ECONOMIC DEVELOPMENT CENTER

TECHNICAL AND INSTITUTIONAL CHANGE IN AGRICULTURAL DEVELOPMENT: TWO LECTURES

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Lecture One

TECHNICAL CHANGE AND AGRICULTURAL DEVELOPMENT

We are, in the closing years of the twentieth century, completing one of the most remarkable transitions in the history of agriculture. Prior to this century, almost all increase in food production was obtained by bringing new land into production. There were only a few exceptions to this generalization--in limited areas of East Asia, in the Middle East, and in Western Europe. By the end of this century almost all of the increase in world food production must come from higher yields--from increased output per hectare. In most of the world the transition from a resource-based to a science-based system of agriculture is occurring within a single century. In a few countries this transition began in the nineteenth century. In most of the presently developed countries it did not begin until the first half of this century. Most of the countries of the developing world have been caught up in the transition only since mid-century.

MODELS OF TECHNICAL CHANGE IN AGRICULTURE

The traditional literature on agricultural development can be classified under five general headings. These are (1) the resource exploitation, (2) the conservation, (3) the location, (4) the diffusion, and (5) the high-payoff input models.

The Resource Exploitation Model

Throughout most of history, expansion of the area cultivated or grazed has represented the dominant source of increase in agricultural production. The most dramatic example in Western history was the opening up of the new continents--North and South America and Australia--to European settlement during the eighteenth and nineteenth centuries. With the advent of cheap transport during the latter half of the nineteenth century, the countries of the new

continents became increasingly important sources of food and agricultural raw materials for the metropolitan countries of Western Europe.

Similar processes had occurred earlier, though at a less dramatic pace, in the peasant and village economies of Europe, Asia, and Africa. The agrarian colonization of the Indus and Ganges river vallies occurred in the third millennium B.C. The first millennium A.D. saw the agricultural colonization of Europe north of the Alps, the Chinese settlement of the lands south of the Yangtze, and the Bantu occupation of Africa south of the tropical forest belts. Intensification of land use in existing villages was followed by pioneer settlement, the establishment of new villages, and the opening up of forest or jungle land to cultivation. In Western Europe there was a series of successive changes from neolithic forest fallow to systems of shifting cultivation of bush and grassland followed first by short fallow systems, and later by annual cropping.

Where soil conditions were favorable, as in the great river basins and plains, the new villages gradually intensified their system of cultivation. Where soil resources were poor, as in many of the hill and upland regions, new areas were opened up to shifting cultivation or nomadic grazing. Under conditions of rapid population growth, the limits to the resource exploitation model were often quickly realized. Crop yields were typically low--measured in terms of output per unit of seed rather than per unit of crop area. Output per hectare and per man-hour tended to decline--except in the delta areas of Egypt and South Asia and in the wet rice areas of East Asia. In many areas the result was increasing immersionization of the peasantry.

Agriculture carried on within the framework of the resource exploitation model was, in most parts of the world, capable of supporting only very limited urban concentrations - trading centers and seats of government. Most food was consumed in the village in which it was produced. Much of the surplus that did

become available was extracted from the village by the land lords in the form of rents, and by the church in the form of tithes. The limited surplus that could be accumulated exerted a decisive impact on political organizations. The military campaigns that Charlemaign waged against the Germans to extend his Frankish kingdom could not be waged until early summer. The great heavy horses that carried his armed knights had to be out on grass, after a winter on poor feed, long enough to get in condition.

There are relatively few remaining areas of the world where development along the lines of the resource exploitation model will represent an efficient source of growth during the last two decades of the twentieth century. The 1960s saw the "closing of the frontier" in most areas of Southeast Asia. In Latin America and Africa the opening up of new lands awaits development of technologies for the control of pests and diseases (such as the tsetse fly in Africa) or for the release and maintenance of productivity of problem soils. The decline in food production that has been experienced in many African countries over the last several decades is an insistent reminder that agricultural growth along the lines described by the resource exploitation model is no longer a reliable source of growth in food production.

The Conservation Model

The conservation model of agricultural development evolved from the advances in crop and livestock husbandry associated with the English agricultural revolution and the notions of soil exhaustion suggested by the early German chemists and soil scientists. It was reinforced by the application to land of the concept, developed in the English classical school of economics, of diminishing returns to labor and capital.

Until well into the twentieth century the conservation model of agricultural development was the only approach to intensification of agricultural

production available to most of the world's farmers. Its application is effectively illustrated by the development of the wet-rice culture systems that emerged in East and Southeast Asia and by the labor- and land-intensive systems of integrated crop-livestock husbandry which increasingly characterized European agriculture during the eighteenth and nineteenth centuries.

During the English agricultural revolution more intensive crop-rotation systems replaced the open-three-field system in which arable land was allocated between permanent cropland and permanent pasture. This involved the introduction and more intensive use of new forage and green manure crops and an increase in the availability and use of animal manures. This "new husbandry" permitted the intensification of crop-livestock production through the recycling of plant nutrients, in the form of animal manures, to maintain soil fertility. The inputs used in this conservation system of farming—the plant nutrients, animal power, land improvements, physical capital, and agricultural labor force—were largely produced or supplied by the agricultural sector itself.

Agricultural development, within the framework of the conservation model, clearly was capable in many parts of the world of sustaining rates of growth in agricultural production in the range of 1.0 percent per year over relatively long periods of time. The most serious recent effort to develop agriculture within this framework was made by the People's Republic of China in the late 1950s and early 1960s. It became readily apparent, however, that the feasible growth rates, even with a rigorous recycling effort, were not compatible with modern rates of growth in the demand for agricultural output—which typically fall in the 3-5 percent range in the less developed countries (LDCs). The conservation model remains an important source of productivity growth in most poor countries and an inspiration to agrarian fundamentalists and the organic farming movement in the developed countries.

The Location Model

Initially, the location model was formulated in Germany by J. H. von Thünen to explain geographic variations in the intensity of farming systems and the productivity of labor in an industrializing society. In the United States it was extended to explain the more effective performance of the input and product markets in regions of rapid urban-industrial development than in regions of slower urban-industrial development. In the 1950s, interest in the location model reflected concern with the failure of agricultural resource development and price policies, adopted in the 1930s, to remove the persistent regional disparities in agricultural productivity and rural incomes in the United States.

The rationale for this model was developed in terms of more effective input and product markets in areas of rapid urban-industrial development. Industrial development stimulated agricultural development by expanding the demand for farm products, supplying the industrial inputs needed to improve agricultural productivity, and drawing away surplus labor from agriculture. The empirical tests of the location model have confirmed repeatedly that a strong nonfarm labor market is a prerequisite for labor productivity in agriculture and improved incomes for rural people.

The policy implications of the location model appear to be most relevant for less developed regions of highly industrialized countries or lagging regions of the more rapidly growing LDCs. Agricultural development policies based on this model appear to be particularly inappropriate in those countries where the "pathological" growth of urban centers is a result of population pressures in rural areas running ahead of employment growth in urban areas.

The Diffusion Model

The diffusion of better husbandry practices was a major source of productivity growth even in premodern societies. The diffusion of crops and animals

from the new world to the old--potatoes, maize, cassava, rubber--and from the
old world to the new--sugar, wheat, and domestic livestock--was an important by-
product of the voyages of discovery and trade from the fifteenth to the nine-
teenth centuries.

Diffusion of crops and animals had historically proceeded as a by-product of
trade, discovery and migration. The diffusion of maize to the Old World is an
example. Within a decade after Columbus had first displayed Indian Corn (maize)
at the Spanish court it was being grown in the Po Valley in Northern Italy. In
that relatively short time it had diffused from Spain and across North Africa to
Turkey and was brought to the Po Valley by Venetian traders.

By the latter part of the nineteenth century all major agricultural nations
were actively engaged in organized crop exploration and introduction. The
famous trip of Captain Bligh to the South Pacific, described in the book and the
film, Mutiny on the Bounty, was undertaken as a crop exploration mission. His
assignment was to bring back breadfruit seedlings and wild sugarcane cultivars.
But his crew was more attracted to brown girls.

The purpose of establishing botanical gardens by the great colonial powers,
was primarily to serve as crop introduction stations. The diffusion of rubber
from Brazil to Southeast Asia illustrates their role. When the process of
vulcanization was invented - making it possible to produce such desirable pro-
ducts as rubber boots, raincoats and tyres - the price of natural rubber, pro-
duced from wild trees in the Amazon basin of Brazil, skyrocketed. Brazil made it
illegal to export either rubber seeds or rubber plants. The British sent a
botanical expedition to Brazil with the ostensible purpose of collecting plants
that had medicinal value. But they also brought back rubber seeds. The seeds
were first sprouted at the Royal Botanical Garden at Kew. The seedlings were

then transferred to the botanical gardens at Kandy (Ceylon) and in Singapore.
The Kandy seedlings died but the Singapore seedlings lived and became the foun-
dation stock of the rubber industry in South East Asia.

In the early post World War II period the diffusion model provided the
intellectual foundation for technical assistance to developing countries.
President Truman talked about American "know-how - show-how." The naive dif-
fusion approach drew on the empirical observation of substantial differences in
land and labor productivity among farmers and regions. The route to agri-
cultural development in this view was through more effective dissemination of
technical knowledge and the narrowing of productivity differences.

The diffusion model has provided the major intellectual foundation of much
of the research and extension effort in farm management and production economics
since the emergence, in the latter years of the nineteenth century, of agri-
cultural economics and rural sociology as separate subdisciplines linking the
agricultural and the social sciences. Developments leading to the establishment
of active programs of farm management research and extension occurred at a time
when experiment station research was making only a modest contribution to agri-
cultural productivity growth. A further contribution to the effective diffusion
of known technology was provided by rural sociologists' research on the dif-
fusion process. Models were developed emphasizing the relationship between dif-
fusion rates and the personality characteristics and educational accomplishments
of farm operators.

Insights into the dynamics of the diffusion process, when coupled with the
observation of wide agricultural productivity gaps among developed and less
developed countries and a presumption of inefficient resource allocation among
"irrational tradition-bound" peasants, produced an extension or diffusion bias
in the choice of agricultural development strategy in many LDCs during the

1950s. During the 1960s the limitations of the diffusion on technology transfer model as a foundation for the design of agricultural development policies became increasingly apparent as technical assistance and rural development programs - based explicitly or implicitly on this model - failed to generate either rapid modernization of traditional farms and communities or rapid growth in agricultural output. There were very few opportunities to generate large productivity gains through the transfer of technology from one agroclimatic zone to another, or even among regions in the same agroclimatic zone. The pipeline was empty!

The High-Payoff Input Model

The inadequacy of policies based on the conservation, urban-industrial impact, and diffusion models led, in the 1960s, to a new perspective: The key to transforming a traditional agricultural sector into a productive source of economic growth is investment designed to make modern, high-payoff inputs available to farmers in poor countries. Peasants in traditional agricultural systems were viewed as rational, efficient resource allocators.

In Transforming Traditional Agriculture, T. W. Schultz insisted that peasants in traditional societies remained poor because there were only limited technical and economic opportunities to which they could respond. The new, high-payoff inputs were classified according to three categories: (1) the capacity of public and private sector research institutions to produce new technical knowledge; (2) the capacity of the industrial sector to develop, produce, and market new technical inputs; and (3) the capacity of farmers to acquire new knowledge and use new inputs effectively.

The enthusiasm with which the high-payoff input model has been accepted and translated into economic doctrine has been due in part to the proliferation of studies reporting high rates of return to public investment in agricultural

research (Table 1.0). It was also due to the success of efforts to develop new, high-productivity grain varieties suitable for the tropics. New, high-yielding wheat varieties were developed in Mexico beginning in the 1950s, and new, high-yielding rice varieties were developed in the Philippines in the 1960s. These varieties were highly responsive to industrial inputs such as fertilizer and other chemicals and to more effective soil and water management. The high returns associated with the adoption of the new varieties and the associated technical inputs and management practices have led to rapid growth in investment in agricultural research and to the development and adoption of the new and more productive crop varieties among farmers in a number of countries in Asia, Africa, and Latin America.

But the acceptance of the high-payoff input model has been incomplete. Many countries have not yet freed their private sector to produce and market the new technical inputs that enhance productivity. Those are functions which the public sector typically performs poorly. The constraints placed on market development continue to deprive farmers and consumers of the gains from new technology that is becoming available.

