PB-225 804

TECHNOLOGY TRANSFER, INSTITUTIONAL TRANSFER, AND INDUCED TECHNICAL AND INSTITUTIONAL CHANGE IN AGRICULTURAL DEVELOPMENT

Vernon W. Ruttan

Minnesota University

Prepared for:

Agency for International Development

June 1973

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

BIBLIOGRAPHIC DATA SHEET	1. Report No. [redacted] 63ϕ.2ϕ8-R982	2.	PB 225 804

4. Title and Subtitle "TECHNOLOGY TRANSFER, INSTITUTIONAL TRANSFER, AND INDUCED TECHNICAL AND INSTITUTIONAL CHANGE IN AGRICULTURAL DEVELOPMENT"	5. Report Date June 1973
	6.
7. Author(s) Vernon W. Ruttan	8. Performing Organization Rept. No.
9. Performing Organization Name and Address University of Minnesota Institute of Agriculture St. Paul, Minn. 55101	10. Project/Task/Work Unit No. 931-11-14ϕ-122
	11. Contract/Grant No. AID/csd-2815-211(d)
12. Sponsoring Organization Name and Address Department of State Agency for International Development Washington, D.C. 20523	13. Type of Report & Period Covered Staff Paper
	14.

15. Supplementary Notes

16. Abstracts

The design of a successful agricultural development strategy involves a unique combination of technical and institutional change. It involves technical innovations capable of generating substantial new income flows. And it involves an adaptive response on the part of cultural, political, and economic institutions to realize the growth potential opened up by the new technical opportunities.

In this paper an attempt is made to show how the addition of an induced innovation perspective can enrich our understanding of the process of technology transfer in agricultural development. An attempt is also made to extend the induced innovation perspective to the process of institutional transfer.

17. Key Words and Document Analysis. 17a. Descriptors

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group 338

18. Availability Statement	19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 51
	20. Security Class (This Page) UNCLASSIFIED	22. Price $4.75

Reproduced by NATIONAL TECHNICAL INFORMATION SERVICE U S Department of Commerce Springfield VA 22151

Staff Paper P73-16 June 1973

Technology Transfer, Institutional Transfer, and Induced Technical and Institutional Change in Agricultural Development

Vernon W. Ruttan

Staff Papers are published without formal review within the Department of Agricultural and Applied Economics. The research on which this paper is based was supported by grants to the University of Minnesota Economic Development Center from the U. S. Agency for International Development (AID/csd-2815) and by the Rockefeller Foundation. This paper was prepared for presentation at a Conference on Agriculture in Development Theory, Villa Serbelloni, Bellagio, Italy, May 23-29, 1973.

TECHNOLOGY TRANSFER, INSTITUTIONAL TRANSFER, AND INDUCED TECHNICAL AND INSTITUTIONAL CHANGE IN AGRICULTURAL DEVELOPMENT*

Vernon W. Ruttan**

The design of a successful agricultural development strategy involves a unique combination of technical and institutional change. It involves technical innovations capable of generating substantial new income flows. And it involves an adaptive response on the part of cultural, political, and economic institutions to realize the growth potential opened up by the new technical opportunities.

In this paper an attempt is made to show how the addition of an induced innovation perspective can enrich our understanding of the process of technology transfer in agricultural development. An attempt is also made to extend the induced innovation perspective to the process of institutional transfer.

PHASES OF TECHNOLOGY TRANSFER

The international diffusion of agricultural technology is not new. The classical studies by Sauer and Vavilov, as well as more recent studies of agricultural origins and dispersals, indicate that the international and intercontinental diffusion of cultivated plants, domestic animals, hand tools, and husbandry practices was a major source of productivity growth in prehistory and in the classical civilizations.[1/] The transfer of crops from the new continents to Europe after the discovery of America had a dramatic impact on European agriculture. The technological bases for the staple exports of many developing countries--cocoa in West Africa and rubber in Southeast Asia, for example,--occurred as a result of the international diffusion of crop varieties.

Before agricultural research and extension were institutionalized, this diffusion took place as a by-product of travel, exploration, and communication undertaken primarily for other purposes. Over a long gestation period--several decades and even centuries--exotic plants, animals, equipment, and husbandry techniques were gradually introduced and adapted to local conditions. In the 19th century the international diffusion process became more highly institutionalized. National governments established agencies to deliberately seek out and introduce exotic crop varieties and animal breeds.[2/] Colonial governments and the great trading companies operating under their protection sought to introduce crops with export potential into new areas of cultivation. These efforts have, over time, had a substantial impact on the location of staple production and on international trading patterns in crop and animal products.

The most dramatic example of agricultural technology transfer during the last several decades has been the development and diffusion of new high yielding varieties of rice, wheat, and maize in the tropics (Table 1). This process involved more than the diffusion of crop varieties and the modification of husbandry practices. It involved a transfer of the capacity to invent a new, location specific biological technology. It involved the transfer of scientific ideas, the migration of individual scientists, and the establishment of relatively sophisticated research facilities.[3/]

TABLE 1. ESTIMATED AREA PLANTED IN HIGH-YIELDING VARIETIES (HYV) OF RICE AND WHEAT IN WEST, SOUTH, AND SOUTHEAST ASIA.

