital output ratios, the traditional analysis of saving, the multiplier analysis, and consumption theory. Assumptions such as a homogeneous labor supply, _ceteris paribus_ or automatic _mutatis mutandis_ (used to control difficult variables such as technology and institutions), and homogeneity of capital are not very useful in an instrumental analysis and can often lead to miscalculations.[1] As Dudley Seers points

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[1]See Paul Streeten, "Appendix 3" in _Asian Drama: An Inquiry into the Poverty of Nations_ by Gunnar Myrdal (New York: Twentieth Century Fund, 1968), pp. 1944-51.

out, Western economic theory was developed to deal with a special case, an exception to most of the world's economies. After analyzing the factors of production, the sectors of the economy, public finance, foreign trade, households, saving and investment, and other influences concerning the industrialized countries, Seers concludes:

> In brief, what is assumed is an autonomous and flexible socio-economic structure, in which each human being responds individually to the material incentives offered, and which is subject to no formidable exogenous strains.[1]

Quite obviously there are exogenous strains on socio-economic structures of the less developed countries which necessitate careful application of Western theory.

Economists in industrialized countries have been conditioned from birth to a certain type of cultural stimuli. Each one becomes familiar with an industrial, monetized economy. Newspapers, radio and television focus on his country and generally treat foreign economies as a kind of aberration from his own.[2] By the time the aspiring economist enters college he is conditioned to accept that his country's institutions are the best available. It only follows that these institutions should serve as models for the nonindustrial countries. With a misplaced sense of globalism, the

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[1]Dudley Seers, "The Limitations of the Special Case," in The Teaching of Development Economics, ed. by Kurt Martin and John Knapp (London: Cass Publishers, 1966), p. 10.

[2]*Ibid.*, p. 19.

economist may assume that foreigners will share his attitudes toward economic and political systems.

Students from nonindustrialized countries may have an unfounded respect for the techniques of the industrialized countries. Western textbooks such as Paul Samuelson's Economics can be misleading to both Western economists and economists from nonindustrial countries if the proposed models and theories are accepted without modification. This text is mainly concerned with economics in the United States today. The focus is on the macro level for the country or the micro level for the firm or the individual. Little attention is paid to the economic problems of the world or industry.[1] Different types of economies such as exporters of metals, petroleum, fruits or coffee are virtually ignored. Nor is there an adequate discussion of the importance of institutional and technological change and the problems which surround such change.

Since the training an undergraduate receives does little to relieve him of his narrow perspective, he is not likely to question the applicability of theory in graduate school. In fact, and especially if the class content is boring, he may concentrate on techniques, polishing the inapplicable, but sophisticated tools offered to him. Instead of becoming a generalist, in the sense that he can perceive

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[1] Ibid., p. 16.

various economies removed from his earlier conditioning, he may endeavor to build more and more abstract models of the kind to which he is accustomed. Thus graduate students may find themselves,

> in a strange world of indifference maps, kinked demand curves, cross elasticity, marginal propensity to consume, liquidity preference, net national product, sampling error, linear programming, and input-output matrices. They spend much of their time gaining familiarity with specialized concepts and techniques, and their success as graduate students is gauged largely by the degree to which they master them.[1]

In such a system the graduate student is rewarded by the elegance of the models he builds and not by their usefulness.

Dudley Seers suggests that macromodels of industrialized countries may not be applicable to nonindustrial countries since these models generally are closed models which largely ignore the foreign sector. But the foreign sector is especially vital to nonindustrialized countries and cannot be slighted.

> The sales of their particular primary products, and thus their development, are determined by (i) the rate of growth of the industrial economies that buy from them, (ii) the income-elasticities of demand for the commodities that they export (which reflect, <u>inter alia</u>, the substitution of artificial materials for natural ones), (iii) protective measures that limit imports into industrial economies, (iv) influences on the distribution of

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[1]H. R. Bowen, "Graduate Education in Economics" <u>American Economic Reviews</u>, 1953 Supplement. Quoted from Seers, "The Limitations of the Special Case," p. 20.

> the remaining markets between various suppliers (company policy, preferential tariff arrangements, etc.).[1]

These factors cannot be ignored in models adapted for nonindustrial countries. The extent to which these countries can lessen their reliance upon the foreign sector depends upon their abilities to succeed at import substitution. And this requires a completely new manufacturing industry as well as advances in social overhead capital (energy sources, etc.). Further, import substitution is limited by the extent of the market and natural resources.[2] Less developed countries may find later stages of import substitution have more obstacles as they try to produce more sophisticated products. The role of technological transfer and diffusion becomes increasingly important as these changes occur.

In the past the development of university systems in the less developed countries has often resulted in an excess of educated manpower for two reasons. First, there is a general lack of technical support personnel relative to the supply of scientists, doctors and engineers in the less developed countries. Most people who qualify for technical support training also are often capable of at-

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[1]Seers, "The Limitations of the Special Case," p. 10.

[2]*Ibid*.

taining the more prestigious degrees offered by higher education. A lack of government planning results in a dearth of intermediate training centers for those who wish to pursue such skills. Second, the university-educated person is likely to prefer the amenities of urban life to a rural setting.[1] Therefore there may be an overall shortage of educated human resources existing simultaneously with large numbers of unemployed or underemployed doctors and engineers in urban areas.

Beyond the direct contributions of universities is the externality of a general improvement in the receptiveness of the population to new technologies. But the external benefits are directly related to the degree of isolationism and elitism in the universities. Thus, universities not only need to be linked to research institutes and government agencies, but also need to establish a climate conducive to the spread of ideas throughout the community.[2] As in the case of technological transfer,

> the full benefits of higher education are not likely to be gained unless the system is adapted in form and content to suit the specific cultural, social, and economic environment.[3]

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[1]Frederick H. Harbison, "Approaches to Human Resource Development" in <u>Leading Issues in Economic Development</u>, ed. by Gerald M. Meier (2nd ed.; New York: Oxford University Press, 1970), p. 612.

[2]Jones, <u>The Role of Science and Technology</u>, p. 31.

[3]<u>Ibid</u>., p. 141.

Universities in the less developed countries should organize their efforts around their countries' unique needs. Unrealistically high standards may be more of an obstacle than an asset to economic development. The basic direction of the university systems should be toward creating a general cultural setting conducive to the acceptance of intelligently selected technologies for the purpose of economic development.

Universities in the developed countries serve as an important channel for technological transfer in at least two ways. First, they can interact with universities in the less developed countries via cooperative projects and exchange programs. Secondly, the universities in the advanced countries educate foreign students who bring vital skills home with them. But in subsidizing their students abroad, the less developed countries need constantly to assess their manpower priorities. Does the less developed country really need a pool of high powered scientists? Does the less developed country have the resources to support such a group of technically sophisticated personnel? If not, scientists trained in the well equipped laboratories of the developed countries will be underutilized and dissatisfied with their positions upon returning to their homelands. In the past, the result has been that many of the most skilled scientists permanently left their home countries, thus draining the resources of the less developed countries.

Technology and Economic Development

The technological choices available to the less developed countries may be arranged into three parts of a spectrum: (1) sophisticated technology, (2) intermediate technology and (3) rudimentary technology.[1] If a country chooses to develop by utilizing sophisticated technology in a few sectors of the economy, it is assumed that there will be a trickle-down effect which will eventually bring modern technology to the rest of the economy. This approach is capital-intensive and is illustrated by the large private farms in Mexico which use modern agricultural equipment. The drawbacks to using sophisticated technology are that it is expensive, it is developed by the advanced countries for their needs and may not be easily adapted, and it causes unemployment problems.

Intermediate technology offers some advantages to the less developed country. It is developed by the less developed country and is usually better suited to the problems of that country. Japan was successful in building up its intermediate technology for supplying its modern industrial sector. At the same time the Japanese utilized

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[1]Jones, The Role of Science and Technology, p. 22.

rudimentary technology in their agricultural sector. The labor-intensive nature of these technologies absorbed potentially surplus labor while providing a link to the modern sector. Thus the labor-intensive use of intermediate and rudimentary technologies served to avoid the unemployment problem and to supply the modern sector with a labor supply capable of adapting to the modern sector. The Japanese have done well in selecting proper portions of sophisticated technology, intermediate technology and rudimentary technology.[1]

The choice of technology has been biased in many of the less developed countries toward a capital-intensive approach.[2] Well meaning programs have subsidized the importation of capital-intensive machinery in several ways. Sometimes the currency in the less developed country is over-valued allowing an influx of "cheap" machinery. Legislation for low interest rates provides businessmen with an incentive to purchase capital-intensive equipment. In some cases a minimum wage adds to the attractiveness of capital

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[1]C. H. G. Oldham, "Science, Technology, and Development" in Leading Issues in Economic Development, ed. by Gerald M. Meier (2nd ed.; New York: Oxford University Press, 1970), p. 322; R. B. Sutcliffe, Industry and Underdevelopment (London: Addison-Wesley Publishing Company, 1971), p. 193; and Henry Rosovsky, Capital Formation in Japan 1868-1940 (London: Free Press of Glencoe, 1961), pp. 40-43.

[2]See Sutcliffe, Industry and Underdevelopment, pp. 146-59 for a detailed discussion of the technological choices available.

goods. Welfare programs and strong unions in some less developed countries have often made it difficult or expensive for an employer to fire or lay off employees during business downturns. The Japanese avoid this problem to some extent by paying a large proportion of the wage in bonus form and then reducing the bonus in recessions.

The impact of this capital-intensive bias generally results in an unemployment or underemployment problem. Earlier transfer of medical technology to the less developed countries resulted in large population increases. Urbanization in the less developed countries attracted many people who expected to better their life styles there, but only found unemployment. With the addition of capital-intensive technology, the situation has become worse. One result is an even more skewed distribution of income. In the case of Mexico,

> the ratio of the income of the top 20 percent of recipients to that of the bottom 20 percent in Mexico increased from 10:1 in 1950 to 17:1 in 1963.[1]

Mexico's choice of technology has created a dual system with large commercial farms using tractors and other machinery which has forced more peasants into subsistence agriculture. Not all of the impact from capital-intensive

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[1]Robert d'A. Shaw, Rethinking Economic Development, Headline Series No. 208 (New York: Foreign Policy Association, December, 1971), p. 4.

technology is bad, however.[1] The growing commercialization of agriculture can be a dynamic force for development. It creates demand for seeds, fertilizer and agricultural implements which must be provided and distributed, thus creating jobs. Also, the increase in the agricultural production means these foods have to be processed, marketed and transported, which means more jobs. If an agricultural surplus arises, it can be used for obtaining foreign exchange.

A token transfer of technology does not necessarily mean that rapid diffusion and adaptation follow. An examination of the diffusion of technology in the eighteenth and nineteenth centuries presents examples of technology being transferred to some countries faster than to others. Also some countries adopted new technologies within their borders at a faster rate than did other countries.

Watt's steam engine was developed by 1776, but was not an essential ingredient in the British economy until the period 1830-1850.[2] Although the steam engine was introduced in France in 1779, it was still not a major source of power in 1850. The diffusion of the steam engine proceeded at an even slower pace in Germany and slower still in Italy. Full utilization of the steam engine also lagged

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[1] _Ibid._, p. 44.

[2] Murphy, "Retrospect and Prospect," p. 9.

in the United States where it was introduced before the end of the eighteenth century, but was not extensively used (except for river boats) until about the 1850s. Table 2 indicates that these lags in technological adaptation, past and present, are striking when contrasted to the relatively short period of innovation in the initiating country. In all of the cases in the eighteenth century, the transfer of technology across national boundaries was faster than the internal assimilation of the technology that followed. The equipment that industrialized the production of cotton textiles followed a similar pattern. Hargreave's jenny was introduced in France only five years after its development, but was not at once put to general use.[1] The water frame developed by Arkwright was brought to France in the 1780s and Germany in the 1790s, but was not in general use for several decades. The adoption of the power loom also followed this established pattern.

Textile machinery did not move to the United States as fast as it was introduced to Europe, but once received, it was utilized at a faster pace. Both Arkwright's water frame and the power loom were diffused much faster in the United States than in Europe. Further, Americans rapidly began to initiate changes in the equipment and in some areas perhaps excelled to a greater extent that the British. The

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[1] Ibid.

TABLE 2

ESTIMATED TIME INTERVAL BETWEEN INVENTION AND INNOVATION IN INITIATING COUNTRY

Invention	Interval (Years)	Invention	Interval (Years)
Freon refrigerants	1	Wireless telephone	8
"Clean circulation"	3	Houldry catalytic cracking	9
DDT	3	Safety razor	9
Distilling of gas oil with heat and pressure	3	Turbojet engine	10
Long-playing record	3	Continuous cracking (Holmes-Manley)	11
Plexiglass, lucite	3	Nylon	11
Shell molding	3	Steam engine (Watt)	11
Spinning mule	4	Terylene, dacron	12
Continuous cracking of gas oil (Cross Process)	5	Continuous cracking (Dubbs)	13
Magnetic recording	5	Continuous cracking (tube and tank process)	13
Spinning jenny	5	Fluid catalytic cracking	13
Streptomycin	5	Gas lift for catylist pellets	13
Ball point pen	6	Radar	13
Power steering	6	Crease resistant fabrics	14
Self-winding watch	6	Jet engine	14
Spinning machine (water frame)	6	Television	22
Steam engine (Newcomen)	6	Distilling of hydrocarbons with heat and pressure	24
Titanium reduction	7	Electric precipitation	25
Triode vacuum tube	7	Zipper	27
Catalytic cracking (moving bed)	8	Cotton picker	53
Hardening of fats	8	Gyrocompass	56
Radio (oscillator)	8	Florescent lamp	79
Wireless telegraph	8		

Source: Adapted from John L. Enos, "Invention and Innovation in the Petroleum Refining Industry," in _The Rate and Direction of Inventive Activity_, ed. by the Universities-National Bureau Committee for Economic Research (Princeton: Princeton University Press, 1962), Tables 1 and 2, pp. 305, 307-308.

initiative shown by the Americans was probably the product of a frontier society free of rigid cultural constraints combined with their geographical distance from Europe.

The technical advance in the making of tools was particularly important since the rates of advance in different countries varied considerably. Americans achieved expertise in this area, and other countries encountered difficulty in adopting the American process. The American focus on specialization eventually underpriced even the British. The continent failed to keep abreast of the Americans and the British and as a result relied upon the British for machine tools. Continental Europe did produce machine tools, but mainly for internal firm use. The British lost their superiority to the Americans largely due to the reluctance of British horological trades to accept the American system, substituting machines for men and incorporating standardized parts. It was the highly skilled British artisans, the descendants of the industrial revolution, who impeded the further diffusion of technology.[1]

The difficulties encountered in the diffusion of eighteenth and nineteenth century technology are probably slight relative to the problems of diffusing twentieth century technology. Cultural differences then were not nearly as great as the differences between advanced countries and

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[1] *Ibid.*, p. 12.

the less developed countries now. Nor was the technological gap as great as it is at present. But the rates of technological diffusion in the eighteenth and nineteenth centuries illustrate the difficulties involved in the transfer process. The mere existence of an invention does not automatically lead to innovation. And the loss of technological and economic superiority seems to be the fate of those who do not create an atmosphere conducive to technological change.

Technological innovation generally has and does occur much faster in the initiating country than in the country trying to adopt the technology. Table 3 suggests that it is possible that the lag is decreasing within the industrial countries. If this is the case, the less developed countries' problems are exacerbated since they must then accelerate their rates of adaptation just to maintain their positions relative to the advanced countries.

William and Helga Woodruff have suggested that the history of international transfer of technology can be separated into two basic periods, the extensive period between 1860 and World War I, and the intensive period from World War I to the present.[1] The extensive period was marked by the transfer of empirical and traditional knowledge empha-

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[1]William and Helga Woodruff, "The Interrelatedness of Continents and the Diffusion of Technology, 1860-1960," Technology and Culture, VII, No. 4 (Fall, 1966), 455-56.

TABLE 3

AVERAGE RATE OF DEVELOPMENT OF SELECTED TECHNOLOGICAL INNOVATIONS -- DEVELOPED COUNTRIES

Factors Influencing the Rate of Technological Development	Average Time Interval (Years)		
	Incubation Period	Commercial Development	Total
Time Period			
Early twentieth century (1885-1919)	30	7	37
Post-World War I (1920-1944)	16	8	24
Post-World War II (1945-1964)	9	5	14
Type of Market Application			
Consumer	13	7	20
Industrial	28	6	34
Source of Development			
Private industry	24	7	31
Federal government	12	7	19

Source: Edwin Mansfield, The Economics of Technological Change (New York: W. W. Norton and Company, Inc., 1968), Table 4.2, p. 102.

sizing transportation and communication (steam powered transportation, and the construction of overhead capital such as ports and towns). The intensive period has focused upon more sophisticated technologies which are mainly transferred among the advanced countries. When these technologies are transferred to the less developed countries they are often used to extract raw materials. There have been very few spread effects from this type of technological transfer. Thus the schema for transfer has often been one of exploitation rather than adaptation.

A number of factors tend to obstruct the transfer and diffusion of technology. The scarcity of foreign exchange in the less developed countries impedes the technological inflow from the advanced countries. The less developed countries are caught in a vicious circle; they cannot purchase adequate flows of technology which means low productivity which causes an inability to purchase flows of technology. Multilateral aid can ease this problem, but the immediate prospects of increased aid, especially in the case of the United States, are not bright.

Even if the financial constraint were eased, there still remain several other problems. The less developed countries require a pool of skilled personnel to receive and disperse new technologies. In many cases these people are scarce and training facilities are very limited. Many of the less developed countries have constraints on their capacity to organize, plan and execute technical assistance.[1] Large inflows of foreign technicians, tend to make the people of any country nervous. And these foreign experts are expensive to the less developed countries in that they require housing, supplies and liaison contacts.[2]

The rate of economic growth of a less developed country is an important factor affecting the inflow of technology and its diffusion. This is one of the "chicken and the egg" type of problems in development economics, but it cannot be ignored.[3] The fact is that a slow rate of economic growth is associated with a slow inflow of technology. In reality, there is probably a complex symbiotic relationship between economic growth and the inflow and diffusion of technology. Slow economic growth is both a cause and a result of inadequate technological inflows. The causes of poor economic growth rates are nearly endless: inadequate resources, low educational level, lack of political leadership committed to development, cultural barriers, etc. Only two of these causes will be discussed, cultural

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[1]Angus Maddison, "Role of Technical Assistance" in Leading Issues in Economic Development, ed. by Gerald M. Meier (2nd ed.; New York: Oxford University Press, 1970), p. 314.

[2]Ibid.

[3]Murphy, "Retrospect and Prospect," p. 15.

barriers and political leadership, since they are expecially crucial to the transfer process. The educational factor will be considered in some depth in the chapters on Mexico and Japan.

C. E. Ayres, utilizing Thorstein Veblen's dichotomy, divides human behavior into two categories, technological and ceremonial.[1] Ceremonial behavior is static, tradition bound, and past binding. Technological behavior is dynamic, secular, and pragmatic. When the people of a country are bound by traditions which inhibit change then the culture represents a barrier to economic development and technological transfer. As suggested earlier in this chapter, the transfer of technology requires both adaptations of a technological package to the culture of the less developed country and a change of some degree in the culture. The chapters of Mexico and Japan will deal with this problem in some detail.

The role of government in the development process as determined by the political leadership may be the most important factor in promoting technological transfer in the 1970s. Certainly the cases of Japan and Mexico indicate the validity of this statement. As this study demonstrates, both development and technological advance were concomitant with changes in the Japanese and Mexican governments. A

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[1]Ayres, The Theory of Economic Progress, p. 100.

strong commitment by government to development is a necessary prerequisite for economic change. If the government of a less developed country lacks this commitment, it represents a formidable barrier to development and technological transfer.

Summary

The terms science, technology and technological transfer were defined and related to the process of economic development. Since most research and development originates in the developed countries it is essential to study the process of transferring technology to the less developed countries. Especially crucial to the successful transfer of technology is the adaptation of technology to each country's unique requirements. In many cases, particularly in the more backward countries in industrialization, institutional adjustment is required to facilitate technological flows. The "brain drain" was seen to be an especially severe problem, but one which, if solved by appropriate action, could yield great benefits to the less developed countries. The need to adapt Western economic theory was seen as crucial to the success of the development process and therefore to technological transfer. Obstacles to technological transfer and diffusion were briefly described to establish the difficulties overcome by Japan and Mexico in the following chapters.

CHAPTER III

MEXICO -- DEVELOPMENT FROM PORFIRIAN ERA THROUGH 1940

Background

The period from 1810 (the Hidalgo revolt against Spanish domination) to 1900 was generally a period of economic stagnation.[1] The fighting between 1810 and 1821 (Mexican independence) greatly damaged the mining industry which was of central importance to the old colonial economic system. There was a capital flight out of Mexico accompanied by most of the inhabitants who had been born in Spain (peninsulares). Agrarian Mexico was left in ruins. Stagnation continued until 1900 due to political instability. Mexico had fifty different governments in its first fifty years of independence. Further, in this period, Mexico fought two wars with the French and one with the United States.[2] Attempts to exploit Mexico's resources with the technology of the Industrial Revolution were upset by domestic political instability and foreign intervention. Thus the growth of mining was hampered in the 1820s and the de-

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[1]Roger D. Hansen, The Politics of Mexican Development (Baltimore: The John Hopkins Press, 1971), p. 11.

[2]Ibid.

velopment of manufacturing was retarded in the 1840s.[1]

Symbolic of Mexico's economic woes was the miserable state of her transportation system up to the Porfirian period (1877-1911). By 1860 Mexico had only fifteen miles of usable railway track. There were only three roads which could be called highways in 1820, and these were in need of repair.

> The inadequacy of the road system during this period was accurately reflected in prohibitive transportation costs. At a time when cotton sold for 15 cents a pound in U.S. markets, the Veracruz producer spent 13 cents a pound to get his fiber from the field to the buyer. The failure of the government to provide an adequate highway network left the country fragmented into thousands of small and isolated communities, each with anywhere from twenty to a thousand inhabitants.[2]

Institutional constraints and political instability resulted in a weak fiscal structure. The few funds which could be raised were usually absorbed by government bureaucracy or local bosses. Thus Mexico relied upon foreign loans which created a large external debt. Eighty percent of government revenues were directed toward repayment of debts. Confiscation, debasement of currency and forced domestic loans were also used as sources of revenue with correspondingly bad effects. A heavy internal tax structure created an environment in which the Mexican producer

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[1]Clark W. Reynolds, The Mexican Economy (New Haven: Yale University Press, 1970), p. 15.

[2]Hansen, Politics of Mexican Development, p. 12.

often could not compete against American and European imports. Only the textile industry was experiencing growth in this period. Due to tariff protection and other government support, textile production in the modern industrial sector may have doubled from 1854 to 1877.[1]

The Mexican terrain presents formidable obstacles to agricultural development. Most of the land is mountainous and therefore not easy to farm. Two mountain ranges have hampered agricultural support activities by making transportation and communication difficult. The population is dispersed throughout the country, isolated by rugged mountains. Extension services, general education, health support, etc., have also been difficult to deliver, given this geographical arrangement. Further,

> the relatively level land is not all favorable to intensive agricultural use. In the north, a significant portion of the level land is arid and semidesert. In the south, the Yucatan peninsula is mostly level, but the soil there is shallow, tends to leach easily, and is not suitable for general agriculture. Agricultural endeavors are further hampered by the uneven distribution of rainfall which supports jungle growth in some areas and only cacti and lizards in others. About 50 percent of the country is subject to inadequate rainfall, and provision for sufficient water to otherwise fertile lands presents a formidable challenge for the Mexican people. Irrigation of the broad tablelands is difficult because most of the rivers and streams have their origins on the seaward side of the two mountain ranges, and

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[1] Ibid., pp. 12-13.

> riverbeds drop abruptly into the Gulf of Mexico or the Pacific Ocean.[1]

Man has created problems in addition to these considerable geographical constraints. With the Spaniards came the European plow which broke up the root structure that had held down the topsoil. They also brought sheep which overgrazed the hillsides leaving them unprotected from erosion. The Spaniards also introduced iron-making which created a large demand for charcoal. Thus much of the forests were destroyed. As the Spaniards cultivated the best land, the Indians were driven to the highlands where their slash and burn agriculture destroyed the natural protection against erosion.[2] The problems faced by the present Mexican government should be perceived against this backdrop as well as the following description of culture and evolution of land systems.

The Mexican Indian had a heritage of obedience to church, king and the warrior class under Aztec rule. This cultural pattern (with the help of superior technological force) was easily adapted to fit the social arrangement imposed by the conquering Spaniards.[3] But the Aztec system

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[1]William E. Cole and Richard D. Sanders, Growth and Change in Mexican Agriculture (Knoxville, Tennessee: Center for Business and Economic Research; The University of Tennessee, 1970), pp. 1-2.

[2]*Ibid.*, p. 2.

[3]Eyler Newton Simpson, The Ejido: Mexico's Way Out (Chapel Hill: University of North Carolina Press, 1937), p. 6.

had allowed for a supplementary land system largely independent of the church and nobles and which was owned by local villages. With the arrival of the Spaniards, huge grants of lands which included villages were awarded to favored recipients. These grants, or encomiendas, theoretically left the ownership of the land to the Indians. The recipient of an encomienda was rewarded by Indian labor and tribute. The encomienda grants, or repartimientos, were intended to be temporary -- a payment by the Indians for the civilization that the Spaniards had brought to them.

The encomiendas were passed from one generation to the next, eventually losing their temporary status. Thus, the Indians gradually lost their landed status and were transformed into serfs within the hacienda system.[1] This system which spread throughout Latin America was (and is) a notoriously inefficient system. The attitudes of the hacendados, the system of land tenure, the traditional labor system, and the man-master relationship were strong institutional constraints preventing technological change.[2]

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[1]This is a very simplified description of the changing land pattern. In fact communal holdings existed side by side with the encomiendas. The conflict between the ejido and the hacienda lasted for some 400 years with the hacienda system consistently winning the struggles. See Simpson, The Ejido, p. 15 and George McCutchen McBride, The Land Systems of Mexico (New York: American Geographical Society, 1923), p. 124.

[2]Milton Lower, "Institutional Basis of Economic Stagnation in Chile," Journal of Economic Issues, II, No. 3 (September, 1968), 289.

The master of a hacienda was trained from birth to command. Servants were at hand to help at every step. As a boy, servants carried his books to and from school. His education was often in Europe. A typical description of the type of education received is illustrated by the following:

> Most of his education had been in letters and arts. He had never studied agriculture nor anything in the line of administration. During the period of schooling, vacations had been spent on the farm where, in association with his father, he had become familiar with some of the problems of its management. He had never done any manual work. His hands had never turned a shovelful of earth, nor had he followed a plow, nor milked a cow, nor yoked a team of oxen. He had hardly learned to saddle and bridle his own horse without the assistance of a mozo.[1]

Everything about the master reflected status and wealth -- his home, his clothing, his horse, the saddle and bridle of his horse, his education, his bearing, etc.

The master's servant, or mozo, was the direct contrast of his patron. More than likely the mozo could not read or write. He lived in a single-room adobe hut and was given a small piece of land to plant corn for his own consumption. Necessities were available at the hacienda store, and thus most of his small wage was returned directly to the hacienda.[2]

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[1]George McCutchen McBride, Chile: Land and Society (New York: American Geographical Society, 1936), p. 10.

[2]Robert A. White, "Mexico: The Zapata Movement and the Revolution," in Latin American Peasant Movements, ed. by Henry A. Landsberger (Ithaca, New York: Cornell University Press, 1969), p. 106.

The evolution of the encomienda system and the consequent shrinking of the communally held land areas was the result of both economic and cultural forces. Plantation crops (sugar, wheat, indigo and cacao) and the raising of cattle and sheep required large land areas. As the demand for ores increased, the work force grew and required a food supply from the agricultural sector. But perhaps the most important factor in creating the hacienda system was the hidalgo mentality which perceived land as a symbol of status and wealth. It was not by accident that haciendas grew to sizes far greater than that needed for economic efficiency.[1]

The Catholic Church was a powerful force in promoting the hacienda system. It was the largest land owner in Mexico and was an important ally to the wealthy landowners and merchants. The Church consistently opposed any popular democratic changes. Much of its land was held in mortmain and could not be transferred or sold. As such it was seen as an obstacle to the cultural and economic development of Mexico by the liberal intellectuals. It is estimated that the Catholic Church held about one-half of all of the real property in Mexico at the time of the Revolution.[2] The

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[1]Cole and Sanders, Growth and Change in Mexican Agriculture, p. 11.

[2]Ibid., p. 12.

Reform government (1855-1872) tried to disperse some of the Church land, but the attempt did not achieve its purpose of distributing land to small farmers. Large landowners increased the size of their holdings while small landowners were often forced to give up their land due to ignorance or insufficient credit. The very idea of private ownership was alien to the Indians who were used to communal ownership. This, plus the Church's threat of eternal condemnation if they acquired land, was a sufficient deterrent to the land reform attempt.[1]

It is the purpose of the following discussion to demonstrate that the trend toward dualism, especially in agriculture, and the increasing inequality is not an accidental phenomenon, but has its roots in the value system of the colonial heritage. This value system is still strong today and places some light on the governmental development strategy both before and since the 1940s.

At the time of the independence from Spain (1821) the class system placed the Indians, who composed half of the population, on the bottom of the scale.[2] Above the Indians were those of mixed races, the castas, who composed from one-third to nearly one-half of the entire population.

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[1]Ibid., p. 14.

[2]Hansen, Politics of Mexican Development, p. 135. The following analysis is based on Chapter 6, "The Roots of Mexican Politics."

The mestizos were the largest group in the castas and were of Indian and Spanish blood. They were generally rejected by both the Indians and the Spanish and faced great obstacles in any attempt toward upward social mobility. The mestizo could hold no political position, could not join most professions, and could not move into some residential sections.

It was possible, however, for the mestizo to move upward in the caste arrangement to criollo status if he were able to obtain wealth. The criollo group was primarily composed of the Spanish born in Mexico. Entry into this class was possible due to the traditional emphasis on wealth above racial origin. Entry into the top class, the peninsulares, was impossible. The peninsulares carefully protected their privileged status and wealth which they received from the Spanish crown.

Initially the criollo had led the revolt against the Spanish in order to improve their social standing. But this class's hatred of the Indians and mestizos became clear in the Hidalgo revolt (1810), and the criollo joined the royalists to put down the revolt which they had initiated. The achievement of independence in 1821 was mostly credited to the conservative criollo, especially the wealthier ones, as a result of their efforts to eliminate ties with a Spanish government which was becoming too liberal. Thus the revolution changed little except that the criollo then had control instead of the peninsulares.

The conservative powers in Mexico opposed further change unsuccessfully. The loss of the Spanish crown created a power vacuum which could only be filled by force. It was in the violent upheaval which followed that the mestizos struggled for power.[1] The mestizo had little to lose -- he could not fall below the Indian on the social scale, and slow economic growth allowed little room for his upward mobility. As Hansen states:

> The mestizo was disinherited by both Mexican societies, Indian and creole. Without a place in the social order, he had lived for generations by his wits, his dissimulation. These qualities, cultivated for survival prior to independence, were of equal value after 1821. The adaptive nature of the mestizo's personality allowed him to take full advantage of the opportunities for his own upward mobility presented by the social and economic instability which accompanied the ensuing period of political chaos.[2]

The mestizo began to respect the only thing that could give him social mobility -- power. The mestizo wanted power for himself and not for any identifiable group.[3] The mestizo

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[1]Ibid., P. 140.