There has been even greater reluctance, in a number of developing countries, to accept the implication of the high input model for the schooling of farm people. The intellectuals and planners in many developing countries find it difficult to understand the importance, for agricultural development, of a literate and a numerate peasantry. When advances in agricultural technology occurred slowly the apprenticeship mode of learning, without formal schooling, from family and village elders was adequate. But when a continuous stream of new biological and mechanical technology becomes available the returns to the acquisition of new skills in production and marketing are driven up. It becomes important not only to accept but also to be able to adapt or reject the new

"packages" of practices and inputs being recommended by research and extension services. Agricultural extension services themselves must be able to advance beyond simply recommending a package of practices or delivering technological and managerial messages to farmers. They must advance from teaching practices to teaching principles!

It seems quite clear that Pakistan has not yet made the investment in the schooling of rural people to enable it to take full advantage of the potentially high-payoff technology that is becoming available. In spite of one of the world's great pieces of agricultural real estate - 35 million acres of irrigated land in the Indus basin - yields remain low by Asian standards. It is hard to avoid a conclusion that underinvestment in human capital has dampened the rate of return to investment in land and water development and to agricultural research and extension.

INDUCED TECHNICAL CHANGE IN AGRICULTURE

The high-payoff input model remains incomplete as a theory of agricultural development. Typically, education and research are public goods not traded through the marketplace. The mechanism by which resources are allocated among education, research, and other public and private sector economic activities was not fully incorporated into the model. It does not explain how economic conditions induce the development and adoption of an efficient set of technologies for a particular society. Nor does it attempt to specify the processes by which input and product price relationships induce investment in research in a direction consistent with a nation's particular resource endowments.

These limitations in the high-payoff input model led Yujiro Hayami and I to develop a model of agricultural development in which technical change is

treated as an exogenous factor. This induced innovation perspective was stimulated by historical evidence that different countries had followed alternative paths of technical change in the process of agricultural development. In the induced innovation model changes or differences in the economic environment influence the direction of technical change.

In discussing the induced innovation Model, I will find it useful, at the risk of some oversimplification, to use the term mechanical technology to refer to those technologies which substitute for labor and the term biological technology to refer to those technologies which generate increases in output per hectare.

Mechanical and Biological Processes in Agricultural Production

The mechanization of agricultural production cannot be treated as simply an adaptation of industrial methods of production to agriculture. The spatial nature of agricultural production results in significant differences between agriculture and industry in patterns of machine use. It imposes severe limits on the efficiency of large scale production in agriculture.

The spatial dimension of crop production requires that the machines suitable for agricultural production must be mobile – they must move across or through materials that are immobile in contrast to moving material through stationary machines as in most industrial processes. Furthermore, the seasonal or spatial characteristics of agricultural production requires a series of specialized machines – for land preparation, planting, weed control and harvesting – specifically designed for sequential operations, each of which is carried out for only a few days or weeks in each season. This means that it is no more feasible for workers to specialize in one operation in mechanized agriculture than in premechanized agriculture. It also means that in a "fully mechanized"

agricultural system the capital-labor ratio tends to be much higher than in the industrial sector in the same country.

In agriculture biological and chemical processes are more fundamental than mechanization or machine processes. This generalization was equally true during the last century as it will be during the era of the "new biotechnology". Advances in biological and chemical technology in crop production have typically involved one or more of the following three elements: (a) land and water resource development to provide a more satisfactory environment for plant growth; (b) modification of the environment by the addition of organic and inorganic sources of plant nutrients to the soil to stimulate plant growth; (c) use of biological and chemical means to protect plants from pests and disease; and (d) selection and design of new biologically efficient crop varieties specifically adapted to respond to those elements in the environment that are subject to mans control. Similar processes can be observed in advances in animal agriculture.

Induced Technical Change: The United States and Japan

One implication of the discussion of mechanical and biological processes is that there are multiple paths of technical change in agriculture available to a society. The constraints imposed by an inelastic supply of land, may be offset by advances in biological technology. The constraints imposed by an inelastic supply of labor may be offset by advances in mechanical technology. These alternatives are illustrated in Figure 1. The 1880-1980 land and labor productivity growth paths for Japan, Denmark, France, Germany, the United Kingdom and the United States, are plotted along with the 1980 partial productivity ratios for a number of developing countries. The impression given by the several growth paths is that nature is relatively "plastic."

In economics it had generally been accepted, at least since the publication of Theory of Wages by Sir John Hicks, that changes or differences in the relative prices of factors of production could influence the direction of invention or innovation. There has also been a second tradition, based on the work of Griliches and Schmookler, that has focused attention on the influence of growth in product demand on the rate of technical change. A model of induced technical change in agriculture is presented in Appendix A. We now turn to an illustration of the role of relative factor endowments and prices in the evolution of alternative paths of technical change in agriculture in the United States and Japan.

Japan and the United States are characterized by extreme differences in relative endowments of land and labor (Table 2). In 1880, total agricultural land area per male worker was more than sixty times as large in the United States as in Japan, and arable land area per worker was about twenty times as large in the United States as in Japan. The differences have widened over time. By 1980 total agricultural land area per male worker was more than one hundred times as large and arable land area per male worker about fifty times as large in the United States as in Japan.

The relative prices of land and labor also differed sharply in the two countries. In 1880 in order to buy a hectare of arable land (compare row 8 and row 16 in Table 2), it would have been necessary for a Japanese hired farm worker to work eight times as many days as a U.S. farm worker. In the United States the price of labor rose relative to the price of land, particularly between 1880 and 1920. In Japan the price of land rose sharply relative to the price of labor, particularly between 1880 and 1900. By 1960 a Japanese farm worker would have had to work thirty times as many days as a U.S. farm worker in order to buy one hectare of arable land. This gap was reduced after 1960

partly due to extremely rapid increases in wage rates in Japan during the two decades of "miraculous" economic growth. In the United States land prices rose sharply in the postwar period primarily because of the rising demand for land for nonagricultural use and the anticipation of continued inflation. Yet, in 1980 a Japanese farm worker still would have had to work eleven times as many days as a U.S. worker to buy one hectare of land.

In spite of these substantial differences in land area per worker and in the relative prices of land and labor, both the United States and Japan experienced relatively rapid rates of growth in production and productivity in agriculture (Tables 3 and 4). Overall agricultural growth performance for the entire one-hundred-year period was very similar in the two countries. In both countries total agricultural output increased at an annual compound rate of 1.6 percent while total inputs (aggregate of conventional inputs) increased at a rate of 0.7 percent. Total factor productivity (total output divided by total input) increased at an annual rate of 0.9 percent in both countries. Meanwhile, labor productivity measured by agricultural output per male worker increased at rates of 3.1 percent per year in the United States and 2.7 percent in Japan. It is remarkable that the overall growth rates in output and productivity were so similar despite the extremely different factor proportions which characterize the two countries.

Although there is a resemblance in the overall rates of growth in production and productivity, the time sequences of the relatively fast-growing phases and the relatively stagnant phases differ between the two countries. In the United States agricultural output grew rapidly up to 1900; then the growth rate decelerated. From the 1900s to the 1930s the was little gain in total productivity. This stagnation phase was succeeded by a dramatic rise in production and productivity in the 1940s and 1950s. Japan experienced rapid increases in

agricultural production and productivity from 1880 to the 1910s, then entered into a stagnation phase which lasted until the mid-1930s. Another rapid expansion phase commenced during the period of recovery from the devastation of World War II. Roughly speaking, the United States experienced a stagnation phase two decades earlier than Japan and also shifted to the second development phase two decades earlier.

The effect of relative prices on the development and choice of technology is illustrated with remarkable clarity for biological technology in Figure 2. In Figure 2, U.S. and Japanese data on the relationship between fertilizer input per hectare of arable land and the fertilizer/land price ratio are plotted for the period 1880 to 1980. In both 1880 and 1980 U.S. farmers were using less fertilizer than Japanese farmers. However, despite enormous differences in both physical and institutional resources, the relationship between these variables has been almost identical in the two countries. As the price of fertilizer declined relative to other factors, scientists in both countries responded by inventing crop varieties that were more responsive to the lower prices of fertilizer. American scientists, however, always lagged behind the Japanese by several decades because the lower prices of land relative to the price of fertilizer in the United States resulted in a lower priority being placed on yield-increasing technology.

The effect of changes in the relative prices of mechanical power and labor in the United States and Japan for 1880-1980 is illustrated in Figure 3. In both 1880 and 1980 U.S. farmers were using more mechanical power than Japanese farmers. But the relationship between the power-labor price ratio and the use of power per worker is again, almost identical in the two countries. But because labor was always less expensive in Japan, the Japanese suppliers of mechanical technology always lagged behind U.S. suppliers by several decades.

These same relationships that hold for Japan and the United States have now been demonstrated for the period 1880-1960 for a number of European countries in the book by Hans P. Binswanger and Vernon W. Ruttan, Induced Innovation: Technology, Institutions and Development.

The effect of a rise in the price of fertilizer relative to the price of land or of the price of labor relative to the price of machinery has been to induce advances in biological and mechanical technology. The effect of the introduction of lower cost and more productive biological and mechanical technology has been to induce farmers to substitute fertilizer for land and mechanical power for labor. These responses to differences in resource endowments among countries and to changes in resource endowments over time by agricultural research institutions, by the farm supply industries, and by farmers, has been remarkably similar in spite of differences in cultures and traditions.

The results of our comparative analyses can be summarized as follows: Agricultural growth in the United States and Japan during the period 1880-1980 can best be understood when viewed as a dynamic factor substitution process. Factors have been substituted for each other along a metaproduction function in response to long-run trends in relative factor prices. Each point on the metaproduction surface is characterized by a technology which can be described in terms of specific sources of power, types of machinery, crop varieties, and animal breeds. Movements along this metaproduction surface involve technical changes. These technical changes have been induced to a significant extent by the long-term trends in relative factor prices.

PERSPECTIVE

In closing decades of twentieth century we are approaching the end of the most remarkable transitions in the history of agriculture.

Prior to the beginning of this century almost all increases in agricultural production occurred as a result of increases in area cultivated. The major exceptions were in Western Europe, where livestock based conservation systems of farming had developed, and in East Asia, where wet rice cultivation systems had developed.

But by the end of this century there will be few significant areas where agricultural production can be expanded by simply adding more land to production. Expansion of agricultural output will have to be obtained almost entirely from more intensive cultivation of the areas already being used for agricultural production. Increases in food and fiber production will depend, in large measure, on continuous advances in agricultural technology.

The task before us is clear. It is imperative, over the next several decades, that we complete the establishment of agricultural research capacity for each commodity of economic significance in each agroclimatic region of the world.

A developing country which fails to evolve a capacity for technical and institutional innovation in agriculture consistent with its resource and cultural endowments suffers two major constraints on its attempts to develop a productive agriculture. It is unable to take advantage of advances in biological and chemical technologies suited to labor-intensive agricultural systems. And the mechanical technology it does import from more developed countries will be productive only under conditions of large-scale agricultural organization. It will contribute to the emergence of a "bimodal" rather than a "unimodal" organization structure.

During the last two decades a number of developing countries have begun to establish the institutional capacity to generate technical changes adapted to national and regional resource endowments. More recently these emerging

national systems have been buttressed by a new system of international crop and animal research institutes. These new institutes have become both important sources of new knowledge and technology and increasingly effective communication links among the developing national research systems.

The lag in shifting from a natural-resource-based to a science-based system of agriculture continues to be a source of national differences in land and labor productivity. Lags in the development and application of knowledge are also important sources of regional productivity differences within countries. In countries such as Mexico and Pakistan, differential rates of technical change have been an important source of the widening disparities in the rate of growth of total agricultural output, in labor and land productivity, and in incomes and wage rates among regions.

Productivity differences in agriculture are increasingly a function of investments in scientific and industrial capacity and in the education of rural people rather than of natural resource endowments. The effects of education on productivity are particularly important during periods in which a nation's agricultural research system begins to introduce new technology. In an agricultural system characterized by static technology, there are few gains to be realized from education in rural areas. Rural people who have lived for generations with essentially the same resources and the same technology have learned from long experience what their efforts can get out of the resources available to them. Children acquire from their parents the skills that are worthwhile. Formal schooling has little economic value in agricultural production.