Country	Rice					Wheat				
	1966/67	1967/68	1968/69	1969/70	1970/71	1966/67	1967/68	1968/69	1969/70	1970/71
	thousand acres									
Iran								25	222	312
Iraq							16	103	482	309
Turkey						1	420	1444	1343	1184
Afghanistan						5	54	302	361	574
India	2195	4408	6625	10729	13593	1270	7270	11844	12133	14559
Nepal			105	123	168	16	61	133	187	243
Pakistan (E)	1	166	382	652	1137			20	22	24
Pakistan (W)		10	761	1239	1548	250	2365	5900	6626	7288
Burma		8	412	356	496					
Ceylon			17	65	73					
Indonesia			488	1854	2303					
Korea					7					
Laos	1	3	5	5	133					
Malaysia	104	157	225	238	327					
Philippines	204	1733	2500	3346	3868					
Thailand					400					
Vietnam		1	100	498	1240					
Total	2505	6486	11620	19105	25293	1542	10186	19771	21376	24493

Source: Dana G. Dalrymple, Imports and Plantings of High-Yielding Varieties of Wheat and Rice in the Less Developed Nations, Foreign Economic Development Service Report-14, U. S. Department of Agriculture in cooperation with Agency for International Development (Washington, Feb. 1972), pp. 48, 49.

A technology transfer typology[4/]

It is analytically useful to distinguish three phases or levels of agricultural technology transfer: (a) materials transfer, (b) design transfer, and (c) capacity transfer.

Material transfer is characterized by the simple transfer or importation of new materials such as seeds, plants, animals, machines, and the husbandry or management practices associated with these materials. Local adaptation through systematic selection of superior individuals or populations and the adaptation of husbandry and management practices is not highly institutionalized. The "naturalization" of plants and animals tends to occur primarily as a result of trial and error by farmers. The analogy in industrial technology transfer is the "turn key" plant.

Design transfer is characterized by the transfer of information in the form of blue prints, formulas, journals and books, and related "software." During this period exotic plant materials, animal breeding stock, or prototype machines may be imported for testing purposes, to obtain genetic materials, or in order to copy their designs. New plants and animals are subject to systematic tests, propagation, and selection. Imported machines are tested and designs modified to adapt them to local ecological conditions or to different tasks.

Capacity transfer occurs primarily through the transfer of scientific and technical knowledge and capacity. The objective is to institutionalize local capacity for invention and innovation of a continuous stream of locally adopted technology. Increasingly plant and animal varieties are developed locally to adapt them to local ecological conditions. Machine designs become less dependent on prototypes developed elsewhere. As local agricultural

science and engineering capacity is strengthened, both biological and mechanical technologies are invented that are precisely adapted to the ecological conditions and factor endowments of the local economy.

An important element in the process of international capacity transfer is the migration of individual scientists and the building of institutions with advanced research, development, and training capacity. In spite of advances in communications, diffusion of the concepts and craft of agricultural science and engineering, and of science and culture generally, depends heavily on extended personal contact and association. The development of the new international agricultural institutes (CYMMIT, IRRI, CIAT, IITA, ICRESAT), and much of the institution building effort of the international aid agencies can be viewed, and evaluated, against the objective of speeding entrance of the LDC's into the capacity transfer stage.

Diffusion and development of sugar cane varieties[5/]

The three phases of international transfer of agricultural technology outlined above can be illustrated by the history of the diffusion and development of sugar cane varieties (cultivars).

Material transfer. In nature the cane plant reproduces only asexually. The initial diffusion of sugar cane was based on the diffusion of planting materials (clones). Until the late 1700's commercial production was based entirely on two closely related species indigenous to India (S. sinense and S. barberi). Sugar cane was cultivated in India as early as 400 B.C. Cane and the art of sugar making were diffused from India to China, Arabia, and the Mediterranean region very early. It was introduced in Madeira and the Azores shortly after 1400. Columbus brought sugar cane to the new world on his second voyage. During the 17th century the Indian varieties were gradually displaced by a higher yielding thicker stemmed variety (S. officinarum) from Southeast Asia which became the dominant commercial variety throughout the 19th century.

Design transfer. Procedures for the sexual reproduction of sugar cane were discovered independently in Java in 1887 and Barbados in 1888. It was discovered that the cane plant can be induced to flower and produce seedlings under appropriate temperature and light control. Each new seedling produced by sexual reproduction becomes a potential new variety since it can be reproduced asexually. The Java station (Proefstation Oost Java) was the first to develop a new variety of commercial significance. The relatively simple breeding methodology diffused rapidly. Important commercial varieties were developed at experiment stations in Hawaii, Barbados, India,

and elsewhere. The varieties developed at the P.O.J. and Coimbatore (India) stations became particularly important sources of genetic materials throughout the world.

Capacity transfer. Breeding for disease resistance become a dominant concern, as many of the new varieties were found to be susceptible to local diseases and pests. The P.O.J. station played a leading role in the development of disease resistant varieties. In 1921 a new disease resistant variety (P.O.J. 2878) was developed by crossing two species, a 118 chromosome disease resistant thin-stemmed wild cane (S. spontaneum) with one of the thick-stemmed 80 chromosome canes (S. officinarum). Through a series of crosses and back crosses new interspecific hybrids were developed that incorporated the hardiness and disease resistance of the noncommercial species. Later the Coimbatore station developed a series of tri-hybrid canes by introducing a third species (S. barberi). This resulted in new varieties adapted specifically to the local climate, soil, and disease conditions.