[2]Ibid., pp. 141-142.

[3]The Indians were careful to redistribute power so as not to attach it to any individual. Thus their perception of power placed them in a position of inevitable subjugation to the mestizo who considered power on an individual basis and as a tool to subjugate the less powerful. See Eric R. Wolf, Sons of the Shaking Earth (Chicago: University of Chicago Press, 1959), p. 239.

conceived life as a zero-sum game in which one either wins or loses. Power was an attribute of the self and was to be used for personal gain. The concept of the use of power to obtain group goals was alien to his personality. Things to be valued were personal strength, manliness and domination of others.

Given these personality traits in addition to the limitations for achievement in the economic sphere, the mestizos plunged into the struggle for power in politics and the military. They achieved these goals and broke the power of the previous ruling elites and the Catholic Church in the War of Reform (1857-1860). They further solidified their position in the Porfirian period. Political power was used to gain personal wealth. The scenario to gain mobility was to get access to the elite power center and then join the elite. There was no desire to open the door to followers -- quite the contrary. Upon attaining power it was used for the self and not for redistribution of wealth. In the Porfirian period, as today,

> we see personalism prevail in the political realm, and from the lowest to the highest levels of the political structure loyalties flow upward from the appointee to the appointer, from the co-optee to the co-opter, from the follower to his patron.[1]

It is the mestizo elite that rule Mexico today. Their value

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[1]Hansen, Politics of Mexican Development, p. 165.

system is much the same as it was in the colonial period and the Porfirian period. One after the other of Mexico's revolutionary politicians have achieved success, acquired vast wealth, and done little for the masses. This has been consistent with mestizo behavior in the past and it continues into the present. This largely explains the economic dualism in Mexican agriculture and the growing inequality of the distribution of income.

The mestizo elite learned the lessons of the Porfirian period. After the Revolution the principal causes of unrest were eliminated. Land reform was initiated, returning the rural Mexican to his traditional role of political apathy. Social and economic mobility were increased allowing ambitious groups to be assimilated by the existing power structure. Political stability has been a crucial factor in the "Mexican miracle," but because of the mestizo power ethic many of the Mexican people have not benefited from economic growth. Within this context it is perhaps easier to see why Mexico ranks so low in education and health care relative to other less prosperous Latin American countries: the leadership has not permitted Mexico to fully develop its most emportant resource, its people. Without the improvement of Mexico's human resources the rate of technological transfer and diffusion will be retarded and restricted to the upper and middle strata of the Mexican people.

Mexico is not the only less developed country to have economic dualisms or vast inequalities of wealth. Thus it would be unwise to place all of the burden of these economic attributes at the foot of the mestizo personality. However, an understanding of the mestizo heritage seems an essential element if one is to interpret Mexico's development, of which technological transfer and diffusion is an integral part.

1877-1910 -- Porfirian Period

The Mexican population had reached 13.6 million by 1900, about double the population of 1800. More than 50 percent of the increase in population occurred between 1875 and 1900. After 1900 the population growth rate dropped to 1.1 percent from the 1.6 percent growth rate for the 1877-1900 period.[1] Since medical technology had improved (new vaccines for typhus) and since Mexico had insignificant net immigration, the sudden drop in the birth rate needs an explanation to demonstrate that the declining birth rate after 1900 was not a result of slow economic growth.

In essence, what transpired was the utilization of previously unused economic capacity, especially in agriculture, permitting a steady growth of the population until 1900. The Porfirian economic policy largely explains the

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[1]Reynolds, The Mexican Economy, p. 20.

sudden drop in the birth rate. Economic growth occurred most rapidly in the export sector between 1877 and 1900. Extractive industries increased by a 7.3 percent compound annual rate while manufacturing increased by 2.8 percent, and the export of cattle, forestry and agricultural products increased by 6.1 percent. In this same period agricultural growth as a whole grew at only one-half of one percent per year.[1] The period 1900 to 1910 continued this trend emphasizing export growth with a lagging domestic agricultural sector.

The Porfirian period witnessed steady economic growth by exploiting the increased foreign demand for Mexican resources. Foreign investment and skills poured into Mexico to develop the natural resources utilizing cheap Mexican labor.[2] A few people prospered, but the vast majority of the Mexican people were excluded from the benefits of growth. There was a redistribution of income toward recipients of rent, interest and profit which allowed increased savings. But these savings accrued to foreigners, not Mexicans.[3] Foreign investment accounted for 80 percent of the total investment in the Porfirian period with the

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[1] Ibid., p. 21.

[2] Peter Ranis, Five Latin American Nations: A Comparative Political Study (New York: The Macmillan Company Company, 1971), p. 93.

[3] Reynolds, The Mexican Economy, p. 24.

United States accounting for 38 percent, Great Britain 29 percent, and France 27 percent.[1]

During the Porfirian period a greater amount of artisan labor was displaced than was absorbed in the new machine manufacturing sector. As a result, the share of labor in all manufacturing declined, and the share of labor in agriculture and services rose.[2]

Mexico's emphasis on exports made the country more vulnerable to fluctuations in foreign trade patterns. The monetized enclaves became especially open to the vicissitudes of trade cycles. A decline in terms of trade following 1905 forced real income down in the monetized sectors. The impact of the deteriorating terms of trade on the economy was still a dampening influence at the outbreak of the Revolution.[3]

Role of Technological Transfer in Agriculture

Very little foreign investment went into traditional agriculture during the Profirian period. Most of the foreign investment directed toward agriculture was concentrated in commodities for commercial export such as cattle, cotton,

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[1]Hansen, Politics of Mexican Development, p. 16.

[2]Reynolds, The Mexican Economy, p. 25.

[3]Ibid.

coffee, sugar and rubber.[1] The emerging industrial sector began to consume quantities of cotton and cottonseed, istle, henequen, guayule, rubber, sugar, tobacco and coffee.[2] These products were processed in plants in which foreigners often played an important role. Porfirio Diaz also welcomed foreign investment in land. It is estimated that about 22 percent of the total land area of Mexico was foreign owned by 1910.[3]

The regime of Porfirio Diaz contributed to the forces for concentrating land in large holdings. Diaz embarked on a policy of economic development through economic liberalism based on the philosophies of Auguste Comte's positivism.[4] The Indians and their culture were perceived as obstacles to development. Thus the scientific planners, or cientificos, utilized the land reform laws of 1857 to acquire communal Indian land holdings. The law had provided for the land held by corporations or the Church to be sold to tenants. But the Diaz regime applied the laws to

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[1] Ibid., p. 24, footnote.

[2] George Wythe, Industry in Latin America (New York: Columbia University Press, 1945), p. 271.

[3] Eduardo L. Venezian and William K. Gamble, The Agricultural Development of Mexico: Its Structure and Growth Since 1950 (New York: Praeger Publishers, Inc., 1969), p. 13.

[4] James D. Cochrane, "Mexico's 'New Cientificos:' The Diaz Ordaz Cabinet," Inter-American Economic Affairs, XXI, No. 1 (Summer, 1967), 61-72.

the communal holdings which resulted in a vast transfer of land from the Indians to land companies and the hacendados.[1] This policy was aided by a philosophy of racism which viewed the Indian as a legal minor and inferior by nature.[2]

The land policies of Diaz also led to a transference of government land to hacendados and land companies on a monumental scale. During the Diaz regime nearly 27 percent of Mexico's land area was transferred to private hands in this manner.[3] The Diaz land program was so ruthlessly effective that 95 percent of the heads of families in rural Mexico held no land in 1910.[4]

Role of Technological Transfer in Industry

Foreign companies initially trained most of the skilled labor in Mexico. This was especially true of the branch factories, mining and smelting units, telephone companies, railroads, and the utilities. The foreign owned railroads were the first to set up apprentice schools. These schools continued to operate for a considerable time

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[1]Robert A. White, "The Zapata Movement," pp. 113-14 and Nathan Whetten, Rural Mexico (Chicago: University of Chicago Press, 1948), P. 86.

[2]Charles B. Parkes, A History of Mexico (Boston: Houghton Mifflin, 1960), p. 116.

[3]Simpson, The Ejido, p. 28.

[4]Frank Tannenbaum, The Mexican Agrarian Revolution (New York: Macmillan, 1929), p. 79.

after Diaz nationalized the railroads. The personnel trained in these schools took over the operation of the railroads after the Americans left in 1911-1914.[1]

The economic growth in the Porfirian period was the result of a combination of political stability and the influx of foreign investment which that stability brought forth. Real economic gains were made, although this statement must be qualified by the long-run structural effects and the distributional abuses in this period.

The Porfirian regime eliminated many of the previous barriers to successful exploitation and development of natural resources. Attempts by the English to improve mining techniques after Mexico's independence from Spain had failed. Costly machinery had to be transported to areas which had previously been mined with crude technology, having the ore hauled out by Indians. These early ventures were unsuccessful due to high transportation costs for both incoming equipment and outgoing ore. One such example was the Real del Monte Company which started in 1821 and closed in 1849.[2]

Political stability and reduced transportation costs stemming from railway construction permitted the successful

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[1]Wythe, <u>Industry in Latin America</u>, p. 284.

[2]<u>Ibid</u>., p. 270.

utilization of modern mining equipment, and foreign capital began to flow into the Mexican mining industry. The Americans and French were particularly heavy investors. Special advantages were offered to large investors which spurred the construction of the first smelters in the early 1890s.[1] As a result of foreign development of Mexican resources the export of copper, zinc, graphite, lead and antimony increased greatly.

Foreign investments were also important in building the railroads, hydroelectric power and the banking system. Mexican investment was small in these areas due to the size of the investments needed and the complexity of the technology. However, Mexico did invest relatively heavily in manufacturing which was related to the growth of the internal and external markets.[2]

The Americans, French, English and Spanish were the most important powers in the early transfer of technology to Mexico. A few representative examples are given to illustrate the nature of Mexico's nascent industrialization. Special attention is paid to the United States' role since the Americans were to become so influential in the industrialization of Mexico.

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[1] Ibid., p. 271.

[2] Hansen, Politics of Mexican Development, p. 18.

The English were the dominant foreign investors for 50 years after Mexico's independence from Spain (1821). The English helped to build the railroads and mining industry in this period. Under Diaz the English expanded into utilities and manufacturing. In this period the English invested in a soap company, vegetable oil mill, a jute mill, a linen factory and a cement plant. The English were early entrants into the petroleum industry but were not successful until after the Americans had developed some large fields.[1]

The French became interested in Mexican investments after the Mexican independence. Many Frenchmen moved to Mexico and remained as permanent settlers. They typically began in retail trade and then moved into manufacturing.[2] More Frenchmen came with the rise of Maximilian, further increasing the French influence. Later, under the Diaz regime, the French and Swiss formed the Société Financière pour l'Industrie au Mexique, S.A. in 1900 and invested in the main cigarette factory, the largest brewery, the largest paper factory, and a large cotton mill.[3]

The Spanish had an early entry into Mexican industry,

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[1]Wythe, Industry in Latin America, p. 290.

[2]Sanford Mosk, Industrial Revolution in Mexico (Berkely: University of California Press, 1950), p. 123.

[3]Wythe, Industry in Latin America, p. 289.

especially textiles, which is the oldest manufacturing industry. The Spanish built upon the indigenous cotton which had been developed by the Aztecs. In the sixteenth century the Spanish brought sheep to Mexico and developed the first woolen mill in Texcoco. Silk was also introduced by the Spanish, but this interfered with their China trade and was soon eliminated.[1]

The Spanish also started the modern papermaking industry in the 1890s. They modernized an antiquated plant and began producing newsprint, mechanical pulp, and a variety of papers. German technology was successfully utilized and the plant was producing about half of the paperboard and paper manufactured in Mexico in the 1940s.[2]

The first modern power-driven textile machinery was imported from the United States in the 1830s. This machinery was on occasion shipped from the American east coast around Cape Horn to San Blas and transported 60 miles to Tepic by mules. Some of this machinery was still in use as late as 1929.[3]

After 1880 the Americans became the dominant foreign influence in the building of railroads, developing smelting

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[1] Ibid., p. 298.

[2] Frank Brandenburg, The Making of Modern Mexico (Englewood Cliffs, N. J.: Prentice Hall, 1964), p. 266.

[3] Wythe, Industry in Latin America, p. 299.

and mining, and the sale of supporting equipment such as vehicles and machinery. The first advanced drilling techniques were introduced by the American dominated Mexican Petroleum Company in 1890. American settlers successfully engaged in developing the manufacturing sector. Small entrepreneurs entered into shoe manufacturing and steel and grew in size with Mexico's advance.[1]

United States' capital has played a central role in Mexican development as demonstrated in Table 4. From the Porfiriato to the 1970s United States' capital has been greater than any other source of foreign capital. This fact combined with the construction of a transportation network between the United States and Mexico beginning in the Porfiriato has greatly affected the direction of the Mexican development. The Mexican economy has been closely tied to the United States' economy. Thus,

> Mexican exports to the United States rose from 42 percent of total exports in 1877 to 76 percent in 1910-11; during the same period, imports from the United States rose from 26 percent to 54 percent. This pattern remained relatively unchanged as late as 1964 when U.S. trade accounted for 67 percent of Mexican exports and imports.[2]

The large investments in mining and railway support has also affected the regional development of Mexico. Areas receiving mining development and connection by rail to the Federal

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[1]*Ibid*., p. 290.

[2]John Leimone, "Patterns of Long-Run Interregional Economic Growth and Development in Mexico" (unpublished Ph.D. dissertation, Vanderbilt University, 1971), p.33.

TABLE 4

APPROXIMATE VALUE OF FOREIGN INVESTMENT
BY COUNTRY AND SECTOR IN 1911
(MILLIONS OF PESOS)

	U.S.A.	U.K.	FRANCE	OTHERS	TOTAL
Public debt	59	83	328	28	498
Banks	34	18	100	14	166
Railroads	535	401	116	78	1,130
Public services	13	212	10	3	238
Mines and metallurgy	499	117	180	22	817
Real estate	81	91	16	6	194
Industry	21	11	72	27	131
Commerce	9	--	80	33	122
Petroleum	40	57	7	0	104
Total	1,292	989	909	210	3,401

Source: John Leimone, "Patterns of Long-Run Interregional Economic Growth and Development in Mexico" (unpublished Ph.D. dissertation, Vanderbilt University, 1971), Table 1, p. 32.

District developed faster and still maintain that development vis-à-vis other regions.[1]

A brief analysis of the railroads, mining and steel, oil and hydroelectric industries is an illustrative interpretation of the Mexican experience. The development of the railroads in Mexico was crucial for creating industrial growth. The Porfirian regime inherited a woefully inadequate railway system. By 1900 there were only 700 miles of track, and much of this was of dubious value.[2] Foreign concessionaires had used different gauges of track which hindered the development of a transportation network. Construction was often of poor quality, resulting in frequent accidents and derailings. The virgin run on the Mexico-Cuautla road ended in disaster when a bridge folded, throwing 300 men into a ravine.[3]

In 1880 Diaz made agreements with three American Companies to begin construction of roads connecting Mexico with the rapidly expanding railway system in the Southwest of the United States.[4] The United States invested heavily

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[1]Ibid., pp. 33-34

[2]Hansen, Politics of Mexican Development, p. 17.

[3]Charles C. Cumberland, Mexico: The Struggle for Modernity (New York: Oxford University Press, 1968), p. 214.

[4]Ibid. See Fred W. Powell's The Railroads of Mexico (Boston: The Stratford Co., 1921) for a detailed description of the many railway lines built in the Porfirian period, especially pages 4-6.

in railroads in order to tie the Mexican market to the U.S. market.[1] In the process, however, Mexico's domestic markets were open to expansion. Railroads allowed local cotton production to be utilized in the domestic textile industry. As a result cotton production nearly doubled in the Porfiriato and Mexico approached self-sufficiency in this area.[2] By 1910 there were 12,000 miles of track; about three-fourths of this was standard gauge, connecting Mexican internal and external markets.

American construction of the Mexican railway system left a heavy stamp on the structure of the rail network. The Mexican government had hoped to connect the east and west coasts in order to develop domestic markets. Instead the Americans built the roads (against the wishes of the Mexican government) to connect the Mexican interior with U.S. markets. Thus,

> a shipment of goods from Mazatlán destined for Durango 100 miles away would have been forced to make a 1,000 mile trip via Nogales, El Paso, and Torreón; small wonder that few men interchanged goods between the two cities. By the same token, any goods produced in the northwest had to traverse roughly the same route to reach a market in Mexico City; the northwest, including the Sonora mining communities, was more intimately connected, by

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[1]See David M. Pletcher, Rails, Mines, and Progress: Seven American Promoters in Mexico, 1867-1911 (Ithaca, New York: Cornell University Press, 1958) for a biography of early American entrepreneurs in the construction of the Mexican railways.

[2]Hansen, Politics of Mexican Development, p. 14.

> transport and communications, to the United States than to Mexico City.[1]

The influence of the railroads on the Mexican economy was great in spite of these obvious limitations. Internal markets did expand though less than they would have under a more rational rail network. Railroad construction did form the base for the mining industry and was a prerequisite to the development of an iron and steel industry.

Mexico was the first country in Latin America to establish a steel industry. In 1900, American, French and Italian interests combined to form the major iron and steel works in Monterrey which began production in 1903.[2] Señor Prieto, a Spanish immigrant, in conjunction with Mexican associates and foreigners was active in forming the new mill.[3] Mexican production of pig iron and steel has steadily risen and continues to be second only to Brazil in this industry in Latin America.

The development of the railroads enabled the exploitation of Mexico's resources on an unprecedented scale. Coal mining started in 1884 and reached a peak by 1910 which it has still not regained.[4] The Guggenheim family

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[1]Cumberland, Struggle for Modernity, p. 217.

[2]Wythe, Industry in Latin America, p. 302.

[3]Brandenburg, The Making of Modern Mexico, p. 266.

[4]Wythe, Industry in Latin America, p. 270.

began to build a vast chain of mines and smelters in the 1890s. The first smelter was a silver-lead smelter located in Monterrey. Other smelters followed quickly throughout northern Mexico. The Guggenheim smelter trust employed mining engineers to find new sources of raw materials for exploitation in order to guarantee a supply of ore for their smelters.[1] Other American mining interests included Robert S. Towne who built smelters and also constructed the Mexican Northern Railway to facilitate his mining operations. The Compania Minera de Penoles and the Montezuma Copper Company were American influenced ventures of great profitability.[2]

Production of petroleum began in about 1901, and by 1911 Mexico ranked third in the world in oil production.[3] Wheetman D. Pearson and Edward Doheny (English and American, respectively) pioneered the petroleum industry in Mexico.[4] Doheny's company brought in modern drilling techniques and hit a gusher in 1910 which catapulted Mexico into the ranks

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[1]Pletcher, <u>Rails, Mines, and Progress</u>, p. 299.

[2]<u>Ibid</u>., p. 299.

[3]Wythe, <u>Industry in Latin America</u>, p. 270.

[4]Jack R. Powell, <u>The Mexican Petroleum Industry, 1938-1950</u> (Berkely: University of California Press, 1956), p. 8.

of the top producers of oil in the world.[1]

Hydroelectric power was first used in manufacturing and mining in 1893. At this time the English constructed a jute mill powered by a hydro plant capable of generating 5,000 horsepower. In 1902 the Mexican Light and Power Company Limited was financed by Americans and Europeans who combined electric utility power plants serving Mexico City. The construction of the large Necaxa hydroelectric plant which supplied the capital and two important mining centers, El Oro and Pachuca, began in 1903.[2] This construction was soon followed by the construction of hydroelectric plants by the English, Canadians, Americans and French. In all, five important foreign companies entered the electric power industry between 1902 and 1906. These companies constructed four crucial power systems between 1905 and 1911 and were to remain the heart of the hydroelectric power industry until after World War II.[3]

1910-1940 Revolution and Reform

Mexico experienced more political instability with

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[1]Pletcher, Rails, Mines, and Progress, p. 298.

[2]Wythe, Industry in Latin America, p. 280.

[3]Miguel S. Wionczek, "Electric Power: The Uneasy Partnership," in Public Policy and Private Enterprise in Mexico, ed. by Raymond Vernon (Cambridge, Massachusetts: Harvard University Press, 1964), p. 22.

the overthrow of Porfirio Diaz. Stability was not regained until the Party of Revolutionary Institutions was formed in 1929. Economic growth suffered in the first years following the revolution as illustrated in Table 5. The growth rate of agricultural production fell from 1.0 percent to 0.1 percent -- just matching the low population growth rate of 0.1 percent. Manufacturing production growth declined from 3.6 percent to 1.7 percent while mining and petroleum production growth rates receded from 7.2 percent to 5.6 percent. Gross domestic product dropped from 3.3 percent to 2.5 percent. However, due to the drop in the population growth rate the per capita product increased from 2.2 percent to 2.4 percent in this period. An interpretation of these figures reveals that nearly a million people died of malnutrition, disease and war. The continuation of relatively high growth rates in mining and petroleum was a result of the protection of these enclaves by private armies.[1]

Rapid recovery began after the low which was reached in 1915. Political stability was improved under the government of General Obregón (1921-1924) and the following president, Plutarco Calles (1924-1928). Net growth in gross domestic product was not attained until after 1920.[2] By

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[1]Reynolds, The Mexican Economy, pp. 26-27.

[2]Ibid.

TABLE 5

GROWTH RATES OF THE MEXICAN ECONOMY, 1900-1965
(COMPOUND ANNUAL RATES OF GROWTH)

	Porfiriato	Revolution and Reform		Development			
	1900-10	1910-25	1925-40	1940-50	1950-60	1960-65	1925-65
Gross domestic product	3.3	2.5	1.6	6.7	6.1	6.1	4.5
Population	1.1	0.1	1.6	2.8	3.1	3.4	2.6
Per capita product	2.2	2.4	0.0	3.9	3.0	2.7	1.9
Agricultural production	1.0	0.1	2.7	5.8	4.3	4.3	4.2
Manufacturing production	3.6	1.7	4.3	8.1	7.3	8.1	6.4
Mining and petroleum production	7.2	5.6	-1.9	2.5	5.3	4.2	1.7

Source: Clark W. Reynolds, The Mexican Economy (New Haven: Yale University Press, 1970), Table 1.4, p. 22.

the mid-1920s production was only slightly higher than the last of the Diaz period.[1] Economic recovery was hampered by several factors,

> including an influenza epidemic (1918-19), overthrow of the Carranza government (1920), the world business depression and a domestic drought (1921), the De la Huerta Revolt (1923-24), conflicts between the church and state and between oil companies and the government (1926-28), and a threatened military revolt in the autumn of 1927.[2]

Foreign investment came to a rapid halt due to fear of expropriation. The banking system collapsed by 1920 followed by a liquidity crisis and deflation which continued in the decade of the 1920s.[3]

In spite of these obstacles, the economy continued to recover until the world-wide depression began in 1929.[4] Then Mexico's export sector deteriorated rapidly causing gross domestic product to decline 12.5 percent below the 1925 level. Gross domestic product did not reach previous levels until the 1940s.[5] Political stability increased with the formation of the Party of Revolutionary Institutions in 1929 which permitted structural changes in the

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[1]Hansen, Politics of Mexican Development, p. 30.

[2]Reynolds, The Mexican Economy, p. 29.

[3]Ibid., p. 30.

[4]Wythe, Industry in Latin America, p. 272.

[5]Reynolds, The Mexican Economy, p. 32.

economy and led to gradual recovery. Exports of petroleum, mining and commercial agriculture began to rise slowly in the 1930s, but production in mining and petroleum in 1940 was still below levels attained in the 1920s. In the period between 1930 and 1940, the government expropriated the petroleum industry, nationalized the railroads, and expropriated land.[1] Table 5 indicates that agricultural production increased by 2.7 percent from 1925 to 1940 while manufacturing increased by a respectable 4.3 percent for the same period. The two sectors serving the domestic market, manufacturing and agriculture, were able to continue growth through the 1930s due to the previously mentioned structural changes.

Industrial production and agricultural output increased in the 1930s, but per capita gains were nonexistent. The population growth rate exploded in the 1930s, an increase from 0.4 percent in the 1910-1930 period to 2.0 percent in the 1930-1940 period.[2]

The structural changes between 1910 and 1940 set the foundation for future economic growth. Land reform, domestic ownership of the petroleum industry, higher taxes in the mining sector and the nationalization of the railroads were some

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[1] Ibid.

[2] The cause of this increase is probably due to land reform which increased farm output and to advances in medical technology. See Reynolds, The Mexican Economy, pp. 19, 33.

of the more fundamental changes. The shift of the population from rural to urban and from agricultural jobs to non-agricultural jobs began in the 1930s and continues into the 1970s.[1]

Role of Technological Transfer in Agriculture

Agricultural production declined as a result of the fighting (except for henequen, an export commodity) and did not reach 1908-1910 levels until about 1945.[2] Very little transfer of technology was occurring in this period as is reflected in the crop production statistics shown in Table 6.[3] It should be noted that a shift of crop production took place after the fall of Diaz. Crop production was directed toward domestic consumption rather than export. The actual rate of growth of crop production doubled between the Porfirian period and the 1910-1940 period. In human terms, after about 1920 the Mexican people began to have enough food to bring them up to a subsistence level.

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[1] Ibid., p. 33.

[2] Venezian and Gamble, Agricultural Development of Mexico, p. 58.

[3] For a geographer's interpretation of the importance of location and the development of the infrastructure see Laurence A. Brown and Barry Lentnek, "Innovation Diffusion in a Developing Economy: A Mesoscale View," Economic Development and Cultural Change, Vol. 21, No. 2 (January, 1973), pp. 274-92.

TABLE 6

GROWTH OF CROP PRODUCTION DURING THE MAJOR PERIODS OF MEXICAN ECONOMIC DEVELOPMENT (COMPOUND ANNUAL RATES OF GROWTH)

	Porfiriato[a] 1877-1910	Revolution and Reform 1910-1940	Development 1940-1960
Total real crop production	0.6	1.1	6.3
Total population	1.4	0.9	2.9
Per capita crop production	-0.8	0.2	3.4

[a]The period in the first column is 1877-1907.

Source: Clark W. Reynolds, The Mexican Economy (New Haven: Yale University Press, 1970), Table 3.2, p. 96.

During the 1910-1940 period the Mexican government did initiate land reform (1917), added to the number of hectares under irrigation and invested heavily in road construction. Road construction and irrigation projects as a percent of total government expenditures doubled from 22.6 percent in the 1925-1929 period to 45.2 percent in the 1935-1939 period. The development of the rural infrastructure in the period of Revolution and Reform established the base for the rapid growth after 1940.

Role of Technological Transfer in Industry

Some of the large foreign-controlled firms sent some of the best of Mexican workers to the United States for technical training. The graduates of Mexico's own technical schools were given the opportunity to work in American owned plants in Mexico and the United States for practical experience. United States companies such as Bethlehem Steel, Midvale Steel and Baldwin Locomotive Works participated in these types of programs. In 1931 a labor law was passed which aided the training of Mexican workers. This law forced employers to contribute to a fund which could be used to pay for training in either a domestic or foreign institute.[1]

The rapidly growing control over the Mexican economy contributed to the overthrow of the Diaz regime. Any country resents huge amounts of control by foreigners, and the Mexicans were no exception. The following quote illustrates the cause of the Mexican uneasiness over foreign influence.

> Foreigners controlled most of the mines and the petroleum industry, the principal electric power plants, a large part of the railway mileage, several of the principal banks, numerous manufacturing and commercial establishments, and about one fifth of the privately owned lands in the republic.[2]

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[1]Wythe, Industry in Latin America, pp. 284-85.

[2]Ibid., p. 45.

The result was a nationalistic reaction to regain control over the Mexican economy. It was not until the 1920s that foreigners began to invest in Mexico again.

Isolated enclaves protected by private armies and the wealth to support various rebel groups were able to maintain production. A brief description of the mining and oil industries is therefore necessary to an analysis of this period. Following the discussion of these two industries is a description of the development of the hydroelectric utilities which were so fundamental to Mexico's industrialization. The last segment in this section deals with the establishment of foreign branch plants in Mexico in the 1920s.

The Revolution had a disruptive effect on the mining industry, forcing some mines to close and greatly curtailing production in others. Production fell drastically in nearly all sectors of the economy between 1910 and 1914. Production recovered somewhat with the ebbing of fighting and the stimulus of new demand caused by World War I. Production increased jerkily until 1938, but the central importance of gold, silver and copper mining to the Mexican economy was a fading phenomenon.[1]

Almost all mining investment was foreign owned.

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[1]Cumberland, Struggle for Modernity, p. 251.

Large returns were made on these investments, and the government reaped large revenues with the increase in taxes after 1917. But the average Mexican benefited little from the mining enclaves. The mining industry, like the petroleum industry and the railroads, was built by foreigners for exploitation -- not for the development of Mexico.

World demand for oil greatly increased due to World War I and the growing use of oil-burning ships. Another tremendous oil strike by the Mexican Petroleum Company (American owned) brought forth more than 250,000 barrels per day -- the largest in the world at that time. Mexico ranked second in the world in oil production by 1920.[1]

In 1917 the new post-revolutionary constitution provided for the nationalization of petroleum resources. Increased regulation and direct government intervention by military force to stop unauthorized drilling was warning enough to the foreign companies. By 1920 the oil companies had begun to cut back on their investments.[2] They rushed to extract as much oil as possible before their property was expropriated and exhausted many of the wells. New investments were channeled into the safer areas of Venezuela

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[1]Wendell C. Gordon, The Expropriation of Foreign-Owned Property in Mexico (Washington, D.C.: American Council on Public Affairs, 1941), p. 50.

[2]Ibid., p. 51.

and Columbia.[1] More stringent tax laws drastically curtailed extraction of Mexican oil after 1921.

The dissatisfaction of the two largest oil companies, Dutch Shell and Standard Oil of New Jersey, with the expropriation of their property in 1938 resulted in a boycott of Mexican oil. Consequently Mexico turned to Japan, Italy and Germany for new markets. This in turn caused the oil companies to accuse Mexico of undercutting democracy.[2] In any case, there was very little technological inflow to the petroleum industry in this period.

Mexico's national oil corporation (PEMEX) invested only slightly in the oil industry in the period between 1938 and 1944 due to shortages of foreign supplies and inadequate financial reserves. Thus the growing domestic demand for oil resulting from the expansion of roads, hydroelectric power and manufacturing in the late 1930s was not satisfied. Supplying internal petroleum needs was complicated by the layout of the existing pipelines which were designed by foreigners to get the oil out of the country instead of to domestic markets. The lack of domestic re-

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[1] Ibid., p. 53.

[2] Ibid., p. 91. Gordon notes that ". . . if that was true, these same companies were betraying democracy as well, for they were selling to Germany 68% of her total oil purchases."

fineries compounded the problems facing PEMEX.[1] It was not until 1945 that Mexico began to truly expand its petroleum industry as is shown in the next section (1940-1965).

The growth of the electric power industry which had begun at the turn of the century continued, in spite of the Revolution, until 1914. Perhaps, as was the case of the oil industry, the foreigners perceived the Revolution as a temporary aberration which would not fundamentally affect their long-run investments. But the Revolution damaged the profits of the electric utilities in several ways. Mining, which was a principal user of electricity, had been hit very hard by various rebel bands. Municipal governments went bankrupt and did not pay their accounts. Other users paid their bills in local paper currency of no value.[2]

The major electric power companies resumed their heavy investment in construction in 1921 after General Obregon took command. Unlike the oil companies, the electric utilities saw a greater future in Mexico without the fear of expropriation. Hydroelectric power was so vital to the Mexican economy and so expensive that the utilities

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[1]International Bank for Reconstruction and Development, Combined Mexican Working Party, The Economic Development of Mexico (Baltimore: John Hopkins Press, 1953), p. 46.