As soon as new technical opportunities become available, this situation changes. Technical change requires the acquisition of new husbandry skills; acquisition from nontraditional sources of additional resources such as new

seeds, new chemicals, and new equipment; and development of new skills in dealing with both natural resources and with the input and product market institutions that link agriculture with the nonagricultural sector.

The processes by which new knowledge can be applied to alter the rate and direction of technical change in agriculture, are, however, substantially greater than our knowledge of the processes by which resources are brought to bear on the process of institutional innovation and transfer. Yet the need for viable institutions capable of supporting more rapid agricultural growth and rural development is even more compelling today than a decade ago. I will attempt to deal with the process of institutional innovation and change in my second lecture.

AGRICULTURAL OUTPUT PER MALE WORKER (LOG. SCALE)
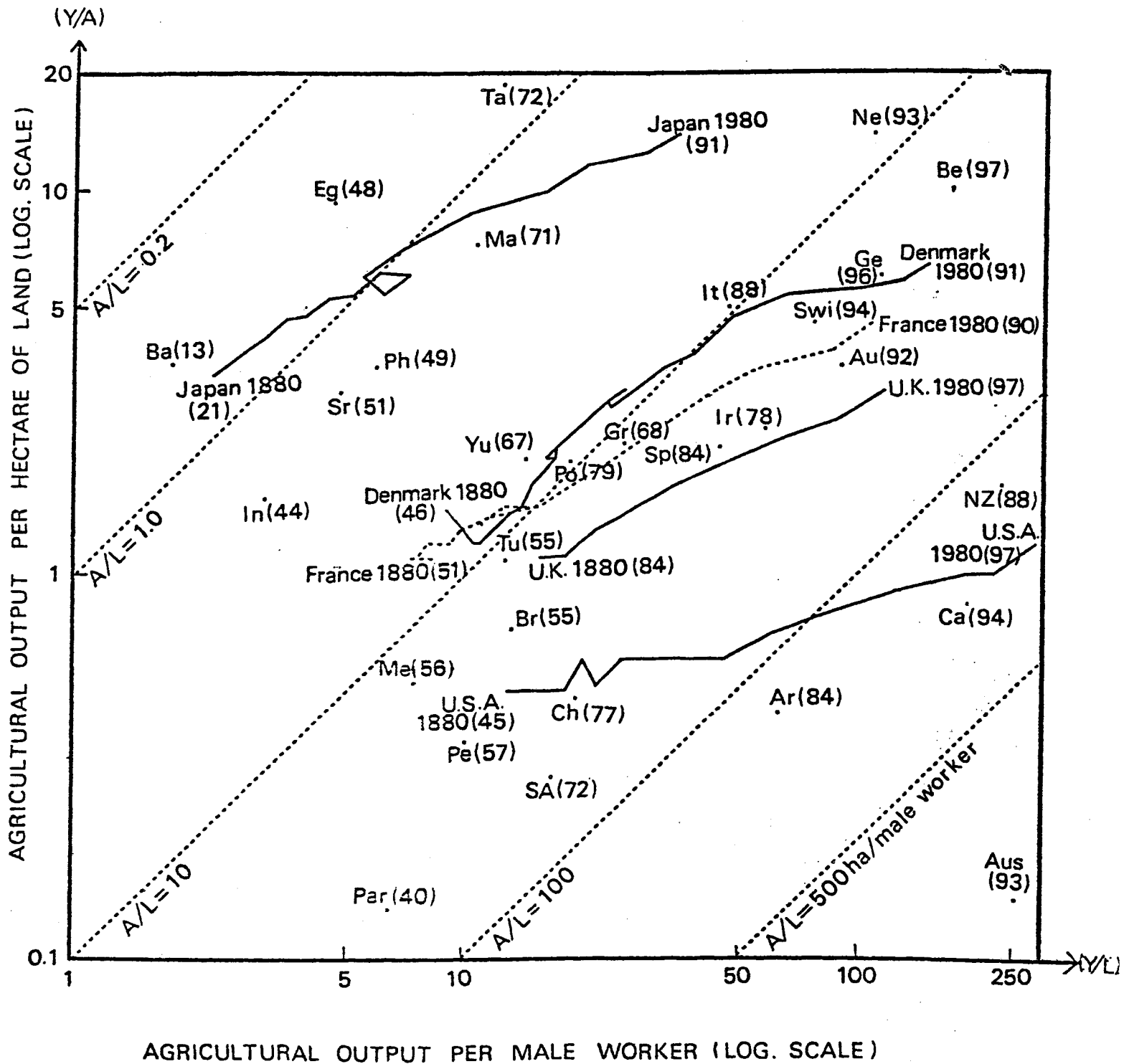
Figure 1. Historical growth paths of agricultural productivity of Denmark, France, Japan, the United Kingdom, and the United States for 1880–1980, compared with intercountry cross-section observations of selected countries in 1980. Values in parentheses are percent of male workers employed in nonagriculture. Data from Appendixes A and B, Hayami and Ruttan, Agricultural Development, rev. ed., 1985.

Symbol key for Figure 1.

Argentina	Ar	Norway	No
Australia	Aus	Pakistan	Pak
Austria	Au	Paraguay	Par
Bangladesh	Ba	Peru	Pe
Belgium (& Luxemburg)	Be	Philippines	Ph
Brazil	Br	Portugal	Po
Canada	Ca	South Africa	SA
Chile	Ch	Spain	Sp
Colombia	Co	Sri Lanka	Sr
Denmark	De	Surinum	Su
Egypt	Eg	Sweden	Swe
Finland	Fi	Switzerland	Swi
France	Fr	Syria	Sy
Germany, F. R.	Ge	Taiwan	Ta
Greece	Gr	Turkey	Tu
India	In	U. K.	UK
Ireland	Ir	U. S. A.	USA
Israel	Is	Venezuela	Ve
Italy	It	Yugoslavia	Yu
Japan	Ja		
Libya	Li		
Mauritius	Ma		
Mexico	Me		
Netherlands	Ne		
New Zealand	NZ		
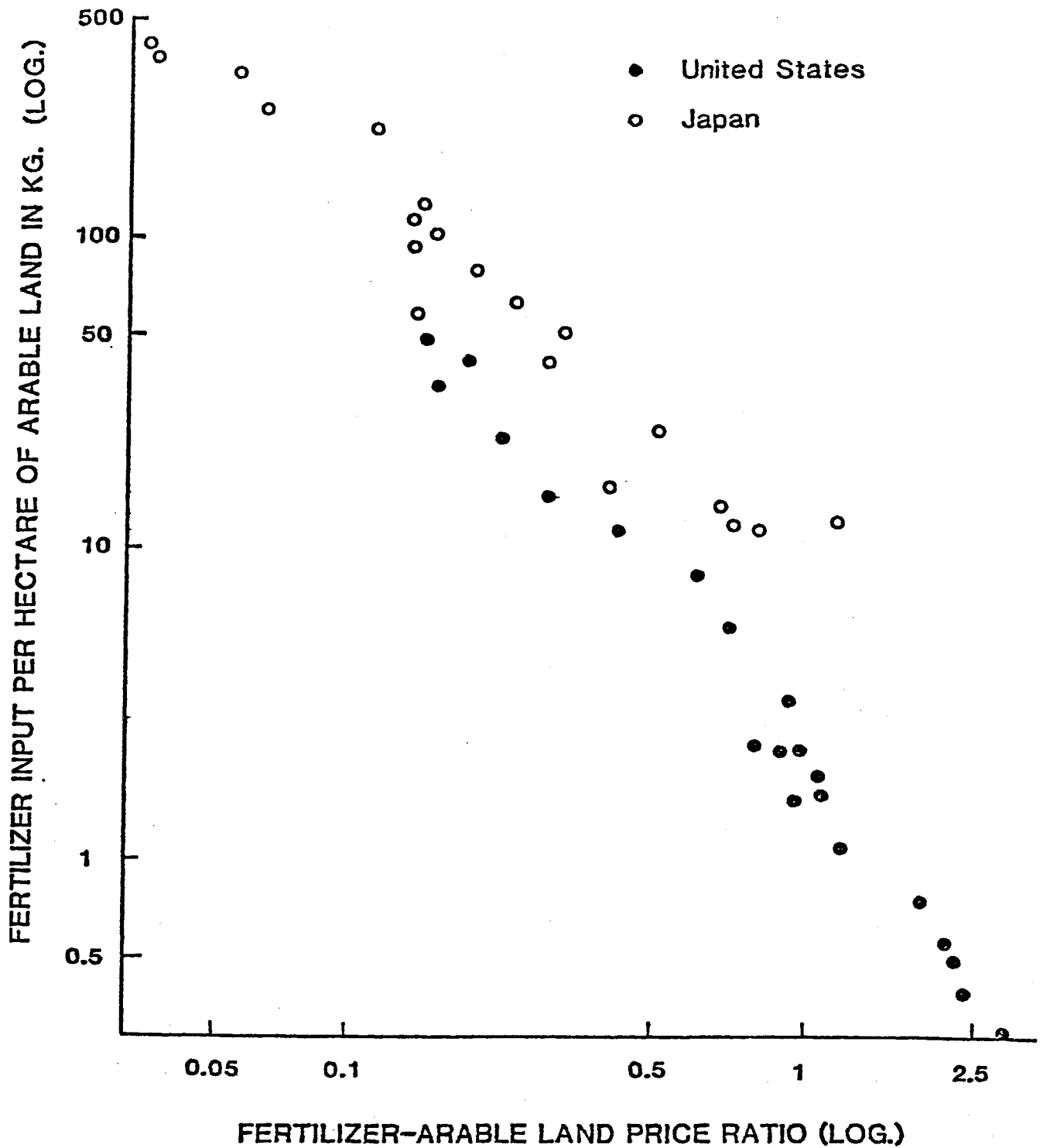
Figure 2. Relation between fertilizer input per hectare of arable land and fertilizer-arable land price ratio (= hectares of arable land which can be purchased by one ton of N + P_2O_5 + K_2O contained in commercial fertilizers), the United States and Japan, quinquennial observations for 1880-1980. Data from Appendix C, Hayami and Ruttan, <u>Agricultural Development</u>, rev. ed. (Baltimore: Johns Hopkins University Press, 1985).
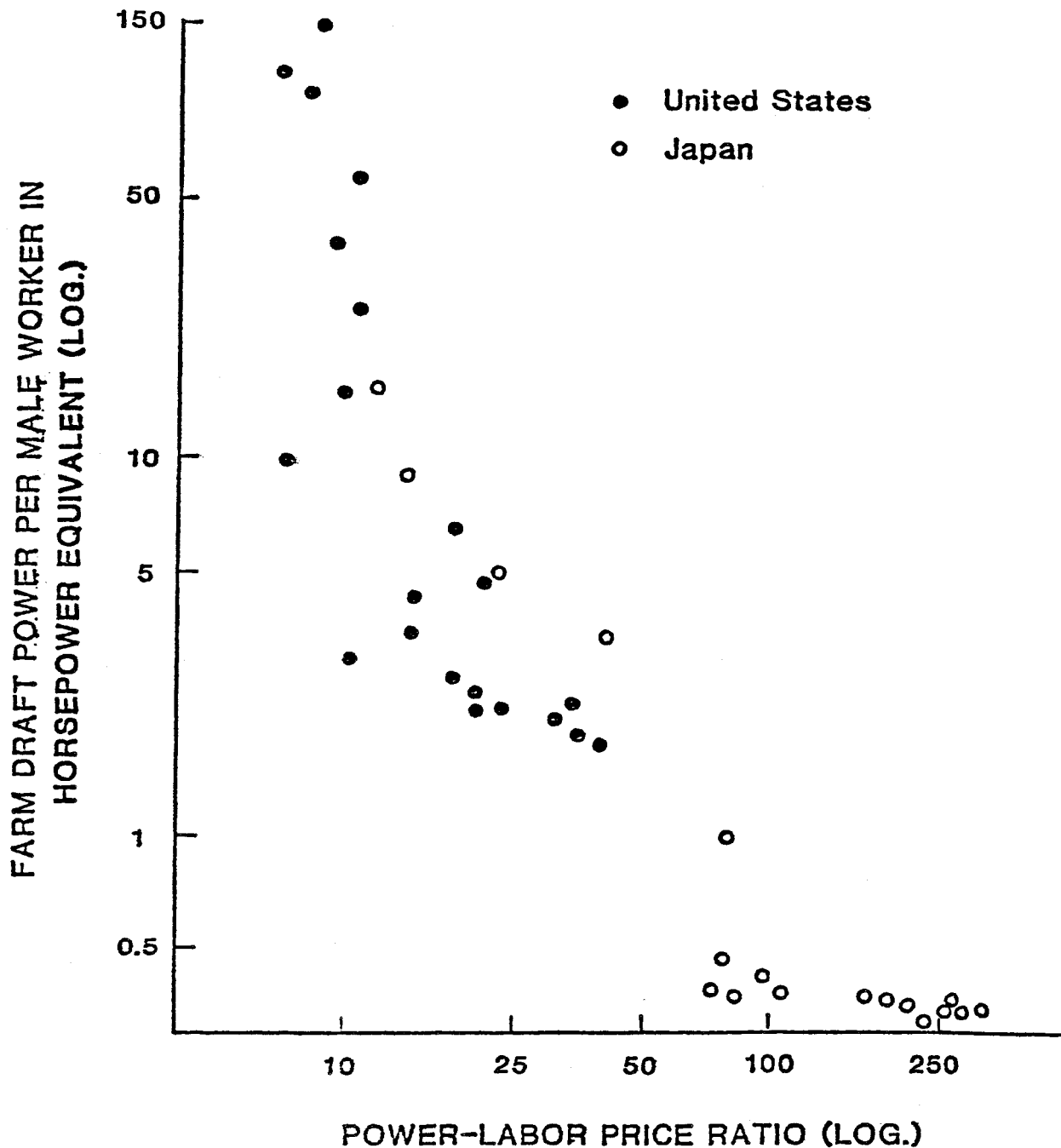
Figure 3. Relation between farm draft power per male worker and power–labor price ratio (= hectares of work days which can be purchased by one horsepower of tractor or draft animal), the United States and Japan, quinquennial observations for 1880–1980. Data from Appendix C, Hayami and Ruttan, Agricultural Development, rev. ed. Number of male workers = U3 and J3, Power = U7 + U8 and J7 + J8, Land price = U19 and J19, Power price = average retail price of tractor per horsepower extrapolated by U21 from the 1976–80 average of $216 for the United States, and extrapolated by J21 from the average of 65,170 yen for Japan.