The introduction of the new P.O.J. and Coimbatore interspecific hybrids was followed by rapid international transfer of the superior P.O.J. and Coimbatore genetic materials and breeding methods. It also set the stage for the development of more sophisticated breeding and agronomic research capacity directed toward the development of varieties and the design of crop management practices suited to the specific soil, climate, disease, and related ecological characteristics of each major producing region. Genetic materials and research methodology moves freely and rapidly among regions. But almost every important sugar cane producing country now has the capacity to produce locally adapted varieties.

Where does the new "green revolution" cereals technology fit in the three phase typology outlined above? In my judgment wheat, rice, and maize are just now entering the capacity transfer stage in most developing countries. The establishment of the new international research institutes has been instrumental in creating and transmitting new approaches for the design of higher yielding grain varieties in the tropics. They also represent an initial step in capacity transfer. It seems apparent that continuation of the momentum of the "green revolution" will require the development of experiment station capacity in each major ecological region for each crop of economic significance in the region.

TECHNOLOGY TRANSFER AND INNOVATION

There are two bodies of literature on which we can draw in attempting to understand the phases of technology diffusion and transfer described in the previous section. There are multiple traditions of research on the diffusion of technical change--in anthropology, geography, sociology, and economics. There is also a more recent body of literature on induced innovation.

Technology transfer

There are substantial differences among the several traditions of research on the diffusion of technical change.[6] The main focus of the work in anthropology, sociology, and geography has been on the impact of communication (or interaction) and of socio-cultural resistance to innovation on diffusion over time and across space. The models of economists have focused primarily on how economic variables such as the profitability of innovation and the asset position of firms influence the rate of diffusion.[7] There has also emerged, in the recent literature, a concern with the feedback effects of technology diffusion on trade relationships.[8]

In general, the diffusion literature provides more insight into the processes of material and design transfer than into the processes leading to capacity transfer. This is primarily because the attributes of the technology, the characteristics of the adopters, and the economic and social organization are typically taken as given.[9] The typical assumptions of commercial availability and of direct transferability of the technology represents a critical limitation in adopting the models used in most diffusion research to understand the international diffusion of technology in situations where variations in ecological conditions and factor endowments severely restrict the diffusion or direct transfer of agricultural technology. An effective understanding of the process of capacity transfer must also include a perception of the process by which technical innovation is induced along an efficient path consistent with relative resource endowments and factor prices.

The study by Griliches of the diffusion of hybrid corn represents a rare attempt to incorporate the process of local adaptation into a

diffusion model.[10] The study is of relevance because the diffusion of hybrid corn among geographic areas, through the development of locally adapted varieties, is similar to our view of the process of international technology transfer in agriculture. "Hybrid corn was the invention of a method of inventing, a method of breeding superior corn for specific locations. It was not a single invention immediately available everywhere. The actual breeding of adaptable hybrids had to be done separately for each area. Hence, besides the differences in the rate of adoption of hybrids by farmers . . . we have also be explain the lag in the development of adaptable hybrids for specific areas."[11]

The procedure employed by Griliches was to summarize the diffusion path by fitting an S-shaped logistic trend function to data on the percentage of corn area planted with hybrid seed in each maturity area. The logistic trend function is described by three parameters--an origin, a slope, and a ceiling. Griliches interpreted his results as indicating that differences among regions in the rate (slope) and level (ceiling) of acceptance are both functions of the profitability of a shift from open-polinated to hybrid corn. Variations in these two parameters among regions are thus explained in terms of farmer's profit-seeking behavior.

What makes the Griliches study particularly relevant to the problem of international technology transfer is that he incorporated into his model the behavior of public research institutions and private agricultural supply firms which make locally adapted hybrid seeds available to farmers. He attempted to explain variations in the date of <u>origin</u>, or of commercial

availability, of hybrid corn by the size and density of the hybrid seed market estimated from the size and density of corn production.