[2]Wionczek, "Electric Power: The Uneasy Partnership," p. 34.

seemed assured a secure place in the growth of the economy. As a result the electric power industry led the economy in the 1920s in growth.[1]

Between 1928 and 1929 the American and Foreign Power Company obtained three of the five largest electric utilities and continued expansion in some of its investments until 1935, marking the end of self-controlled private investment in Mexican electric utilities. The electric power industry did not resume expansion until after World War II.[2]

Before World War I American and European pharmaceutical companies had licensed their products to Mexican laboratories and had sent manufacturing representatives to ensure quality control. Not until around 1925 did these companies begin to establish branch plants in Mexico. Other manufacturers and assembly plants followed, including Ford (1926), Simmons (bedding supplies, 1927), packing houses near the American border (1929-1930), International General Electric Company (electric light bulbs, 1930), corn products, compound lard, celluloid products (1931), dry cell batteries (1932), Quaker Oats (1934), General Motors assembly of trucks (1936), General Motors assembly of automobiles (1937) and Chrysler products (1939).[3]

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[1] Ibid., pp. 36-37. [2] Ibid., pp. 46-48.

[3] Wythe, Industry in Latin America, p. 291, and Brandenburg, The Making of Modern Mexico, p. 296.

Americans entered the tire industry in 1933 when two United States companies (General Tire and Goodrich) made agreements with two Mexican firms to supply financial and technical assistance. Goodyear followed a decade later with similar arrangements.[1]

Most branch factories were American, but the English did establish the biggest thread plant, and a British-American tobacco firm accounted for over one-half of Mexican cigarette consumption.[2]

In spite of the foreign influence in manufacturing, the Mexicans maintained control over the important sectors such as iron and steel, breweries, glass, cement, textiles, soap and furniture. There were some minority American investments in these areas and a few foreign technicians (Danish, American and German) were used under the control of Mexicans.[3]

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[1]Wythe, Industry in Latin America, p. 291.

[2]*Ibid.*

[3]*Ibid.*

CHAPTER IV

MEXICO -- DEVELOPMENT AFTER 1940

1940-1965 -- Steady Growth

Economic development faltered during the three decades of revolution, reform, and depression following the first surge forward in the Porfirian period. World War II had a buoyant effect on the Mexican economy through the expanded demand for exports of raw materials.[1] Textile exports increased rapidly in 1942 when Mexico began to move into the markets in Central America and the West Indies. Exports again expanded rapidly during the Korean War (more than 20 percent per year for the years 1949, 1950 and 1951) and had a stimulating effect on other sectors of the economy including the steel and cement industries.[2] Gross domestic product increased at an annual rate of 6.7 percent through the 1940s, and continued to grow at a rate above six percent through the 1950s and the 1960s.[3] The fundamental structural changes in the Mexican economy during the revolution and reform period (1910-1940) assured that the

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[1]Mosk, Industrial Revolution in Mexico, p. 125.

[2]Flavia Derossi, The Mexican Entrepreneur (Paris: OECD, 1971), p. 17.

[3]See Table 6.

new economic growth was more soundly based than its typical export-oriented economy of the past. Thus the external demand spread to the internal sector with a multiplier effect which stimulated domestic production.[1]

Foreign investment began to flow back into Mexico due to the policies of President Avila Camacho (1941-1946) who promoted settlements with the former owners of Mexico's petroleum companies and for the payment on defaulted bonds. However, President Avila Camacho did pass a 51 percent law which essentially guaranteed Mexican control over most economic sectors.[2] The foreign exchange accumulated in World War II was used to purchase capital goods imports and was therefore an important factor in facilitating technological transfer. The capital goods inflow was aided by the undervalued exchange rate throughout most of the 1940s, the relaxation of import controls on capital goods, and easy credit terms in the United States. As a result of the influx of new technology, output and productivity increased rapidly. The main constraint was the pace at which capital goods could be imported, installed and made operative. However, the emphasis on the importation of capital goods has resulted in a bias toward capital-intensive techniques which is perhaps

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[1] Reynolds, The Mexican Economy, p. 37.

[2] This "guarantee" was not vigorously enforced and foreign control continued in several key areas.

less than optimal given Mexico's underemployed human resources.

The years following World War II to the present have been marked by the building of overhead capital in Mexico. Road construction, railroads, irrigation, rural electrification, electric power plants, and communications have aided the Mexican development and have provided the basic economic structure for sound economic development.[1]

Manufacturing has consistently been the forerunner in the Mexican economy in the three decades following 1940. Manufacturing increased at a rate of 8.1 percent in the 1940s, 7.3 percent in the 1950s, and 8.1 percent through the mid-1960s.[2] Agricultural production also increased at respectable rates in these decades: 5.8 percent in the 1940s, 4.3 percent in the 1950s, and 4.3 percent up to the mid-1960s. The extractive industries grew slowly in the 1940s (2.5 percent) and then accelerated in the 1950s and mid-1960s (5.3 percent and 4.2 percent, respectively).

The general economic scenario was one of initial import substitution followed by an expanding domestic market which resulted in economic gains for a greater number of peo-

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[1]Reynolds, <u>The Mexican Economy</u>, pp. 39, 41.

[2]See Table 6.

ple.[1] However, the absolute increase in economic growth did not result in accelerating returns on a per capita basis. Productivity on a per capita basis continued to grow, but at a decreasing rate. Thus per capita product increased by 3.9 percent in the 1940s, 3.0 percent in the 1950s and 2.7 percent up to the mid-1960s.[2] The population growth rate was responsible for the decline in per capita gains. The population growth rate was 2.8 percent in the 1940s, 3.1 percent in the 1950s, and 3.4 percent up to the mid-1960s. Mexico, as with many of the less developed countries, has had its economic growth greatly tempered by very high population growth rates and a highly skewed distribution of wealth and income. Further, as rapid as the growth of the modern sector has been, it has not grown fast enough to prevent sizable unemployment and underemployment in the urban areas.[3]

A significant flow of technology occurs between the United States and Mexico through their respective universities. There were 2,053 students receiving government grants between 1952 and 1964, of which 1,742 were Mexican. Nearly

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[1]Reynolds, The Mexican Economy, p. 39

[2]See Table 6.

[3]John Isbister, "Urban Employment and Wages in a Developing Economy: The Case of Mexico," Economic Development and Cultural Change, XX, No. 1 (October, 1971), 43.

half of the grantees entered the natural sciences.[1] An additional 6,229 Mexican students came to the United States' universities between 1952 and 1962-1963. Many of these students were supported by foundations or private agencies, and nearly half of these students majored in the physical sciences.[2]

Role of Technological Transfer in Agriculture

Mexico's most notable accomplishments in agriculture have been achieved since the 1940s. The institutional resistance of the hacienda system and the turmoil following the revolution delayed the development of Mexican agriculture.

The overthrow of Diaz was largely a result of his land policy and his ready acceptance of foreign economic investments. As a result, the Revolution led to a program of general land reform. The cry of "Land for the landless" unified the peasants who believed land reform would cure their problems. Article 27 of the 1917 Constitution allowed villages to again acquire communal land, the ejido. It also permitted the distribution of small private plots, an idea

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[1]Cole and Sanders, Growth and Change in Mexican Agriculture, pp. 392, 394.

[2]Ibid., p. 403.

that had been popular with Mexican liberals for 100 years.[1]

Although land reform was initiated in the 1917 Constitution, it was another seventeen years before the government took any vigorous action in this direction.[2] So it was not until 1934 that any real effort was directed to redistribution of land. The following discussion briefly outlines the three basic kinds of land holdings in Mexico and their economic significance.

These three types of landholding in Mexico are:

1) Ejido -- Indian communal holdings.

2) Large government or private holdings -- over 5 hectares.

3) Minifundia -- small private holdings of 5 hectares and under.

The ejido land is held in common and may be worked in common or divided among individuals and worked privately. Almost all ejidal land is worked individually today. These lands cannot be sold, mortgaged, or rented; however, the individual plots can be transferred from father to son. In 1960 the ejido accounted for about 26 percent of total land area and 43 percent of cultivated land.[3]

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[1] Cole and Sanders, Growth and Change in Mexican Agriculture, p. 21.

[2] It probably took so long to act on land reform because of the general political turmoil that followed and conservative resistance to such a program. See Cole and Sanders, Growth and Change in Mexican Agriculture, p. 20.

[3] Ibid., p. 24.

The ejido sector has probably not grown at a pace equal to the private commercial farms in terms of productivity. While ejidal production increased only 210 percent during the 1940-1960 period compared to 364 percent for the large commercial farms the ejido did not receive as large a quantity of inputs as the private commercial farms. Large private farms increased the amount of land under cultivation as well as the value of machinery at a much greater rate than did the ejido. But still in 1960 the ejidal,

> crop production totaled 43 percent of Mexican aggregate production that year. They produced 36 percent of total agricultural output, and supplied 34 percent of all farm products marketed. Finally, over 25 percent of total ejidal crop production was exported.[1]

While 85 percent of ejido plots are of a subsistence nature, the above statement reflects that they are as commercially oriented as the large private land holdings. (Fifty percent of the large private farms and nearly all of the private farms under 5 hectares are subsistence oriented.)[2]

The large commercial farms appeared between 1935 and 1950 and were made profitable by the massive government program of building irrigation systems and roads. About three-quarters of the land opened up by irrigation was located in northern and northwestern Mexico. Of this, over

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[1]Hansen, Politics of Mexican Development, p. 61.

[2]Ibid., p. 62.

half is privately owned. Yields are three to four times larger than before irrigation began. Much of the land is farmed for export and often it is highly mechanized. Output on these private farms has increased 364 percent from 1940 to 1960.[1]

Production has increased only 142 percent on the minifundia for the 1940-1960 period, but these plots were always farmed without the benefits of credit, farm machinery, or irrigation. Even so these plots produced higher yields on a per-hectare basis for several crops than either the large commercial farms or the ejidos (corn, cotton and beans). Evidently, the desire to hold on to their own plots of land has been a great incentive to the small landowners.

There is very little good land left to be distributed to individuals in today's Mexico. The land pattern consists basically of small labor-intensively farmed plots and large areas of land (ejido or private) which can or are being farmed with capital-intensive methods. The large private commercial farming in the north and north Pacific have received disproportionately large public investments in irrigation and roads. For example,

> from 1940 to 1960 the North Pacific and North received almost 80 percent of federally irrigated land, over 50 percent of newly paved highways, and

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[1]*Ibid.*, p. 60.

> accounted for 67 percent of net private investment in agriculture.[1]

In the other regions of Mexico the public investment in roads and irrigation has generally served the large private farms rather than the ejido or the small private landowners. Construction of new railway trunk lines, roads and irrigation projects tends to generate large private investments which take advantage of the improved infrastructure. The peasant, whether on small private lands or ejido, has little access to credit, extension services, or the general education or cultural background to enable him to switch from subsistence agriculture to commercial farming.

The long-run trend has been toward the gradual elimination of the subsistence sector. However, there are perhaps some six million peasants still living by subsistence agriculture. This is roughly the same number that was engaged in subsistence agriculture in 1910 and represents over 10 percent of the Mexican population.[2] Further, the commercial agricultural sector and the nonagricultural sector have not grown at a pace rapid enough to absorb displaced labor. Thus slums continue to grow around the urban centers, and unemployment and underemployment remain high. Mexico's dualistic structure, unlike that of Japan, is be-

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[1]Reynolds, The Mexican Economy, p. 159.

[2]Ibid., p. 160.

coming more dualistic as the gap between the modern sector and traditional sector widens.

The examination of technological transfer to both the agricultural sector and the industrial sector must be perceived within this framework. Technology is not easily transferred to people who are deprived of the cultural-institutional setting conducive to its acceptance. The literature on Mexico's economic development is filled with the word "dilemma." Dilemmas of public vs. private, dualism vs. integration, revolutionary psychology vs. growing inequality, etc.[1] The growth of technological enclaves in Mexico will continue. The question remains, will the Mexicans educate their people as did the Japanese, permitting a gradual integration of the modern and traditional sectors while facilitating the flow and diffusion of new technologies, or will present economic forces and cultural behavior patterns obstruct this development?

Within the context of the land system just described the Mexican government greatly increased the inputs to agriculture in the 1940s. Increased agricultural output was needed to support Mexico's import substitution program which

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[1]The difference between revolutionary psychology and practice is striking. One need only stroll down the boulevards in Mexico City, named after the Revolution, to see a modern Hilton Inn rising toward the sky with beggars on ragged blankets at its base.

began in World War II. Agricultural products were needed for the manufacturing sector and its work force and as a source of foreign exchange to obtain capital goods for industrialization.[1]

Irrigation facilities had increased between the Revolution (1910) and 1930 by nearly 700,000 hectares. It is estimated that about one million hectares were being irrigated in 1910 although much of this was of a temporary nature. An additional 222,330 hectares were irrigated during the 1930-1940 period. The real effort to improve agricultural production started in the 1940s. Over 700,000 additional hectares came under cultivation in this period.[2]

Inputs of fertilizer also increased after the 1940s. The magnitude of these increases is truly amazing. Nitrogen consumption between 1948-1952 and 1966 increased by 2,410.5 percent, phosphate 1,064.1 percent, and potassium 545.4 percent.[3] Table 7 reveals that fertilizer consumption per hectare is still well below an optimum level when compared to countries such as the United States. This is

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[1]*Ibid.*, p. 52.

[2]*Ibid.*, p. 51. Some transfer of technology came from the United States via Mexican students and engineers visiting United States projects such as the Tennessee Valley Authority. See Bureau of Educational and Cultural Affairs, *Resources Survey for Latin American Countries* (Washington, D. C.: Department of State, 1965), p. 399.

[3]Venezian and Gamble, *Agricultural Development of Mexico*, p. 103.

probably due to the large area of Mexico that remains without irrigation, inadequate supplies of other inputs such as better seeds, the low income of most of the farmers and their lack of access to credit, the institutional resistance of the poorer, uneducated farmers, and the lack of a sufficient extension service to promote agricultural information.[1]

TABLE 7

FERTILIZER USE IN SELECTED COUNTRIES

Country	Fertilizer Consumption (in Tons of Nutrient Elements) per 1,000 Hectares of Arable Land
Mexico	8.6
United States	36.2
Japan	248.7
Western Europe	78.5

Source: Eduardo L. Venezian and William K. Gamble, The Agricultural Development of Mexico: Its Structure and Growth Since 1950 (New York: Praeger Publishers, Inc., 1969), p. 102.

The development of stabilized tortilla flour is a good example of Mexican innovation combined with foreign technical and organizational assistance. In the late 1940s

[1] Ibid., p. 104. Wendell Gordon has cited the Mexican case as an example of providing excellent research without proper follow up to ensure the transfer of technology to the farmer. See Wendell Gordon, "Capitalism and Technological Adaptation in Latin America," Journal of Economic Issues, III, No. 1 (March, 1969), 83.

the Bank of Mexico sponsored a project through the Instituto Mexicano de Investigaciones Technológicas to stabilize tortilla flour. Tortillas, the staple food of Mexico, are made from masa, a paste which is created by precooking maize in a solution of lime. The result is nixtamal which has to be ground to make masa, and consumed quickly to prevent decomposition. The Mexican institute combined efforts with the Armour Research Foundation and successfully began production of a stabilized flour in 1954. The Quaker Oats Company constructed plants in the United States for Mexican consumption after obtaining patent rights. The stabilized flour can be stored easily and later mixed with water to form masa at the consumer's convenience.[1]

Another example of Mexican innovation is the development of a process to make paper from bagasse. Bagasse is the term applied to sugarcane stalks after the milling process. The first successful production of paper made from bagasse began in 1964 after a decade of research by the Compañía Industrial de San Cristóbal, S.A. Doctor Dante Sandro Cusi acquired patents on previous research and added his own innovations to create a successful process. The Scott Paper Company entered into the production of bagasse paper utilizing Doctor Cusi's method under a fifty-fifty ownership arrangement.

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[1]Strassmann, Technological Change and Economic Development, pp. 242-43.

Mexico's most dramatic agricultural advance has been in the development of new strains of seeds. The Rockefeller Foundation and the Mexican government initiated a research program in 1943 to study Mexico's crop structure with the objective of increasing yields by the application of modern science to Mexican agriculture. The program has resulted in unprecedented success in developing new varieties of corn, wheat, potatoes and other crops.[1] This research is transformed into production by the Productora Nacional de Semillas, a government monopoly. The Productora Nacional de Semillas' production for the improved seed varieties is illustrated in Table 8.[2] Unfortunately the use of hybrid corn has not been very widespread in Mexico. Most of the corn is grown in the traditional agricultural areas of Mexico where the educational level is very low. Government support in terms of irrigation, roads, extension services and credit availability has been lacking in these regions. The use of the new corn seed varieties requires a combination of inputs and new techniques which necessitate government assistance.[3]

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[1]Venezian and Gamble, Agricultural Development of Mexico, p. 154.

[2]Most of the production of the improved production crop seed varieties is done by private firms (cotton and sugar cane). See Venezian and Gamble, Agricultural Development of Mexico, p. 106.

[3]Ibid., p. 107.

TABLE 8

PRODUCTION OF IMPROVED SEEDS FOR SELECTED CROPS
(METRIC TONS)

Crop	1949-50	1955-56	1959-60	1960-61	1961-62	1965-66
Corn[a]	2,250	5,200	6,840	[b]	7,360	3,920
Wheat	--	--	20	409	6,508	27,886
Beans	--	--	93	90	--	1,480
Sorghum	--	--	166	79	153	5,445
Rice	--	--	--	--	--	4,275
Potatoes[a]	--	--	--	--	--	13,052
Oilseeds	--	--	--	--	--	2,590

[a]For corn and potatoes, figures shown are average production for the two years indicated; for other crops, the periods correspond to the cropping year.

[b]Not applicable, given explanation in note a.

Source: Eduardo L. Venezian and William K. Gamble, The Agricultural Development of Mexico: Its Structure and Growth Since 1950 (New York: Praeger Publishers, Inc., 1969), Table 24, p. 106.

The Rockefeller Foundation and the Mexican Ministry of Agriculture cooperative program in agricultural research has proved to be a model example of international scientific cooperation. The program operated through the Office of Special Studies and now within the International Food Crop Improvement Plan. This program has served as the model for the other agricultural research institutes in Mexico and deserves special examination.[1]

Before an agreement was made between the government and the foundation, the foundation sent three highly qualified American agricultural scientists to survey the potential for research. After extensive travel and investigation, these men recommended that the project should be initiated. The project was well funded, well staffed with the highest caliber of scientists, and well organized. The area of concentration was narrowly directed toward the most important crops: beans, wheat and corn. Field work, under the direction of one of the scientists, brought pathologists, entomologists, and geneticists together to pool their talents.[2]

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[1]The Mexican experiment was so successful that it has served as a model throughout the world. New rice varieties have been developed by the International Rice Research Institute in the Philippines which is patterned after the Mexican model. Norman Borlaug, one of the first American scientists working in the pioneering Mexican experiment received the Nobel Prize for his efforts. See Lester R. Brown and Gail W. Ginsterbusch, Man and His Environment: Food (New York: Harper and Row, 1972), p. 130.

[2]Delbert T. Myren, "The Rockefeller Foundation Program in Corn and Wheat in Mexico," in Subsistence Agriculture and

Mexican trainees were deeply involved in the project and received on-the-job training which later enabled the Mexicans to build a cadre of the highest quality of agricultural scientists in all of Latin America.[1] New varieties of seeds were maintained in "banks" and became a reservoir which has attracted international attention and cooperation, including cooperation with the Bureau of Plant Industry of the United States Department of Agriculture.[2]

The Rockefeller Foundation projects produced about 700 Mexican graduates with on-the-job training between 1943 and 1963.[3] Between 1945 and 1964, scholarships were awarded to 150 agronomists on the Masters Degree level and 70 scholarships on the Ph.D. level.[4]

It is difficult to assess the separate impact of the new variety of seed on Mexican agriculture. Improved fertilizers and pesticides, mechanization, land reform, the creation of rural social overhead capital, political sta-

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Economic Development, ed. by Clifton R. Wharton, Jr. (Chicago: Aldine Publishing Company, 1969), p. 440.

[1]Arthur T. Mosher, Technical Co-operation in Latin-American Agriculture (Chicago: University of Chicago Press, 1957), p. 110.

[2]Ibid., p. 111.

[3]Bureau of Educational and Cultural Affairs, Resources Survey, p. 410.

[4]Venezian and Gamble, Agricultural Development of Mexico p. 154.

bility and a growing demand for Mexico's agricultural products enter into the dramatic increase in production. But it is a fact that when the Rockefeller Foundation began its studies in Mexico,

> it was a hungry country, importing much of its food from the United States. By 1964, only a quarter of a century later, wheat production had tripled, corn production had doubled, and the average Mexican was consuming more food. Both wheat and corn were being exported, and the economy was prospering.[1]

Although the Rockefeller Foundation has had the most spectacular success, at least two other research institutes are worth mentioning.[2]

The Ford and Rockefeller Foundations support the International Maize and Wheat Improvement Center which is engaged in research on an international scale. Mexican and Rockefeller Foundation scientists have been working for the Center for over twenty years in an attempt to study genetic and production problems related to maize and wheat on a comprehensive scale.[3]

The National Livestock Research Institute through its National Center for Livestock Research is engaged in studying nutrition, new vaccines, disease control, biolog-

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[1]Lester R. Brown, Seeds of Change: The Green Revolution and Development in the 1970s (New York: Praeger Publishers, Inc., 1970), p. 3.

[2]For greater detail, see Bureau of Educational and Cultural Affairs, Resources Survey, p. 410.

[3]Venezian and Gamble, Agricultural Development of Mexico, p. 164.

ical products and pastures and forages in cooperation with the Rockefeller Foundation. In the mid-1960s, the Research Institute employed 60 professional and technical people in four experimental stations. Eight of these professionals were studying outside of Mexico.[1] The United States government has assisted the Mexican agricultural development through several agencies. Some of the more important of these are discussed briefly.

The Agency for International Development has financed a number of cooperative educational contracts between Mexico and the United States. The only such exchange program in agricultural research listed by the State Department was between the Texas Agricultural and Mechanical University and Escuelo Superior de Agricultura.[2]

The Department of Agriculture entered a cooperative program with the Mexican government in 1947 to eliminate foot-and-mouth disease. By 1961 this goal had been reportedly accomplished. Other research has been directed toward entomology and crop breeding. The Department of Agriculture has provided for nearly 300 Mexicans to do agricultural research in the United States between 1953 and 1965. The

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[1] Ibid., pp. 155-58.

[2] Bureau of Educational and Cultural Affairs, Resources Survey, p. 396.

Department also publishes papers related to Mexican agricultural problems.[1]

The Department of Commerce conducted an exhibition in Mexico City in 1963 in which some 100 United States firms displayed products, including farm machinery.[2]

The small number of personnel engaged in extension services to the agricultural sector, as documented in Table 9, has greatly decreased their effectiveness. The limitations of the extension service becomes apparent when related to the United States, which has one extension agent to every 540 farm families and to Japan, which has a ratio of 1 to 650, compared to the Mexican ratio of 1 to 10,000.[3] The Extension Department of the Secretariat of Agriculture operates the Federal Agricultural Extension Service, but the staff numbers only slightly over 400.[4] The government is attempting to decentralize the Extension Service to provide more flexibility at local levels. The Ford Foundation is helping the government to make the Extension Service programs more responsive to local needs.

Elementary and practical education facilities are

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[1] Ibid.

[2] Ibid., p. 397.

[3] Venezian and Gamble, Agricultural Development of Mexico, p. 137.

[4] Ibid., p. 165.

TABLE 9

EDUCATION LEVEL: ACTIVE POPULATION IN AGRICULTURE BY MAJOR SKILLS, 1950 AND 1960

	1950		1960	
Type of Worker	Number	Per 1,000 of Total	Number	Per 1,000 of Total
Professionals and technicians	1,197	0.2	8,072	1.3
Managers, salesmen and other employees	26,868	5.6	83,215	13.5
Labor[a]	4,810,067	94.2	6,053,643	85.2
Total active agricultural population	4,838,132	100.0	6,144,930	100.0

[a]Labor is more than 50 percent illiterate.

Source: Eduardo L. Venezian and William K. Gamble, The Agricultural Development of Mexico: Its Structure and Growth Since 1950 (New York: Praeger Publishers, Inc., 1969), Table 29, p. 116.

very inadequate. Only 10 percent of all students in the rural areas complete the sixth grade. In fact, there are many regions that simply have no educational facilities beyond the sixth grade. To make matters worse, the drop-out rate beyond the third grade is quite high in rural areas. The total number of students engaged in agricultural institutions on the elementary and practical level only numbered about 1,000 students in the mid-1960s.[1]

Mexico has received some limited help from private United States organizations such as the Cooperative for American Relief Everywhere (CARE). CARE works with the agricultural program sponsored by the Mexican Ministry of Education and provides agricultural handtools and instructions in animal husbandry, dietary requirements and other related information.[2]

The National School of Agriculture, Chapinzo, is the most important agricultural school of higher learning. The National School cooperates with regional agricultural schools and offers their personnel and research facilities on a temporary basis. There is an effort to connect the activities of research, extension and education through Plan Chapingo which was started in 1963. The National

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[1]*Ibid*., pp. 143-45.

[2]Bureau of Educational and Cultural Affairs, *Resources Survey*, p. 408.

School was enlarged to handle the headquarters of several government agricultural organizations in 1967 in conjunction with this plan. The government has received the assistance of the Ford and Rockefeller Foundations and the United Nations Special Fund. The purpose of the project is to establish a pool of sophisticated Mexican agriculturalists who can provide direction and leadership in the areas of agricultural education, research and extension services.[1]

There are only eleven schools offering university degrees in agriculture and seven of these have been established since 1950. Only two universities offer postgraduate education in the agricultural sciences.[2]

Although Mexico has done well by Latin American standards in agricultural development, its success is clouded with grave problems. The development of the rural infrastructure has been directed toward large private commercial farms. Most of the new technologies have also gone into these areas (fertilizers, pesticides, tractors, airplanes, new seeds, etc.). The majority of Mexican farmers have benefited little from the new technologies. Government aid in the form of extension services, general education and health improvement has been insufficient. There

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[1]Venezian and Gamble, Agricultural Development of Mexico, p. 142.

[2]Ibid., pp. 145-49.

are two rural Mexicos: one is utilizing modern technology on large farms; the other is engaged in antiquated modes of production. It is very likely that greater returns in productivity could be made by developing the second Mexico.

Role of Technological Transfer in Industry

Mexico's economic and social base have changed greatly since 1940. The shift has been from rural to urban, from traditional to modern, from an export base economy to a more diversified economy. This section examines technological transfer within this context. It is necessary to deal in some detail with the features of various Mexican economic sectors in order to comprehend the process of technological transfer and diffusion in these sectors. First, two of the traditional sectors, textiles and mining, are briefly described. Then some of the more modern basic sectors (border plants, automobiles, steel, electric utilities and petroleum) are delineated. Finally, the problem of technological dependence is discussed. The focus is upon United States domination of sophisticated technologies and the general shift from economic dependence to technological dependence.

World War II spurred Mexican textile production which has traditionally been a leading industrial sector. The most important textile output, cotton, increased by nearly 64 percent between 1939 and 1945.[1] Plants operated two and three shifts a day where they had previously worked only one shift. Machinery was antiquated and maintenance was neglected in these war years. Inefficient production was in part due to the negligence of management in previous years to acquire modern machinery, preferring instead to hide inefficiency behind high tariff barriers. Union restrictions were another cause of restricting the importation of modern technology. The trade unions resisted labor-saving machinery -- requiring four operators per loom compared to the ratio of thirty to one in the United States at that time.[2]

The demand for cotton textiles in World War II broke down some of the previous barriers to the acquisition of modern technology. Some new machines were acquired, but there were not many available due to war shortages in the producing countries.[3] New machines were imported following the war and some new plants were built. But by and large the textile industry remained in a technologically retarded state. Mexico could not compete against the industrial powers in the textile export market, especially

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[1]Mosk, Industrial Revolution in Mexico, p. 124.

[2]Ibid., p. 216.

[3]International Bank for Reconstruction and Development, The Economic Development of Mexico, p. 67.

with inferior equipment. Thus little new equipment was ordered, ensuring a low competitive status in future international textile markets.

Mexico's boom year in textiles was 1951, but even in this year the textile industry operated at less than half its capacity. This was largely due to the poor state of the cotton industry which suffered from inefficiency, poor purchasing power of rural Mexicans, and the substitution of synthetics for cotton in urban areas.[1]

In spite of the weaknesses in the Mexican cotton industry, cotton remained the most important export from 1950 through 1965.[2] Cotton yields have increased due to the use of new varieties and better agricultural technology. Textile mills still utilize foreign equipment which is usually at least a decade behind the technology used in the developed countries. This is not necessarily a criticism of Mexican practice, since the introduction of the latest textile technology would result in mass unemployment. Mexico seems to be imitating Japan's practice of labor-intensive technology in textiles until other sectors of the economy

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[1]Morris Singer, Growth, Equality, and the Mexican Experience (Austin: The University of Texas Press, 1969), p. 168.

[2]Joseph Grunwald and Philip Musgrove, Natural Resources in Latin American Development (Baltimore: The John Hopkins Press, 1970), p. 432.

can absorb the labor that would be displaced by capital-intensive technology.

The Mexican experience in the production of woolen cloth is perhaps illustrative of how not to improve a market. Mexican wool has been of traditionally poor quality. Sheep breeding has not been directed toward better wool. The main economic policy in the wool sector has been to seek protection against foreign competitors (Australian wool). Mexico did not set up extension services to improve the quality of raw wool nor were workers trained to handle modern equipment in the manufacture of wool.

The Mexican rayon industry began in the 1930s when the number of rayon plants grew rapidly. However, many of these plants were crude backyard operations producing poor quality fabric for the lower income groups. After World War II, more modern equipment was brought in from the United States. The reliance upon Japan and Italy for rayon yarn greatly reduced production during the war years. During the war, the Celanese Corporation of America began to join with Mexican firms in the construction of rayon yarn-producing plants. The extent of the Celanese Corporation involvement in rayon production in the 1940s became a concern to many Mexicans who feared the company was controlling the rayon industry in Mexico.

Mining has traditionally been one of Mexico's key economic sectors. However, mining has consistently been shrinking as a share of total investment. And since mining investment is almost entirely foreign owned and of an enclave nature, there has been very little transfer of technology in this area, especially in terms of spreading throughout the population. However, more of Mexico's extracts are being used domestically as illustrated in Table 10 thus changing the old traditional export economy.

Some technological transfer related to mining has transpired through the United States Department of the Interior. Between 1946 and 1962, over forty Mexican scientists were engaged in geological research under the supervision of the Department of the Interior. Other Mexicans have received training at the Department's Bureau of Mines and the Bureau of Land Management.[1]

United States firms operate just inside the Mexican frontier under an arrangement to compensate for the elimination of the bracero program.[2] These plants employ cheap Mexican labor to make solid-state electronics, textiles and handicraft goods which are competitive with Hongkong and

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[1]Bureau of Educational and Cultural Affairs, Resources Survey, p. 398.

[2]The termination of the bracero program eliminated an important channel of technological transfer. The Mexican farmer had a chance to observe first hand the use of different technology. Perhaps the program should have been expanded rather than phased out. See Gordon, "Capitalism and Technological Adaptation," p. 82.