Table 1.0 Summary Studies of Agricultural Research Productivity

Study	Country	Commodity	Time Period	Annual Internal Rate of Return (%)
Index Number:				
Griliches, 1958	USA	Hybrid corn	1940-1955	35-40
Griliches, 1958	USA	Hybrid sorghum	1940-1957	20
Peterson, 1967	USA	Poultry	1915-1960	21-25
Evenson, 1969	South Africa	Sugarcane	1945-1962	40
Barletta, 1970	Mexico	Wheat	1943-1963	90
Barletta, 1970	Mexico	Maize	1943-1963	35
Ayer, 1970	Brazil	Cotton	1924-1967	77+
Schmitz and Seckler, 1970	USA	Tomato harvester, with no compensation to displaced workers	1958-1969	37-46
		Tomato harvester, with compensation of displaced workers for 50% of earnings loss		16-28
Ayer and Schuh, 1972	Brazil	Cotton	1924-1967	77-110
Hines, 1972	Peru	Maize	1954-1967	35-40[a] 50-55[b]
Hayami and Akino, 1977	Japan	Rice	1915-1950	25-27
Hayami and Akino, 1977	Japan	Rice	1930-1961	73-75
Hertford, Ardila, Rocha, and Trujillo, 1977	Colombia	Rice	1957-1972	60-82
		Soybeans	1960-1971	79-96
		Wheat	1953-1973	11-12
		Cotton	1953-1972	none
Pee, 1977	Malaysia	Rubber	1932-1973	24
Peterson and Fitzharris, 1977	USA	Aggregate	1937-1942	50
			1947-1952	51
			1957-1962	49
			1957-1972	34
Wennergren and Whitaker, 1977	Bolivia	Sheep	1966-1975	44
		Wheat	1966-1975	−48
Pray, 1978	Punjab (British India)	Agricultural research and extension	1906-1956	34-44
	Punjab (Pakistan)	Agricultural research and extension	1948-1963	23-37
Scobie and Posada, 1978	Bolivia	Rice	1957-1964	79-96
Pray, 1980	Bangladesh	Wheat and rice	1961-1977	30-35
Regression Analysis:				
Tang, 1963	Japan	Aggregate	1880-1938	35
Griliches, 1964	USA	Aggregate	1949-1959	35-40
Latimer, 1964	USA	Aggregate	1949-1959	not significant

Table 1.0 continued

Study	Country	Commodity	Time Period	Annual Internal Rate of Return (%)
Peterson, 1967	USA	Poultry	1915-1960	21
Evenson, 1968	USA	Aggregate	1949-1959	47
Evenson, 1969	South Africa	Sugarcane	1945-1958	40
Barletta, 1970	Mexico	Crops	1943-1963	45-93
Duncan, 1972	Australia	Pasture Improvement	1948-1969	58-68
Evenson and Jha, 1973	India	Aggregate	1953-1971	40
Cline, 1975 (revised by Knutson and Tweeten, 1979)	USA	Aggregate	1939-1948	41-50[c]
		Research and extension	1949-1958	39-47[c]
			1959-1968	32-39[c]
			1969-1972	28-35[c]
Bredahl and Peterson, 1976	USA	Cash grains	1969	36[d]
		Poultry	1969	37[d]
		Dairy	1969	43[d]
		Livestock	1969	47[d]
Kahlon, Bal, Saxena, and Jha, 1977	India	Aggregate	1960-1961	63
Evenson and Flores, 1978	Asia— national	Rice	1950-1965	32-39
			1966-1975	73-78
	Asia— International	Rice	1966-1975	74-102
Flores, Evenson, and Hayami, 1978	Tropics	Rice	1966-1975	46-71
	Philippines	Rice	1966-1975	75
Nagy and Furtan, 1978	Canada	Rapeseed	1960-1975	95-110
Davis, 1979	USA	Aggregate	1949-1959	66-100
			1964-1974	37
Evenson, 1979	USA	Aggregate	1868-1926	65
	USA	Technology oriented	1927-1950	95
	USA	Science oriented	1927-1950	110
	USA	Science oriented	1948-1971	45
	Southern USA	Technology oriented	1948-1971	130
	Northern USA	Technology oriented	1948-1971	93
	Western USA	Technology oriented	1948-1971	95
	USA	Farm management research and agricultural extension	1948-1971	110

Source: Robert E. Evenson, Paul E. Waggoner, and Vernon W. Ruttan, Economic Benefits from Research: An Example from Agriculture," *Science*, 205 (September 14, 1979), pp. 1101-7. Copyright 1979 by the American Association for the Advancement of Science.
a. Returns to maize research only.
b. Returns to maize research plus cultivation "package."
c. Lower estimate for 13-, and higher for 16-year time lag between beginning and end of output impact.
d. Lagged marginal product of 1969 research on output discounted for an estimated mean lag of 5 years for cash grains, 6 years for poultry and dairy, and 7 years for livestock.

Sources for Table 10.3: The results of many of the studies reported in this table have previously been summarized in the following works.

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James K. Boyce and Robert E. Evenson, *Agricultural Research and Extension Systems* (New York: Agricultural Development Council, 1975), p. 104.
Robert Evenson, Paul E. Waggoner, and Vernon W. Ruttan, "Economic Benefits from Research: An Example from Agriculture," *Science*, 205 (September 14, 1979), pp. 1101-7.
Robert J. R. Sim and Richard Gardner, *A Review of Research and Extension Evaluation in Agriculture* (Moscow, Idaho: University of Idaho, Department of Agricultural Economics Research Series 214, May 1978), pp. 41, 42.

The sources for individual studies are

H. Ayer, "The Costs, Returns and Effects of Agricultural Research in São Paulo, Brazil" (Ph.D. dissertation, Purdue University, 1970).
H. W. Ayer and G. E. Schuh, "Social Rates of Return and Other Aspects of Agricultural Research: The Case of Cotton Research in São Paulo, Brazil," *American Journal of Agricultural Economics,* 54 (November 1972), pp. 557-69.
N. Ardito Barletta, "Costs and Social Benefits of Agricultural Research in Mexico" (Ph.D. dissertation, University of Chicago, 1970).
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Philip L. Cline, "Sources of Productivity Change in United States Agriculture" (Ph.D. dissertation, Oklahoma State University, 1975).
Jeffrey S. Davis, "Stability of the Research Production Coefficient for U.S. Agriculture," (Ph.D. dissertation, University of Minnesota, 1979).
R. C. Duncan, "Evaluating Returns to Research in Pasture Improvement," *Australian Journal of Agricultural Economics,* 16 (December 1972), pp. 153-68.
R. Evenson, "The Contribution of Agricultural Research and Extension to Agricultural Production" (Ph.D. dissertation, University of Chicago, 1968).
R. Evenson, "International Transmission of Technology in Sugarcane Production" (New Haven, Conn: Yale University, Mimeographed paper, 1969).
R. E. Evenson and P. Flores, *Economic Consequences of New Rice Technology in Asia,* Los Banos, Laguna, Philippines: International Rice Research Institute, 1978.
R. E. Evenson and D. Jha, "The Contribution of Agricultural Research Systems to Agricultural Production in India," *Indian Journal of Agricultural Economics,* 28 (1973), pp. 212-30.
P. Flores, R. E. Evenson, Y. Hayami, "Social Returns to Rice Research in the Philippines: Domestic Benefits and Foreign Spillover," *Economic Development and Cultural Change,* 26 (April 1978), pp. 591-607.

Z. Griliches, "Research Costs and Social Returns: Hybrid Corn and Related Innovations," *Journal of Political Economy*, 66 (1958), pp. 419-31.

Z. Griliches, "Research Expenditures, Education and the Aggregate Agricultural Production Function," *American Economic Review*, 54 (December 1964), pp. 961-74.

Y. Hayami and M. Akino, "Organization and Productivity of Agricultural Research Systems in Japan," in *Resource Allocation and Productivity in National and International Agricultural Research*, Thomas M. Arndt, Dana G. Dalrymple, and Vernon W. Ruttan, eds. (Minneapolis: University of Minnesota Press, 1977), pp. 29-59.

R. Hertford, J. Ardila, A. Rocha, and G. Trujillo, "Productivity of Agricultural Research in Colombia," in *Resource Allocation and Productivity in National and International Agricultural Research*, Thomas M. Arndt, Dana G. Dalrymple, and Vernon W. Ruttan, eds. (Minneapolis: University of Minnesota Press, 1977), pp. 86-123.

J. Hines, "The Utilization of Research for Development: Two Case Studies in Rural Modernization and Agriculture in Peru" (Ph.D. dissertation, Princeton University, 1972).

A. S. Kahlon, H. K. Bal, P. N. Saxena, and D. Jha, "Returns to Investment in Research in India," in *Resource Allocation and Productivity in National and International Agricultural Research*, University of Minnesota Press, 1977), pp. 124-47.

M. Knutson and Luther G. Tweeten, "Toward an Optimal Rate of Growth in Agricultural Production Research and Extension," *American Journal of Agricultural Economics*, 61 (February 1979), pp. 70-76.

R. Latimer, "Some Economic Aspects of Agricultural Research and Extension in the U.S." (Ph.D. dissertation, Purdue University, 1964).

J. G. Nagy and W. H. Furtan, "Economic Costs and Returns from Crop Development Research: The Case of Rapeseed Breeding in Canada," *Canadian Journal of Agricultural Economics* 26, (February 1978), pp. 1-14.

T. Y. Pee, "Social Returns from Rubber Research on Peninsular Malaysia" (Ph.D. dissertation, Michigan State University, 1977)

W. L. Peterson, "Return to Poultry Research in the United States," *Journal of Farm Economics*, 49 (August 1967), pp. 656-69.

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A. Tang, "Research and Education in Japanese Agricultural Development," *Economic Studies Quarterly*, 13 (February-May 1963), pp. 27-41 and 91-99.