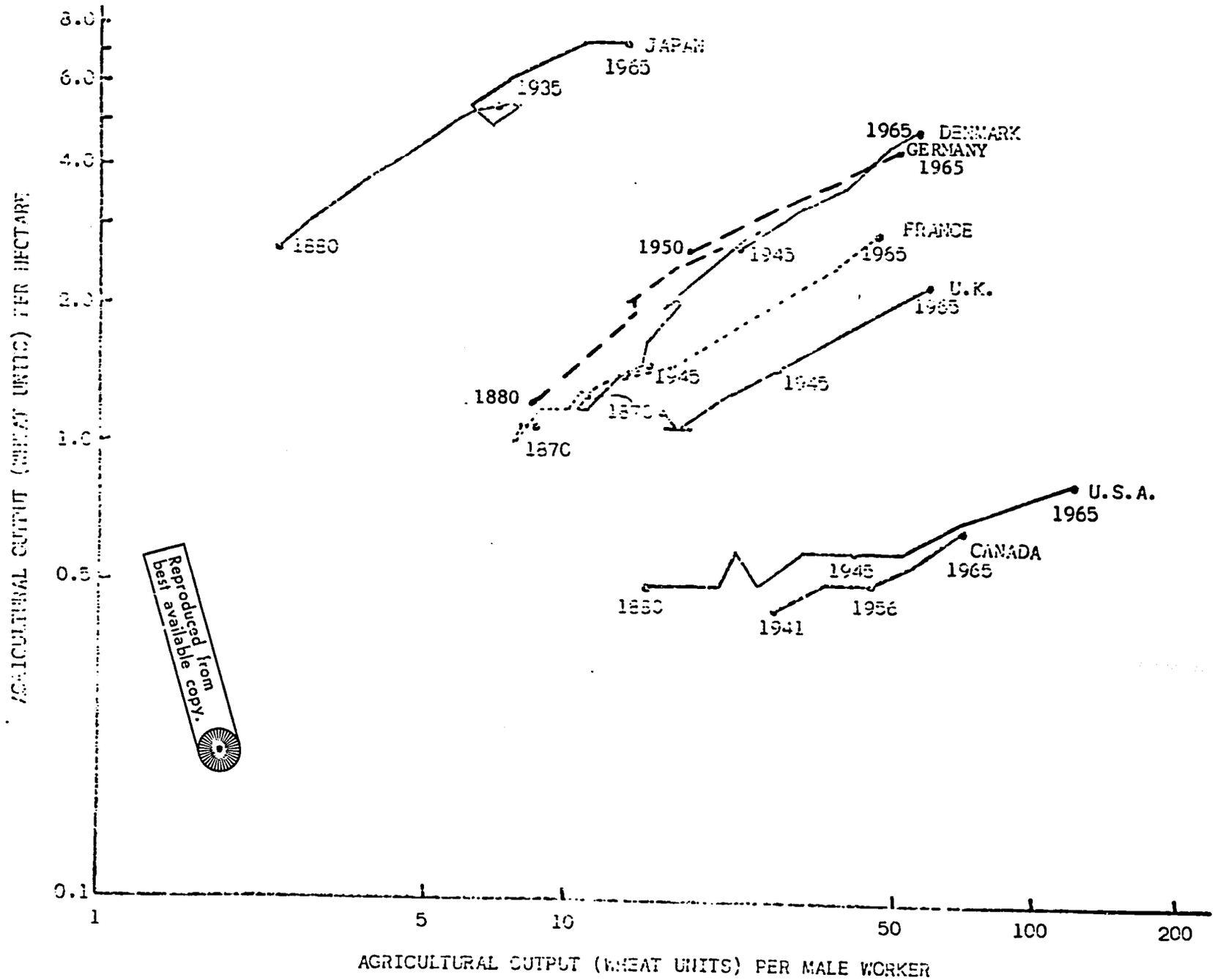
From this analysis Griliches derived the conclusion that both the efforts of the agricultural experiment stations and the commercial seed companies were guided by the expected return to research, development, and marketing costs. The particular merit of the Griliches model is that it incorporates the mechanism of local adaptation into the process of inter-regional transfer of agricultural technology. This mechanism is based on the behavior of public research institutions and private agricultural supply firms. Modification of the model is needed, however, in applying it to the study of international technology transfer.[11a/]

Induced technical change

Within the last decade the theoretical and empirical implications of relative resource endowments and factor prices on the "choice of technology" and on the direction of technical effort has undergone an extensive re-evaluation.[12/] The effect of the theoretical discussion has been a rehabilitation of the Hickian view that relative factor prices affect not only the choice of existing technology but the direction of technical effort and hence the direction of factor bias in the new production functions that become available to producers over time and among areas.[13/]

The effect of empirical investigation has been to confirm that the alternative paths of technical change followed by countries with such diverse resource endowments as Japan, Denmark, and the United States (Figure 1) have occurred in response to relative factor prices which in turn represented reasonably accurate indicators of relative factor endowments.[14/] Studies in LDC's have demonstrated that institutionally determined biases in relative factor prices have induced patterns of technical change that have been inconsistent with relative resource endowments.[15/]

A major implication of this research is that reliance on diffusion processes based primarily on materials and design transfer can, in the absence of the investment necessary to reach the capacity transfer level, severely bias the direction of technical change. Furthermore, the induced innovation perspective provides a useful guide to the design of a national research strategy in which experiment station capacity is developed to the fullest extent in those areas of biological technology which permit a nation to take advantage of unique environmental resources and in those areas of mechanical technology where resource endowments depart most sharply from the endowments in developed countries.



Reproduced from best available copy.

Figure 1. Historical growth paths of agriculture development in the United States, Japan and Germany, 1880-1965, and Denmark, France, and the United Kingdom, 1870-1965, and Canada, 1941-1965.

The transfer of high-yielding rice varieties to the tropics[16/]

The transfer of the new high yielding grain varieties from the temperate region to the tropics illustrates the process of material, design, and capacity transfer. The "proto-type" for high yielding "fertilizer consuming" rice varieties that have recently become available to producers in a number of tropical countries evolved in Japan first as a result of selection by farmer "seedmen" and later under the stimulus of a concerted research effort by the national and prefectural experiment stations. In Japan the development and diffusion of the fertilizer responsive varieties was closely associated with a decline in the price of fertilizer relative to the price of rice and to the price of land.

In the 1920's a strenuous effort was made to transfer Japanese rice production technology to Korea and Taiwan. The effort was induced by the rapid increases in the price of rice in Japan during and after World War I. Under the Sanmai Zoshoku Keikaku (Rice Production Development Program) the Japanese government invested in irrigation and water control and in research and extension in order to develop and diffuse high yielding rice varieties adapted to the local ecology of Korea and Taiwan.