TABLE 10

PRODUCTION, EXPORTS, AND CONSUMPTION
OF MINING COMMODITIES
(THOUSANDS OF METRIC TONS)

Commodity	Period	Production	Exports	Consumption
Copper	1935-39	40	35	--
	1950-51	62	56	8.3
	1962-64	52	31	28
	1965-66	56	19	42
Iron ore	1935-39	123	106	268
	1950-51	535	177	908
	1962-64	2,111	57	2,103
	1965-66	2,456	5	2,693
Lead	1935-39	234	218	--
	1950-51	232	201	8.9
	1962-64	184	116	55
	1965-66	170	100	67
Zink	1935-39	149	147	--
	1950-51	202	182	11
	1962-64	246	207	28
	1965-66	233	142	79
Tin	1935-39	--	--	--
	1950-51	--	--	0.5
	1962-64	0.9	--	1.3
	1965-66	1.0	--	1.2
Coal	1935-39	899	--	1,256
	1952-53	1,375	--	1,433
	1961-63	1,929	--	1,910
	1965	2,006	--	2,142

Source: Joseph Grunwald and Philip Musgrove, Natural Resources in Latin American Development (Baltimore: The John Hopkins Press, 1970), Table B-1-14, p. 86.

Taiwan. The work is largely labor-intensive with some sixty companies employing more than 4,000 Mexicans in 1967.[1] United States firms entered into these agreements anticipating low cost labor in labor-intensive work. Significant flows of technology transpires in the process as Mexican labor is exposed to more modern capital and more sophisticated techniques.[2] Thus the border project may play an important role in the introduction of intermediate technology to be used in building manpower resources.

In addition to the influx of foreign automobile assembly plants established in the 1930's, the Mexican government began producing automobiles and trucks using Fiat patents. This venture failed and was replaced by a government-Renault partnership to assemble economy automobiles. Automobile assembly firms had to use 60 percent locally made parts by 1965. Eight foreign automobile assemblies were operating in Mexico in the early 1960s. These were Ford, General Motors, Renault, Chrysler-Fiat, Kaiser, Toyota, Volkswagen, and the German Borgward factory which was shipped to Mexico by a Mexican organization.[3]

The steel industry has played an important role in

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[1]Reynolds, The Mexican Economy, pp. 214-15.

[2]Benjamin J. Taylor and M. E. Bond, "Mexican Border Industrialization," MSU Business Topics, XVI, No. 2 (Spring, 1968), 34.

[3]Brandenburg, The Making of Modern Mexico, p. 297.

the industrialization of Mexico. Foreign technology has been a crucial element in the successful development of the steel industry. The Altos Hornos de Mexico, S. A., was built in the early 1940s and was partially financed by the Export-Import Bank of Washington and the American Rolling Mill Company which provided the technical supervision of the construction of the plant.[1] Rolling mills and blast furnaces were imported from the United States. The blast furnace for the Altos Hornos plant was dismantled in the United States and sent to Mexico for installation. Patents were acquired, and technical supervision was employed by the Americans.

Mexico's steel industry expanded greatly with the increase in demand from the war. This expansion was restricted, however, by the amount of iron and steel Mexico could import from the United States. Mexico's iron and steel industry has expanded steadily since the war and Mexicans are beginning to make their own technological contributions in this industry. One example is a process utilizing natural gas in the blast furnace instead of coke. The process was developed by Hojalata y Lamina, S.A. in Monterrey. It combines Mexico's resources of abundant

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[1]Mosk, Industrial Revolution in Mexico, pp. 139-43. Also see p. 27. The Altos Hornos and American Rolling Mill cooperation is representative of the kind of investments now made by American firms. Patent rights and technical supervision replace direct cash investments.

electrical power, high-grade iron ore, and supplies of natural gas in a process uniquely suitable to the Mexican environment. Efficiency is increased by the savings of coke and the reduction of costly scrap iron. Interestingly, the Japanese are now utilizing similar techniques to cut down their reliance on coke and imported scrap.[1]

Mexicanization of electric utilities in 1935 decreased the direct flow of foreign investment in this sector, causing the government to bring in foreign technical assistance following the war. The group of American experts was directed by Edward Falek, who had been the head of the United States Office of War Utilities Administration.[2] The electric power industry has expanded steadily since 1945 under the direction and control of the Mexican government. In 1960 the two remaining large foreign owned firms, American and Foreign Power Company and the Mexican Light and Power Company, were nationalized.[3]

Mexico's petroleum industry began to expand again after World War II. Increased financial reserves accruing from the war permitted PEMEX to increase the size of its

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[1]Fredda Jean Bullard, Mexico's Natural Gas: The Beginning of an Industry (Austin: Bureau of Business Research, The University of Texas at Austin, 1968), p. 305. The "Hy L" process has decreased the use of scrap iron in the Mexican steel industry by 62 percent from 1957 to 1962.

[2]Wionczek, "Electric Power: The Uneasy Partnership," p. 34.

[3]Ibid., p. 92.

investment several times. The refinery capacity increased by 91 percent from 1938 to 1950. The import of American technology included not only refinery construction, but also drilling equipment, exploration techniques, pipelines and supporting railway equipment.[1] Significantly, capital goods accounted for more than 38 percent of total imports in 1950 as compared to a 20 percent share of imports in 1943. Mexico received more than 80 percent of its imports between 1940 and 1950 from the United States.[2] However, this percentage had declined to 63 percent by 1968 as shown in Table 11.

PEMEX, in spite of early difficulties, has proved to be a success, pointing to the fact that Mexicans have been able to operate a complex industry with a minimum of foreign assistance. This is especially pleasing to Mexicans, who were repeatedly informed by American oil companies that they were incapable of operating a petroleum complex.[3]

The Mexican government controls many of the basic communications, transportation and industrial sectors of the economy. In 1962, as illustrated in Table 12, the

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[1]International Bank for Reconstruction and Development, The Economic Development of Mexico, p. 47.

[2]Ibid., pp. 119-21.

[3]Grunwald and Musgrove, Natural Resources, p. 260 and Cumberland, Struggle for Modernity, p. 315.

TABLE 11

MEXICO'S FOREIGN TRADE, BY GEOGRAPHICAL AREA: SELECTED YEARS, 1940-1968
(PERCENTAGE OF EXPORTS AND IMPORTS)

	1940	1945	1950	1956	1960	1965	1968
Exports	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	89.4	83.5	86.4	72.6	72.0	62.6	68.2
Europe	5.4	0.6	5.5	15.2	13.5	15.2	12.5
Rest of North and Central America	1.9	15.8	6.3	1.2	1.1	0.9	0.8
Latin America	n.a.	n.a.	n.a.	4.2	4.1	8.6	10.5
Rest of world	3.3	0.1	1.8	6.8	9.3	12.7	8.0
Imports	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	78.8	82.4	84.4	78.2	72.1	65.7	63.0
Europe	13.8	4.9	10.4	15.6	20.9	24.7	27.0
Rest of North and Central America	3.6	11.1	3.2	3.0	2.9	2.5	1.7
Latin America	n.a.	n.a.	n.a.	1.3	1.3	2.6	2.9
Rest of world	3.8	1.6	2.0	1.9	2.8	4.5	5.4

Source: B. Griffiths, Mexican Monetary Policy and Economic Development (New York: Praeger Publishers, Inc., 1972), Table 17, p. 46.

TABLE 12

MEXICO: NONPRIVATELY OWNED SECTORS OF THE ECONOMY, 1962

	Percentage Owned By the State
Communications and transportation	
Telegraph	100
Railroads	97
Municipal railways	92
Maritime transportation (by tonnage)	70
Docks and other port facilities	90
International commercial aviation (owned domestically, according to projects pending)	65
Newsprint manufacture by paper mills in which state owns majority equity	100
Newsprint distribution	100
Motion picture distribution and exhibition	80
Motion picture production (financing)	35
Basic industries	
Electric power (installed capacity)	85
Electric power (sales to public)	96
Petroleum exploration (ownership of sells, natural gas reserves, oil lines and gas lines)	97
Petroleum refining	96
Petrochemicals (percent of total investments)	70
Iron and steel production (by mills in which the state enjoys majority control)	60
Other indicators	
Private investment as percent of total investment, 1950	61
Private investment as percent of total investment, 1961	55
Percentage of total national investment directly attributable to foreign capital, 1951	13
Percentage of total national investment directly attributable to foreign capital, 1961	23

Source: Rawle Farley, The Economics of Latin America: Development Problems in Perspective (New York: Harper and Row, 1972), Table 10.2, p. 216.

state owned 100 percent of the telegraph sector, 97 percent of the railroads, 85 percent of electric power capacity, 97 percent of petroleum exploration, and 96 percent of petroleum refining. The flow of foreign capital into Mexico (1970) is less than 10 percent of total manufacturing investment. This would not seem obtrusive except for the type of investment represented by foreigners. These investments (most of which are of United States origin) are generally in high technology sectors of the economy such as electronics, chemicals and sophisticated machinery which are the key economic sectors. The problem is not one of foreign domination by ownership, but rather a dependence on foreign technology. Like most other Latin American countries, Mexico has brought in modern technology intact with little adaptation to local needs.[1] Mexico, unlike Japan, has grown increasingly dependent on foreign technology of the most sophisticated nature. Thus Table 13 shows that foreign investment accounts for 61 percent of machinery, 60 percent of electronics, and 50 percent of the chemical sector. The major transition in foreign investment and correspondingly technological transfer has been a shift from the private businessman to the multinational corpora-

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[1]William P. Glade, "The Employment Question and Development Policies in Latin America," Journal of Economic Issues, III, No. 3 (September, 1969), 52.

TABLE 13

CONCENTRATION OF FOREIGN INVESTMENT IN SELECTED SECTORS UTILIZING SOPHISTICATED TECHNOLOGY

Sector	Ratio of Foreign Controlled Firms to Total Number of Large Firms	Percentage in Total Investment By Foreign Investment	A Few Foreign Concerns in Sector Represented
Paper	9/14	75	Kimberly Clark, Scott Paper
Vehicles	7/16	66	General Motors, Ford
Rubber	5/5	100	Goodyear, Firestone
Machinery	8/12	61	SKF, Singer, International Harvester, John Deere
Electronics	8/12	60	General Electric, RCA, Philco, Phill
Chemical	8/15	50	Union Carbide, Monsanto Chemical, Du Pont de Nemours
Chemical-Pharma-ceutical	14/19	61	Parke Davis, Ciba, Roche, Eli Lilly, Johnson and Johnson, American Cynamid

Source: Flavia Derossi, The Mexican Entrepreneur (Paris: Organization for Economic Co-operation and Development, 1971), p. 70.

tion; from European investment to United States investment; from basic industries such as cattle raising, mining, transportation, petroleum and electric power to manufacturing, commerce and light industry; and finally from traditional sectors to modern sectors.[1] Nationalization of basic industries has complemented and aided the transfer of foreign investment into modern and highly profitable technologies. It is in these areas where the greatest growth potential exists.

Between 1950 and 1959, the United States accounted for $344 million dollars of direct private investment to Mexico. More than 90 percent of foreign-controlled firms were owned by the United States or Canada. Approximately 65 percent of United States investment was directed toward industry and was responsible for 16 percent of value added by manufacturing.[2] Over 80 percent of United States investment is largely concentrated in the Federal District. Much of this investment is centered in the modern sector as shown in Table 14.

Foreign investments in Mexico have been very profitable. The rates of return on capital invested is probably

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[1]Derossi, The Mexican Entrepreneur, p. 60.

[2]W. Paul Strassmann, Technological Change and Economic Development: The Manufacturing Experience of Mexico and Puerto Rico (Ithaca, New York: Cornell University Press, 1968), p. 294.

TABLE 14

UNITED STATES INVESTMENTS IN MEXICO ACCORDING TO BRANCHES OF ACTIVITY AND LOCATION (NUMBER OF INVESTMENTS PER REGION)

Branches of Activity	F.D. and Mexico	Nuevo-León	Other States	Total
Food	29	2	8	39
Beverages	2	--	--	2
Tobacco	--	1	--	1
Textiles	8	1	6	15
Garment	8	1	2	11
Wood Cork	1	--	--	1
Wood Furniture	--	--	1	1
Paper	15	1	--	16
Printing	8	--	--	8
Leather	5	1	--	6
Rubber	11	1	--	12
Chemicals	146	12	10	168
Petro-chemicals	5	2	--	7
Minerals	8	5	4	17
Steel and Iron	15	2	2	19
Metal	72	7	6	85
Mechanicals	40	7	3	50
Electrical	63	7	12	82
Vehicles	17	4	--	21
Various Manufacturers	49	1	3	53
Total Manufacturing	502	55	57	614
Traditional Industry	61	6	17	84
Modern Industry	441	49	40	530
Building	4	--	1	5
Services	132	20	25	177
Mining	7	3	24	34
Agriculture	--	1	6	7
Total	645	79	113	837

Source: Flavia Derossi, The Mexican Entrepreneur (Paris: Organization for Economic Co-operation and Development, 1971), Table H, p. 72.

twice that of capital invested in the United States. The United States accounted for approximately 70 percent of all direct foreign investment in the late 1960s.[1] A clear picture of the magnitude of direct foreign investment and the net profit outflows is shown in Table 15. Note that the inflow since the mid-1950s has about doubled while the net outflow has increased approximately fourfold. Fewer companies compete in the modern sector than in the traditional sector and the growth of the modern industries is high. Between 1951 and 1963 chemicals have grown by 12.3 percent, vehicles 10.1 percent, machines 9.4 percent compared to 3.3 percent growth in textiles.[2] Mexico has been successful in acquiring new technology, but not in establishing a scientific research base which is a prerequisite for technological independence. As a consequence,

> technological dependency appears in fact built in with the development of domestic firms; all the positive features of Mexican industrialization: the process of industrial concentration, the increasing number of industries in the modern sectors: the considerable percentage of firms making technological improvements, lead to it. It looks as if any further increase in size and any additional adoption of new products and new methods would further increase dependency, so that it can be foreseen that the domestic industry will in the

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[1] B. Griffiths, Mexican Monetary Policy and Economic Development (New York: Praeger Publisher, 1972), p. 60.

[2] Derossi, The Mexican Entrepreneur, p. 123.

TABLE 15

DIRECT FOREIGN INVESTMENT IN MEXICO
(THOUSANDS OF DOLLARS)

	Investments (Inflow)				Net Profits (Outflow)		
	New Investment	Reinvestment	Inter-Company Accounts (net)	Total	Profits Remitted	Remittances of Interest and Other Payments	Total
1939	41,980	3,553	-269	45,264	11,900	2,887	14,787
1940	3,979	-5,816	3,284	1,447	21,394	3,855	25,249
1941	11,532	-5,587	5,318	11,263	28,143	4,625	32,768
1942	16,851	-9,959	10,013	16,905	36,457	4,576	41,033
1943	9,191	7,436	66	16,693	25,875	7,054	32,929
1944	30,926	5,690	11,755	48,371	21,997	5,288	27,285
1945	-1,349	19,961	4,650	23,262	19,692	9,279	28,971
1946	22,126	13,375	2,223	37,724	35,557	8,756	44,313
1947	18,344	19,352	24,207	61,903	40,120	15,163	55,283
1948	79,741	-85	7,035	86,691	61,439	7,221	68,660
1949	59,618	8,482	-4,487	63,613	39,443	6,353	45,796
1950	38,010	18,453	15,920	72,383	39,428	8,150	47,578
1951	49,608	49,932	21,069	120,609	38,575	13,091	51,666
1952	36,514	37,033	-5,375	58,172	46,385	24,217	70,602
1953	37,183	3,527	1,106	41,816	56,957	22,371	79,328
1954	77,786	12,826	2,547	93,159	38,127	24,352	62,479
1955	84,926	12,479	7,951	105,356	48,658	18,474	67,132
1956	83,325	29,142	13,918	126,385	54,452	36,519	90,971
1957	101,024	29,046	1,521	131,591	47,785	40,402	88,187
1958	62,833	26,045	11,389	100,267	47,169	49,378	96,547
1959	65,581	16,152	-578	81,155	59,070	53,399	112,469

TABLE 15 -- Continued

	Investments (Inflow)				Net Profits (Outflow)		
	New Investment	Reinvestment	Inter-Company Accounts (net)	Total	Profits Remitted	Remittances of Interest and Other Payments	Total
1960	62,466[a]	10,570	5,392	78,428	72,166	58,830	130,996
1961	81,826	25,178	12,258	119,262	57,338	65,551	122,889
1962	74,871	36,190	15,422	126,483	56,439	66,715	123,154
1963	76,944	36,040	4,492	117,476	68,119	81,408	149,527
1964	95,060	50,221	16,652	161,933	89,951	95,910	185,861
1965	120,087	61,252	32,537	213,876	83,297	91,599	174,896
1966	111,112	73,700	-2,013	182,799	103,414	100,320	203,734
1967	105,400[b]	105,518	16,800	194,000	24,263	132,263	156,526
1968	111,000	110,200	5,700	226,900	89,200	156,200	245,200
1969	n.a.	n.a.	n.a.	197,300	n.a.	n.a.	291,300

[a]Does not include $116.5 million corresponding to foreign disinvestment, represented by the purchase of electric companies.

[b]Includes $64.4 million corresponding to foreign disinvestment, represented by the sulphur companies.

Source: B. Griffiths, Mexican Monetary Policy and Economic Development (New York: Praeger Publishers, Inc., 1972), Table 24, p. 64.

> future be even more dependent on foreign technology, in particular on that from the U.S.A.[1]

The result of technological dependence in Mexico beyond the obvious fact that the interest of the multinational corporations may not coincide with the interests of Mexico is that the flow of resources to purchase technical assistance will continue to increase as illustrated in Table 16. Royalties paid increased nearly fivefold between 1955 and 1964 while investment of foreign capital had not even doubled in volume. The scientific and technological gap between the developed countries and Mexico is increasing, indicating a greater dependence upon foreign technology in the future. Mexico seems to fit the product cycle theory as outlined in Chapter II rather well. New products are developed in the United States, marketed there first, then imported to Mexico, and finally manufactured or assembled in Mexico.

The pattern of Mexican imports has been shifting from consumer to capital goods as demonstrated in Table 17. This shift represents Mexico's import substitution policy, but it also has important ramifications in the transfer of technology. The increase in capital goods imports reflect a growing dependency on foreign embodied technology which is of far greater importance than their monetary value.

One indication of the structural shift which has

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[1] *Ibid.*, p. 128.

TABLE 16

INDEX OF MEXICAN ACQUISITION COSTS OF FOREIGN TECHNOLOGY FOR SELECTED YEARS (1950 = 100)

Year	Investment of Foreign Capital	Royalties Paid	Payment for Other Services	Registered Licenses
1950	100	100	100	100
1955	168	254	676	248
1960	191	742	895	171
1964	274	1,189	1,577	348

Source: Flavia Derossi, The Mexican Entrepreneur (Paris: Organization for Economic Co-operation and Development, 1971), p. 130.

TABLE 17

COMPOSITION OF MEXICO'S OFFICIALLY REGISTERED IMPORTS BY GROUPS OF PRODUCTS, 1940-1960[a]

Groups of Products	1940	1945	1950	1955	1960[b]
Total registered imports	100.0	100.0	100.0	100.0	100.0
Consumer goods	23.9	21.7	15.8	15.4	12.1
Nondurable	13.8	11.4	8.3	7.0	6.6
Durable	10.1	10.3	7.5	8.4	5.5
Fuel[c]	2.6	2.7	4.1	7.9	4.1
Raw materials	42.0	38.3	39.4	37.2	44.4
Metallic	12.0	9.8	10.5	10.4	11.4
Nonmetallic	30.0	28.5	28.9	26.8	33.0
Capital goods	30.6	36.8	40.0	39.3	39.1
Construction materials	6.3	5.7	7.8	5.9	4.4
Other goods for agriculture	3.4	3.5	4.6	5.0	3.2
Other goods for manufacturing and mining	13.8	23.7	23.1	22.7	24.0
Other goods for transportation	7.1	3.9	4.5	5.7	7.5

[a]Detail does not add exactly to 100 percent, mainly because an "unclassified" category of less than 1 percent is here omitted.

[b]Preliminary figures.

[c]The imported fuel, most of which is petroleum products, may be considered part consumer goods and part production goods, the exact proportions being undetermined.

Source: Rafael Izquierdo, "Imports and Import Contols," in Public Policy and Private Enterprise in Mexico, ed. by Raymond Vernon (Cambridge, Massachusetts: Harvard University Press, 1964), Table 2, p. 246.

been occurring in Mexico is the rapidly declining share of traditional exports in the gross domestic product. A growing share of exports consists of manufactured goods. Mexico, like Japan, seems to be moving away from the export of raw materials and primary goods and toward the export of goods from the modern sector. This is partially due to the depletion of traditional resource supplies, the increased domestic demand for those resources, and especially due to the changing structure of the Mexican economy.

Foreign firms are locating in Mexico to participate in the export of manufactured goods. In the late 1960s, Volkswagen established a subsidiary in Mexico to produce for the United States market. In the same period, Rolls-Royce acquired a franchise to produce diesel engines in Mexico for export to the Latin American market.[1]

If an accurate description of the Mexican industrial sector has been given, the dominant trends are from a traditional export based economy to a more diversified, modern economy. The traditional sectors, including textiles and mining, are becoming relatively less important to the economic base. Government ownership of other basic sectors such as utilities, petroleum, railroads and communications has erased much of the foreign exploitation of the past. However, it was pointed out that the shift in

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[1]Reynolds, The Mexican Economy, p. 214.

foreign investment, particularly United States investment, has been toward the most modern industries (electronics, chemicals, machinery, etc.) which are the growth industries and the most profitable investments. Therefore, nationalization has helped to shift foreign investment into more profitable ventures. Mexico's dependence on United States technology seems to be increasing, not diminishing. The specter raised is a shift from economic dependence to technological dependence.

Summary

Mexico's Spanish heritage, the mestizo personality, land system and culture greatly affected the process of acquiring and adapting new technologies. Mexican development, from the Porfirian period to the present, has its roots in the past. The rapid economic expansion of the Porfirian period must be qualified by the long-run structural impact of foreign investment in rail transportation, oil pipelines, and mining and agricultural export enclaves. Mexico was developed for foreign exploitation and any side benefits to the domestic economy were nearly incidental to the process. This type of economic growth was not conducive to the overall development of the country. Mexican railroad track was built largely to service American mining interests and tropical agricultural exports. Its pipelines were connected to the harbor at Veracruz for export. Lacking an internal network of railways or pipelines to urban areas or domestic refineries, Mexico classified as a typical export-based economy. The transfusion of technology within such a setting was narrowly restricted to modern enclaves with very little spread effects. The vast majority of the Mexican people suffered under the export-oriented policies of the Diaz regime, while the traditional elite and the foreigners reaped rich rewards for the opening of Mexico. The land was ripe for revolution.

The period 1910-1940 was a tumultuous era encompassing revolution, depression and the impact of two world wars. After the worst of the fighting ebbed in 1914, the Mexican economy recovered slowly during the remaining years. Growth was hampered by the decline in foreign investment and retaliation by the giant oil companies against the government. However, there was an influx of foreign branch plants in the 1920s.

During this period the government dramatically changed the Mexican infrastructure. The Revolution was aimed at the Porfirian tolerance of foreign exploitation and the land enclosures. The 1917 Constitutuion provided the framework for expropriation and nationalization of key sectors of the Mexican economy. Redistribution of land began in this period and has resulted in both agricultural gains due to increased incentives and to diseconomies of scale due to the small size of many of the farms. Government inputs to agriculture in the form of roads and irrigation projects set the stage for the growth in the 1940-1965 period.

The overthrow of Diaz broke down many of the institutional barriers to the development of Mexico. The record of growth of Mexican agriculture and nonagricultural sectors has been exceptionally good in relation to most other less developed countries. However, the benefits of economic growth have not been distributed to many Mexicans. The government tore down old barriers and built up the infrastructure of rural Mexico in terms of roads and irrigation projects, but it did not develop the human resources. General education, extension services, and health facilities were all slighted. Thus the Mexican agricultural sector has become more dualistic with the large commercial private farms being favored. This presents great obstacles in the transfer of technology to any but a few large landowners.

The transfer of nonagricultural technology has perhaps been more even and successful than in the agricultural sector. Foreign ownership is small compared to the total value of assets. However, there is a trend toward technological dependence in the sophisticated technological sectors of the economy which may overshadow the financial independence.

An examination of the material presented on the Mexican experience reveals that the government has been eclectic in both its selection of technology and the role of the state vis-a-vis the private sector. The government has regulated foreign investments and established financial institutions and research institutes with the goal of incorporating foreign technology suited for Mexican development.

In the private sector firms have acquired foreign technology through capital goods imports, licensing agreements, and foreign technical advisors. This technology was adjusted to the human and material resources of Mexico. It was noted that there has been a bias toward capital-intensive techniques resulting from the generally low educational level, easy credit terms in the United States, and low import duties on foreign capital goods.

CHAPTER V

JAPAN -- DEVELOPMENT THROUGH THE MEIJI PERIOD, 1868-1912

Background

The Tokugawa feudal system ended with the Meiji Restoration in 1868 after a period of more than 260 years. Japanese feudalism had much in common with European feudalism. The Japanese had nearly eliminated trade with foreigners and were virtually isolated from the rest of the world.[1] Within this isolation, the social structure was rigid and perhaps less conducive to change than the feudal societies of Europe.[2]

But there were important differences between the Japanese and European brands of feudalism.[3] Unlike Europe, in Japan the feudal lords were not independent but were subordinate to the Tokugawa Shogunate. Secondly, the influence of the Shinto and Buddhist religions, though impor-

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[1]G. B. Sansom, "History: From Earliest Times to 1853," in Japan, ed. by Hugh Borton (Ithaca, New York: Cornell University Press, 1951), p. 268.

[2]Harold G. Moulton, Japan : An Economic and Financial Appraisal (Washington, D. C.: The Brookings Institution, 1931), p. 8.

[3]Kamekichi Takahashi, The Rise and Development of Japan's Modern Economy, trans. by John Lynch (Tokyo: The Jiji Press, Ltd., 1969), p. 48.

tant, did not represent an independent force as did Christianity in Europe. Third, during European feudalism, the merchant's role was separate from church and state, whereas the Japanese merchant submitted totally to the command of the Shogunate.

The importance of these differences between European and Japanese feudalism is that they are responsible for Japan's unique ability to transfer the loyalty from the Tokugawa Shogunate to the new prefectural government in the Meiji Restoration. This, combined with other factors stated later in this chapter, explains Japan's smooth and rapid transition from feudalism to capitalism.

Perhaps the main characteristic of Japanese feudalism was the centralized control of the Tokugawas. This system was designed to maintain the power of the Tokugawas. The status quo was maintained by avoiding foreign contact and by ensuring that local lords did not gain independent power.[1] As a result, a rigid class structure developed which allowed very little change. The favored class, the samurai, received a disproportionate share of the economic surplus. Much of the surplus was dissipated on luxurious consumption by the samurai class. In an effort to maintain and increase the consumption of the elite, the Shogunate increased the tribute required from the agricultural sector,

[1]Moulton, Japan, p. 6.

causing a decline in the incentive of the farmer.[1] The Shogunates' tribute system drained the agricultural sector, and their disinterest allowed the productive industries to stagnate. By the time of the Meiji Restoration, the strength of the Tokugawa's centralized feudal structure had been significantly eroded.[2]

Japan's feudal structure limited economic growth in a variety of ways.[3] Human resources were wasted, since roles were determined by status, tradition, and heritage rather than ability. The samurai class drained the economic surplus for luxury consumption while holding a disdain for problems of production and trade. The self-sufficiency of the feudal system restricted foreign and domestic trade. Production was directed not toward producers' goods, but for the needs of the samurai, villagers and the religious class. The use of inferior technology had nearly exhausted the mining industry. These constraints upon the economy resulted in low productivity and stagnation. Karl Marx's remark about the necessity for the elimination of European feudal institutions also applies to the Japanese feudal institutions. "They had to be burst asunder; they were burst asunder."[4]

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[1]Takahashi, Japan's Modern Economy, p. 51.

[2]*Ibid.*, p. 49.

[3]*Ibid.*, pp. 92-93.

[4]Karl Marx, "Manifesto of the Communist Party," in

The Tokugawa legacy was not, however, entirely without positive contributions. Although the samurai class lived in comparative luxury at the expense of the other classes, they did represent an important pool of human talent.[1] The samurai were warriors, but when the era of warfare ended, their education shifted from warfare to assimilating culture. Their education enabled them to comprehend the culture and technology of the West and to adapt to the Western technology.

Another aspect of Tokugawa feudalism was the lords' alternating year of residency in the City of Edo. This pattern was established to keep the lords from building a continuous power base and to weaken their power by draining off their wealth.[2] The City of Edo attained a population of over one million in the Tokugawa period and created a market demand for skills which could later be used in the post-feudal society. Shipbuilding, construction, civil engineering, sword making, cloth dyeing, industrial arts, a warehouse system, water mills for the milling of flour and hiring procedures for the factory system were some of the results of the

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Marx and Engels: Basic Writings on Politics and Philosophy, ed. by Lewis S. Feuer (Garden City, New York: Doubleday and Company, Inc., 1959), p. 12.

[1]Takahashi, Japan's Modern Economy, p. 53.

[2]G. C. Allen, A Short Economic History of Modern Japan (London: Alen and Unwin, 1963), p. 10.

tremendous purchasing power centered in Edo.[1]

Other contributions in Edo included commercial skills, an emerging market system, formation of a credit system and the development of transport and communications systems.[2]

Further, the level of agricultural productivity was high by Asian standards at the end of the Tokugawa period which enabled the Meiji regime to utilize the existing economic surplus.[3]

Local communities were controlled by the _bushi_ (warriors) before the Tokugawa period. Land use and rights to land were traditionally defined but were subject to change by the _bushi_. Upon gaining power, the Tokugawa government ordered the _bushi_ to towns to be controlled by the _diamyo_ (lord). The _shogun_ (overlord) recognized certain land areas controlled by the _diamyo_ which were the basis of his wealth.[4] The _diamyo_ received between 40 to 60 percent of the yield of the land he controlled. Representatives of the _diamyo_ collected the tribute once a year from clusters of

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[1]Takahashi, _Japan's Modern Economy_, p. 55.

[2]_Ibid._, pp. 56-57.

[3]Thomas C. Smith, _The Agrarian Origins of Modern Japan_ (Stanford, California: Stanford University Press, 1959), p. 211.

[4]Erwin H. Johnson, "Land Tax and Its Impact on Use and Ownership in Rural Japan," _Economic Development and Cultural Change_, XIX, No. 1 (October, 1970), 51.

houses or <u>buraku</u>. Then the <u>buraku</u> divided up the burden among the individuals in the community. Within each <u>buraku</u> existed a complex set of social obligations within each household and between households. These obligations to other households did not go beyond the households in the <u>buraku</u>.[1]

The class structure in the Tokugawa period consisted of a rigid heirarchy beginning at the top with the <u>bushi</u>, composed of the lords and their retainers, the samurai, who were divided into upper and lower classes, followed by the farmer, artisan, and at the bottom, the merchant.[2] An hereditary class system maintained the social order and severely restricted mobility from class to class. Only a fixed ratio of the population was allowed samurai status (five or six percent of the entire population). Farmers, who composed the vast majority of the population, were fixed in proportion since they could not move upward and did not want to become artisans or merchants since these were lower classes. The status quo was maintained by respecting the "law of the ancestors" and engaging in numerous ceremonial rites to validate the existing social structure.