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L. L. Bauer and C. R. Hancock, "The Productivity of Agricultural Research and Extension Expenditures in the Southeast," *Southern Journal of Agricultural Economics*, 7 December 1975), pp. 177-22.

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H. Graham Purchase, "The Etiology and Control of Marek's Disease of Chickens and the Economic Impact of a Successful Research Program," in *Virology in Agriculture: Beltsville Symposium in Agricultural Research-I*, John A. Romberger, ed. (Montclair, N.J.: Allanheid, USMUN, 1977), pp. 63-81.

Table 2. Land-labor endowments and relative prices in agriculture: United States and Japan, selected years.

	1880	1900	1920	1940	1960	1980
USA						
(1) Agricultural land area (million ha.)	327	465	458	452	440	427
(2) Arable land area (million ha.)	93	157	194	189	185	191
(3) Number of male farm workers (thousand)	7,959	9,880	10,221	8,487	3,973	1,792
(4) (1)/(3) (ha./worker)	41	47	45	50	111	238
(5) (2)/(3) (ha./worker)	12	16	19	22	47	107
(6) Value of arable land ($/ha.)	109	106	341	178	696	3,393
(7) Farm wage rate ($/day)	0.90	1.00	3.30	1.60	6.60	25.31
(8) (6)/(7) (days/ha.)	188	106	103	111	105	134
Japan						
(9) Agricultural land area (thousand ha.) a/	5,509	6,032	6,958	7,102	7,042	5,729
(10) Arable land area (thousand ha.)	4,749	5,200	5,998	6,122	6,071	5,461
(11) Number of male farm workers (thousand)	8,336	8,483	7,577	6,362	6,230	2,674
(12) (9)/(11) (ha./worker)	0.66	0.71	0.92	1.12	1.13	2.14
(13) (10)/(11) (ha./worker)	0.57	0.61	0.79	0.96	0.97	2.04
(14) Value of arable land (yen/ha.)	343	917	3,882	4,709	1,415.000	7,642,000
(15) Farm wage rate (yen/day)	0.22	0.31	1.39	1.90	440	5,054
(16) (14)/(15) (days/ha.)	1,559	2,958	2,793	2,478	3,216	1,512

a/ Agricultural land areas in Japan for 1880-1960 are estimated by multiplying arable land areas by 1.16, the ratio of agricultural land area to arable land area in the 1960 Census of Agriculture; this conversion factor changed to 1.05 for 1980 based on the 1980 Census of Agriculture.

Source: Data from Appendix Tables C-2 and C-3 in Yujiro Hayami and Vernon W. Ruttan, Agricultural Development: An International Perspective, rev. ed. (Baltimore: Johns Hopkins University Press, 1985).

Table 3. Average Annual Rates of Change (Percentage per Year) in Output, Inputs, and Productivity in U.S. Agriculture, 1870-1979.

Item	1870-1900	1900-1925	1925-1950	1950-1965	1965-1982
Farm output	2.9	0.9	1.6	1.7	2.1
Total inputs	1.9	1.1	0.2	-0.4	0.2
Total productivity	1.0	-0.2	1.3	2.2	1.8
Labor inputs[a]	1.6	0.5	-1.7	-4.8	-3.4
Labor productivity	1.3	0.4	3.3	6.6	5.8
Land inputs[b]	3.1	0.8	0.1	-0.9	0.0
Land productivity	-0.2	0.0	1.4	2.6	1.8

Sources: Data from USDA, Changes in Farm Production and Efficiency (Washington, D.C.: 1979); and D. D. Durost and G. T. Barton, Changing Sources of Farm Output (Washington, D.C.: USDA Production Research Report No. 36). February 1960. Data are three-year averages centered on the year shown for 1925, 1950, and 1965.
a. Number of workers, 1870-1910; worker-hour basis, 1910-1971.
b. Cropland use for crops, including crop failures and cultivated summer fallow.

Table 4. Average Annual Change in Total Output, Inputs, and Productivity in Japanese Agriculture, 1880- 1980.

Item	1880-1920	1920-1935	1935-1955	1955-1965	1965-1980
Farm output	1.8	0.9	0.6	3.5	1.2
Total inputs	0.5	0.5	1.2	1.3	0.7
Total productivity	1.3	0.4	-0.6	2.2	0.5
Labor inputs	-0.3	-0.2	0.6	-2.5	-3.7
Labor productivity	2.1	1.1	0.0	6.0	4.9
Land inputs	0.6	0.1	-0.1	0.1	-0.6
Land productivity	1.2	0.8	0.7	3.4	1.8

Sources: Data from Saburo Yamada and Yujiro Hayami, "Agricultural Growth in Japan, 1880-1970," in Agricultural Growth in Japan, Taiwan, Korea and the Philippines, Yujiro Hayami, Vernon W. Ruttan, and Herman Southworth, eds. (Honolulu: University Press of Hawaii, 1979), pp. 33-58; Saburo Yamada, "The Secular Trends in Input-Output Relations of Agricultural Production in Japan, 1878-1978," a paper presented at the Conference of Agricultural Development in China, Japan, and Korea, Academica Sinica, Taipei, December 17-20, 1980; Saburo Yamada, Country Study on Agricultural Productivity Measurement and Analysis - Japan (Tokyo: University of Tokyo Institute of Oriental Culture, October 1984, mimeo).

Lecture Two

INSTITUTIONAL CHANGE AND AGRICULTURAL DEVELOPMENT

Over the last several decades economists have made major contributions
to our understanding of the impact of natural science knowledge on technical
change and the impact of technical change on economic growth. We have also
significantly advanced our understanding of the sources of demand for and
supply of technical change.

In work published in the early 1970s Yujiro Hayami and I extended the
theory of induced technical change and tested it against the history of
agricultural development in the United States and Japan. It is now generally
accepted that the theory of induced technical change provides very substantial
insight into the process of agricultural development for a wide range of
developed and developing countries. And economic historians are increasingly
drawing on the theory of induced technical change in attempting to interpret
differential patterns of productivity growth among countries and over time.
The central elements of the theory of induced technical change were discussed
yesterday in my first lecture.

The demonstration that technical change can be treated as largely
endogenous to the development process does not imply that the progress of
either agricultural or industrial technology can be left to an 'invisible
hand' that drives technology along an 'efficient' path determined by
relative resource endowments. The capacity to advance knowledge in science
and technology is itself a product of institutional innovation. Whitehead has
insisted that "the great invention of the nineteenth century was the invention
of the method of invention."

In the case of agriculture, for example, in both Japan and the United
States, much of the technical change that has led to growth of output per
hectare has been produced by public sector institutions. These institutions--
state (or prefectoral) and federal (or national) agricultural experiment

stations--obtain their resources in the political market place and allocate their resources through bureaucratic mechanisms. The success of the theory of induced technical change gives rise, therefore, to the need for a more careful consideration of the sources of institutional innovation and design.

In this paper I elaborate a theory of institutional innovation in which shifts in the demand for institutional change are induced by changes in relative resource endowments and by technical change. I also consider the impact of advances in social science knowledge and of cultural endowments on the supply of institutional change. After examining the forces that act to shift the demand and supply of institutional change I then present the elements of a more general model of institutional change. The perspective on the role of institutional change in the process of economic development presented in this paper is much more positive than the views that were held by the American institutional school or in the recent literature on social choice and collective action.

WHAT IS INSTITUTIONAL INNOVATION?

Institutions are the rules of a society or of organizations that facilitate coordination among people by helping them form expectations which each person can reasonably hold in dealing with others. They reflect the conventions that have evolved in different societies regarding the behavior of individuals and groups relative to their own behavior and the behavior of others. In the area of economic relations they have a crucial role in establishing expectations about the rights to use resources in economic activities and about the partitioning of the income streams resulting from economic activity--'institutions provide assurance respecting the actions of others, and give order and stability to expectations in the complex and uncertain world of economic relations.'

In order to perform the essential role of forming reasonable expecta-
tions in dealings among people, institutions must be stable for an extended
time period. But institutions, like technology, must also change if
development is to occur. Anticipation of the latent gains to be realized
by overcoming the disequilibria resulting from changes in factor endowments,
product demand, and technical change represents powerful sources of demand for
institutional innovation. Institutions that have been efficient in generating
growth in the past may, over time, become obstacles to further economic
development. The growing disequilibria in resource allocation due to
institutional constraints on the opportunities for economic growth create
an environment in which it becomes profitable for political entrepreneurs
or leaders to organize collective action to bring about institutional change.

This perspective on the sources of demand for institutional change is
similar, in some respects, to the traditional Marxian view. Marx considered
technological change as a primary source of institutional change. 'At a
certain stage of their development, the material forces of production in
society come in conflict with the existing relations of production, or--what
is but a legal expression for the same thing--with the property relations
within which they had been at work before. From forms of development of the
forces of production these relations turn into their fetters. Then comes
the period of social revolution. With the change of the economic foundation
the entire immense super-structure is more or less rapidly transformed.'

The view that Professor Hayami and I have used in our work is somewhat
more complex. We consider that changes in factor endowments and product
demand are equally important sources of institutional change. Nor is
institutional change limited .to the dramatic or revolutionary changes of

the type anticipated by Marx. Basic institutions such as property rights
and markets are more typically altered through the cumulation of 'secondary'
or incremental institutional changes such as modifications in contractual
relations or shifts in the boundaries between market and nonmarket activities.

There is a supply as well as a demand dimension in institutional change.
Collective action leading to changes in the supply of institutional innovations
may be generated by tension among interest groups. Clearly, the process is
much more complex than the simple class conflict between those who derive
their income from the ownership of property and those who derive their income
from labor. The supply of institutional innovations is strongly influenced
by the cost of achieving social consensus (or of suppressing opposition).
The cost of institutional change is dependent on the distribution of
political resources. And it also depends critically on cultural tradition
and on ideology.

Advances in knowledge in the social sciences (and in related professions
such as law, administration, planning, and social service) can reduce the
cost of institutional change in a somewhat similar manner as advances in
the natural sciences reduce the cost of technical change. Education, both
general and technical, that facilitates a better understanding among people
of their common interests can also reduce the cost of institutional innovation.

Our insistence that important advances in the understanding of the
processes of institutional innovation and diffusion can be achieved by
treating institutional change as endogenous to the economic system represents
a clear departure from the tradition of modern analytical economics.
This does not mean that analytical economics must be abandoned. On the
contrary, it is suggested that the scope of modern analytical economics be
expanded by treating institutional change as endogenous.

DEMAND FOR INSTITUTIONAL INNOVATION--MARKET INSTITUTIONS

In some cases the demand for institutional innovation can be satisfied by the development of new forms of property rights, more efficient market institutions, or even by evolutionary changes arising out of direct contracting by individuals at the level of the community or the firm. In other cases, where externalities are involved, substantial political resources may have to be brought to bear to organize nonmarket institutions in order to provide for the supply of public goods. It may be useful to illustrate, from the agricultural history of England, Thailand and the Philippines, how changes in factor endowments, technical change, and growth in product demand have induced change in property rights and contractual arrangements in order to promote more efficient resource allocation.

The agricultural revolution that occurred in England between the fifteenth and the nineteenth centuries involved a substantial increase in the productivity of land and labor. It was accompanied by the enclosure of open fields and the replacement of small peasant cultivators, who held their land from manorial lords, by a system in which large farmers used hired labor to farm the land they leased from the landlords. The First Enclosure Movement, in the fifteenth and sixteenth centuries, resulted in the conversion of open arable fields and commons to private pasture in areas suitable for grazing. It was induced in substantial part by expansion in the export demand for wool. The Second Enclosure Movement in the eighteenth century involved conversion of communally managed arable land into privately operated units.

There has been a continuing debate among students of English agricultural history about whether the higher rents that landowners received after enclosure was (a) because enclosed farming was more efficient than open field farming, or (b) because enclosures redistributed income from farmers

to landowners. It is now agreed, however, that it was largely induced by the growing disequilibrium between the fixed institutional rent that landlords received under copyhold tenures (with lifetime contracts) and the higher economic rents expected from adoption of new technology which became more profitable as a consequence of higher grain prices and lower wages. When the land was enclosed there was a redistribution of income from farmers to landowners and the disequilibrium was reduced or eliminated.