In the case of Korea it was possible to achieve rapid expansion of rice production through the direct transfer of Japanese rice varieties (materials) and cultural practices (designs) under the stimulis of relatively low fertilizer prices and administrative incentives. In Taiwan the problem was more difficult. It was not easy to adapt Japanese varieties to the more tropical environment of Taiwan. Research designed to improve the local varieties and to adapt Japanese varieties to the local environment had been initiated shortly after the Japanese occupation. It was not

until the late 1920's, however, that well adapted Ponlai varieties "developed by cross-breeding of Japanese varieties or between Japanese and traditional Taiwan (Chailai) varieties to have photo-sensitivities different from the original Japanese varieties"[17/] become available for rapid diffusion. In spite of favorable resource endowments resulting from heavy investment in irrigation development during the first two decades of the Japanese occupation and relatively low fertilizer prices, the diffusion of high yielding fertilizer response varieties was delayed until local experiment station capacity for adaptive research had been established. It appears reasonable to interpret the transfer of Japanese rice production technology as a response by the colonial government to a potential high pay-off (for Japan) from investment in research leading to an adjustment from a secular disequilibrium toward an equilibrium for the fertilizer rice price ratios prevailing in the 1920's.

The question remains why the transfer of the high yielding rice technology from Japan and Taiwan to South and Southeast Asia was delayed until the late 1960's? Why did rice yields in Southeast Asia increase so slowly in spite of substantial declines in the fertilizer-rice price ratio (Table 2)? A first response must be sought in the fact that the public sector investment in local experiment station capacity necessary to invent the locally adopted varieties was not initiated until the early 1960's. When the investment was made by the Ford and Rockefeller Foundations at the International Rice Research Institute, by the Government of the Philippines at the Bureau of Plant Industry and the University of the Philippines, by the Indian Council of Agricultural Research, and others, the rapid diffusion

Table 2. Fertilizer-rice price ratios and rice yields per hectare in selected Asian countries and in Japan, 1883–1962

Country	Currency unit	Price of fertilizer: per m. ton of nitrogen (1)	Price of rice: per m. ton of milled rice (2)	Fertilizer-rice price ratio (1)/(2)	Rice yield per hectare: m. ton of paddy (3)
Intercountry comparison					
1963-65					
India	rupee	1,750	595[a]	2.9	1.5
			723[b]	2.4	
Pakistan (East)	rupee	1,632	780	2.1	1.7
Philippines	peso	1,048	530	2.0	1.3
Thailand	U.S. dollar	229	70	3.3	1.6
Japan	1,000 yen	97	99	1.0	5.0
1955-57					
India	rupee	1,675	417[a]	4.0	1.3
			505[b]	3.3	
Pakistan (East)	rupee	1,322	511	2.6	1.4
Philippines	peso	962	352	2.7	1.1
Thailand	U.S. dollar	393	79	5.0	1.4
Japan	1,000 yen	119	77	1.5	4.8
Japan's time series					
1958-62	1,000 yen	100	85	1.2	4.9
1953-57	1,000 yen	113	75	1.5	4.2
1933-37	yen	566	208	2.7	3.8
1923-27	yen	1,021	277	3.7	3.6
1913-17	yen	803	125	6.4	3.5
1903-07	yen	815	106	7.7	3.1
1893-97	yen	670	69	9.7	2.6
1883-87	yen	450	42	10.7	n.a.

[a] Price at Sambalpur (Orissa).

[b] Price at Bombay. (1) Price paid by farmers. Intercountry data: average unit price of nitrogen contained in ammonium sulphate; 1963-65 data are the averages for 1962/63–1964/65; 1955-57 data are the data of 1956/57; government subsidies of 50 percent for 1963-65 and of 40 percent for 1955-57 are added to Pakistan's original data. Japan data: average unit price of nitrogen contained in commercial fertilizers. (2) This is the wholesale price at milled rice basis. Japan data are converted from brown rice basis to a milled rice basis assuming 10 percent for processing cost. (3) Japan data are converted from a brown rice basis to a milled rice basis assuming 0.8 for a conversion factor.

Source: Intercountry data: FAO, *Production Yearbook*, various issues. Japan data: Kazushi Ohkawa et al. (ed.), *Long-term Economic Statistics of Japan*, Vol. 9 (Tokyo: Toyokeizaishimposha, 1966), pp. 202-3; Nobufumi Kayo (ed.) *Nihon Nogyo Kisotokei*, (Tokyo: Norin Suisangyo Seisankojokaigi, 1958), p. 514; Toyokeizaishimposha, *Bukku Yoran* (Tokyo, 1967), p. 80; Institute of Developing Economies, *One Hundred Years of Agricultural Statistics in Japan* (Tokyo, 1969), p. 136.

Reproduced from best available copy.

of capacity to develop locally adapted new varieties was facilitated by conceptual and methodological advances in breeding technique.[18/] The first new varieties, such as IR-8, IR-5, and C4-63, diffused rapidly among farms in the regions where they were first released and to other tropical rice producing regions and countries. This has been followed by diffusion of the capacity to breed locally new varieties which are more precisely adapted to local ecological regions. These new local varieties are now replacing the initial "green revolution" varieties.[19/] The constraint on growth of output imposed by lack of fertilizer responsive varieties is now being replaced by constraints imposed by investment in irrigation.[20/]

We have described, in the case of rice, a situation where transfer of the high yielding rice technology to the tropics was delayed by an institutional lag in the development of research capacity. When that capacity emerged in the 1960's, the new varieties were sufficiently superior to the local varieties in many tropical areas that simple material and design transfer provided a powerful source of productivity growth in many areas. These stages are now being followed by the diffusion of the research capacity to provide locally adopted varieties and to protect the yield advances already made against depreciation.