Even clothing and housing were used to cement class

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[1] <u>Ibid</u>., p. 52.

[2] Takahashi, <u>Japan's Modern Economy</u>, p. 51. See also, Chie Nakane, <u>Japanese Society</u> (Berkely, California: University of California Press, 1970), p. 142.

relations. The samurai wore identifiable clothing when they traveled while the farmers could wear nothing more elaborate than dark blue, cotton cloth. The samurai class was always identifiable at a mere glance.[1]

The value system of any society affects its potential to bring about economic growth and technological change. In the Tokugawa period this potential was greatly restricted. The emphasis on heredity rather than ability was not conducive to economic and technological change (as mentioned earlier, hereditary status purposely limited change to maintain the status quo). Not until Japan was faced with an outside threat did the old status system break down. Men who obtained important positions through heredity were often not capable administrators. Over the years this system gradually weakened the Tokugawa power base. With the threat of outside intervention, the Japanese rapidly moved to a value system which selected men according to competence rather than status.

The samurai contempt for the lower classes was not conducive to economic and technological change. Neither trade nor manufacturing were taken seriously by the samurai. The samurai who were appointed as financial administrators were from the lower class and were looked down on by other members of the samurai class. As a result the brighter men

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[1]Takahashi, Japan's Modern Economy, p. 52.

did not enter into finance, and the financial position of the clans was in ruinous condition by the end of the Tokugawa period.[1] Again, it was the threat of foreign intervention that drew talented men into the financial sector and who could work there for the good of country and Emperor without losing face. Money-making became a respectable activity, just as it had eventually become respectable in Europe with the rise of Calvinism.[2]

The samurai influence was essential to the smooth and rapid transition from feudalism to capitalism. During this transition, the samurai were important in developing a government devoted to national economic growth and provided a source of entrepreneurial talent.[3] Many of the samurai, fearing the threat of domination by foreigners, supported the new prefectural government. While they had always been loyal to only one superior, their lord (diamyo), they traditionally paid allegiance to a higher power, the Emperor. Seeing the inability of the Shogunate to cope with

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[1] Ibid., p. 77.

[2] The Japanese value system did not change without stress. The samurai must have had great emotional conflict during this adjustment. The poetry and literature of the time reflect this conflict of values. It should be noted that the villagers who were engaged in agriculture did not change their values as fast as their urban counterparts and remained a bastion of conservatism for many years. See Smith, Agrarian Origins of Modern Japan, pp. 206-10.

[3] Takahashi, Japan's Modern Economy, p. 31.

the foreigners, the samurai rapidly transferred their loyalty to the new government by identifying such support with tribute to the Emperor.[1]

It should be emphasized that not all samurai supported the overthrow of the Tokugawa regime. Samurai of different rank and from different regions took very different positions toward the restoration movement. It was primarily the middle and lower samurai who supported change in the hopes that they might increase their status. Their position was not high enough to warrant support of the feudal system nor low enough to completely destroy the system. The result was not a samurai movement but rather a samurai influence contributing to a smooth transition from one form of government to a new arrangement offering greater prospects for advancement.[2]

The new government was largely composed of the samurai class and was molded by the samurai influence. With the elimination of feudalism, the samurai lost their privileged status. Under the new system, they were rewarded according to their ability and performance instead of their relative position in the old social heirarchy.

The samurai directed their efforts toward achiev-

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[1]Allen, Economic History of Modern Japan, p. 25.

[2]W. G. Beasley, The Meiji Restoration (Stanford: Stanford University Press, 1972), p. 421.

ing status in the new system by demonstrating their devotion to the nation with intelligent, hard work. They carried their traditional intellectual talents and their belief in their worth to the nation into the government bureaucracy.[1] The samurai spirit was well suited to the needs of a government striving for economic change. This spirit was characterized by a willingness to submit to the needs of the nation even at personal or family sacrifice.[2] Their dedication to the government over their personal desires resulted in an efficient and nearly corruption-free bureaucracy directed toward the assimilation of Western civilization for the purpose of establishing an independent Japanese state. As government officials, they worked with diligent pride, sensing their responsibility as a trust of the Emperor.[3] The samurai traditionally looked down upon

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[1]Henry Dyer, Dai Nippon (London: Blackie and Son, Ltd., 1904), pp. 38, 39. See also, E. H. Norman, Japan's Emergence as a Modern State (New York: Institute of Pacific Relations, 1940), p. 83.

[2]Takahashi, Japan's Modern Economy, p. 26.

[3]The samurai's dedication to a higher affiliation is not unique to that class. The Japanese have traditionally placed a low value on blood kinship relations, favoring the family unit regardless of blood relationship (fictive kinship). Thus servants and clerks are treated as a part of the family, while sisters who have married and left the family unit do not have very close family ties. The samurai dedication to state or corporation is thus not very different from the rest of the population's attitude toward group allegiance. Even today the Japanese attitude toward the family is seen in the modern corporations. It is more important to identify one-

money-making for personal gain (they had received stipends according to social rank) and therefore were content to work for the state while sacrificing personal gain.[1]

Since the samurai viewed themselves as the chosen people they readily faced the task of assimilating Western civilization.[2] With the fall of the old order, they developed an insatiable desire for Western knowledge which was combined with their new desire to rise in society. Even the lowest samurai classes channeled their resources into the education of their children so they might improve their position. When the parents could not afford this, the samurai youth worked to put themselves through school. This drive of the samurai for education spread out to the rest of Japanese society resulting in a nearly universal quest for knowledge. The extremely high literacy rate in Japan today stems from this early samurai influence.

Although the samurai's greatest contribution was in the government, they also provided valuable business leadership. Since the samurai traditionally looked down on money-

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self with the corporation than with the particular job in the corporation. Similarly, in academia it is more important to relate your university affiliation than the specific degree obtained. See Nakane, Japanese Society, pp. 7, 8.

[1]Dyer, Dai Nippon, p. 43.

[2]Takahashi, Japan's Modern Economy, p. 29.

making, only a few entered into the business sector.[1] But those few were influential and contributed a different type of entrepreneurship than came from the merchant class. The samurai businessman was a "gentleman businessman" more interested in national development than private gain. Japan had need of this kind of altruistic entrepreneur, since in the early Meiji period almost all business ventures bore a high risk of failure.[2] It was essential to have a class of entrepreneurs more interested in promoting modern economic development than their own personal gain.[3] The samurai who entered into the business world were able to preserve their identity by utilizing a philosophy of "service to the nation through industry."[4] In this manner they did not feel they were deserting the samurai tradition but exemplifying it in the only avenue they had left. Even today the leading Japanese businessmen speak of the duty of the businessman to the community.[5]

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[1]S. Uyehara, The Industry and Trade of Japan (London: P. S. King and Son, Ltd., 1936), p. 8. It should be noted that the samurai were not experienced businessmen, and often their new business adventures failed.

[2]Takahashi, Japan's Modern Economy, p. 28.

[3]Since the Japanese merchant class had been treated with contempt for years it would have been rather naive to expect them to embark on economic adventures in the name of a higher cause.

[4]Takahashi, Japan's Modern Economy, p. 34.

[5]James G. Abegglen, The Japanese Factory: Aspects

The old merchant class in Japan was conservative and not open to new forms of economic organization. The samurai entrepreneur, being new to the world of business, was not inhibited by traditional practices and was able to create and work within new institutions. Therefore, they did not inhibit technological change when it came but actually actively promoted it. And concurrently, the samurai entrepreneur was influential in creating a new organization in the economy -- the corporate system.[1]

The samurai's devotion to higher goals than personal gain was crucial in the rapid effective acceptance of the company system in Japan. Japanese merchants lacked this quality and were not suited to developing the company system. Further,

> the situation was the same in Europe where it took over a century to develop the company system, and it was so in neighboring China where, though there were outstanding national characteristics among the private businessmen the development of the company system was very slow.[2]

The immediate adoption of the company system in the first Meiji period was important in developing an institutional framework capable of procuring large amounts of capital,

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of Its Social Organization (Glencoe, Illinois: The Free Press, 1958), pp. 11-25.

[1]Takahashi, Japan's Modern Economy, p. 39.

[2]Ibid.

competing with the large trading companies of the West, and absorbing the high risks involved at the time.

The new Japanese government was from its inception heavily committed to economic development. Table 18 demonstrates that government expenditures in the Meiji period compare favorably to relative government expenditures in the West. A heavy concentration of government expenditures did go to the military sector but still had an important impact on the developing Japanese economy.[1] The government and the private sector shared nearly evenly the amount of investment in the Meiji period. In the agricultural sector, however, most investment came from the private sector.[2] The fact that the Ministry of the Interior was created almost as soon as the Meiji government was established demonstrates that the Japanese government did not ignore agriculture. The new technological developments in both agriculture and industry were supported by the government.

The government played a more active role in developing Japan's industry simply because the merchant class had no modern industrial experience. The government built some

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[1]Military expenditures ranged from 10 percent to 21 percent of gross domestic capital formation between 1887 and 1913. See Henry Rosovsky, Capital Formation in Japan, 1868-1940 (London: Free Press of Glencoe, 1961), p. 15.

[2]*Ibid.*, p. 13.

TABLE 18

GOVERNMENT CURRENT EXPENDITURE ON GOODS AND SERVICES AS A PROPORTION OF GROSS NATIONAL PRODUCT AT CURRENT MARKET PRICES, 1870-1913

COUNTRY	1870	1913
Canada	4.6	8.1
Germany	5.9[a]	8.7
Italy	8.1	9.7
Japan	6.8[b]	9.1
Norway	3.8[b]	6.3
Sweden	4.7	5.6
United Kingdom	4.9	7.0
United States	3.7[c]	4.2

[a] 1870-1890

[b] 1879

[c] 1869-1878 average

Source: Adapted from Angus Maddison, Economic Growth in Japan and the U.S.S.R. (New York: W. W. Norton and Company, Inc., 1969), Table 5, p. 13.

railroads and subsidized others. There were government banks, insurance companies, and ". . . a cotton spinning mill, a silk reeling mill, an agricultural machinery plant, a cement works, a glass factory, a brick factory, nine modern mines, and shipyards, as well as military installations."[1] Most of the factories were not financially successful and were sold to private interests beginning in the 1880s.[2] The government may not have been successful at creating financially successful factories, but it did build much of the necessary overhead capital which was later used by private enterprise. The iron and steel industry, the paper industry, the sugar industry, and the beer industry are examples of this.[3] The government was more directly successful in mining and in subsidizing the merchant marine. By 1913 Japan's merchant marine had become the sixth largest in the world.[4] This accomplishment is important when compared to China and India which relied almost entirely on foreign shipping lines.[5]

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[1]Angus Maddison, Economic Growth in Japan and the U.S.S.R. (New York: W. W. Norton and Company, Inc., 1969), pp. 22-23.

[2]W. W. Lockwood, The Economic Development of Japan: Growth and Structural Change 1868-1938 (New York: Oxford University Press, 1966), p. 15.

[3]Maddison, Economic Growth, p. 24.

[4]Ibid., p. 23.

[5]Ibid.

The Meiji government inherited an educated population that included the samurai, wealthy farmers, and merchants. Although the traditional education stressed classical Chinese, it was somewhat secular. With the fall of feudalism, Japan adjusted its educational system to promote the building of a modern society:

> The alphabet was simplified to foster literacy; the Ministry of Education was established in 1871 and the school system law was passed in 1872. The education system was standardized throughout Japan, and in 1886 four years of schooling were made compulsory, and in 1907 this was extended to six years. In 1868, school enrollments (mainly in Buddhist temple schools) were about 10 per cent of children aged 5 to 19. By the end of the Meiji period almost two-thirds of the children in this age group were getting elementary schooling, and a fifth went to secondary schools.[1]

The Japanese success in increasing literacy was essential to the rapid diffusion of new technology.

The Japanese built vocational schools, modern universities, research institutions, agricultural colleges, and sophisticated technical skills in medicine, navigation, fisheries, military science and commerce.[2] The increased emphasis on education is illustrated by the increase in construction expenditures for new schools in Table 19 and the rising enrollment ratio in Table 20.

Japanese education was supplemented by sending

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[1]*Ibid.*, p. 16.

[2]*Ibid.*

TABLE 19

LOCAL GOVERNMENT CONSTRUCTION ON NEW SCHOOLS, 1877-1913 (THOUSANDS OF YEN)

Year	New School Construction	Year	New School Construction
1877	758	1896	2,811
1878	818	1897	3,262
1879	747	1898	4,348
1880	799	1899	6,386
1881	896	1900	9,809
1882	987	1901	12,362
1883	1,406	1902	10,888
1884	1,067	1903	9,545
1885	896	1904	2,847
1886	583	1905	3,028
1887	627	1906	6,965
1888	927	1907	13,296
1889	787	1908	21,090
1890	737	1909	22,045
1891	737	1910	18,207
1892	1,221	1911	16,708
1893	1,627	1912	14,374
1894	1,602	1913	10,909
1895	1,485		

Source: Adapted from Henry Rosovsky, Capital Formation in Japan, 1868-1940 (London: Free Press of Glencoe, 1961), Table VII-2, pp. 170,173.

TABLE 20

ENROLLMENT RATIOS IN JAPANESE EDUCATION, 1880-1915

Year	Primary and Two Secondary Levels, Enrollment as Percent of Population Aged 5-19	Upper Secondary Enrollment as Percent of Population Aged 15-19	Higher Education Enrollment as Percent of Population Aged 20-24
1880	31	1	0.3
1915	63	21	1.3

Source: Adapted from Angus Maddison, Economic Growth in Japan and the U.S.S.R. (New York: W. W. Norton and Company, Inc., 1969), Table 6, p. 17.

students to the West and bringing foreign experts with skills in military science, law, medicine, agriculture and industry.

Foreign experts were utilized at all educational levels and were influential in establishing new research institutions. Foreign literature was translated, aiding the technological inflow. Almost 4,000 foreigners were employed by the government during the period 1876-1895. On the average, the foreign experts were paid ten times more than their Japanese counterparts.[1]

1868-1913 -- Building an Economic Base

The Meiji era witnessed two wrenching developments which changed the fundamental orientation of the Japanese political economy. These were the opening of Japan to world commerce (Commodore Perry 1853-1854) and the crumbling of feudalism.[2] It was largely the foreign threat that caused the rapid demise of feudalism. The Japanese were able to make the rapid transition rapidly and smoothly due to the informed public's fear of foreign domination and the weakness of the Shogunate at the end of the Tokugawa period.

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[1]Ibid., pp. 16-17. Some 600 students were sent abroad from 1868 to 1895. In the same period nearly 4,000 government officials traveled to foreign countries.

[2]Takahashi, Japan's Modern Economy, p. 91. It should be noted that perhaps Japan made the transition from feudalism to capitalism with less turmoil than other countries going through this phase.

Traditionally the Japanese glorified the Emperor above the Shogunate, and the Emperor gave his blessings to the anti-Shogunate forces which allowed a peaceful transition in the effective government of Japan. The new Imperial government was thus politically endowed with vast prestige enabling it to enact the needed reforms to combat foreign domination. With the fall of feudalism, Japan's government began to take an active role in transforming Japanese institutions into a form amenable to assimilating a modern economy. This was a formidable task since Japan had perhaps been more severely restricted by rigid feudal institutions than any other pre-capitalist country.[1] As one eminent Japanese scholar states:

> Every effort was made for over two hundred years to suppress growth and change . . . society was frozen into a legally immutable class mold . . . . Maintenance of the warrior class continued to take the surplus of society, leaving little for investment . . . . The closed class system smothered creative energies and tended to freeze labor and talent in traditional occupations.[2]

The feudal institutions were an obstacle to larger markets, specialized and mobile labor, and the accumulation of capital.[3] It was the elimination of feudal barriers which

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[1]Paul A. Baran, Political Economy of Growth, Prometheus Paperbacks (New York: Marzani and Munsell, 1957), p. 151.

[2]Thomas C. Smith, Political Change and Industrial Development in Japan: Government and Enterprise, 1868-1880, as quoted by Baran, Political Economy of Growth, p. 152.

[3]Maddison, Economic Growth, p. xv.

allowed the introduction of Western technology into a more receptive institutional framework.

Several factors may explain why Japan was able to embark on a path of sustained economic growth while its Asian neighbors remained in the backwash of Japan's forward surge. In the first two Meiji decades (1868-1885), Japanese government stressed the assimilation of Western technology and opened economic advancement to all classes based on ability instead of status. Compulsory education was introduced in 1872 as a part of this policy. These changes were peacefully accomplished within a consciously planned dismantling of feudalism in a short period of time. Other Asian countries did not accomplish these things and were thus susceptible to the dehabilitating effects of colonialism.[1] Japan was able to avoid foreign domination partly due to the fact that poverty and a lack of natural resources did not attract foreign interests. A perhaps typical Western opinion appeared in the Japan Herald in 1881 which included the following statement:

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[1]Takahashi, Japan's Modern Economy, p. v. Paul Baran suggests several reasons for the imperial powers' lack of an attempt to colonize Japan as they had done in India and China. First, Japan had little to offer as a market or as a source of raw materials. Second, the European powers were over extended in their imperialist efforts. Third, they did not want to spark a war over a rivalry in Japan. See Baran, Political Economy of Growth, pp. 159-60.

> Whilst by no means of opinion that the natural resources of Japan, whether mineral or agricultural, are particularly or noticeably great, or that its population is especially hardworking or prudent, nevertheless it has the promise of a moderate future before it. Without expecting too much from its Government -- for a government is seldom found to differ widely from the people whose affairs it administers -- a condition of moderate affluence and tolerable content is before it. Wealthy we do not at all think it will ever become: The advantages conferred by nature, with the exception of climate, and the love of indolence and pleasure of the people themselves, forbid it. The Japanese are a happy race, and being content with little, are not likely to achieve much.[1]

As a result of the Western evaluation of Japan's limited economic potential and the changing attitude of the Japanese government toward foreign investment there was comparatively little foreign investment in manufacturing until after World War I. In the late 1890s, when Japan's rapid industrialization became apparent, another barrier to foreign investment appeared. The *zaibatsu* had gained powerful control over the basic economic sectors in Japan and were able to match the West in terms of entrepreneurial and managerial talent. Unlike China, the foreigners could not operate in an institutional arrangement of their own making and were thus at a disadvantage vis-à-vis the *zaibatsu*.[2]

Economic growth was necessarily slow in the first

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[1]Allen and Donnithorne, *Western Enterprise*, p. 225.

[2]*Ibid.*

years of the Meiji Restoration due to the efforts to transform a feudal society into a modern economic system. Until 1885, effort was directed toward eliminating feudal barriers and building the substructure for future development. From 1886 to the end of the Meiji period (1913), the Japanese built on this foundation with striking success.

Development of the economy was spurred by renegotiation of treaties which had been detrimental to economic growth. Japanese sovereignty over its trade was generally reinstated. Concurrently foreign capital was permitted to flow into Japan. Japan's involvement in the Sino-Japanese and Russo-Japanese wars gave a further impetus to development. Military success in China brought around $200 million in reimbursements to Japan, almost equal to one-third of Japan's gross national product.[1] The fruits of war were largely used to promote economic and technological development. They,

> made possible the expansion of the army and navy, the extension of the railroad, telegraph and telephone services, the establishment of the Yawata Iron Mill, as well as the adoption of the gold standard.[2]

Military success impressed the Western powers, and Japan was able to take advantage of the huge and unprotected

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[1]Maddison, Economic Growth, p. 15.

[2]M. Shinohara, Growth and Cycles in the Japanese Economy (Tokyo: Kinokuniya, 1962), as quoted by Maddison, Economic Growth, p. 15.

markets of China and India. These markets, along with her colonies served as a mass market for her manufactured goods.[1]

Data for the economic growth in the first decade of the Meiji period is sketchy and there are no reliable estimates for this period. The growth rate from 1879 to 1913 has been estimated to be 3.3 percent a year although this may be high.[2] Agricultural growth was considerably less, perhaps less than 2 percent a year. Most estimates for industrial growth center around 5.5 percent a year for this period.

Japan's growth rate in the Meiji period is probably comparable to Western countries in their same phase of development. The distinctive factor in Japan's development in the Meiji period was its high investment level which enabled future growth. For example,

> the joint share of government and investment in Meiji G.N.P. was considerably higher than in Europe. The share of gross domestic fixed capital formation in G.N.P. was 9.1 per cent from 1887 to 1913, and government current expenditures absorbed up to 10 per cent of G.N.P. in this period.[3]

It will be demonstrated that a great deal of Japan's invest-

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[1]Maddison, Economic Growth, p. 27.

[2]Ibid., p. 30. Estimates range from 2.7 percent (Maddison) to 4.3 percent. (See Kazushi Ohkawa and Henry Rosovsky, "A Century of Japanese Economic Growth," in The State and Economic Enterprise in Japan, ed. by W. W. Lockwood (Princeton, New Jersey: Princeton University Press, 1965), pp. 89-92.

[3]Maddison, Economic Growth, p. 33.

ment went to developing and incorporating new technologies.

Japan's rapid acceptance of Western technology is attributable to several factors: the fear of foreign domination; the intellectual drive of the samurai class; the fact that Japan had already absorbed Chinese culture which eased the stress of accepting Western culture; a common denominator in race, law and language; a trait of obedience of the population; and a government willing to give high priority to technological improvement.[1] In short, the Japanese cultural milieu was conducive to technological change. Institutional resistance had crumbled and viable social arrangements were adapted from the previous cultural heritage to promote economic and technological change.

Role of Technological Transfer in Agriculture

The Meiji Restoration brought forth the Land Reform of 1873 replacing with prefectures the land system which had been controlled by the *diamyo*. The small *buraku* were combined into villages or *mura*. The tax in kind was eliminated along with the feudalistic structure and replaced by a system more consistent with a monetized economy.[2] A

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[1] *Ibid.*, pp. 11-12. The Japanese had also been exposed to the Dutch influence and were not completely unaware of Western culture. They referred to their Western knowledge as "Dutch Learning." See Allen, *Economic History of Modern Japan*, p. 18.

[2] *Ibid.*, p. 57.

3 percent tax was placed on all land according to land value to ensure the government continuous revenues regardless of variance in agricultural yields.[1] Land was surveyed and its value was estimated for tax purposes. Responsibility for record keeping, such as ownership, was given by the central government to the newly established village office in each mura. The village office reported to the county level which was closely related to the prefectural government which in turn was in contact with the central government.[2]

The new land system was more compatible with Japan's surge toward modernization, but it carried with it a social cost. The new taxes were collected from the tenants in kind. Smaller landowners could not pay their taxes and many were forced off their land. Perhaps 7 percent of all farm households lost their land between 1883 and 1890. As the concentration of land grew, the large landowners passed the burden of their taxes on to their tenants.[3] The grow-

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[1]This is a steeper tax than it first appears. The actual tax on the gross value of the crop amounted initially to about 34 percent. See Shigeto Tsuru, "The Take-Off in Japan (1868-1900)" in Economics of Take-Off Into Sustained Growth, ed. by W. W. Rostow (New York: St. Martin's Press, Inc., 1963), p. 146.

[2]Johnson, "Land Tax and Its Impact," p. 59.

[3]Hugh Borton, Japan's Modern Century: From Perry to 1970 (2nd ed.; New York: The Ronald Press Company, 1970), p. 175.

ing population pressure ensured high rents, and the large landowners had little desire to farm the land themselves or with hired labor. As a consequence small plots were leased to unsupervised tenants, thus inhibiting the growth of large farms.[1]

The bulk of Japanese governmental expenditures were directed toward sectors other than agriculture. But it was not until 1910 that factory manufacturing output exceeded cottage industry production. In 1910, Japan still had essentially a pre-industrial economy with agriculture responsible for more than 40 percent of net national product.[2]

The first decade of the Meiji period witnessed the assimilation of ideas from the newly opened West. Japanese representatives came back from the Vienna Exposition of 1873 with new kinds of plants, seeds and tools.[3] In 1872 the Shinjuku experimental station was established, partly in anticipation of testing the fruits of the Vienna Exposition. By 1876, some 313 varieties of foreign wheat and 398 foreign trees and grasses were being grown by the Shinjuku station.

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[1]K. Bieda, The Structure and the Operation of the Japanese Economy (Sydney: John Wiley and Sons Australasia Pty. Ltd., 1970), p. 243.

[2]Rosovsky, Capital Formation in Japan, p. 8.

[3]R. P. Dore, "Agricultural Improvement in Japan: 1870-1900," in The Sociology of Economic Development: A Reader, ed. by Gayl D. Ness (New York: Harper and Row, Publishers, 1970), p. 556.

Foreign tools were also purchased and studied at the experimental station. Several methods were used to diffuse the accumulation of agricultural knowledge. The exhibition method was one method of diffusing knowledge and the experimental stations were intended to be permanent exhibitions. Five exhibitions, the Promotion of Industries Exhibitions, between 1877 and 1903 were an important avenue of disseminating agricultural information. The Museum of Agriculture was established in Tokyo in 1874, and after 1880 national prizes were given for certain products. By 1885 the Japanese had begun to turn out trained personnel from their new agricultural schools and evening schools of continuing education.[1]

Japan's limited attempt to expand agriculture in the Meiji period was initially misguided. Mechanization and extensive cultivation techniques were borrowed from the Americans and British with little success. Most of the Japanese farmland, excepting a few acres of Hokkaido, were suited for small scale agriculture. Both the Americans who were hired to bring modern techniques to Hokkaido and the English who were to develop techniques for the rest of Japan tried to transplant Western agricultural technology in unaltered form in Japan. The Western experts concentrated on three forms of technology transplant: (1) dry-

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[1] _Ibid._, p. 557.

field farming techniques, extensive in nature, using horse-drawn equipment; (2) animal husbandry which included the introduction of pigs, sheep, cows and horses; (3) new seed varieties of corn, wheat, etc.[1]

The first of these efforts was the most misguided. Western techniques were extensive in nature and simply not applicable to wet paddy fields which are suitable to intensive techniques which the Japanese had developed in the Tokugawa period. The second attempt to transfer animal husbandry ran contrary to existing agricultural patterns in Japan and was not likely to catch hold without considerable government effort and even then with questionable returns. The third form of technology transfer, new seeds, was much more successful than the first two and was easily adaptable to local climactic conditions and existing agricultural techniques. The Japanese government recognized its error in utilizing extensive farming technology, sold its infant farm machinery factory in 1888, and resorted to improving traditional Tokugawa techniques.

Japanese interest in water control brought Dutch engineers in 1872 with knowledge of drainage and reclamation of land. Like their Western counterparts, the Americans and English, the Dutch also made the mistake of trying to literally transplant their technology unchanged

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[1]Takahashi, Japan's Modern Economy, pp. 126, 127.

into the different setting of Japan. The Dutch built flood control installations on major rivers throughout Japan. Unfortunately, the Dutch technology was designed only to control water coming up from the sea. In Japan it is also necessary to control the flood waters flowing down from the mountains. The deficiencies of the transplanted technology became evident with the breaking of the Yodo River levees in 1885, the Joganji River flood in 1891, and the flood of the Chikugo River in 1899. By 1896, the government was forced to completely revamp its water control programs.[1]

After their initial failure in transferring Western agricultural technology, the Japanese made better use of German scientists brought in in 1881 to the Komaba School of Agriculture with surveys which permitted rational adaptation of Western technology to the special nature of Japanese agriculture.[2] Komaba College was established by the government and eventually became the Faculty of Agriculture of Tokyo University. A private agricultural college was established in Saporo. In 1883 the Komaba college had a faculty of thirteen, and of these, four were foreigners.[3]

The government began to formalize and widen the

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[1]Takahashi, Japan's Modern Economy, p. 127.

[2]Ibid.

[3]Dore, "Agricultural Improvement in Japan," p. 557.

channels of communication at an early stage. The publication of an agricultural bulletin was started in 1874. Representatives were appointed in each prefecture in 1877 to correspond with the government Reclamation Bureau, called the Department, which would print information of value in the bulletin. Almost 2,000 farmers were receiving the bulletin by 1885.[1]

Experimental stations and research institutions were established in each prefecture in 1893.[2] These institutions disseminated information to the farmers and were largely successful due to the high literacy of the population. New techniques were accepted rapidly as a result of the Japanese respect for paternalistic leadership, a Confucian desire for learning, and demographic advantages of densely concentrated hamlets.[3] In 1873 reform of the feudal land taxes eased the burden on the peasant which gave him considerably more incentive to increase his production than in the past. The opening of Japan to international markets allowed the expansion of the production of rice, tea and silk which provided new sources of foreign exchange.

The prefectural governments aided the dissemination of information and played a vital role in the pragmatic

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[1] _Ibid._, p. 558.

[2] Maddison, _Economic Growth_, p. 20.

[3] _Ibid._, p. 21.

implementation of that information. Besides initiating local organizations, they provided the necessary face-to-face contact with the farmers.

> There was a difference between the central government mailing a circular recommending the selection of seed by salt water or the drying of sheaves on wooden racks, and the prefectural office issuing the same recommendations to the village officials. In the latter face-to-face relationship with its still strong kanson-mimpi "the official is noble, the people base," overtones, a recommendation was likely to be taken as an order.[1]

In some cases, the prefectural governments did order farmers to accept certain techniques or face legal punishment. There was some resistance to such authority, but the improved techniques were eventually adopted.

Both the central and prefectural governments participated in creating local agricultural associations. Various agricultural organizations had been organized on a local basis, either by the prefectural government or by private initiative. In 1880 the central government began to support and coordinate these organizations by urging each prefectural government to establish an agricultural organization. In 1881 the Japan Agricultural Association was formed, which evolved into the Imperial Agricultural Association. In 1905 compulsory membership in the Association was required of all farmers.[2]

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[1]Dore, "Agricultural Improvement in Japan," pp. 560-61.

[2]*Ibid.*, p. 558.

Agricultural output increased in the Meiji period as a result of better use of land, better seeds and an increase in the utilization of fertilizers. During the period from 1880-1915 the amount of land under cultivation increased 30 percent. Phosphate fertilizer consumption increased seven times from 1878 to 1913. Inputs of nitrogen increased five times and potash three times in the same period. Other technological contributions included the artificial incubation of silk worms permitting year-round production; dry paddy cultivation making double cropping possible; a rotary thresher operated by pedal was invented in 1910 and permitted the use of wheat and barley as second crops as well as reducing the manpower bottleneck at harvest time; and the short soled plough which improved the efficiency of ploughing small land plots.[1]

The government's policy of importing foreign cattle, sheep, pigs, horses and poultry after 1867 helped to improve the Japanese diet and also provided new sources of fertilizer and traction power. This approach was supplemented by government support of literature on livestock farming and the training of veterinarians.[2]

Agricultural development was, on the whole, successful in the Meiji period. The agricultural sector was able

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[1]Maddison, Economic Growth, pp. 21-22.

[2]Ibid., p. 22.

to expand with only limited inputs and supplied most of government revenues as well as much of the savings and foreign exchange for the Japanese economy. The growth in agricultural output allowed other sectors to absorb the increase in the labor supply.[1] Much of the success in agricultural output was the result of the pragmatic application of Western technology to Japan's unique social and geographical resources.

Role of Technological Transfer in Industry

As previously noted, the Japanese government directed the bulk of its investment into the emerging industrial sector of the economy. By the 1880s, Japan had begun to shift from direct government production to subsidizing industry. The close relationship between government and private enterprise in the Meiji period achieved the government's goal of building the foundation of an industrial economy.