The Thailand example, based on an exceedingly useful study by David Feeny of the political economy of Thai agricultural development, draws on more recent economic history. In Thailand, at the middle of the last century, land was abundant and labor was scarce. Property rights in land were poorly defined and were based primarily on occupancy. But property rights in people were defined in almost baroque complexity. There were several gradations in slavery, ranging from war captives to debt shares. And there was also a complex system of servile obligations on the part of the peasantry to the nobility and the king. Debt slavery provided a form of collateral for credit transactions in the absence of well defined property rights in land. One could sell ones child, ones wife, or ones self into debt slavery with, under certain conditions, a right of redemption.

A shift from "property rights in man to property rights in land" began when Thailand opened itself up to international trade, under British and French pressure. The trend was reinforced following the construction of the Suez Canal and the reduction in shipping rates to Europe. The sharp increase in the demand for rice associated with cheaper access to European markets made land suitable for rice production more valuable. The land available for rice production, which had been abundant, became more

scarce. Investment in land development for rice production became
profitable. The response was a major transformation of property rights.
Traditional rights in human property (corvee and slavery) were replaced
by more precise private property rights in land (fee-simple titles).
These changes were encouraged by the king and his advisors because it reduced
the status of the Thai nobility from that of warlords to landlords. And
it was accepted by the nobility because it substituted increasingly
valuable land rights for less valuable feudal privilege.

In Japan, at the beginning of the feudal Tokugawa period (1603-1867),
peasants' rights to cropland had been limited to the rights to till the soil
with the obligation to pay a feudal land tax in kind. As the population
grew, commercialization progressed and irrigation and technology were
developed to make intensive farming more profitable. Some peasants divided
their holdings into smaller units and leased them out to ex-servants or
extended family members. Some accumulated land through mortgaging arrange-
ments that made other peasants de facto tenants. As a result of the
accumulation of illegal leasing and mortgaging practices, peasants' property
rights in land approximated those of a fee-simple title by the end of the
Tokugawa period. These rights were readily converted to the modern
private-property system in the succeeding Meiji period.

Research conducted by Yujiro Hayami and Masao Kikuchi in the Philippines
during the late 1970s has enabled us to examine a contemporary example of
the interrelated effects of changes in resource endowments and technical
change on the demand for institutional change in land tenure and labor
relations. The case is particularly interesting because the institutional
innovations occurred as a result of private contracting among individuals.

The study is unique in that it is based on a rigorous analysis of microeconomic data in a village over a period of about 20 years.

Changes in Technology and Resource Endowments

Between 1956 and 1976, rice production per hectare in the study village rose dramatically, from 2.5 to 6.7 metric tons per hectare per year. This was due to two technical innovations. In 1958, the national irrigation system was extended to the village. This permitted double-cropping to replace single-cropping, thereby substantially increasing the annual production per hectare of rice land. The second major technical change was the introduction in the late 1960s of the modern high-yielding rice varieties. The diffusion of modern varieties was accompanied by increased use of fertilizer and pesticides and by the adoption of improved cultural practices such as straight-row planting and intensive weeding.

Population growth in the village was rapid. Between 1966 and 1976 the number of households rose from 66 to 109 and the population rose from 383 to 464, while cultivated area remained virtually constant. The number of landless laborer households increased from 20 to 54. In 1976, half of the households in the village had no land to cultivate, not even land for rent. The average farm size declined from 2.3 to 2.0 hectares.

The land is farmed primarily by tenants. In 1976, only 1.7 hectares of the 108 hectares of cropland in the village were owned by village residents. In both 1956 and 1966, 70 percent of the land was farmed under share tenure arrangements. In 1963, a new agricultural land reform code was passed which was designed to break the political power of the traditional landed elite and to provide greater incentives to peasant producers of basic

food crops. A major feature of the new legislation was an arrangement
that permitted tenants to initiate a shift from share tenure to leasehold,
with rent under the leasehold set at 25 percent of the average yield for
the previous three years. Implementation of the code between the mid-1960s
and the mid-1970s resulted in a decline in the percentage of land farmed
under share tenure to 30 percent.

Institutional Innovation

The shift from share tenure to lease tenure was not, however, the
only change in tenure relationships that occurred between 1966 and 1976.
There was a sharp increase in the number of plots farmed under subtenancy
arrangements. The number increased from one in 1956, to sixteen in 1976.
Subtenancy is illegal under the land reform code. The subtenancy arrange-
ments are usually made without the formal consent of the landowner. All
cases of subtenancy were on land farmed under a leasehold arrangement. The
most common subtenancy arrangement was fifty-fifty sharing of costs and
output.

The incentive for the emergence of the subtenancy institution was that
the rent paid to landlords under the leasehold arrangement was below the
equilibrium rent--the level which would reflect both the higher yields of
rice obtained with the new technology and the lower wage rates implied by
the increase in population pressure against the land.

To test this hypothesis, market prices were used to compute the value
of the unpaid factor inputs (family labor and capital) for different tenure
arrangements during the 1976 wet season. The results indicate that the
share-to-land was lowest and the operators' surplus was the highest for the
land under leasehold tenancy. In contrast, the share-to-land was the
highest and no surplus was left for the operator who cultivated the land

under the subtenancy arrangement (Table 1). Indeed, the share-to-land when the land was farmed under subtenancy was very close to the sum of the share-to-land plus the operators' surplus under the other tenure arrangement. A substantial portion of the economic rent was captured by the leasehold tenants in the form of operators' surplus. On the land farmed under a subtenancy arrangement, the rent was shared between the leaseholder and the landlord.

A second institutional change, induced by higher yields and the increase in population pressure, has been the emergence of a new pattern of employer-labor relationship between farm operators and landless workers. According to the traditional system called hunusan, laborers who participated in the harvesting and threshing received a one-sixth share of the harvest. By 1976, most of the farmers (83 percent) adopted a system called gamma, in which participation in the harvesting operation was limited to workers who had performed the weeding operation without receiving wages.

The emergence of the gamma system can be interpreted as an institutional innovation designed to reduce the wage rate for harvesting to a level equal to the marginal productivity of labor. In the 1950s, when the rice yield per hectare was low and labor was less abundant, the one-sixth share may have approximated an equilibrium wage level. With the higher yields and the more abundant supply of labor, the one-sixth share became larger than the marginal product of labor in the harvesting operation.

To test the hypothesis that the gamma system was adopted rapidly primarily because it represented an institutional innovation that permitted farm operators to equate the harvesters' shares of output to the marginal productivity of labor, imputed wage costs were compared with the actual harvesters' share (Table 2). The results indicate that a substantial gap

existed between the imputed wage for the harvesters' labor alone and the actual harvesters' shares. This gap was eliminated if the imputed wages for harvesting and weeding labor were added.

Those results are consistent with the hypothesis that the changes in institutional arrangements governing the use of production factors were induced when disequilibria between the marginal returns and the marginal costs of factor inputs occurred as a result of changes in factor endowments and technical change. Institutional change, therefore, was directed toward the establishment of a new equilibrium in factor markets.

Efficiency and Equity

It is important to recognize that subtenancy and _gamma_ contracts were the institutional innovations to facilitate more efficient resource allocations through voluntary agreements by assigning more complete private property rights. The land reform laws gave tenants strong protection of their tenancy rights with the result that a part of land property rights, which is the right to continue tilling the soil at a rent lower than the marginal product of land, was assigned to tenant operators. But the laws prohibited tenants from renting their land to someone else who might utilize it more efficiently, when they become elderly or found more profitable off-farm employment, for example. Subtenancy was developed to reduce such inefficiency due to the institutional rigidity in the land rental market based on the land reform programs. Likewise, the _gamma_ system was developed to counteract the institutional rigidity in the labor market based on the traditional custom in the rural community in the form of a fixed harvester's share.

It might appear that these institutional innovations increased efficiency at the expense of equity. But, if the subtenancy system had not been

developed, the route would have been closed for some of the landless

laborers to become farm operators and use their entrepreneurial abilities

more profitably. If the implicit wage rate for harvesting work had been

raised in the absence of the gamma contract, it might have encouraged

mechanization in threshing and thereby reduced employment and labor earnings.

It must be recognized that the institutional innovations that resulted in

more efficient markets as a result of the assignment of more complete private

property rights do not necessarily impair equity, as is often argued by

Marxist and populist critiques of private market institutions.

In the case reviewed here the induced innovation process leading toward

the establishment of equilibrium in land and labor markets occurred very

rapdily in spite of the fact that many of the transactions--between landlords,

tenants, and laborers--were less than fully monetized. Informal contractual

arrangements or agreements were utilized. The subleasing and the gamma

labor contract evolved without the mobilization of substantial political

activity or bureaucratic effort. Indeed, the subleasing arrangement evolved

in spite of legal prohibition! Where substantial political and bureaucratic

resources must be mobilized to bring about technical or institutional change,

the changes occur much more slowly, as in the cases of the English enclosure

movements and the Thai and Japanese property rights cases referred to at

the beginning of this section.

The Philippine village study reviewed in this section was specifically

designed to facilitate the analysis of the interrelationships between

changes in resource endowments, technical change and institutional change.

It would be extremely valuable to have additional studies specifically

designed for this purpose. It would, for example, be particularly useful

to examine the interrelationships among the expansion of gravity irrigation

systems, the public programs to reduce water logging and salinity, the

development of private tubewells, the introduction of high-yielding varieties

of wheat and rice, the mechnization of land preparation and harvesting, and

the rapid growth of rural population for changes in market and nonmarket

institutions in the Pakistan Punjab.

DEMAND FOR INSTITUTIONAL INNOVATION: NONMARKET INSTITUTIONS

The examples of institutional change advanced in the previous section,

such as the Enclosure in England and the evolution of private property

rights in land in Japan and Thailand, have contributed to the development

of a more efficient market system. Institutional changes of this type are

profitable for society only if the costs involved in the assignment and

protection of rights are smaller than the gains from better resource

allocation. If those costs are very high, it may be necessary to design

nonmarket institutions in order to achieve more efficient resource

allocation.

For example, in Japan, although the system of private property rights

was developed on cropland during the pre-modern period, communal ownership

at the village level permitted open access to large areas of wild and forest

land which were utilized for the collection of firewood, leaves, and wild

grasses to fertilize rice fields. However, over time more detailed common

property rules were stipulated for the use of communal land in order to

prevent resource exhaustion.

Detailed stipulations of the time and place of utilization of communal

land as well as rules for mobilizing village labor to maintain communal

property (such as applying fire to regenerate pasture) were often enforced

with religious taboos and rituals. Those communal village institutions remained viable because it was much more costly to demarcate and partition wild and forest land than cropland among individuals and to enforce exclusive use. Any villager's use of communal land involves externality. For example, his collection of firewood reduced the availability of the firewood for other villagers. If property rights are not assigned, there may be only limited incentive for resource conservation. This is not a serious problem if the resource that is subject to open access is abundant relative to population. However, as population pressure begins to rise, a common understanding regarding appropriate use, reinforced by social sanctions, may act to limit excessive exploitation. But, as population growth continues to press against limited land resources and the market value of the resource product rises, it becomes necessary to impose more formal regulations regarding the access of individual villagers to communal land.

Group action to supply public goods, such as the maintenance of communal land, may work effectively if the size of the group involved is small, as in the case of a village community. However, if a large number of people are involved in the use of a public good, as in the case of marine fisheries, it is more difficult to regulate their resource use or to prevent free riders by means of voluntary agreements. Action by a higher authority with coercive power, such as government, may be required to limit free riding.

The 'socialization' of agricultural research is common not only in socialist economies but also in market economies. This can be explained by the failure of the market in allocating resources efficiently for the supply of public goods for a large, unidentifiable clientele group. New information or knowledge resulting from research is typically endowed with the attributes of a public good characterized by <u>nonrivalness</u> or jointness

in supply and utilization, and nonexcludability or external economies.
The first attribute implies that the good is equally available to all.
The second implies that it is impossible for private producers to appropriate
through market pricing the full social benefits arising directly from the
production (and consumption) of the good--it is difficult to exclude from
the utilization of the good those who do not pay for it. A socially optimal
level of supply of such a good cannot be expected if its supply is left to
private firms. However, present institutional arrangements are such that
much information resulting from basic research is nonexcludable. This is
the major reason why it has been necessary to estalish nonprofit institutions
to advance basic scientific knowledge.