INSTITUTIONAL TRANSFER AND INNOVATION

Viewed from a historical perspective the recent development of high yielding varieties of wheat, rice, and maize in the tropics represented an institutional innovation[21] by national and international agencies to make available, or obtain access to, the new income streams made possible by advances in the technology of plant breeding and fertilizer manufacture during the 1960's. It also appears that the technical changes embodied in the new high yielding cereal varieties is biased toward saving an increasingly scarce factor (land) and using an increasingly abundant factor (fertilizer). It can also be viewed as an attempt to evolve a science based agriculture using material inputs produced by the industrial sector to augment an inelastic supply of (raw) land.

The process of institutional transfer and innovation has represented an essential element in the process. Capacity transfer has depended on the successful institutionalization of public (or philanthropic) sector capacity to generate a continuous stream of new biological technology. Under modern conditions technology transfer is increasingly dependent on capacity transfer. Yet the literature on institutional transfer and innovation is, if anything, even more unsatisfactory than the literature on technology transfer and innovation.[22]

There are two bodies of literature that provide a limited basis on which to build an understanding of the processes involved in institutional transfer and innovation. One is the literature on institution building that has evolved out of an effort, primarily in the field of public administration, to provide technical assistance agencies with an effective methodology for external intervention to induce more effective institutional performance.[23]

The second body of literature has evolved out of the efforts by a number of economists and political scientists to develop models of bureaucratic behavior.[24] These two bodies of literature offer some insights into the process of institutional transfer and innovation.

The institution building perspective

The institution building perspective involved an explicitly normative orientation toward social change. An "institution" is viewed as a package of behaviors and relationships that describe a particular organization and its interactions with its environment. The test of effective "institutionalization" in the institution building perspective is the normative impact of the organization on its setting. In this view the appropriate test for the institutionalization of experiment station capacity for rice research would be in terms of the impact of the new knowledge resulting from rice research on rice yields, the incomes of rice producers, or the price of rice to urban consumers.

The concern with the effectiveness of technical assistance has clearly exerted a substantial impact on the institution building literature. There is a pervasive concern with the problem of transferring particular organizational forms from the developed to the developing nations and with the institutionalization of capacity for technology transfer and innovation.[24a]

At the same time the institution building perspective has been criticized for not giving more explicit attention to the development of a typology by which organizations can be differentiated on the basis both of technology and environmental characteristics.[25] Siffin argues, for example, that it is easier to institutionalize an organization whose operations are primarily concerned with a well developed technology than an organization that is not technology centered. He points out that the relatively "closed system" quality of many technologies means that the behaviors they require are quite particular to their operations--and not to the socio-cultural system at large. On the

other hand where there is no closed-system technology, as in community development efforts, effective institutionalization may be exceedingly difficult to achieve.

From my perspective the major limitation of the institution building literature is analogous to the limitations of the literature on the diffusion of technology: (a) it is more relevant to the problems of material and design transfer than capacity transfer and (b) there is no model of the process by which institutional innovations are generated. In my judgment the most significant contribution of the research on institution building is the recent recognition of the close link between technical and institutional change. This opens up the possibility of developing models of organizational behavior induced by either technical innovation or institutional innovation.

Models of bureaucratic behavior

The effort to model bureaucratic behavior has been primarily positive in orientation. It has represented an attempt to extend the micro-economic theory of the firm and of the consumer to model the relationships between the public or semi-public organization (or bureau) and its environment and to analyze the consequences of these relationships for public choice and for the generation of budgets and the supply of services or other output. The effect has been the development of an "economic" or "rational" theory of bureaucratic behavior as an alternative to the "organic" or "altruistic" model.[26]

The significance of this development is that it provides an approach to the modeling of the consequences of maximizing behavior on the budget and output performance of bureaus in response to variation in the several components of the bureaus environment--including the characteristics of the "markets" through which (a) it generates revenue, (b) it acquires factors of production, and (c) through which its output is distributed. A major positive implication of the formal models developed thus far is that, given the "markets" in which they operate, bureaus will be successful in capturing a relatively large share of the rents generated by their activities.[27] The rents captured by the bureau may be relatively low where the demand for their services is relatively elastic or relatively high where the demands for their services are relatively inelastic. In general, the tests of the models to this point have been either synthetic or anecdotal.[28]

A second set of inferences deals with the mobilization of group behavior. Olson, in particular, has shown that in the "public goods" market there are severe constraints on the capacity to mobilize collective action.[29] A major implication of this second line of investigation is the importance of a

proliferation of voluntary organizations--the source of demand for public services--around activities which generate private gains. It is further argued that the performance of the market for public services is improved by decentralization on the supply side.

The economic models of bureaucratic behavior and collective action provide preliminary insights into the role of economic factors in generating a supply of bureaucratic services--new knowledge of crop production practices, for example. In my judgment, however, the static nature of the models that have been discussed in the literature implies greater constraints on the capacity for collective action and on the bureaucratic response to economic incentives than is consistent with historical experience.[30/] This failure stems, in my judgment, on a concentration on the short run allocative and distributional implications of collective action and bureaucratic behavior and a failure to explore more fully the dynamic implication of the potential gains from institutional innovation.

It is possible to summarize the major inferences from the institution building and bureaucratic behavior literature for the process of institutional transfer and innovation.