The opening of the Japanese economy to world trade was an important factor in stimulating technological transfer. A strong demand for Japanese exports of silk, coal and porcelain-ware brought higher production and the application of Western technologies to these industries. Increased imports of producer and consumer goods resulted in

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[1] Ibid.

a classical example of cross-fertilization of knowledge. Although monetary units do not fully describe the importance of Japanese imports and exports in terms of technological transfer, they do offer one perspective of their influence. Imports of producers' durables increased from slightly over 1 million yen in 1868 to over 50 million yen in 1913. In the same period exports of producers' durables increased from an insignificant quantity to over 5.6 million yen as shown in Table 21.

Japan's economic base began to change with the introduction of Western technology. Great gains were made in mining, manufacturing, communications and transportation (especially shipping and railroads). The importation of kerosene and kerosene lamps permitted the use of night shifts.[1] Imported cheap iron and steel increased the diffusion of new agricultural tools and machine tools.

It was not until after the third Meiji decade that the impact of heavy investments in capital became prominently noticeable. The first thirty years of Japan's capital investment were necessary before the results of the new technology could be realized in increased productivity. The substantial investments in transportation, railroads, shipping, communications and mining did not reach a "critical mass" or a "take-off" stage until previous efforts could merge into an interrelated system.

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[1]Takahashi, Japan's Modern Economy, p. 97.

TABLE 21

JAPANESE IMPORTS AND EXPORTS OF PRODUCERS' GOODS, 1868-1913 (THOUSANDS OF YEN)

Year	Imports	Exports	Year	Imports	Exports
1868	1,157.2		1891	3,868.9	99.0
1869	480.0		1892	3,253.9	96.5
1870	187.0		1893	5,162.2	200.7
1871	129.8		1894	15,136.5	194.4
1872	274.6		1895	13,300.3	310.9
1873	463.6		1896	12,175.1	250.1
1874	606.8		1897	28,850.9	256.8
1875	1,897.8		1898	25,974.9	234.3
1876	501.8		1899	13,212.9	257.3
1877	1,961.6		1900	15,919.8	412.7
1878	769.6		1901	18,956.0	730.8
1879	777.2		1902	14,053.3	1,353.5
1880	1,291.9	0.9	1903	14,927.9	1,494.5
1881	756.7	2.6	1904	25,447.3	1,760.2
1882	722.3	6.5	1905	36,579.1	2,767.9
1883	1,056.8	34.8	1906	28,262.9	3,195.0
1884	2,731.4	10.3	1907	39,515.5	8,066.3
1885	1,660.3	34.6	1908	45,799.3	6,598.5
1886	1,166.4	37.5	1909	27,535.3	3,019.5
1887	2,183.3	72.3	1910	23,231.0	2,978.9
1888	5,634.8	89.3	1911	42,104.5	2,988.3
1889	5,289.6	34.7	1912	44,123.0	4,366.0
1890	6,188.1	54.4	1913	50,490.9	5,611.5

Source: Adapted from Henry Rosovsky, Capital Formation in Japan, 1868-1940 (London: Free Press of Glencoe, 1969), Table XI-2, pp. 337-339.

The initial introduction of Western industrial technology was hampered by a shortage of Japanese capital. A glance back at Table 4 exemplifies Japan's excess of imports over exports of producers' durable goods. The capital shortage was complicated by the great expense of the heavy industrial systems Japan was trying to transfer from the West. Expensive equipment was made even more costly by overseas transportation costs and the expense of foreign experts. As in the case of agriculture, the Japanese initially tried to transfer industrial technology from the West in unaltered form. But with the capital constraint and a large supply of low-cost labor the government recognized the advantages of encouraging labor-intensive technologies.

In the 1870s the Japanese began to stress the adaptation of Western technology to industry. Private businessmen saw the government's error of attempting to introduce Western technology in unchanged form and began to work on adapting it to the uniqueness of the Japanese case. The Besshi copper mines are a good example of Japanese modification of Western technology. In 1874 Sumitomo Besshi paid foreign technologists to make a detailed geological survey of the Besshi copper mines to see what changes should be made in plant operations.[1] Specifications were established to guide new procedures and to acquire machinery best suited to the Besshi mines. Labor

[1] *Ibid.*, pp. 138, 139.

was substituted for machinery when possible. When capital became available, modern mechanization was adopted.

The problems of shortages of capital in Japan and the lack of technological know-how were complicated by the lack of marketing outlets for large-scale production.[1] These factors caused the Japanese to focus on small and medium sized businesses. But Western machinery was designed for large-scale production and had to be adapted to the smaller Japanese business unit. This was accomplished by producing a new version of the Western machinery in Japan. The transplant of Western machinery *in toto* did not work as illustrated by the government's failure in such attempts. Perhaps the best example of the Japanese modification of Western machinery is the silk industry.

The first mechanized silk reeling plant was established by the government in 1871 and was a transplant of French technology.[2] It was intended to be a model for future mechanization but its huge size defied mass imitation for the reasons stated above. Smaller business units utilized wooden machines which were cheaper and simpler than the expensive French machinery made of steel. Labor-intensive techniques were substituted for machinery when necessary.

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[1] *Ibid.*, p. 141.

[2] *Ibid.*, p. 142.

The textile industry is another example of Japanese indigenization of Western machinery. In the first Meiji decade expensive and complicated machinery was imported from the West. In the second Meiji decade the Japanese began to produce their own textile machinery which was cheaper and easier to operate. Thus small-scale operations could afford mechanization, and the labor force could adapt more easily to the simplified machinery.

The rapid adaptation of Western machinery to Japanese needs resulted in import substitution as various Western goods were produced domestically. The import of this transition can be seen in Table 22 for such varied products as umbrellas, cement, clothing and matches. Table 23 demonstrates that the Japanese were highly successful in their newly acquired manufacturing techniques as testified to by the number of formerly Western products which the Japanese began to export. Table 24 suggests that the Japanese were also successful in producing their own durable equipment. The production of locomotives shown in Table 25 is a specific example of the Japanese experience.

Although the adaptation of large scale Western machinery to the small-scale Japanese business unit was important in developing the Japanese economy, it was the introduction of heavy industry and modern mass production which enabled the Japanese to embark on a path of rapid economic

TABLE 22

WESTERN-STYLE GOODS IMPORTED -- TENDENCY TO DOMESTIC SUPPLY (THROUGH SECOND MEIJI DECADE)

Product	Maximum Import Money Value 1,000 Yen	Year	Import Level in 1884 1,000 Yen
Stationery supplies	129	1879	7
Sailing ships	122	1879	3
Shoes	296	1872	11
Collars	14	1873	--
Scarves	53	1878	7
Gloves	47	1873	16
Shirts	41	1873	--
Socks	22	1873	14
Knitted cotton underwear	767	1873	17
Glass products	537	1873	146
Unbleached muslin	3,505	1874	856
Furniture	85	1873	10
Matches	96	1876	2
Laundry soap	48	1876	11
Cosmetic soap	56	1880	17
Umbrellas	412	1873	1
Miscellaneous goods	1,066	1873	209
Cement	52	1875	32
Lamps	139	1880	54

Source: Kamekichi Takahashi, The Rise and Development of Japan's Modern Economy, trans. by John Lynch (Tokyo: The Jiji Press, Ltd., 1969), Table 1, p. 145.

TABLE 23

TIME WHEN NEWLY INTRODUCED WESTERN PRODUCTS' INDUSTRIES' MERCHANDISE BECAME IMPORTANT EXPORT GOODS

Product	Year of Appearance in Export Lists	Year When Export Quantity Exceeded 500,000 Yen
Matches	1878	1887
Cotton rugs	1880	1894
Cotton knitted goods	1878	1893
Umbrellas	1880	1893
Cosmetic soap	1879	1905
Socks	1880	1906
Tooth powder	1873	1918
Gloves	1880	1916
Shoes	1880	--
Jinrikisha	1880	--
Unbleached muslin	1896	1899
Cement	1896	1903
Glass porducts	1902	1909

Source: Kamekichi Takahashi, The Rise and Development of Japan's Modern Economy, trans. by John Lynch (Tokyo: The Jiji Press, Ltd., 1969), Table 2, p. 147.

TABLE 24

DURABLE EQUIPMENT EXCLUDING MILITARY
(OVERLAPPING DECADE AVERAGES)
(MILLIONS OF YEN)

Decade	Total Domestic Output of Durable Equipment	Total Net Imports
1887-96	4.5	8.1
1892-1901	4.1	17.1
1897-1906	24.4	23.8
1902-11	60.6	29.3
1907-16	111.7	28.4
1912-21	340.1	26.9
1917-26	468.9	85.1
1922-31	247.5	108.2
1927-36	722.4	25.2
1931-40	1,925.3	-105.3

Source: Adapted from Henry Rosovsky, Capital Formation in Japan, 1868-1940 (London: Free Press of Glencoe, 1969), Table 17, p. 50.

TABLE 25

COUNTRY OF ORIGIN OF LOCOMOTIVES USED
BY JAPAN NATIONAL RAILWAYS

Year	Britain	U.S.	Germany	Switzerland	Japan
1872	10				
1877	36				
1882	47				
1887	95	2			
1892	240	26	28		
1897	484	282	55	3	11
1902	684	524	70	11	30
1907	966	908	160	11	95
1912	983	995	226	11	162

Source: Henry Rosovsky, Capital Formation in Japan, 1868-1940 (London: Free Press of Glencoe, 1969), Table 25, p. 94.

growth. As stated earlier, the fruits of such investments did not become evident until after the third Meiji decade. The Japanese government had directly or indirectly supported modern industry in the first three Meiji decades. Mining, shipyards, model factories, cement, glass, and type foundry plants were developed by the government and then sold to private interests. Railroads, telegraphy, the Yokosuka shipyards, the Akabane military arsenal, and the Osaka mint were kept under public control.[1] The government had drawn heavily from tax levies and gains made through the eradication of the inefficient feudal structure to finance these investments. As the amount of human resources and capital accumulation increased, productivity increased, permitting a more rapid development of the modern large-scale operations.

The typical expansion of Japan's modern industry followed the pattern of initial importation of foreign equipment combined with foreign exports and then developing its domestic capacity to produce modified Western equipment. Table 24 illustrates Japan's import of durable equipment increasing from 8.1 million yen in the period 1887-1896 to 28.4 million yen in the period 1907-1916. Total domestic

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[1] Ibid., pp. 231, 232. The government did rely on British financing for their first railroads (1869). British Engineers used British materials and equipment to construct the railway between Tokyo and Yokohama. See G. C. Allen and Audrey G. Donnithorne, Western Enterprise in Far Eastern Economic Development: China and Japan (New York: The Macmillan Company, 1954), p. 192.

output of durable equipment for the corresponding periods increased from 4.5 million yen to 111.7 million yen. Japan's large increase in domestic production complemented its importation of embodied Western technology and was crucial for continuing growth. As the above figures demonstrate, imports could not possibly have satisfied Japan's drive toward industrialization. Japan's rapid increase in durable equipment permitted expansion without foreign domination. Thus in the construction of railroads Japan imported a large amount of equipment, as shown in Table 25, but was able to maintain domestic control over this key sector of the economy.

CHAPTER VI

DEVELOPMENT SINCE THE MEIJI PERIOD, 1913-1965

1913-1938 Accelerated Growth

Japan's economic growth accelerated with the advent of World War I. This growth was made possible by the foundation constructed in the Meiji era. Total output between 1913 and 1938 increased by 4 percent per year while agricultural and manufacturing output increased 1.2 percent and 7 percent, respectively, in this same period. Growth of real gross national product in the period 1913-1938 increased by 4 percent and the real gross national product per capita increased 2.6 percent in this time span.[1]

World War I broke the European control over international trade and opened new markets to the Japanese. As the European powers directed their efforts toward war production the Japanese moved into previously unaccessible markets. The vast textile markets in India and China were exploited by Japan while the British were preoccupied with war. The export of cotton cloth in physical volume increased by 185 percent between 1913 and 1918.[2] Great

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[1]Maddison, Economic Growth, pp. 35-36.

[2]Lockwood, Economic Development of Japan, p. 38.

gains were also made in heavy industrial production, e.g., steel, machinery and ships. Between 1914 and 1919 the number of factory workers in Japan nearly doubled from 1,187,249 to 2,024,870. The Nagoya physical output index rose 29 percent in mining while railway freight doubled in volume. In this period Japan began to build its infant chemical industry and engineering capabilities.[1] Japan's tremendous growth in exports permitted the payment of debts and the financing of its growing industrial base.

In 1920 a depression hit Japan which was followed by a natural disaster, the earthquake of 1923 which destroyed huge amounts of property. A reconstruction boom occurred after the earthquake but ended in financial panic in 1927.

The great worldwide depression of the 1930s affected Japan's growth but perhaps not so much as other countries. Many of the industrialized countries began to dump their goods in foreign markets. Japan, lacking many natural resources, imported raw materials and was able to acquire them at attractive prices. Cheap raw materials gave Japan a competitive edge over the industrialized countries where prices were maintained at a higher level.[2] Japan's competetive success caused other countries to retaliate with

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[1] _Ibid_., p. 40.

[2] Takahashi, _Japan's Modern Economy_, p. 5.

trade barriers which limited Japanese growth. This touched off the Manchurian Incident (1931) giving Japan a source of raw materials and prompted a strategy of self-sufficiency in heavy industry and chemicals.[1] From 1931 to 1938 Japan heavily engaged in the production of military goods. Heavy industry was rapidly developed to support the military.

Japanese exports increased an astounding 70 percent in volume in the period 1929 to 1937. In value the amount of exports increased 5.2 percent annually between 1931 and 1937 and exports accounted for 27 percent of gross national product by 1937. The characteristics of Japanese exports were changing dramatically, reflecting Japan's industrial transition. In 1913, 29 percent of Japanese exports were finished goods. By 1938, this figure had increased to 58 percent. The export of tea had become insignificant and the export of raw silk accounted for only 14 percent of Japan's exports in 1938.[2]

Great gains were made in the industrial sector for the period 1913 to 1938, but agriculture did not fare nearly so well. Instead of a net contribution, the agricultural sector was subsidized by the emerging industrial sector. The government stabilized the price of rice and

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[1] Ibid., p. 6

[2] Maddison, Economic Growth, pp. 37, 38.

insured crops. Agriculture accounted for 61 percent of the total labor force in 1913. This figure dropped to 46 percent by 1938.[1]

Role of Technological Transfer in Agriculture

Agricultural production did not match the impressive growth rate of industry in the inter-war period. Korea and Formosa supplied food imports to Japan's lagging agricultural sector. The export of tea became relatively unimportant while silk exports failed to regain the peak achieved in 1929.[2] In fact, about the only favorable agricultural development was the enlargement of the ammonium sulphate industry which caused fertilizer prices to fall and consumption to increase.[3]

Small farm size and tenancy limited technological innovations, but the government did promote the production and use of fertilizer, increased irrigation and drainage, and stimulated the use of some light machinery.[4] Further,

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[1] Ibid., p. 84.

[2] Maddison, Economic Growth, p. 44.

[3] Shūjirō Sawada, "Innovation in Japanese Agriculture, 1880-1935," in The State and Economic Enterprise in Japan: Essays in the Political Economy of Growth, ed. by W. W. Lockwood (Princeton, New Jersey: Princeton University Press, 1965), p. 344.

[4] Production was further limited by the small amount of cultivated land area, approximately 16 percent of the total land area, due to the mountainous terrain. See Jerome

advisory services were increased by the government subsidization of co-operatives.[1]

The technological developments of Meiji agriculture continued into the 1930s but at a much slower pace. Traditional social structure, such as the small family farm, limited the amount of technological and economic growth.[2] Fortunately, the growth of the traditional sector in Japan continued long enough to permit the modern industrial sector to establish a firm base. Thus, when technological and economic growth slowed down in the inter-war period Japan's modern industrial sector had been secured.[3] After the war, government support of agriculture increased greatly, and land reforms were enacted. Especially important were the contributions of the nonagricultural sector to agricultural technology. Insecticides, pesticides and chemical fertilizers were especially important in this regard.[4]

B. Cohen, Japan's Economy in War and Reconstruction (Minneapolis: University of Minnesota Press, 1949), p. 364.

[1]Maddison, Economic Growth, p. 44.

[2]Sawada, "Innovation in Agriculture," p. 348. One interesting indication of Japan's labor intensive approach to agriculture is the fact that the Minister of Commerce and Industry reported that only 99 farm tractors were in Japan in 1942, and 65 of these were located in Hokkaido. See Cohen, Japan's Economy in War and Reconstruction, p. 364.

[3]Ohkawa and Rosovsky, "Japanese Economic Growth," pp. 76-77.

[4]Ibid., p. 74.

In general, agricultural growth was very slow in the inter-war period, and the amount of technological transfer to Japanese agriculture in this period was very small. The Tokugawa and Meiji technological improvements were running into diminishing returns by the early 1900s. It was not until the post-World War II period that Japanese agriculture began to move rapidly forward.

Role of Technological Transfer in Industry

Throughout the last half of the nineteenth century, the West was influential in Japanese commerce, shipping and the financing of Japan's foreign trade. By World War I the Western influence in these areas had become relatively minor. The case of manufacturing was quite different. After World War I, the Western influence in Japanese manufacturing became much more important than in the past. The reason for this can be traced to the early intervention by the Japanese government in the manufacturing sector which delayed the entry of foreign firms. Foreign firms were faced with competition from Japanese firms subsidized by a government which was fearful of foreign domination. Further, Western firms were skeptical of the profitability as well as the security of their investments in Japan. The general foreign attitude toward Japan was to use it as an outlet for manufactured goods and a source of some raw materials. Westerners did not think it worthwhile to enter into the development of public utilities, mining, communications or manufacturing.

Even the foreign investment after World War I was not great in relation to the total investment of the Japanese economy. Total foreign business investment increased from 70 million yen in 1913 to 200 million yen in 1933, not a quantitatively significant amount compared to the total Japanese investment. Japanese investment outside of Japan proper was nearly 2,500 million yen in 1931. The small size of foreign investment belies its importance in terms of technological inflow. Similarly, the importation of foreign automobiles, machinery and instruments only amounted to 39 million yen in 1909-1913 and 120 million yen in 1929-1933, not even 10 percent of Japan's total imports, but was tremendously important in transferring technology to Japan.[1]

The foreign contribution to Japan was especially important after World War I in the manufacturing industries that required advanced technology. But even in this area the Japanese maintained a great deal of control over the foreign investment. Often the foreign investment flowed into firms originally established by the Japanese, and it was accepted only when it was necessary to permit further advances. The foreigner was therefore not a pioneer per se

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[1]Lockwood, Economic Development of Japan, p. 325.

and his role was often similar to the Western advisors in the Meiji period.[1] However, following World War I foreign technology could no longer be acquired by merely bringing in foreign advisors. The transfer of technology was done through the licensing of patents and the technical follow-up within a financial arrangement between foreign and Japanese firms.

It is interesting to note that the Japanese developed a conglomerate form of business organization before the American trend toward conglomerates began. To a great extent this is a product of Japan's adaptation to Western technology. As the _zaibatsu_ bought out the mining industry, shipbuilding, etc., from the government, they needed to provide facilities for repair of imported Western equipment and eventually the manufacture of that equipment. There were no other outside companies in Japan capable of supplying this equipment and the large companies established their own machine-building plants. In some cases a single plant would engage in a variety of productive activities. The Hidachi factory produced a vast range of electrical equipment, railway cars, mining machinery, automobiles and machine tools.[2]

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[1] Allen and Donnithorne, _Western Enterprise_, p. 228.

[2] G. C. Allen, "Japanese Industry: Its Organization and Development to 1937," in _The Industrialization of Japan and Manchukuo, 1930-1940_, ed. by E. B. Schumpeter (New York: The Macmillan Company, 1940), pp. 612-13.

After World War I many of the heavy industry companies manufactured equipment under patent by foreign firms and acquired license rights. Turbines were licensed by Mitsubishi Heavy Industries from Escher Wyss and Ljungstron. Boilers were manufactured by Hidachi and licensed from Yarrow. Much of the production of telephone equipment and electric lighting products was licensed from Americans.[1]

Japanese and foreigners often joined together in forming engineering firms. Toyo-Babcock was owned by Mitsui and Babcock and Wilcox. General Electric joined Mitsui in the Shibaura Engineering Works. Armstrong-Vickers combined with Mitsui to form Japanese Steel.[2]

Siemens Schuckert of Germany combined with Furukaw and Westinghouse and Mitsubishi Electrical Engineering Company entered into the manufacturing and distribution of electrical goods. Other foreign firms, mostly American, acquired minority interests in industries such as glass, aluminum, petroleum, sewing machines and film.[3] Toyo Electrical Engineering Company had patent licensing agreements with Dick Kerr and Company of England. The Sumitomo Electrical Wire and Cable Company had patent agreements with British, American and Italian firms.[4] Foreign firms

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[1] Ibid., p. 612.

[2] Ibid.

[3] Lockwood, Economic Development of Japan, p. 323.

[4] Allen and Donnithorne, Western Enterprise, p. 230.

produced cotton card-clothing, sewing thread, paper bags, carbon brushes, protective paints and automatic sprinkler equipment.[1]

Several engineering plants were entirely owned by foreigners in the period between 1920 and 1940. General Motors and Ford accounted for four-fifths of the yearly production of automobiles. Almost the entire Gramophone output was produced by one foreign firm.[2]

It is useful to examine briefly the history of several industries which effectively transferred technology from the West. This is by no means a detailed analysis, nor is it all-inclusive. The purpose is to illustrate the pattern of successful technological transfer in Japan.

At the beginning of the twentieth century, two foreign oil companies were established in Japan, the Standard Oil Company and a subsidiary of Shell, the Rising Sun Petroleum Company. These companies imported refined oils and built oil refineries to handle crude oil imports. Following World War I these companies rapidly expanded their operations and created distribution outlets in Japan and in its colonies. The Rising Sun Petroleum Company and Standard Oil still maintained 45 percent of the sales of gasoline in 1935. The Japanese government finally brought

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[1] *Ibid.*, p. 231.

[2] Allen, "Japanese Industry," p. 612.

the two companies under control in 1936.

The electric lamp industry was consolidated in 1905 by the Tokyo Electric Light Company of America. Expansion outside of this company was limited by General Electric's patent on the tungsten filament. The patent expired in 1927 and several medium-size companies began to produce house lamps. By 1935 Japan produced almost three-fourths of its house lamps for domestic consumption and exported the remainder.

The Dunlop company began to manufacture in Japan in 1909 in order to avoid tariffs. Dunlop supplied the great majority of Japan's rubber tires for motor vehicles and much of the production of bicycle tires until World War II. The second largest producer of rubber goods was the Yokohama Rubber Company which was formed by the Goodrich Company and Furukawa.

Another indication of the technological flow into Japan is the importance of the utilization of Western technology in Japan's war machine. Shortly after World War I Japan embarked on the building of an aircraft industry and hired a British firm to train the Japanese in operations and design until they were capable of running their own installation.[2] Japan entered World War II with its aircraft industry equipped with 50 percent foreign-

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[1] Ibid., p. 231.

[2] Ibid., p. 193.

made tools. Japan's technicians were trained in American aircraft plants such as Douglas, Boeing and Lockheed. Japanese propellers and engines were based on American designs acquired under licensing agreements. The Japanese were also experimenting with German technology in the area of rocket and jet powered planes, although these never did become operational.[1]

Technological transfer to Japan was aided by foreign importers who would send the Japanese samples of foreign products for the Japanese to emulate, producing cheap tools for the importers. In about 1934 an American chain store sent samples of Czech glass atomizers and tableware to the Japanese and ordered large quantities of the cheap copies. An Italian merchant sent straw hats from Italy to be copied and sold to the Americans. Other Western products such as bicycles, toys and Gramophones were obtained by the Japanese and produced for export to the foreigners who had supplied the samples.[2]

1938-1965 -- Explosive Growth

Given the devastating impact of the war upon Japan's economy, it is hardly surprising that most people, including the Japanese, were pessimistic about the future. Jerome

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[1]Lockwood, Economic Development of Japan, p. 331.

[2]Allen and Donnithorne, Western Enterprise, p. 209.

Cohen in his book Japan's Economy in War and Reconstruction could find few bright spots in the economic future of Japan. The prospects for the production of steel, textiles, food, etc., all looked quite gloomy. In regard to food production he stated in 1948:

> U.S. grain imports have in the post-war period come to replace the traditional sources of Japanese food imports. Nor can the gap be closed by the expansion of domestic output and the gradual elimination of imports. The limited arable land area and the expanding Japanese population combine as factors to make this hope pure wishful thinking on the part of the Japanese.[1]

Japan today is self-sufficient in the production of rice, its main food, and faces a rice surplus problem. The Japanese have surprised the world in their achievements in nearly every sector of their economy. By 1954 Japan's gross national product had regained its pre-war peaks. Gross national product on a per capita basis matched pre-war levels by 1957. By 1959 exports had regained their pre-war volume.[2]

Explosive growth began in 1953 after Japan had recovered from the post-war shock of institutional change. Gross national product increased by 9.4 percent annually between 1953 and 1965. Manufacturing set the pace as output increased 13.6 percent each year for the 1953-1965

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[1]Cohen, Japan's Economy in War and Reconstruction, p. 478.

[2]Maddison, Economic Growth, p. 50.

period. Agricultural output grew at a respectable 4.2 percent yearly rate in this period.[1]

This rapid growth took place within a worldwide economic boom which gave additional impetus to the Japanese economy.[2] The *zaibatsu* who had been broken in the post-war period regained their powerful organizations and, combined with government cooperation, they formed a formidable competitive force in the international markets.[3]

Japan's gross national product per capita grew at a remarkable 8.3 percent between 1953 and 1965.[4] Abortion clinics were set up throughout Japan and contributed to the decline of the birth rate from 34 per 1,000 in 1947 to 20 per 1,000 in the late 1960s. The decline in the birth rate meant that less effort needed to be devoted to social overhead projects for nonproductive children. This enabled more resources to be directly chaneled into improving industrial output.[5]

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[1] *Ibid*.

[2] James B. Cohen, *Japan's Postwar Economy* (Bloomington: Indiana University Press, 1958), p. 19.

[3] The resurgence of the *zaibatsu* actually took a somewhat looser form of *keiretsu* (meaning linked group) composed of former zaibatsu but without the central control of the past. See Bieda, *Japanese Economy*, p. 210.

[4] Maddison, *Economic Growth*, p. 51.

[5] Herman Kahn, *The Emerging Japanese Superstate: Challenge and Response* (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1970), p. 77.

Japan's extraordinarily high rate of saving has permitted high investment. Saving as a percent of gross national product was more than 30 percent in 1960 and has risen to almost 40 percent in the 1960s. Half of the saving is done by firms, 30 percent results from personal saving and the remainder is accounted for by the government.[1] Given the expansionary attitude of the keiretsu, the commitment to economic growth by the government and the high value placed on education (requiring saving) by the Japanese people, it becomes obvious that the saving is predominately chaneled into areas which accelerate economic growth. The combination of the historical frugality of the Japanese and the elimination of military expenditures has aided the investment process. Investment in research and development, purchasing of foreign technology, education, transportation, communications, industry and agriculture have been vital contributions to Japan's explosive growth.

Japan's gross national product declined from 1939 to 1944 due to the ravages of World War II. Japan emerged from the war without her colonies, her merchant marine destroyed and perhaps one-fourth of the buildings destroyed. Japan's recovery lagged as the very economic and social structure underwent jolting change. The zaibatsu were broken, crippling Japan's competitive ability. China and

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[1] Bieda, Japanese Economy, p. 49.

North Korea were lost as trading partners while European countries erected formidable trade barriers. The Japanese had to assimilate some five million returning soldiers and expatriates from former colonies. Japan's industrial sector had been fractured by the war and could not absorb the returning manpower. The vast military complex was dismantled, leaving Japanese industry without its principal raison d'etre. For more than sixty years the Japanese had allocated more of their resources to the military than any other country. What capacity was left was not readily translated into peace time production.[1]

In spite of these obstacles, Japan became the third largest industrial power in the world (in terms of gross national product) in only a quarter of a century. Many books in the literature offer essentially the same interpretation for this success. Some of the success factors mentioned are: the high propensity of the Japanese to save, foreign aid from the United States, land reform, a strong commitment to development by the government, a high level of education and an ability to assimilate new technologies. All of these factors are important, but if any one factor were most crucial, it would probably be the development of human resources. The Japanese quite simply had developed

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[1]Maddison, Economic Growth, pp. 45-48 and also Cohen, Japan's Economy in War and Reconstruction, pp. 417-504.

their most important resource, people. Secondly, they began to direct their knowledge toward nonmilitary oriented sectors of their economy. In the words of one expert on world resources:

> Japan has demonstrated for all times, that a country with educated people anywhere in the world, if it puts progress as its goal, avoids wasting its resources on military ventures, and plans for economic development, can make substantial progress. Japan has done this by concentrating on the development of human resources and man-made institutions, a cooperative government, a unique labor-management relationship, and a banking system devoted to the concept of economic development.[1]

Japan's spectacular recovery did not spring mysteriously from the rubble of its devastated cities. Japan has an ancient heritage of advanced culture. Even in the Tokugawa period the peasant farmer had a relatively high exposure to education.[2] The Meiji Restoration relied upon the agricul-

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[1]W. N. Peach and James A. Constantin, Zimmerman's World Resources and Industries (3rd ed.; New York: Harper and Row, Publishers, 1972), p. 535.

[2]Thomas C. Smith concludes his authoritative book The Agrarian Origins of Modern Japan with the following paragraph: "For the past century . . . the villages have been exporting much of their best human material, or rather those best fitted for the relentless competitive struggle of urban life. Part of the dynamism of Japanese modernization must be found in this continuous flow of talented, aggressive, ambitious people. What was there in village life to produce such people in great number from the end of the Tokugawa period on? What social alchemy made of peasant boys men who could found international banks and trading companies? I do not know, but beyond question part of the answer is to be found somewhere in the history of change in rural Japan before 1868." See Smith, Agrarian Origins of Modern Japan, p. 213.

tural sector as the principal source of revenue for industrial development. Japan's social fabric, the religion, kinship patterns and samurai ethic were translated into resources for development. World War II interrupted the surge of growth which began in the Meiji period. After the war the Japanese still had their cultural heritage and a high level of literacy. War had not destroyed this heritage which was the foundation for the Japanese recovery.

Role of Technological Transfer in Agriculture

Attempts by the government following the Meiji Restoration to create large farms failed. The failure was a result of the lack of appropriate machinery in that period combined with the peculiarities of rice production. Further, the lure of high rents from landless peasants was a great incentive to breakdown large farms.[1] Thus, the cultivated land under tenancy rose until it reached a peak of 46 percent of all cultivated land in 1941.[2]

The agricultural sector had to absorb millions of returning soldiers, expatriates of former colonies and the displaced workers from Japan's war-wrecked industry. The Second Land Reform initiated in 1946 broke up large ownerships and allowed millions of farmers to purchase small

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[1] Ibid., p. 244.

[2] R. P. Dore, Land Reform in Japan (London: Oxford University Press, 1959), p. 19.

plots of land. Thus large numbers of people were engaged in labor-intensive agriculture in the post-war period while the nonagricultural sector slowly recovered. The unemployment problem in the cities was alleviated at the same time that more human effort was directed toward the critical food shortage.