A unique aspect of agricultural research, particularly that directed
to advancing biological technology, is that many of the products of
research--even in the applied area--are characterized by nonexcludability.
Protection by patent laws is either unavailable or inadequate. The nature
of agricultural production to be conducted would make it difficult to
restrict information about new technology or practices. Furthermore, even
the largest farms are relatively small units and would not be able to
capture more than a small share of the gains from inventive activity.
Private research activities in agriculture have been directed primarily
toward developing mechanical technology for which patent protection is
established.

Another important attribute of the research production function is that
it has a stochastic form. Research, by nature, is characterized by risk
and uncertainty. Success in a research project is like hitting a 'successful
oil well.' Any number of dry holes may be bored before the successful one
is found. Richard Nelson has pointed out that this stochastic nature of

the research production function, which is especially strong in the case of basic research, contributes to the failure of the market in attaining optimum resource allocation over time:

'The very large variance of the profit probability distribution from a basic research project will tend to cause a risk-avoiding firm, without the economic resources to spread the risk by running a number of basic-research projects at once, to value a basic-research project at significantly less than its expected profitability and hence, ... at less than its social value.'

The public-good attributes of the agricultural research product together with the stochastic nature of the research production function make public support of agricultural research socially desirable. It does not necessarily follow, however, that agricultural research should be conducted in governmental institutions financed by tax revenue. If the benefit consists primarily of producers' surplus, agricultural research may be left to the cooperative activities of agricultural producers (i.e., to the activities of such institutions as agricultural commodity organizations and cooperatives). In the United States organized producers are funding an increasing share of agricultural research by means of a tax or a cess on production.

The willingness of organized producers to share the costs of research appears to be related to the elasticity of demand in domestic and international markets for the specific commodity. Research on a number of tropical export crops grown under plantation conditions such as sugar, bananas, and rubber is also often supported in this manner. The emergence of new institutional arrangements such as plant variety registration, which provides patent like protection for new crop varieties, also acts to shift the

optimum allocation of agricultural research resources in favor of the private sector.

However, most agricultural commodities are produced by a number of small producers. Under these conditions voluntary cooperation to support research would be very costly to organize. Furthermore, most agricultural commodities, except those intended for export, are characterized by low price elasticity of demand. As a result, a major share of the social benefit produced by research tends to be transmitted to consumers through lower market prices. In such a situation the cost of agricultural research should be borne by the general public.

If agricultural research were left entirely to the private sector the result would be serious bias in the allocation of research resources. Resources would flow primarily to those areas of mechanical and chemical technology that are adequately protected by patents and to those areas of biological technology where the results can be protected by trade secrets (such as the inbred lines used in the production of hybrid corn seed). Other areas, such as research on open pollinated seed varieties, biological control of insects and pathogens, and improvements in farming practices and management, would be neglected. The socialization of agricultural research or the predominance of public institutions in agricultural research, especially in the biological sciences, can be considered a major institutional innovation designed to offset what would otherwise represent a serious distortion in the allocation of research resources.

THE SUPPLY OF INSTITUTIONAL INNOVATION

We have identified the disequilibria in economic relationships associated with economic growth, such as technical change leading to the genera-

tion of new income streams and changes in relative factor endowments, as important sources of demand for institutional change. But the sources of supply of institutional innovation are less well understood. The factors that reduce the cost of institutional innovation have not been widely studied by economists or by other social scientists.

In the Philippines village case changes in tenure and labor market institutions were supplied, in response to the changes in demand generated by changing factor endowments and new income streams, through the individual and joint decisions of owner-cultivators, tenants and laborers. But even at this level it was necessary for gains to the innovators to be large enough to offset the risk of ignoring the land reform prohibitions against subleasing and the social costs involved in changing traditional harvest-sharing arrangements. While mobilization of substantial political resources was not required to introduce and extend the new land and labor market institutions, the distribution of political resources within the village did influence the initiation and diffusion of the institutional innovations.

The supply of major institutional innovations, however, necessarily involves the mobilization of substantial political resources. It is useful to think in terms of a supply schedule of institutional innovation that is determined by the marginal cost schedule facing political entrepreneurs as they attempt to design new institutions and resolve the conflicts among various interest groups (or suppression of opposition when necessary). This implies that institutional innovations will be supplied if the expected return from the innovation that accrues to the politician entrepreneurs exceeds the marginal cost of mobilizing the resources necessary to introduce the innovation. To the extent that the private return to the political

entrepreneurs is different from the social return, the institutional innovation will not be supplied at a socially optimum level.

The supply of institutional innovation depends critically on the power structure or balance among interest groups in a society. If the power balance is such that the political entrepreneurs' efforts to introduce an institutional innovation with a high rate of social return are adequately rewarded by greater prestige and stronger political support, a socially desirable institutional innovation may occur. However, if the institutional innovation is expected to result in a loss to a dominant political block, the innovation may not be forthcoming even if it is expected to produce a large net gain to society as a whole. And socially undesirable institutional innovations may occur if the returns to the entrepreneur or the interest group exceed the gains to society.

The failure of many developing countries to institutionalize the agricultural research capacity needed to take advantage of the large gains from relatively modest investments in technical change may be due, in part, to the divergence between social returns and the private returns to political entrepreneurs. In the mid-1920s, for example, agricultural development in Argentina appeared to be proceeding along a path roughly comparable to that of the United States. Mechanization of crop production lagged slightly behind that in the United States. Grain yields per hectare averaged slightly higher than in the United States. In contrast to the United States, however, output and yields in Argentina remained relatively stagnant between the mid-1920s and the mid-1970s. It was not until the late 1970s that Argentina began to realize significant gains in agricultural productivity. Part of this lag in Argentine agricultural development was due to the disruption of export markets in the 1930s and 1940s. Students of Argentine

development have pointed to the political dominance of the landed aristocracy, to the rising tensions between urban and rural interests, and to inappropriate domestic policies toward agriculture. The Argentine case would seem to represent a situation where the bias in the distribution of political and economic resources imposed exceptionally costly delays in the institutional innovations needed to take advantage of the relatively inexpensive sources of growth that technical change in agriculture could have made available.

Cultural endowments, including religion and ideology, exert a strong influence on the supply of institutional innovation. They make some forms of institutional change less costly to establish and impose severe costs on others. For example, the traditional moral obligation in the Japanese village community to cooperate in joint communal infrastructure maintenance has made it less costly to implement rural development programs than in societies where such traditions do not prevail. These activities had their origin in the feudal organization of rural communities in the pre-Meiji period. But practices such as maintenance of village and agricultural roads and of irrigation and drainage ditches through joint activities in which all families contribute labor were still practiced in well over half of the hamlets in Japan as recently as 1970.

Japanese scholars who are concerned about the modernization of social institutions tend to emphasize the decline in the practices of such traditional forms of cooperation--they emphasize that the traditional forms of cooperation are practiced in _only_ about half of the rural hamlets in Japan. Scholars who are concerned about the continuity of traditional cultural values stress the continued viability of traditional institutions. They point out that only about half of the hamlets still practice traditional forms of cooperation. In my view such traditional patterns of cooperation

have represented an important cultural resource on which to erect modern

forms of cooperative marketing and joint farming activities. Similar

cultural resources are not available in South Asian villages where, for

example, the cast structure inhibits cooperation and encourages occupational

specialization.

Likewise, the aspirations associated with the adoption of new ideological

commitments may reduce the cost to political entrepreneurs of mobilizing

collective action for institutional change. For example, in the United

States the Jeffersonian concept of agrarian democracy provided ideological

support for the series of land ordinances culminating in the Homestead Act

of 1862, which established the legal framework designed to encourage an

owner-operator system of agriculture in the American West. Strong

nationalist sentiment in Meiji Japan, reflected in slogans such as 'A

Wealthy Nation and Strong Army' (Fukoku Kyohei), helped mobilize the

resources needed for the establishment of vocational schools and agricultural

and industrial experiment stations. In China, communist ideology,

reinforced by the lessons learned during the guerrilla period in Yenan,

inspired the mobilization of communal resources to build irrigation systems

and other forms of physical infrastructure and social overhead capital.

Thus, ideology can be a critical resource for political entrepreneurs

and an important factor affecting the supply of institutional innovations.

Advances in social sciences that improve knowledge relevant to the

design of institutional innovations that are capable of generating new

income streams or that reduce the cost of conflict resolution also act to

shift the supply of institutional change to the right. Throughout history,

improvements in institutional performance have occurred primarily through

the slow accumulation of successful precedent or as by-products of expertise

and experience. Institutional change was generated through the process of trial and error much in the same manner that technical change was generated prior to the invention of the research university, the agricultural experiment station, or the industrial research laboratory. With the institutionalization of research in the social sciences and related professions the process of institutional innovation has begun to proceed much more efficiently. It is becoming increasingly possible to substitute social science knowledge and analytical skill for the more expensive process of learning by trial and error.

If this view is correct it suggests that a major source of demand for social science knowledge is derived from the demand for institutional innovation. But how responsive is the supply of social science knowledge to the demand for institutional change arising out of social conflict or economic growth. Is the supply of social science knowledge sufficiently elastic to reduce the cost of institutional change? Or is society typically forced with a situation where the demand for institutional innovation shifts against a relatively inelastic supply curve? The most pervasive view among historians or economic thought is that the supply of social science knowledge is relatively inelastic.

My own view is somewhat more optimistic. In the field of development the research that led to advances in our understanding of the production and consumption behavior of rural households in less developed countries represents an important example of the contribution of advances in social science knowledge to the design of more efficient institutions. In a number of countries this research has led to the abandonment of policies that viewed peasant households as unresponsive to economic incentives. And it has led to the design of policies and institutions to make more productive

technologies available to peasant producers and to the design of more
efficient price policies for factors and products. Similarly, the
diffusion of education designed to raise the intellectual level of the
general public and to facilitate better understanding of the private and
social costs of institutional change may reduce the cost to political
entrepreneurs of introducing socially desirable institutions and raise the
cost of biasing institutional change in a manner that is costly to society.

How might we test this view that the demand for institutional change,
or improvements in institutional performance, is a primary source of demand
for social science knowledge? One method is to draw on comparative inter-
national experience. Which societies tend to draw most extensively on social
science knowledge and which societies draw least on social science knowledge
in policy design and reform? It seems clear that societies in which the
design of social institutions is strongly determined by ideology or religion
exhibit a very weak demand for social science knowledge. The USSR, for
example, tends to draw primarily on that narrow range of economics most
closely related to engineering – input/output analysis, mathematical
programming, and sector modeling. In China much of the capacity in economics
is devoted to rationalizing the implications of shifts in economic ideology.
Relatively little capacity is devoted to institutional design.

It also seems clear that the demand for social science knowledge is
strongest in those societies and in those historical periods in which the
burdens of ideology, religion and tradition impose relatively weak constraints
on institutional design. And within any society it seems apparent that
the demand for social science knowledge is strongest when that society
is attempting to confront the problems of the present rather than when it

is attempting to recapture romantic memories of the past or pursuing utopian visions of the future.

TOWARD A MORE COMPLETE MODEL OF INSTITUTIONAL CHANGE

This review of the state of our knowledge with respect to the forces and processes of institutional innovation leaves one with two general perspectives. The first is that it is possible to use the tools of modern analytical economics to advance our understanding of the process of institutional change. The second is that the state of our knowledge remains highly unsatisfactory. But how do we continue the tentative advances that have been made? Instead of attempting to provide a direct response to this question let me map out where we have been and where I think we are in this quest.

I illustrate, in Figure 1, the elements of a model that maps the general equilibrium relationships among resource endowments, cultural endowments, technologies and institutions. The model goes beyond the conventional general equilibrium model in which resource endowments, technologies, institutions, and culture (conventionally designated as tastes) are taken as given and are ignored in the analysis.

In the study of long-term social and economic change the relationships among the several variables must be treated as recursive. The formal microeconomic models that are employed to analyze the supply and demand for technical and institutional change can be thought of as 'nested' within the general equilibrium framework of Figure 1.