Institutional transfer is clearly facilitated when the object is to institutionalize an organization whose operations are primarily concerned with applying a well developed technology. It is easier, for example, to institutionalize experiment station or family planning than community development capacity. It also seems clear, from the induced innovation perspective, that the capacity of the technology to generate new income streams represents an important source of demand for institutional transfer.

The partitioning of the potential new income streams opened up through the transfer of a technology centered institution represents a source of demand for institutional innovation. There is continuous pressure from within the institution (firm or bureau) to internalize the gains and to externalize the costs resulting from the transfer. There will be continuous pressure from the external environment, from society, to externalize the gains and internalize the costs. The effect of the institutional changes induced by this process is to improve social efficiency by moving toward the equating of the private and social profitability of an activity. But the markets in which public sector institutions function are imperfect. Clearly there are limits to the capacity of voluntary associations to bring about sufficient equity in the distribution of power to simulate a "perfect" market for the allocation of institutional resources and products.

It is clear that we do not yet have available a fully articulated theory of induced institutional change even though some of the elements of such a theory are available to us. It is possible, however, to illustrate the implications of the insight that are available to us from historical experience.

The Second Enclosure Movement in England represents a classical illustration. The issuance of the Enclosure Bills facilitated the conversion of communal pasture and farmland into single private farm units, thus encouraging the introduction of a more intensive integrated crop-livestock "new husbandry" system.[31/] The Enclosure Acts can be viewed as an institutional innovation designed to exploit the new technical opportunities opened up by innovations in crop rotation utilizing the new fodder crops (turnip and clover), in response to rising food prices. Indeed, the long history of modernization of land tenure relationships, involving a shift from share tenure to lease tenure and owner-operator systems of cultivation in much of western agriculture, can be explained, in part, as a shift in property rights designed to internalize the potential gains of innovative activity by individual farmers. Similarly the political and legislative history of farm price programs in the United States from the mid-1920's to the present can be viewed as a struggle between agricultural producers and consumers regarding the partitioning of the new income streams resulting from technical progress in agriculture.[32/]

The close link between technical and institutional change is particularly apparent in the realization of the productivity gains resulting from the transfer of rice technology from Japan to Taiwan.[33/] The essential technological

and environmental elements for rapid development of the Taiwan rice economy were available by the mid-1920's. New and improved rice varieties had been introduced and research and development institutions with the capacity for continuous improvements in varietal characteristics had been established. Much of the potential rice land was served by irrigation systems capable of delivering water to the land throughout the year. Technical inputs such as fertilizer were made available through economic integration with the Japanese economy. The rising demand for rice in Japan created incentives to increase the marketable surplus of rice in Taiwan.

Rice yields rose rapidly, at approximately 2.0 percent per year, between the mid-1920's and the late 1930's when Japanese military efforts began to divert resources from development objectives. In spite of continued varietal development, it appears that the yield potential, under optimum environmental conditions, did not change significantly between the late 1920's and the mid-1960's. Yet rice yields rose rapidly between the early 1950's and the mid-1960's even though the technological and environmental factors affecting growth did not change significantly during this period. The rapid growth in rice output and productivity during the postwar period represent a response to institutional changes which facilitated the realization of the productivity potential inherent in the technical changes and resource investments of the pre-World War II period. The evolution of the farmers associations into effective extension and marketing organizations and the improvement in incentives resulting from the land reform of 1949-52 were among the more significant institutional sources of continued productivity growth.

The innovative role of the Sino-American Joint Commission on Rural Reconstruction was a major factor in the implementation of the land reform program and the development of the farmers associations and other institutional innovations in rural development.[34/] Indeed the JCRR would appear to embody much (a) of the "institution building" wisdom on the central role of a suitable technology around which to organize energies for institutional change and (b) of the analytical insight into the power of decentralized organization for effective collective action from the efforts to model bureaucratic behavior.

The cases presented in this section, to illustrate the process of induced institution change, are clearly informed by the institution building, bureaucratic behavior, and induced technical change models. They are, at least to me, intuitively plausible. Yet these illustrations, and the historical and analytical literature on which they are based, do not convey the same sense of conviction as the body of theoretical and empirical literature on induced technical change. The empirical literature on institutional behavior and innovation represents, at best, sophisticated storytelling informed by partial theoretical insights.[35/]

We do not, for example, have available a successful effort to quantify the contribution of changes in land tenure institutions to economic growth in Taiwan or elsewhere that conveys the same kind of precision, or conviction, that has been developed in measuring the contribution of technical change to factor augmentation or output. The formal analysis of land tenure systems, including the examples presented at this conference, provide only limited insight into the sequence of tenure changes that have been associated with the transition from the premodern conservation systems of agriculture to the more modern industrial and science based systems of agriculture.[36/]