The Second Land Reform was very successful in increasing agricultural output and in absorbing the labor supply not demanded by the industrial sector. Approximately one-third of the farming land was expropriated and redistributed to previous tenants. Land tenancy was effectively eliminated by the reform program. The new owners purchased the land under generous loan arrangements with the government. Payments were no longer made in kind but in cash. Since the payments were set at very low rates, the farmers have had relatively little trouble in meeting their obligations.[1] The end of the land tenancy system greatly increased the farmers' incentive to produce and to improve their land. The concomitant redistribution of income allowed them to acquire new seed varieties, fertilizers, pesticides and mechanically powered cultivators, tractors, sprayers, dusters, ventilating and drying machines, trucks and powered

[1]There were a significant number of repossessions by landlords from previous tenants. Some were justified, such as those families that had temporarily leased land while their sons went to war. See Dore, Land Reform in Japan, P. 152.

tricycles. Japan now has the highest utilization of chemical fertilizers, pesticides and mechanical power per ha (1 ha = 2.45 acres) than any other country in the world.[1]

As the nonagricultural sector began to grow more rapidly, there began an exodus from rural to urban areas and from agricultural to nonagricultural employment. During the period 1953-1965, 4.6 million fewer workers were engaged in agriculture. At the same time the number of nonagricultural jobs was growing by 3.8 percent annually.[2] Japan's labor-intensive agriculture became more mechanized as the flood of labor flowed into the industrial sector. As stated earlier, the average farm size did not increase significantly for a variety of reasons, and Japanese agriculture remains labor-intensive though highly mechanized.

The role of technological transfer to agriculture is not so easily traced in the post-war period as in earlier periods. Perhaps this is because Japan had already developed its own labor-intensive technology and had little need of foreign flows.[3] It produces most of its own small tractors and power-operated sprayers, cultivators, etc.

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[1]Bieda, Japanese Economy, pp. 249, 261.

[2]Maddison, Economic Growth, pp. 52-53.

[3]Japan did import both European and American pesticide technology. See Allen, Economic History of Modern Japan, p. 122.

Even an automatic rice-planting machine was developed in the 1960s.[1] Japan is now an exporter of rice, a result of increased inputs and a protectionist policy, but also as a result of the Green Revolution. However, Japan, a country seemingly so conscious of comparative advantage, could do much better by importing much more of its agricultural supplies. This would enable it to devote more energy toward the industrial sector and allow the less developed countries to purchase more Japanese products.[2]

While Japan's Second Land Reform was successful in solving the problems of the 1940s and 1950s it has since become a hindrance to further development. Instead of labor surpluses, there are now labor shortages -- in both industry and agriculture (as witnessed by the increased mechanization of Japanese agriculture).[3] Returns are far higher in the industrial sector, but the land system retards the flow of manpower to the urban areas. Larger farms are prevented by government maximum limits on land holdings,

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[1]Bieda, Japanese Economy, p. 253.

[2]Lester R. Brown, Seeds of Change: The Green Revolution and Development in the 1970s (New York: Praeger Publishers, Inc., 1970), pp. 191-92.

[3]Increasingly farming is becoming a part-time occupation. Much of the work is done by women and the elderly. In 1967 there were nearly one million more women engaged in farming than men. See Prue Dempster, Japan Advances: A Geographical Study (2nd ed.; London: Methuen and Company, Ltd., 1969), p. 119.

low land rents from leasing and prohibition of leasing some lands, an inadequate pension plan, an attachment to land ownership, inflated prices of land, government price supports, expensive urban housing and high capital gains taxes.[1]

Japan's land system has evolved from a feudalistic arrangement to a concentration of land ownership (but not large farms) under the Meiji Restoration to the present highly labor-intensive agricultural land-use pattern. Japan's labor-intensive approach in the post-war period may serve as a model to the less developed countries today who have labor surpluses. However, the labor-intensive agricultural system may well have outlived its usefulness in Japan.

Role of Technological Transfer in Industry

In 1945 industrial activity was only 63.2 percent of the 1934-1936 base industrial activity index. Public utilities were only 87.8, industrial production only 60.2, mining only 73.0 and manufacturing only 59.1 percent of the 1934-1936 base years figures as shown in Table 26. Not until 1951 did the index for any of these sectors except public utilities surpass the 1934-1936 base. By 1955 all of these indexes except mining had surpassed the war and pre-war peaks.[2]

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[1]Bieda, Japanese Economy, p. 254.

[2]The fact that Japan has had to import large amounts of raw material such as oil, coal and iron, may be an advantage. The transportation by huge ships may be cheaper than

TABLE 26

INDEXES OF JAPANESE INDUSTRIAL ACTIVITY, 1934-1956
(1934-1936 = 100)

Year	Industrial Activity	Public Utilities	Industrial Production	Mining	Manufacturing
1934	89.9	90.9	89.8	92.0	89.6
1935	99.2	100.4	99.0	98.3	99.1
1936	110.3	108.7	110.5	109.7	110.6
1937	128.6	119.1	129.7	118.2	130.7
1938	141.1	130.3	142.4	126.0	143.7
1939	146.6	136.7	147.8	131.3	149.2
1940	147.9	140.4	148.8	142.7	149.3
1941	150.0	153.5	149.6	145.0	150.0
1942	145.6	154.5	144.5	140.7	144.8
1943	159.7	156.2	160.1	147.0	161.2
1944	176.2	154.4	178.8	138.5	182.1
1945	63.2	87.8	60.2	73.0	59.1
1946	39.2	109.1	30.7	52.2	28.9
1947	46.2	124.0	37.4	66.6	35.1
1948	61.8	137.9	54.6	80.3	52.5
1949	76.7	155.4	71.0	92.2	68.9
1950	88.0	168.1	83.6	96.9	82.0
1951	119.4	184.7	114.4	110.8	115.1
1952	131.8	201.2	126.4	114.2	128.2
1953	161.2	220.7	155.1	122.6	159.7
1954	173.5	236.9	166.9	117.0	173.8
1955	187.9	255.0	180.7	117.7	189.4
1956	227.4	294.8	219.1	129.7	231.3

Source: Bank of Japan, Economic Statistics of Japan (Tokyo: Bank of Japan, 1956), p. 203.

The United States occupation forces had initially followed a policy of making the Japanese create their own recovery. It soon became obvious that this policy was unrealistic. In order to ease the United States tax burden and to stave off communism, it was deemed necessary to aid Japan's reconstruction. Two billion dollars of direct aid flowed into Japan in the five years following the war.[1] Japan, like Germany, was able to reconstruct its industrial base with the most modern technology. Japan's international trade relations began to normalize in 1952 when it was allowed to enter the General Agreement on Tariffs and Trade. The United States helped Japan enter trade agreements with other countries. United States corporations formed arrangements with Japanese corporations to transfer technology through patents, machinery, copyrights and the training of technicians. In conjunction with direct government aid and private cooperation, the World Bank greatly aided the reconstruction of the Japanese steel and electric power industries.[3]

The Korean War spurred the growth of Japan's indus-

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land transportation. These ships unload raw materials directly to factories and steel mills located in port cities. See Kiyoshi Kawahito, The Japanese Steel Industry: With an Analysis of the U.S. Steel Import Problem (New York: Praeger Publishers, Inc., 1972), pp. 56, 123.

[1]Cohen, Japan's Postwar Economy, p. 18.

[2]Cohen, Japan's Economy in War and Reconstruction, p. 20.

trial activity, generating profits which were used to acquire new technologies. A domestic boom followed the Korean War, driving profits upward and resulting in the very high capital formation. Table 27 shows comparative rates of capital accumulation for Japan and other selected Western countries. Japan has continued to have a greater rate of capital accumulation than any other country in the world.[1] This capital formation was different in kind from the pre-war investment. This time capital formation was not directed to military growth, but to improving general industrial productive capacity with the most up-to-date technology.

TABLE 27

CAPITAL ACCUMULATION RATES IN MAJOR COUNTRIES[a]
(Annual Percentage Changes)

Year	Japan	U.S.	U.K.	West Germany	France	Canada
1939	24%	8%	11%	19%	13%	n.a.
1950	25	21	11	23	19	24%
1951	32	19	16	23	20	26
1952	28	16	13	23	19	23
1953	28	17	15	21	17	25
1954	25	16	14	22	18	22
1955	25	19	17	25	18	24
1956	29	18	16	24	19	28

[a]Public and private gross capital formation.

Source: Jerome B. Cohen, Japan's Postwar Economy (Bloomington: Indiana University Press, 1958), p. 52.

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[1]Maddison, Economic Growth, p. 57.

Ten years after World War II the Japanese had constructed modern plants which contained, however, obsolete equipment. The Japanese sought technical assistance from foreign countries. Thus,

> by March 31, 1957, 662 private technical assistance contracts had been signed, 448 of them, or 67 percent, with U.S. firms. These agreements, which follow no one set pattern, provide for Japanese use of foreign patents, permit the sending of Japanese engineers and technicians to the foreign corporation's plants for training, bring United States and other foreign engineers and specialists to Japan to train the Japanese in new techniques and procedures, etc. The capitalized value of these contracts, at the end of 1955, was placed at $353 million and during fiscal 1956 the Japanese paid royalties on them amounting to $28 million.[1]

Over 50 percent of the contracts were for developing machinery, although many contracts were also designed to build the chemical industry.[2] With rare exceptions the Japanese government has refused to approve wholly owned foreign subsidiaries or joint ventures that have more than 50 percent of the equity under foreign control (IBM is a wholly owned subsidiary, but it was created before the Second World War.)[3] A great number of cooperative ventures can be cited. A few typical examples of foreign agreements should be illustrative.

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[1]Cohen, Japan's Postwar Economy, p. 53.

[2]Ibid.

[3]John E. Tilton, International Diffusion of Technology: The Case of Semiconductors (Washington: Brookings Institution, 1971), p. 146.

B. F. Goodrich and the Japanese Geon Co., Ltd., cooperated to double the output of the most modern vinyl plastic. Goodrich supplied the technical support necessary to complete the project. RCA entered into over two dozen agreements with Japanese companies to build radio and television sets. The latest technology in transistors and cathode ray tubes was transferred to the Tokyo Shibaura Denki corporation from RCA. E. I. du Pont contracted to develop Japanese manufacturing capacity in synthetic fibers. Both the Yawata and Fuji Steel companies were aided by Armco in modernizing their plants.[1]

Foreign technology flowed into the electrical machinery industry as Japanese firms made contracts with foreign enterprises like Westinghouse, Escher Wyss, Siemens-Schuckert, and Brown Boveri. After 1952 license arrangements were made with foreign automobile manufacturers such as Kaiser Motor Company, Hillman, Renault, Willys Overland and Austin.[2]

The case of the semiconductor industry typifies the Japanese procedure for acquiring industrial technology.[3]

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[1]Cohen, Japan's Postwar Economy, pp. 53-54.

[2]G. C. Allen, Japan's Economic Recovery (London: Oxford University Press, 1958), p. 102.

[3]Government approval from the Ministry of International Trade and Investment is required of foreign investments and generally not granted except on favorable grounds. See Kahn, The Emerging Japanese Superstate, p. 80.

Throughout the 1950s the Japanese relied on foreign technical assistance (mainly the United States) for obtaining the latest technological developments. During the 1960s Japanese research and development increased in the semiconductor field but still remained only nearly one-third of the United States research and development as a percent of sales.[1] Most Japanese research and development was devoted to engineering and development projects as opposed to basic research. Thus few major technological breakthroughs occurred in Japan, but many imaginative improvements were accomplished. This is the same strategy followed by other Japanese industries and has resulted in great gains from relatively small investments.[2] The lag between innovation and imitation has been quite short as shown in Table 28.

By the late 1960s the acquisition cost of foreign technology had increased, and technology became more difficult to obtain. Further, Japanese technology had advanced so greatly that it often rivaled foreign technology and therefore restricted the amount of useful foreign technology available.[3] These factors caused the Japanese government to

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[1]Tilton, International Diffusion of Technology, p. 139.

[2]Ibid., p. 140.

[3]The case of the Texas Instruments company's attempt to form a wholly owned subsidiary is informative. When the Japanese government refused to approve their request, Texas Instruments denied patent rights to Japanese firms. But the

TABLE 28

PERCENTAGE OF MAJOR SEMICONDUCTOR DEVICES FIRST PRODUCED IN JAPAN, BY FIRM, AND AVERAGE IMITATION LAGS, 1953-1968

Type and Name of Firm	Percentage of Innovations Initiated	Average Imitation Lag (Years)
Receiving tube firms		
Nippon Electric	46	2.25
Toshiba	12	3.00
Subtotal	58	
Subaverage		2.40
New firms		
Sony	27	1.57
Fujitsu	15	4.75
Subtotal	42	
Subaverage		2.73
Total and average	100	2.54

Source: John E. Tilton, International Diffusion of Technology: The Case of Semiconductors (Washington, D. C.: Brookings Institution, 1971), Table 6-3, p. 143.

initiate a change in Japan's traditional imitative approach. More government effort in the area of the subsidization of basic research is probable in the future.[1] In fact, Japan has invested 1.4 percent of gross national product (1964) to research and development, which is the same as for Germany, but below that of the United States (3.4), Russia (2.6), United Kingdom (2.3) and France (1.9). However, about half of the research and development for those countries is defense oriented.[2]

Summary

Japan was successful in its attempt to transfer Western technology for economic development. Japan's inherited economic surplus in agriculture was large enough to permit acquisition of technology in the Meiji period. Resources were channeled into the industrial sector, and increases in productivity became evident after the third Meiji decade. Japan's military success gained it a large indemnity from China which was directed into further devel-

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Japanese produced the integrated circuits without purchasing the patent rights. Administrative delay prevented prosecution against these companies. When Texas Instruments relented in the late 1960s to sell their patents, the Japanese had become very sophisticated in the production of integrated circuits which increased the difficulty of Texas Instruments' entry into that market. See Tilton, International Diffusion of Technology, pp. 146-47.

[1] Ibid., p. 140.

[2] Maddison, Economic Growth, pp. 61, 62.

opment. World War I opened new markets to Japan and stimulated the industrial sector of the economy. Japan was even able to take advantage of the world depression in the 1930s by purchasing cheap raw materials from the industrial powers as they dumped their goods in foreign markets. Military expenditures in the 1930s rapidly increased the growth of Japan's heavy industry preparing it for war.

The Japanese cultural heritage was adjusted to accept the rapid infusion of Western technology. The samurai class was transformed from a parasitic group to a rich source of bureaucratic and entrepreneurial talent. The Japanese people had a common denominator in race, law and language, and a trait of obedience.

The political leadership beginning with the Meiji Restoration was committed to the acquisition of Western technology for the purpose of rapid industrialization. Fortunately, Japan was free of the imperialistic exploitation from which its neighbors China and India suffered so much.

Japan's remarkable recovery from World War II was a result of the efficient and ingenious use of human resources developed before the war. The Japanese government devoted these resources to development and constructed the institutions necessary for accomplishing this goal. Japan's labor-intensive agriculture absorbed the urban unemployed until the industrial sector began to draw on this labor resource. Japan was aided by the course of world events: United States fear of communism, the Korean War and world-wide post-war prosperity. The Japanese culturally inherited frugality and determination led to high saving which permitted investment to be directed toward development. Japan's capital formation growth rate has been the fastest in the world. Expenditures on research and development have been high since the 1960s, and virtually none of this is wasted on the military.

Japan has continued its tradition of tight control over foreign investment. This has not stemmed the flow of foreign technology into Japan in the form of licensing of patents, joint ventures, bringing in foreign technical specialists and sending Japanese engineers, scientists and technicians to observe foreign technology. The transfer of technology to Japan's receptive cultural fabric has been the foundation of the Japanese success story.

CHAPTER VII

JAPAN AND MEXICO: A COMPARISON[1]

Introduction

The purpose of this chapter is to point to differences and similarities in the transfer of technology to Japan and Mexico. Some differences between the two countries are obvious, but important. Japan is an island nation with a dense population. Mexico has a smaller population (although a very high growth rate) and is adjacent to the largest industrial nation, the United States.

Japan is now the third ranking industrial nation in the world (in terms of gross national product), so it is not the purpose of this chapter to compare this economic superpower to the developing economy of Mexico. However, it may be useful to compare the process of development and the corresponding transfer of technology to these countries. To make such a comparison meaningful, it is necessary to consider the land systems and cultures of the two countries as well as the course of historical events. Land systems in conjunction with population density and natural endow-

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[1]The material in this chapter is primarily based on the preceeding chapters on Mexico and Japan.

ment are essential in determining whether capital-intensive or labor-intensive techniques may be employed. The cultural milieu of each country determines the receptivity to new technologies. Historical events such as foreign domination affect the land systems and culture and thus the basic infrastructure of society.

Role of Government

With the termination of the Tokugawa period in Japan and the Porfirian period in Mexico, both governments engaged in pragmatic and eclectic action which was fundamental to their successful economic development. Both governments purposely strived for economic development and the acquisition of foreign technology. In each case the government was active in building the economic infrastructure, providing institutions and overhead capital necessary for later economic expansion. Importantly, the governments of both countries directed economic development in such a manner as to lessen the dependence on foreign powers. In both cases the governments were influential in initiating the growth of both the industrial and agricultural sectors.

Financial institutions were created to promote development and to facilitate the purchase of new technologies. In 1925 the Bank of Mexico was established and evolved into the major financial institution responsible for the post-1940 economic growth. Fiscal and monetary policies have been directed toward the goal of economic growth within the context of political stability. The Nacional Financiera was created in 1934 and has provided long-term financing of industrial projects deemed most necessary to break bottlenecks to economic expansion. Other financial institutions formed in the late 1920s included the Ejidal Credit Bank and the Agricultural Credit Bank to encourage agricultural development and the Foreign Trade Bank to promote the Mexican export sector.[1]

In Japan the government established a variety of financial institutions to promote economic development. The Yokohama Specie Bank was established in 1880 to promote the financing of exports. The Bank of Japan was created in 1882 as the central bank responsible for controlling the Japanese banking system. In the period 1897-1900 the Banks for Industry and Agriculture were established providing credit in Japan's 46 prefectures. Regional banks were also established in Hokkaido, Formosa and Korea. The Hypothec Bank was established in 1897 to facilitate channeling funds from agriculture and the network of local banks into the industrial sector. The creation of the Japan Industrial Bank in 1902 further aided the flow of credit to industry.[2]

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[1]Hansen, The Politics of Mexican Development, p. 35.

[2]Maddison, Economic Growth in the West, p. 23-26.

The respective governments have played different roles in regard to the agricultural sector. The Japanese were able to tax the agricultural sector heavily in the Meiji period and channel the funds into industrial development via the acquisition of foreign technology as described in Chapter V. At present the agricultural sector is a drag on the rest of the economy due to diminishing returns from inputs into small land plots. On the other hand, Mexico was unable to tax the agricultural sector immediately after the Porfirian period since most of the rural population were living at a subsistence level. Since the 1940s, the large public investment in agriculture has permitted increasing exports of agricultural products which have earned foreign exchange that often finds its way into the industrial sector. Thus agriculture, though it still receives greater investments than it provides in revenues, provides an important link to the acquisition of foreign technology.[1]

In the area of education, the Japanese government was much more active in developing human resources than was the Mexican government. The Japanese government was fortunate to inherit a relatively highly educated populace and readily embarked on programs directed toward better education. This early emphasis on education was stressed

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[1]Reynolds, The Mexican Economy, p. 179.

in Chapter V. The Ministry of Education was established in 1871 and standardized education throughout the country. By 1907 six years of schooling were compulsory. At the close of the Meiji period, some 20 percent of the children went on to secondary education. The Japanese government built schools, subsidized local education programs, and generally encouraged education. Universities, vocational schools, agricultural colleges, and research institutes were formed. Informal education was aided by agricultural extension services and the general exposure of the population to the industrial process. The Japanese did not hesitate to bring in large numbers of foreigners to bolster their educational system. The high level of education in Japan was of great importance to the acceptance of Western technology.

The Mexican government did not emphasize general education but was instrumental in creating institutions in agriculture and industry, as detailed in Chapter IV, which were of fundamental importance to the development of the economy. This effort has largely been directed to elite institutions available to only a small segment of the population. This point is emphasized by the fact that even today, only about 10 percent of the children in rural areas finish six years of education -- a dramatic contrast to Japan's experience in the Meiji period.

The Mexican Ministry of Education has attempted to spread education informally through the dissemination of handtools and information to the peasant population, but the magnitude of educational aid is very low. The National School of Agriculture does make important contributions to agriculture on the university level and cooperates with the Rockefeller Foundation in the area of agricultural research. But, as mentioned in Chapter IV, the dissemination of the fruits of higher education and research is hampered by the poor educational level obtained by the mass of the Mexican population.

The Japanese and Mexican governments have displayed a great deal of eclecticism in their approach to the acquisition of foreign technology for economic development. Both countries utilized import controls to encourage import substitution and to channel scarce reserves of foreign exchange into technology embodied in capital goods imports. Beginning with the Meiji period, the Japanese government fostered the importation of Western technology for both the agricultural and nonagricultural sectors. By trial and error the government experimented with Western technology, developing and adapting technologies compatible with the unique requirements of the Japanese socio-economic setting. When foreign technology was not useful or too expensive, or if it was too capital-intensive, it was eliminated or adapted to Japanese needs. As noted in Chapter V much of the industrial system which was built upon foreign technology was turned over by the Japanese government to the private sector after a relatively short period. Thus from the Meiji period to the present there has been a close working arrangement between the government and the private sector. The eclectic selection of foreign technology begun in the Meiji period has been a consistent theme continuing to the present day.

The Mexican government encouraged the importation of technology in a variety of ways, but initially its alternatives were narrower than were those of the Japanese as a result of its long history of foreign domination and different endowment of natural resources. Extractive industries, eventually nationalized, were an obvious asset to be exploited with modern technology. The government was virtually forced by circumstances to improve those industries which had initially been developed by foreigners. But with government guidance Mexico built the necessary infrastructure of roads, irrigation projects, hydroelectric plants, etc., as outlined in Chapter III and Chapter IV which permitted the rapid growth of manufacturing and large commercial farming. The government controlled, to varying degrees, the establishment of foreign branch plants, the importation of modern technology for government-owned enterprises, the border industries, and the import substitution programs. Thus, the Mexican government, like the Japanese government, played an influential role in developing the economy and determining the channels of technological transfer.

Cultural Values and Ethic

Throughout this paper it has been stressed that successful technological transfer and diffusion depends on the adaptation of a process package to the uniqueness of each country's cultural milieu. The degree of success achieved by Mexico and Japan in economic development is at least in part due to the ability of both countries to acquire new technologies within the traditional framework without tearing apart the existing institutional fabric. However, the Japanese have been even more successful at smooth institutional adjustments than the Mexicans.

The Mexican Revolution broke traditional values and replaced them with new images rooted in the past. Everything of foreign origin became suspect -- only the Indian heritage was respected as the national culture. The Church and large landowners were easily identified targets and were rejected along with foreign domination.[1]

Religion was a greater barrier to economic develop-

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[1]Derossi, The Mexican Entrepreneur, p. 23.

ment and technological change in Mexico than in Japan. The Catholic Church acted to enforce the status quo of an archaic, rigid social arrangement and an inefficient land system. Buddhism was much less a barrier to the Japanese, and its influence was further reduced by the Meiji government as described in Chapter V.

The Meiji Restoration broke the outmoded feudal ties to the past. Certain attributes of the Japanese culture, including loyalty to superiors and respect for authority, allowed the Japanese to make the transition from feudalism to capitalism with relative ease and rapidity. Loyalty to the Tokugawa Shogunate was transferred to the Emperor. Important segments of the samurai class supported the change partly out of fear of foreign domination. Previously wasted human resources were utilized under the new prefectural government which focused its effort upon industrialization through the rapid assimilation of Western technology. The government was aided in this effort by a relatively well educated population and by an agricultural sector which could supply the needed impetus for industrialization.

Japan had a rich heritage conducive to the acceptance of Western technology. The intellectual drive of the samurai and their previous exposure to Chinese culture facilitated technological acceptance. Japan's common denominator in race, law and language aided the acceptance of new technology for national development. The trait of obedience in the population combined with a government which purposely promoted new technology in an eclectic manner were essential factors in the rapid assimilation of Western technology.

The Mexican heritage was quite different in that Mexico suffered under Spanish exploitation for hundreds of years before the Profirian era. The Spanish took advantage of the cultural heritage of the Mexican Indians, i.e., their respect for the warrior class, king, and church and superimposed their own system, which was similar to the Indian culture in these respects, on that of the Indian culture. Whereas the Japanese cultural traits were used as a vehicle for attaining independence and rapid economic development via the assimilation of Western technology, the Spanish utilized the Indian cultural traits for exploitation. The transference in one culture was internal; in the other it was externally imposed.

The Porfirian regime was interested in rapid development but did not have the human resources which were available to the Japanese government such as a relatively educated peasantry and a dedicated upper class. The theme in the Porfirian period was to exploit Mexico's natural resources and to develop an infrastructure to aid this endeavor. Unlike the Japanese, who brought in foreign technology and rapidly sent the foreigners home, the Mexican government accepted foreign investments which led to foreign domination. While the Japanese built an industrial base for the purpose of maintaining independence, the Mexicans were subjugated by foreign powers. As a result the Mexican railroads were built north and south instead of east and west to facilitate the export of tropical fruits and ores to the United States. Pipelines were built to Veracruz to ship oil out of the country and not to Mexican cities (where no refineries had been built) for internal development. In the case of Mexico, unlike Japan, there was a long history of foreign entrepreneurs who came to Mexico and remained there. The contributions of these men aided the technological flow into Mexico but their positive contribution must be weighed against the exploitative impact of foreign domination.

Japan developed the necessary overhead capital in the Meiji period, as described in Chapter V, which enabled economic growth to accelerate in the 1913-1938 period. The new Meiji government channeled available resources into economic development projects. Taxes on agriculture were another important source of revenue in this period of initial development. The tremendous influx of foreign capital into Mexico in the Porfirian period was of some value, but the enclave nature of these investments led to little technological diffusion.

A brief comparison of the samurai ethic and the mestizo personality sheds some light on the differences in economic development and acquisition of technologies in Japan and Mexico. The samurai ethic often resulted in selfless dedication to economic development through the acquisition and diffusion of foreign technology. The samurai's impact was felt mostly in the new government in the form of bureaucrats, but they also formed a small but powerful group of gentlemen entrepreneurs. Their commitment to higher authority and their selfless dedication were a sharp contrast to the Mexican mestizos.

The mestizo had no place in the social order and as a result, developed a personality which was self-serving and highly individualistic. The mestizo class gained political control in the power vacuum which resulted at the end of the Spanish rule. Power was personal and was used for the domination of others since the mestizo sought national power for self-aggrandizement and little else. Foreign technology was valued as a means of obtaining national power, but the mestizo personality was ill suited for aiding the diffusion of this technology to the mass of the population. Thus while Japan created human resources and institutions conducive to the broad acceptance of new technology the mestizo influence restricted the development of a social system amenable to domestic technological incubation.

Even today the samurai ethic and mestizo personality have an influence on the Japanese and Mexican cultures. The mestizo personality contributes to the direction of development taken by Mexico as is reflected in part by the uneven distribution of wealth, income and social services. Economic dualism in both agriculture and industry appear to be firmly entrenched in Mexico whereas in Japan this dualism is weakening with the steady growth of the modern sector.

The mestizo personality often finds its expression today in family controlled businesses which have traditionally been associated with a high resistance to new technologies. This situation is changing, however, and the modern Mexican entrepreneur increasingly finds prestige in his managerial role instead of simple wealth-holding.[1] Therefore, recently there has been a strong force for the modernization of industry and a greater degree of acceptance of new technology.

The samurai ethic is still expressed in the roles of government leaders and corporation executives. The

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[1]Derossi, The Mexican Entrepreneur, p. 110.

fictive kinship pattern existing in modern Japanese corporations has its roots in the traditional kinship organization. There is great respect for one's company and a corresponding paternalistic attitude on management's part to take care of the employees. The Japanese corporation readily accepts new technology which is in turn accepted by the Japanese worker. This dedication is exemplified by the following workers' song of the Matsushita Electric Company which is sung every morning before work:

> For the building of a new Japan,
> Let's put our strength and mind together,
> Doing our best to promote production,
> Sending our goods to the people of the world,
> Endlessly and continuously,
> Like water gushing from a fountain,
> Grow, industry, grow, grow, grow!
> Harmony and sincerity!
> Matsushita Electric! [1]

Such fanatical dedication to production by workers is not found in Mexico, nor probably any place in the world.

Land Systems and Agricultural Technology

Historical events, culture and geographical differences have created different land use patterns in Mexico and Japan. The Spanish developed the hacienda system supported by the Church, state and the hidalgo mentality. The concentration of land increased under Diaz and it was not until 1934 that land reform began on a massive scale.

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[1]Herman Kahn, The Emerging Japanese Superstate: Challenge and Response (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1970), p. 110.

Partly as a result of the popularity of land reform, Mexico now has a dualistic agricultural system. Political pressure has required that the government channel most of the agricultural inputs into large commercial farms. These farms are highly mechanized and utilize modern farming techniques. The many small farms, whether ejido or minifundia, have received much less in terms of irrigation, roads, credit accessibility, general education of the peasants, and extension services. Thus the small farmer is using antiquated techniques without the aid of capital inputs comparable to those received by the large commercial farms. The result is that technological transfer and diffusion have been severely limited in this sector of Mexican agriculture. The fruits of the research by groups such as the Rockefeller Foundation have reached relatively few of the peasants engaged in small-scale farming. Lack of educated peasant farmers, extension services, and sufficient capital inputs, combined with small uneconomical land plots, have retarded the exploitation of much of the potential agricultural output in Mexico. The use of small land plots has, however, absorbed much of the labor that would have been superfluous in the industrial sector. But as it will be pointed out, there are major differences in the role of small land units in Mexico and Japan.

Historically the Japanese never developed much large-scale farming as a result of the relatively small amount of cultivatable land and the dense population. But there has been some concentration of land ownership. Since the Tokugawa period, the agricultural output has been high by Asian standards making possible the Meiji government's heavy reliance on the wealth of the agricultural sector in building Japan's industrial base. Unlike the Mexican farmer, the Japanese farmer has been fairly well educated and has become increasingly so since the Meiji period. Further, since the Meiji period the government has been active in aiding agricultural development by providing general education and extension services to the farmers. Though the government has varied in its efforts to aid agriculture, it has continued to build a valuable human resource base. This combination of government assistance and educated farmers has greatly facilitated the diffusion of agricultural technology. This human resource base has done well by Japanese agriculture and has provided Japan's growing industrial sector with hard-working labor. The small land plots, especially after the reform in the post-World War II period, helped absorb labor which would have been unemployed in the industrial sector. In the 1960s and 1970s, Japan has faced a shortage of both agricultural and industrial workers so that Japan's intensive agricultural system is now a hindrance to economic growth.

The dualism in Mexico's agricultural sector and the near universality of small farming in Japan have led to different types of technological adaptation. The technological flow into Mexican agriculture has been embodied in modern machinery imports, technological assistance in building plants to produce fertilizers and pesticides, technical supervision of irrigation projects, educational exchange programs with foreign countries, and the establishment of research centers such as the Rockefeller Foundation.

As noted earlier, the dualistic development of Mexican agriculture hindered the transfer and diffusion of technology outside of the large commercial farms. Further, the Mexican focus on large farms in conjunction with the peasant attachment to owning land has necessitated the creation of many small and inefficient farms. A policy of developing more farms of moderate size might have resulted in more efficient land use and a greater absorption of surplus labor. New seeds, fertilizers and pesticides yield greater returns in terms of cost-benefit calculations on relatively small farms rather than on capital-intensive farms.