One advantage of the 'pattern model' outlined in Figure 1 is that it helps to identify areas of ignorance. Our capacity to model and test the relationships between resource endowments and technical change is relatively

strong. Our capacity to model and test the relationships between cultural endowments and either technical or institutional change is relatively weak. A second advantage of the model is that it is useful in identifying the model components that enter into other attempts to account for secular economic and social change.

For example, historians working within the Marxist tradition often tend to view technical change as dominating both institutional and cultural change. In his book, Oriental Despotism, Karl Wittfogel views the irrigation technology used in wet rice cultivation in East Asia as determining political organization. In terms of Figure 1 his primary emphasis was on the impact of resource endowments on institutions (C) and (B).

A serious misunderstanding can be observed in contemporary neo-Marxian critiques of the 'green revolution.' These criticisms have focused attention almost entirely on the impact of technical change on labor and land tenure relations. Both the radical and populist critics have emphasized relation (B). But they have tended to ignore relationships (A) and (C).

Why have scholars working within the Marxian or other radical political economy traditions tended to attribute changes in property rights and income distribution to technical change which, in a more comprehensive analysis, appear to reflect the impact of changes in resource endowments - particularly the changes in man-land ratios associated with demographic change? A partial answer to this question must be sought in the rather simple model that is conventionally employed in Marxian analysis (Figure 2). In the Marxian model the resource endowment and technology categories of Figure 1 are subsumed under the rubric of "forces of production." It is not stretching conventional usage too much to associate "relations of production" and "superstructure" in Figure 2 with "institutions" and "cultural endowments"

in Figure 1. There is a long history of debate over whether Marx was a technological determinest as reflected in (M) and (m) in Figure 2. It is quite clear that Lenin's view of the relationship between the superstructure, the relations of production and the forces of production gave substantial weight to relations (L) and (l).

It does seem clear that many of the critics of the green revolution have conducted their analysis encumbered by ideological blinders. This blindness traces back to the debates between Malthus and Marx. The result has been repeated failure to effectively identify the separate effects of population growth and technical change on the growth and distribution of income. The analytical power of the more complete induced innovation model was illustrated in the work by Hayami and Kikuchi, discussed earlier in this paper, on the impact of both technical change and population growth on changes in land tenure and labor market relationships in the Philippines.

American scholars such as Armen Alchian and Harold Demsetz, working within what has come to be called the "property rights" paradigm, identify a primary function of property rights as guiding incentives to achieve greater internalization of externalities. They consider that the clear specification of property rights reduces transaction costs in the face of growing competition for the use of scarce resources as a result of population growth and/or growth in product demand.

Douglass North and John Paul Thomas, building on the Alchian-Demsetz paradigm, have attempted to explain the economic growth of Western Europe between 900 and 1700 primarily in terms of changes in property institutions. During the eleventh and thirteenth centuries the pressure of population against increasingly scarce land resources induced innovations in property rights that in turn created profitable opportunities for the generation and adoption

of labor-intensive technical changes in agriculture. The population decline

in the fourteenth and fifteenth centuries was viewed as a primary factor

leading to the demise of feudalism and the rise of the national state (line C).

These institutional changes in turn opened up new possibilities for economies

of scale in nonagricultural production and in trade (line b).

In a more recent work Mancur Olson has emphasized the proliferation of

institutions as a source of economic decline. He also regards broad-based

encompassing organizations as having incentives to generate growth and

redistribute incomes to their members with little excess burden. For

example, a broadly based coalition that encompasses the majority of agri-

cultural producers is more likely to exert political pressure for growth-

oriented policies that will enable its members to obtain a larger share of

a larger national product than a smaller organization that represents the

interests of the producers of a single commodity. Small organizations

representing narrow interest groups are more likely to pursue the interests

of their members at the expense of the welfare of other producers and the

general public. In contrast, an even more broadly based farmer-labor

coalition would be more concerned with promoting economic growth than an

organization representing a single sector. But large groups, in Olson's

view, are inherently unstable because rational individuals will not incur

the costs of contributing to the realization of the large group program--

they have strong incentives to act as "free riders." As a result, organiza-

tional 'space' in a stable society will be increasingly occupied by special

interest 'distributional coalitions.' These distributional coalitions

make political life more devisive. They slow down the adoption of new

technologies (line b) and limit the capacity to reallocate resources

(line c). The effect is to slow down economic growth or in some cases initiate a period of economic decline.

What are the implications of the theory of institutional innovation outlined in this paper for the research agenda on the economics of institutional change? In our research on the direction and rate of technical change we were able to advance significantly our knowledge by treating technical change as endogenous—as induced primarily by changes in relative resource endowments and the growth of demand. We have also attempted to develop a theory of induced institutional innovation in which we treat institutional innovation as endogenous. There is now a significant body of evidence that suggests that substantial new insights on institutional innovation and diffusion can be obtained by treating institutional change as an economic response to changes in resource endowments and technical change.

We also insist on the potential significance of cultural endowments, including the factors that economists typically conceal under the rubric of tastes and that political scientists include under ideology. But our capacity to develop rigorous empirical tests capable of identifying the relative significance of the relationships between cultural endowments and the other elements of the model outlined in Figure 1 is nowhere near as satisfactory as the econometric tests analysis that has been used to test the induced technical change hypothesis discussed in my first lecture.

. Until our colleagues in the other social sciences provide us with more helpful analytical tools, we are forced to adhere to a strategy that focuses primarily on the interactions between resource endowments, technical change, and institutional change. The strategy suggested here does not have the

clear advantage of allowing us to explore how far a strategy based on the
rather straightforward extension of standard microeconomic theory will take
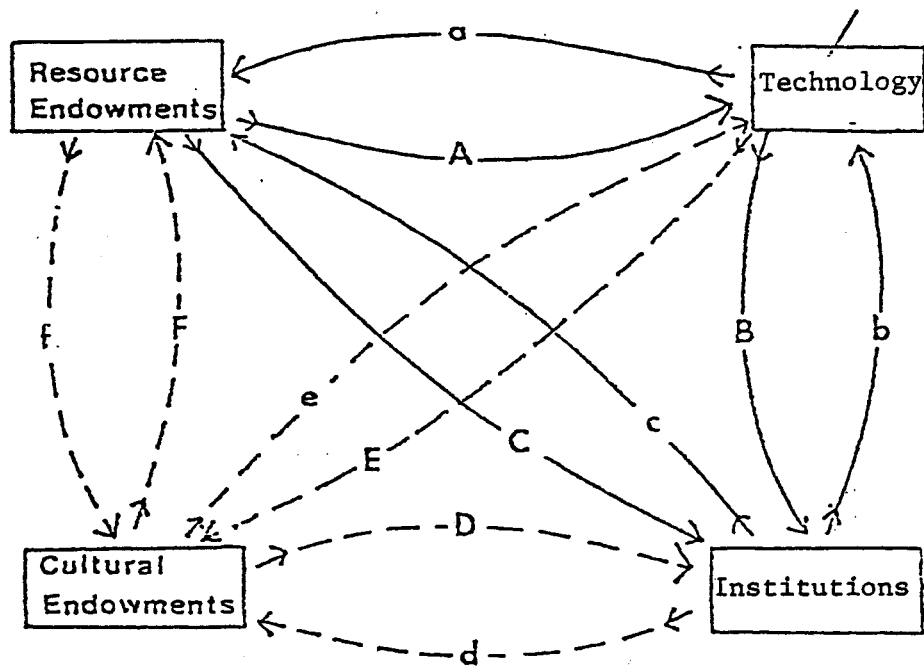us in the analysis of both technical and institutional change.

Figure 1.0   Interrelationships between changes in resource
              endowments, cultural endowments, technology,
              and institutions.

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┌─────────────────────────┐
│  Forces of Production   │
│  [machines, materials   │
│    labor, technology]   │
└─────────────────────────┘
        M│    ↑¦1
         ↓    ¦
┌─────────────────────────┐
│  Relations of Production│
│  or  Economic Structure │
│ [class relations, property rights] │
└─────────────────────────┘
        m│    ↑¦L
         ↓    ¦
┌─────────────────────────┐
│     Superstructure      │
│  [culture, ideology     │
│   politics, religion]   │
└─────────────────────────┘
```
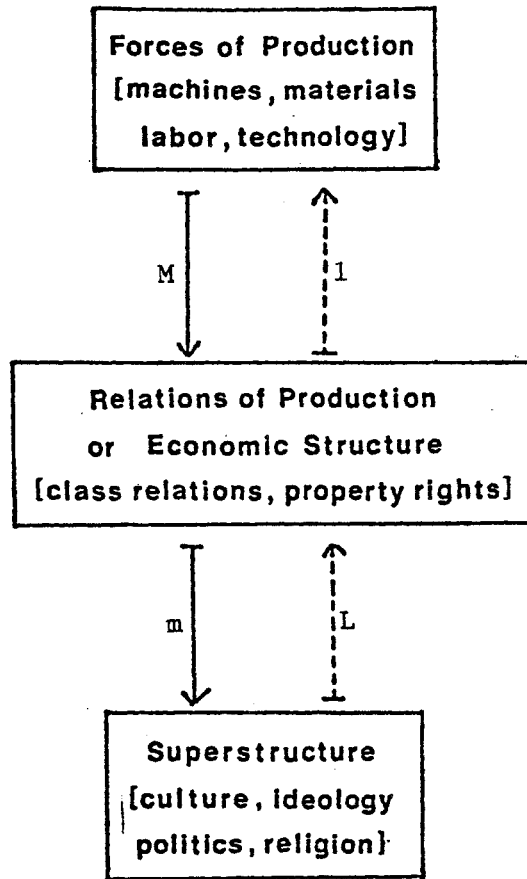
Figure 2.0   The Marxian Model

Table 1.0   Factor Shares of Rice Output per Hectare, 1976 Wet Season

	Number of Plots	Area (ha)	Rice Output	Current Inputs	Land-owner	Sub-tenancy	Factor shares[a]			
							Total	Labor	Capital[b]	Operators' Surplus
			- - - - - - kg/ha - - - - - -							
Leasehold land	44	67.7	2,889	657	567	0	567	918	337	410
			(100.0)	(22.7)	(19.6)	(0)	(19.6)	(31.8)	(11.7)	(14.2)
Share tenancy land	30	29.7	2,749	697	698	0	698	850	288	216
			(100.0)	(25.3)	(25.4)	(0)	(25.4)	(30.9)	(10.5)	(7.9)
Sub-tenancy land	16	9.1	3,447	801	504	801[c]	1,305	1,008	346	-13
			(100.0)	(23.2)	(14.6)	(23.2)	(37.8)	(29.3)	(10.1)	(-0.4)

a   Percentage shares are shown in parentheses.

b   Sum of irrigation fee and paid and/or imputed rentals of carabao, tractor and other machines.

c   Rents to sub-leasors in the case of pledged plots are imputed by applying the interest rate of 40 percent crop season (a mode in the interest rate distribution in the village).

Source: Yujiro Hayami and Masao Kikuchi, Asian Village Economy at the Crossroads: An Economic Approach to Institutional Change (Tokyo: University of Tokyo Press, 1981, and Minneapolis: University of Minnesota Press, 1982), pp. 111-13.

Table 2.0 Comparison between the imputed value of harvesters' share
and the imputed cost of <u>gamma</u> labor.

	Based on employers' data	Based on employees' data
No. of working days of <u>Gamma</u> labor (days/ha)[a]		
Weeding	20.9	18.3
Harvesting/threshing	33.6	33.6
Imputed cost of <u>Gamma</u> labor (P/ha)[b]		
Weeding	167.2	146.4
Harvesting/threshing	369.6	369.6
(1) Total	536.8	516.0
Actual share of harvesters:		
In kind (kg/ha)[c]	504.0	549.0
(2) Imputed value (P/ha)[d]	504.0	549.0
(2) - (1)	-32.8	33.0

[a] Includes labor of family members who worked as <u>Gamma</u> laborers.

[b] Imputation using market wage rates (daily wage = P8.0 for weeding,
P11.0 for harvesting).

[c] One-sixth of output per hectare.

[d] Imputation using market prices (1 kg = P1).

Source: Yujiro Hayami and Masao Kikuchi, <u>Asian Village Economy at the
Crossroads: An Economic Approach to Institutional Change</u> (Tokyo:
University of Tokyo Press, 1981, and Minneapolis: University of
Minnesota Press, 1982), p. 121.