It is much easier to criticize economic policies in retrospect from the vantage of hindsight. Small farms resulting in the early period of Mexican land reform may have been necessary to promote political stability as the Porfirian enclosures had been one of the main factors in the rural discontent which resulted in revolution. Although the distribution of uneconomic farm plots may have sacrificed short-run efficiency, it may have been a political necessity yielding stability for future economic development.[1] Yet another consideration to be taken into account is that the initial land redistribution helped to break the feudal land system which permitted the government to make innovations in the industrial and agricultural sectors.[2]

Perhaps the Mexican government can move toward the creation of more economically efficient farm sizes as the peasant realizes he may gain from such a policy. Once the small farm owner becomes aware that mere land ownership is not likely to greatly improve his standard of living he may be more amenable to new farm size arrangements if assured of personal security.

The Japanese approach to agriculture has been labor-intensive and has been closely related to intermediate technologies providing a link to the modern sector. Had the Mexicans followed the Japanese example, they might well have made better progress not only in agriculture, but also in

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[1]Alexander J. Kondonassis, "Contributions of Agriculture to Economic Development: The Cases of England, U.S.A., Japan, and Mexico," Spoude (April-June, 1973), 377-96.

[2]*Ibid.*

their intermediate and modern technological sectors. Certainly more labor could have been absorbed in agriculture with perhaps greater productivity resulting from a more even allocation of inputs. However, as mentioned above, this approach may not have been a realistic political alternative for the Mexican government.

Some commonalities exist in the agricultural experiences of Japan and Mexico. In both countries the governments enacted reforms which broke feudal ties and thus permitted nascent industrialization. Small farm plots in both countries have helped to contain the movement to urban areas while remaining a labor source for future industrialization. In Japan and Mexico, the increase in agricultural productivity has resulted in higher farm incomes which have stimulated the demand for manufactured goods as well as permitted more investment to be channeled into the agricultural and industrial sectors of the economy. And in both countries the increase in agricultural productivity resulted in increased reserves of foreign exchange which enabled them to purchase capital goods for the industrial sector.[1]

The Japanese proved to be masters of eclecticism in their approach to adapting Western technology to their agri-

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[1]This analysis draws upon the work presented in Kondonassis, "Contributions of Agriculture to Economic Development," 377-96.

cultural system. Chapter V offered numerous examples of the Japanese talent for pragmatic selectivity in the experimentation with Western techniques. Dry-field farming technology was attempted with little success and rapidly discarded. Animal husbandry techniques were imported with more success and were complemented by the government's de-emphasizing the Buddhist influence which had previously been a barrier to advances in this field. The greatest success was accomplished with the introduction of new seed varieties, greater utilization of fertilizer, crop rotation and the improvement of simple tools. Irrigation projects, though initially misguided by Dutch technologists, were adapted to Japanese requirements and helped to increase agricultural productivity. Thus the Japanese achieved success in the agricultural sector by selectively applying Western techniques to Tokugawa agricultural methods which resulted in their own unique Meiji technology.

Industrial Technology

The outstanding difference in the transfer of industrial technology in the early development of Japan and Mexico was the degree of foreign domination and direction of technological flow. In the Porfirian period, Mexico received large amounts of technology in the form of railroads, mining, and hydroelectric construction. There was little technological diffusion due to the enclave nature of these projects. Further, the development of Mexico's infrastructure was molded toward the export of raw materials rather than toward the internal development of the country. Japan, on the other hand, immediately directed technological inputs toward the internal development of Japanese industry, attempting to attain the goal of independence from foreign domination.

The opening of Japan to foreign markets stimulated domestic industries such as silk, coal and porcelain ware which began to utilize Western techniques. Unlike the Mexican case, the fruits of increased exports were funneled back into the Japanese economy. During the Meiji period, the Japanese rapidly developed a sound structure for future economic growth. Western technology was used in shipping, railroads, communications, manufacturing and mining. And this industrial base was purposely designed for Japanese development -- not for foreign exploitation. Foreign technicians, engineers, and scientists were welcomed briefly until the Japanese could operate their own industries and adjust Western technology to the unique requirements of Japanese conditions.

Within this context the Japanese began by trial and error to adapt Western technology to their labor-intensively suited economy. Often labor was substituted for machinery. Inexpensive wooden machinery replaced expensive steel machines.

The importation of Western products was an important source of technology transfer and many of these products were soon imitated for export.

Chapter V enumerated several cases of Japanese experimentation with Western industrial technology. As in the case of agriculture, mistakes were made in attempting to incorporate Western technology _in toto_. But these errors were soon corrected. The geological survey of the Besshi copper mines was offered as a typical example. Plant operations were changed to utilize cheaper, labor-intensive techniques wherever possible. Later, as more capital became available, more modern and expensive machinery of a capital-intensive nature was imported.

Small markets, shortages of capital and an unskilled labor supply necessitated small and medium size business units. Thus Western machinery, not designed for small-scale production, was modified for Japanese purposes. The textile industry was an exemplary case where expensive French machinery made of steel was found incompatible with the Japanese system. Wooden machines replaced the more expensive steel models, and labor was substituted for capital whenever possible. The Japanese labor force, markets and capital resources were much better served by this adaptive process.

At the end of the Meiji period, Japan had a sound base for future development, while at the end of the Porfirian period Mexico had an infrastructure built for exploitation and which led to relatively little technological diffusion when compared to Japan. Japan accomplished the goal of technological transfer for development in spite of a scarcity of capital and high costs of acquisition due to the need for overseas transportation. Japan, an island nation, developed its industries around coastal harbors while rapidly building its merchant marine. Although transportation costs were relatively high, the Japanese compensated for this by its singular focus upon industrialization as supported in Chapters V and VI.

The modes of transfer of technology to Japan and Mexico differed greatly in the period 1910-1940 following the Meiji Restoration (1912) and the Porfirian period (1910) largely due to historical events. Mexico was in a state of political turmoil for much of this period while Japan continued to build on its economic base established in the Meiji period. Mexico did manage to finally achieve political stability in the 1920s, initially under the guidance of General Obregón and more permanently with the formation of the Establishment of the Party of Revolutionary Institutions in 1929, and proceeded to build an economic base for later expansion. The Party of Revolutionary Institutions has maintained stability by co-opting labor and agrarian leaders while rewarding the political, agricultural, and industrial elites, and to some degree the growing middle class.[1] The nationalization of railroads and the expropriation of oil companies and land reform created a setting more conducive to national economic development and the concomitant transfer and diffusion of industrial technology.

Transfer of technology into the extractive industries and railroads of Mexico dropped sharply in the 1910-1940 period due to nationalization and expropriation. Hydroelectric technology continued to flow into the country due to the different relationship between the hydroelectric companies and the Mexican government as explained in Chapter III. A number of foreign branch plants were established in the 1920s in the manufacturing sector, but these were generally under varying degrees of control by Mexican interests. Mexico managed to maintain control of basic industries such as iron and steel, cement, glass and textiles. Foreign technicians were often utilized under the control of Mexican firms or the Mexican government. Foreign investments have become steadily smaller as a share of the total value of total assets. Thus the Mexicans began to follow the Japanese experience of economic development largely independent of foreign economic influence.

Mexican firms have often demonstrated the capacity to adapt foreign technology to their needs following the

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[1]Hansen, Politics of Mexican Development, pp. 112-20.

Japanese example with some distortion due to a bias for capital-intensive techniques. Before the Porfirian period foreign entrepreneurs brought new innovations to Mexico as described in Chapter III. The French were especially important, since many Frenchmen settled in Mexico and helped to develop retailing and later manufacturing. The Spanish were influential in forming the papermaking industry and introducing modern equipment and techniques acquired from the Germans. American settlers were important in developing the manufacturing sector, particularly the shoe industry and the steel industry.

But indigenous entrepreneurs also played an important part in the Mexican experience of industrialization. The Mexican role expanded with nationalization, and Mexicans, often with the help of foreign advisors, began their own innovations. The lack of an educated skilled work force has forced Mexican managers to adjust Western factory techniques. Much more supervision is required than in the industrialized countries. Directions must be simple and often pictorial as many of the workers are illiterate. A typical explanation for the utilization of antiquated equipment comes from a Mexican woods products manager:

> We use the mechanization of the 1930s because newer equipment requires understanding that two or three years of school might make difficult to impart.[1]

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[1]Strassman, Technological Change and Economic Development, p. 71.

The lack of a high level reserve of human resources has caused the Mexican manager to have to choose between utilizing antiquated equipment which is prone to break down and which requires close supervision and task simplification or purchasing capital-intensive equipment to alleviate labor problems. Low import duties on capital goods as well as easier credit terms from United States suppliers of machinery often bias the decision-making process toward the substitution of capital for labor.

Some examples of brilliant Mexican innovation were mentioned in Chapter IV. The development of the "Hy L" process in the steel industry in an illustration of what Mexican talent can do. This process is well suited to Mexico's abundant supply of hydroelectric power, natural gas and high grade iron ore. The process of making paper from sugar stalks after the milling operation (bagasse) was improved upon and made economical by a Mexican firm. Stabilized tortilla flour is another example of Mexican innovation (in conjunction with United States firms' assistance) mentioned in Chapter IV. This development makes one of the main staple foods of Mexico less perishable while maintaining a higher nutritional level.

Japan had built the beginnings of an industrial base in the Meiji period. Consequently, Japan was ready to take advantage of the First World War by greatly increasing its share of the export market. However, with the fall of Diaz in 1910, Mexico was gripped by heavy fighting and political instability. Though recovery began in 1915, Mexico did not have the economic infrastructure nor stability to gain as greatly as Japan from World War I. Benefits from increased Mexican exports, such as oil, accrued to foreigners.

Japan used its huge gains from increased exports to accelerate industrialization. Heavy industry grew rapidly in steel, machinery and ships. During this period Japan began to build its chemical and engineering industries. The surge in exports not only permitted rapid industrial expansion but aided the payment of debts, thus increasing Japanese independence. The importation of embodied technology grew after World War I and was an important source of technological transfer. This was especially the case for automobiles, machinery and instruments.

Barriers to entry of foreign firms were eased after World War I allowing an increase in technological flow in the manufacturing sector. As in the Mexican case, foreign investment continued to decline as a share of total Japanese investment. However, the kind of foreign investment was very important since the technological transfer was often of a very sophisticated nature. The Japanese generally maintained tight control over foreign investments and accepted foreign help only when it became necessary to make further advances. After World War I, the Japanese were required to shift from their policy of bringing in foreign advisors for brief periods to a policy of licensing patents in conjunction with arrangements for technological follow-up between Japanese and foreign firms. Some companies in engineering, automobile assembly and Gramophones were entirely or nearly entirely foreign owned. Most of these companies lost their control during and after World War II.

The textile industry has played an important role in the development of Japan and Mexico. Mexico has imitated the Japanese experience by utilizing the intermediate technology of the textile industry as a link to the modern sector. Antiquated textile machinery imported from foreign countries was and still is combined with labor-intensive techniques following the Japanese example. The textile industry has been absorbing much labor which could not be absorbed by the growing industrial sector in Mexico. If Mexico follows the Japanese example, this labor will be transferred into more sophisticated manufacturing activities at a later date. The textile industry in Mexico has basically utilized intermediate technology as Japan did which integrates the agricultural and industrial sectors. However, Mexico does not have the relatively high educated human resources which were so useful in developing Japan's rudimentary and intermediate technologies. Thus it is questionable whether Mexico can imitate the Japanese story with the same success. Further, Mexico's rapidly expanding population creates additional pressure for very rapid growth of the industrial sector which may not be forthcoming.

The United States firms operating just inside the Mexican border have facilitated the creation of intermediate technologies conducive to eventual absorption of labor into the modern industrial sector. But the limited size of this activity and its geographical setting have limited its impact on the overall economy. It is an example, however, of a Mexican advantage in acquiring technology which was not accessible to Japan. Another important channel of technological transfer which was not available to the Japanese, the bracero program, has been canceled.

Mexico continued to develop its economic base during the 1940s and took advantage of the war and post-war boom. Japan suffered a devastating defeat and faced staggering recovery problems. The technological flow to Mexico in the 1940s increased through the growth of capital goods imports. As the Mexican overhead capital developed the manufacturing sector grew rapidly.

New technologies have accelerated the movement from traditional to modern sectors and from rural to urban areas. Mexico no longer is an export-based economy dependent on enclave technologies. However, Mexico apparently has shifted from foreign financial dependence to foreign technological dependence in the high technological areas such as chemicals, electronics and sophisticated machinery.[1] Even though the government has had control of many of the basic economic sectors, technological dependence has not been eliminated. In fact, nationalization of such industries as mining and petroleum may have helped shift foreign investments into more profitable ventures. The multinational corporations have thus shifted there sphere of interest to the modern high growth industries with the aid of the Mexican government.

The Japanese are also dependent on United States technology, but their dependency is abating. The Japanese have steadily moved away from dependence on foreign technology and have internally developed some of the most sophisticated technology in the world. The growth of modern industry in Mexico, unlike the case of Japan, has not been accompanied by sufficient scientific research to

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[1]Leon Hollerman, "Mexico's Dilemma in Economic Development and the Japanese Solution," Inter-American Economic Affairs, XXIII, No. 2 (Autumn, 1969), 80.

become less dependent on foreign technology. The Japanese acquired foreign technology selectively and adjusted it to their unique needs. Mexico has often imported foreign technology *in toto* and relied on continued technological assistance from foreign countries.

If the product cycle theory mentioned in Chapter II is valid, Mexico and other less developed countries may experience great difficulty in overcoming technological dependence. While it is true that the less developed countries may initiate industrialization through the production of goods requiring intermediate technologies, it does not necessarily follow that they will be able to make the next step to building an independent modern sector utilizing their own sophisticated technologies. The lag between invention and innovation appears to be decreasing in the advanced countries. This places an even greater pressure on the less developed countries to accelerate their growth in order to simply maintain their relative technological position vis-a-vis the advanced countries.

Summary

This chapter has attempted to bring out some of the commonalities and differences in the Mexican and Japanese experiences. The differences between the two countries' development and technological acquisition are great, but there are some common factors. The role of the government in each country was critical in building the economic infrastructure and determining the channels of technological transfer. In both countries a great deal of eclecticism was displayed by the government and the private sector in the acquisition of new technology. Both countries' methods of acquiring technology within their institutional frameworks have roots in the past. Both countries managed to achieve institutional changes without tearing apart their cultural fabric. A quality of submissiveness in the population of Japan and Mexico affected the modes of technological transfer -- in one case national independence was the result while in the other case the result was foreign domination.

Several commonalities existed in the agricultural sector as a result of government reform and small labor-intensive land plots. Both governments initiated land reform, and the two countries are still burdened with inefficient small land plots in the agricultural sector. In both cases, especially in Mexico, land reform was a politically popular measure which took precedence over economic efficiency. Small farms in each country were an asset in absorbing potentially surplus labor while the industrial sector was still in its nascent stage. Japan was seen to be much more successful in adapting new technologies to labor-intensive agriculture as a result of the educational level of the farmer and elaborate governmental support in the form of extension services. Both governments initiated agricultural policies conducive to industrialization. The new Meiji tax system provided revenues for the acquisition of Western technology. Mexican land reform broke up the hacienda system which had been an obstacle to industrialization. In both countries increased agricultural productivity resulted in greater farm incomes which caused an increase in demand for manufactured goods.

Textiles played an important role in the acquisition and adaptation of technology in both countries. Intermediate labor-intensive technology in the textile industries was useful in absorbing labor surpluses while building a semi-skilled labor force in both countries. Mexico was able to take advantage of the World War II textile market, as Japan had in World War I, to expand exports and build up supplies of foreign exchange to be utilized for the purchase of foreign technology.

Japan and Mexico have a history of fear of foreign domination and have directed their policies since the early 1900s toward economic independence. Wholly owned foreign branch plants have become less important in both countries as the focus has shifted to acquisition of technology through the licensing of patents and joint ventures, often within the framework of multinational corporations.

The vast differences in history, geographical location, and land systems were contrasted. The resource endowments of the two countries were very different and affected the types of technologies acquired from foreign countries. The role of religion was less a barrier in technological acceptance in Japan than in Mexico. Mexico's experience of foreign domination, enclave technology, and early traditional export-based economy is quite different from the Japanese experience. The homogeneity of Japanese culture and the differences between the samurai ethic and the mestizo personality were emphasized. The Japanese advantage in education, agriculture, extension services, labor-intensive agriculture, imitation of Western products for export and use of foreign technical advisors are quite different from the Mexican example. It was noted that Mexico did have the bracero program and border industries as a source of technology not available to the Japanese. Finally, the possibility was raised that Mexico, unlike Japan, is becoming more technologically dependent upon sophisticated foreign technology. Whether Mexico and other less developed countries can overcome this tendency remains an important and unsettled question.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

The purpose of this study has been to compare, from a cultural and historical perspective, the experiences of Mexico and Japan in acquiring foreign technology. Technology and technological transfer were defined and related to the process of economic development. Since most research and development takes place in the developed countries the study of the transfer of new technologies to the less developed countries was seen as a crucial factor in their development. An examination of the cultural setting and institutional arrangements of a country was deemed necessary to understanding the processes of technological transfer and diffusion. It was noted that technology is not generally successfully transferred *in toto* but requires adaptation to each country's unique requirements. Further, the more backward a country in terms of industrialization, the more likely institutional adjustment is necessitated.

A vast variety of channels of technological transfer exist. These were discussed placing special emphasis upon the role of the multinational corporations, the local firm, governments, research institutes, and universities. Three factors emerged as crucial to the successful transfer of technology through these channels. First there is a need for multilateral assistance from the developed to the less developed countries. The assistance may take the form of soft loans, grants, special trading status, technicians, student exchange programs, funding of regional development organizations, etc. Multilateral assistance of this type is essential for a steady flow of technical assistance unencumbered with political vagaries. Second there must be a commitment on the part of the government of the less developed country to direct technical assistance toward consciously planned development. Third the multinational corporations play a key role in the transfer process. However, it is by no means certain that the development of the less developed countries and the interests of the multinational corporations are always compatable. Some countervailing power in the form of cooperation between nonprofit international agencies and the governments of the developed and less developed countries may be necessary to prevent exploitation or misguided economic growth.

The product cycle theory was examined in conjunction with the rise of multinational corporations. This theory may at least partially explain the pattern of investments of the multinational corporations. New products originate in the developed countries as a result of their heavy research and development. After the products are established in domestic markets they are eventually exported to other countries. Finally the less developed countries may begin to produce these products for domestic consumption and eventually export these products to other countries. The validity of the product cycle theory is still being hotly debated and was not offered as a factual process but rather brought forth as a plausable possibility. If the theory is valid, it raises the spectre of the less developed countries being left in a technological backwash. With some equivocation it was noted that the production by the less developed countries of the goods at the end of the product cycle may have positive effects in initiating industrial growth. Thus the stage was set for potential economic development or technological exploitation. The end result depends on political and historical events. At the time of the writing of this study, the outlook does not appear to be encouraging to the author.

The purpose of the study, however, has not been to predict from a clouded crystal ball but rather to examine the setting in which technological transfer and economic development take place. The cases of Japan and Mexico were used to illustrate the successes and failures of this process. Other countries may not be able to imitate the Japanese and Mexican examples, but there are lessons to be learned from an examination of their experiences. The accelerating pace of technological change and the emergence of the multinational corporation create a different set of circumstances to be coped with by the less developed countries. But even within this new environment, the less developed countries may be able to avoid the mistakes of the past and take advantage of the lessons of history.

One factor, foreign domination, was of overwhelming importance in the development of Mexico. The land system and mestizo personality grew out of this heritage. It is within this context that the initial foundation for the transfer of technology and economic development took place. From Spanish rule through the Porfirian period the resources of Mexico were directed toward the interests of foreign powers. The vast influx of capital into Mexico during the Porfirian period resulted in relatively small benefits for long-run development. Railway lines were built north and south to connect raw materials to the United States instead of east and west for the development of the Mexican infrastructure. Pipelines were directed to Veracruz for shipment to foreign countries instead of to the Mexican interior, where no refineries had been constructed for Mexican development projects. Technological enclaves in agriculture and the extractive industries led to little technological diffusion.

Greater domestic control followed the Porfirian period, and foreign branch plants were established under the guidance of the Mexican government. Even under these circumstances foreign firms managed to circumvent government regulation. Increased nationalization marked by the expropriation of the oil industry in 1938 gave Mexico greater independence in many key sectors of the economy. During World War II and the following decades Mexico was able to acquire foreign technology, mainly in the form of capital goods, which resulted in steady economic development. But history and tradition especially the mestizo personality, contributed to the very uneven distribution of the fruits of economic growth. Dualisms in agriculture and industry have inhibited the transfer and diffusion of technology to a large segment of the Mexican population. The lack of available credit and the general neglect of the peasant population has tended to cement the dualistic nature of the Mexican system.

Dualism as an obstacle to development was seen to be especially severe in the agricultural sector. The brilliant research of the Rockefeller Foundation and the ensuing Green Revolution did not spread to the peasant farmer. A general lack of education and an insufficient extension service system impeded the diffusion of the new technology to the vast majority of Mexican farmers. This was unfortunate since the new seed varieties are well suited to labor-intensive techniques and require relatively little inputs such as large irrigation systems. The result has been an inefficient allocation of agricultural inputs within the context of a cost-benefit analysis. Further, the reliance upon large commercial farms utilizing capital-intensive techniques has virtually necessitated, given the present land system, a large number of small farms of inefficient size. And even if Mexico becomes self-sufficient in the production of modern capital-intensive farm machinery, foreign parts still have to be imported, putting a strain on foreign exchange reserves. Another impact of capital-intensive agricultural technology was a displacement of rural labor which could not be absorbed in the industrial sector. Agricultural dualism has left large segments of the rural population with very little purchasing power and therefore has impeded the interaction between the agricultural and industrial sectors of the Mexican economy. It was noted, however, that the Mexican government may have had little choice but to establish small farm plots in order to achieve poltical stability.

Dualism in the industrial sector apparently does not obstruct technological diffusion to the degree it does in agriculture. In fact the industries utilizing intermediate technologies may serve as a bridge to the modern sector. Border industries, automobile assembly, textiles, and the footwear industries all offer the possibility of integrating intermediate technologies with the modern sector while absorbing large amounts of labor. However, it was noted that the dualism in the Mexican industrial sector appears to be becoming a permanent part of the economic system. Japan, on the other hand, purposely and steadily phased out intermediate technological industries while shifting more and more to industries requiring advanced technology.

The two chapters on Japan were developed along a format similar to the analysis of Mexico. Two factors were basic to the successful transfer and diffusion of technology in Japan. From the beginning the new prefectural government emphasized independent development through the acquisition and dissemination of Western technology. This effort was aided by the relatively high level of education of the Japanese population and their willingness to accept new technologies. Through trial and error the Japanese adapted Western technology to their unique requirements. Institutional adjustment, especially the changing role of the samurai, was smooth and oriented around the assimilation of Western techniques for the building of a modern, powerful, and independent Japan.

Western technology was adapted to the labor-intensive wet paddy farming of Tokugawa heritage. Increased productivity in agriculture permitted the acquisition of Western industrial technology necessary for building the base of a modern economy. Military success and increased exports added to the foreign exchange reserve, permitting further acquisition of foreign technology. Western scientists, engineers, and technicians were brought to Japan only long enough for the Japanese to learn to use their technology, and then the foreigners were sent home.

After World War I the Japanese were forced to acquire foreign technology through the establishment of branch plants and the licensing of patents. But even within this changed environment the Japanese were selective in their choice of technologies and demanded technological follow-up by foreign interests. Foreign technology was not accepted _in toto_ but adapted to the labor-intensive nature of Japan's industry.

Following World War II, the Japanese recovery faltered and then steadily grew with the help of land reform and American aid. Once again the Japanese pursued economic development through the selective acquisition of foreign technology. The government closely supervised agreements between foreign and Japanese firms and helped Japanese firms to acquire technology useful to the development of the modern sector on favorable terms. The pattern of development was strikingly similar to that of the Meiji period, establishing the historical continuity of the Japanese experience. Japan's recent success has its roots deeply embedded in its past. The re-emergence of the _zaibatsu_ in the form of the _keiretsu_ gave Japan powerful business organizations capable of competing with the modern multinational corporations. Japan's development since World War II was marked by a dependence on foreign technology. Japan initially often imitated foreign technology but has steadily moved away from technological dependence by establishing its own research and development base. It was noted that the Japanese research and develoment has been of a non-military nature and therefore extremely rewarding.

The comparison of the Mexican and Japanese experiences has revealed vast differences but also some important commonalities. The successes and failures of technological transfer and diffusion in both countries had roots in the past. Institutional adjustment was achieved in both countries without destroying the cultural fabric. Traits of obedience existed in the populations of Japan and Mexico and both countries were oriented toward obtaining economic development for national power. Both governments were important in establishing an economic base for future expansion. Each government was eclectic in its acquisition of new technologies and in the role the government played vis-a-vis the private sector. Textiles were important in the acquisition of intermediate technologies of the two countries. Both Japan and Mexico were able to overcome the foreign exchange obstacle by increasing their exports while other countries were at war. The two countries also had a fear of foreign domination which affected their model of technological acquisition. Political stability in both countries created a framework conducive to the acquisition of foreign technology. In both countries there was a shift from the acquisition of foreign technology through foreign owned branch plants to the utilization of licensing patents within a context of joint ventures and multinational corporations.

Mexico has been referred to as the Japan of the Western hemisphere due to its rate of economic growth since the 1940s and the government's active role in striving for economic development. Yet the differences between the two countries perhaps offer more enlightenment than their commonalities. Great contrasts have existed in land systems, cultural heritage, historical events, geographical location, and resource endowment. Particularly important was the Japanese emphasis on education, agricultural extension services, and the adaptation of Western technology to Japan's unique requirements. Japan's freedom from foreign domination and policy of using foreign advisors only for periods long enough to acquire domestic expertise were different from the Mexican experience.

Both Japan and Mexico developed economic dualisms in their industrial sector. The main flow of foreign technology has been directed toward the modern sector of both countries. But in the case of Japan the economy apparently has become less dualistic while in Mexico dualism has become more deeply embedded in the economic system. Thus there has been greater diffusion of industrial technology in Japan than in Mexico.

Japan's agricultural sector has always been labor-intensive whereas Mexico has developed a dualistic agricultural economy. This pattern in Mexico resulted in an influx of capital embodied technology on the large commercial farms at the near exclusion of the rest of the rural economy. Perhaps Mexico could make significant gains in agriculture by imitating the Japanese model of labor-intensive methods on medium size land plots. Japan, it was seen, needs now to engage in less labor-intensive methods and devote more human resources to the modern industrial sector.

The comparison of Japan and Mexico brought forth commonalities and differences in the process of technological transfer which may be useful to the less developed countries in their attempt to achieve economic development through the acquisition of new technologies. This was the primary purpose of this study and this goal seems to have been fulfilled. The importance of technological acquisition for economic development was established. The successes and failures of the two countries examined dramatically demonstrated the need for the less developed countries to selectively acquire technology suited to their unique requirements. The selection of rudimentary, intermediate, and sophisticated technologies must be made according to each country's resource endowment. As yet there is no general ecconomic theory for the less developed countries to use, they must adapt their economic theory as well as their technology and institutions to their own special case.

The Japanese and Mexican experiences illustrate the need for development economists to understand the historical background, culture, and the process of technological and institutional adjustment in the less developed countries. The experiences of these two countries demonstrate the necessity that the less developed countries establish governments committed to economic development while avoiding foreign domination or uncritical emulation of advanced economies. Human resources should be developed within an institutional framework conducive to the acceptance of new technology.

It was concluded that one reason for the degree of success of Japan and Mexico in their acquisition of technology was their ability to utilize cultural patterns rooted in the past for the transition to modernization. Institutional change was achieved in both countries without tearing apart the cultural fabric. The less developed countries, it would appear, should attempt to follow this pattern of institutional adjustment based on their unique cultural heritage.

The role of the state has been a vital factor in creating political stability and building the economic infrastructure of Japan and Mexico. It would seem that in this age of more sophisticated technology the role of the state is still a crucial element in the development process. The fact that both countries devote only a minute portion of their resources to the military may be informative to governments seeking rapid development.

The selectivity of both governments, especially Japan, in the acquisition of foreign technology should be particularly illuminating to the less developed countries. The Japanese pragmatically experimented with Western technology in both agriculture and industry. They experienced some failures in acquiring technology not suited for their unique requirements. Through trial and error the Japanese selected, imitated, and adapted Western technology to their land system, labor force, and natural resource endowment. The Japanese proved, both in the Meiji period and in the years following World War II, that a paucity of natural resources was not an absolute barrier to economic development.

In the introductory chapter of this study, an additional hypothesis stated was that human resources are perhaps the most important factor in the development process. The experiences of both Japan and Mexico appear to validate this hypothesis. Japan's initial development in the Meiji period and dramatic postwar recovery was receptive to acquiring new technologies for the purpose of economic development. Education of both a formal and informal nature was largely responsible for the high level of human resources in Japan. Japan's human resources enabled the Japanese to overcome obstacles to technological transfer such as a paucity of natural resources, a shortage of capital, and high transportation costs.

The general lack of an educated population has not aided the Mexican process of acquiring and diffusing technology. The result has been lower productivity in both the agricultural and non-agricultural sectors. It was seen that insufficiently educated supervisors and workers reduce productivity and direct managers to acquire capital-intensive technologies out of proportion to the available supply of labor. Inadequate primary education and a poor extension service in rural areas has hampered the diffusion of technological advances created in Mexico's fine research centers. Thus in considering their priorities the less developed countries may do well to consider the development of their human resources through initially rudimentary education techniques.

Japan and Mexico sent students and technologists to foreign countries for the purpose of acquiring human skills necessary for transmitting technology to their countries. Mexico has had an advantage over Japan in this aspect due to the close proximity of the United States. However, Japan's greater stress on education compensated for geographical isolation and as a result Japan has continuously sent a proportionately greater number of students to foreign countries. Students from both countries have concentrated on engineering, the physical sciences, and other areas of study crucial to the development process. The less developed countries may find it useful to concentrate their educational efforts in a similar manner.

Another lesson from the study of the Japanese and Mexican experience is the necessity for face to face contact with the foreigners conveying the new technologies. In both cases technological transfer was more successful when licensing agreements included face to face contact and technological follow-up. It is not enough to simply ship a piece of machinery or a technological process to a less developed country. Personal demonstration and help in modification of the technology to each unique situation is required. Examples throughout this study seem to support this conclusion.

Both Mexico and Japan were able to overcome the financial barrier to the acquisition of foreign technology. In both cases increased agriculture productivity permitted the transfer of an economic surplus to the industrial sector. In each case the two countries were able to obtain more foreign exchange by increasing their exports. The agricultural sector was of paramount importance in the general acquisition of technology -- a point which should not be ignored by less developed countries.

Japan and Mexico developed labor-intensive agriculture and adapted foreign technology to their land systems. Mexico, unlike Japan, also developed large commercial farms utilizing capital-intensive technology. The impact of Mexico's dualistic approach to agriculture has resulted in great increases in production, especially in the large capital-intensive sector. The labor-intensive sector has absorbed potentially surplus labor thus easing the migration from rural to urban areas. In both countries the small land plots have caused economic inefficiency but may have been politically necessary. Many less developed countries may find that labor-intensive agriculture is well suited to their needs. The challenge is to adapt and create technologies to different types of labor-intensive systems which is dependent upon each countries resource base. The Green Revolution has made this task easier than in the past.

The commonalities revealed in the experience of the two countries suggest that the less developed countries may profit by following the general approach of Japan and Mexico in acquiring foreign technology. However, the thrust of the study emphasized that each country must tailor foreign technology to their own distinctive characteristics.

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