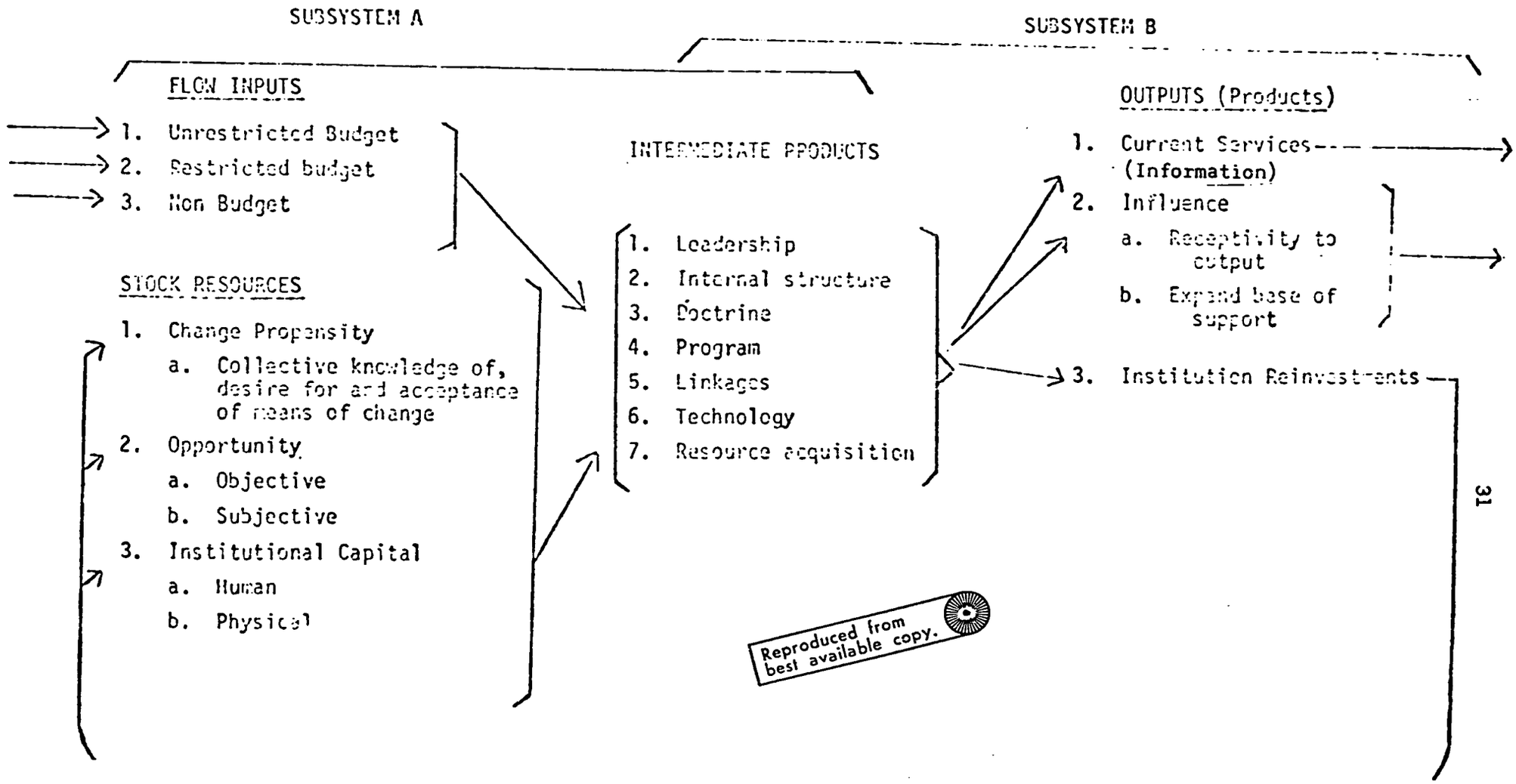
Our capacity to bring the tools of economics to bear on the process of institutional transfer and innovation, or on the interaction between technical and institutional change, remains rudimentary.

KNOWLEDGE IN TECHNICAL AND INSTITUTIONAL CHANGE

The search for an induced development model, in which technical and institutional change can be treated as endogenous to the development process, does not imply that agricultural development can be left to an "invisible hand" that directs either technical or institutional change along an "efficient" path determined by "original" resource endowments. I do argue that the policies which a country adopts with respect to the allocation of resource to technical and institutional innovation must be consistent with national physical and human resource endowments if they are to lead to an "efficient" growth path. Conversely, failure to achieve such consistency can sharply increase the real costs, or abort the possibility, of achieving sustained growth in the agricultural sector, or in the total economy.

At the same time, it seems clear to me that our understanding of the processes by which resources can be brought to bear to achieve effective technology transfer or innovation is significantly greater than our understanding of how to bring resources to bear on the problem of institution innovation and transfer. I would like, in this final section, to suggest that this is in part due to the development of a more rigorous conceptualization of the contribution of knowledge in the natural (biological and physical) sciences to technical change than of social science knowledge to the process of institutional change.

Economists have, in recent years, made substantial advances in measuring the contribution of advances in the natural sciences and technology to the growth of output.[37/] The research and development system has been viewed as having a production function along the lines suggested in Figure 2. The return to investment in the production of new knowledge has been evaluated



Reproduced from best available copy.

Figure 2. Systems model of experiment station performance and development.

Source: "The Agricultural Experiment Station: An Institutional Development Perspective," Agricultural Science Review, Vol. 10, Second Quarter, 1972, pp. 11-16.

in terms of its contribution to commodity and service output in agriculture or industry. The demand for new knowledge in the natural sciences and natural science based technology is viewed as derived from the demand for commodities and services. Increasingly sophisticated analytical efforts have been devoted to the formalization of research resource allocation and decision processes.

The same progress has not yet been made in conceptualizing the contribution of new knowledge in the social sciences and professions to the process of institutional change. Institutional change has typically been treated as an evolutionary process only marginally responsive to the availability of new knowledge. It seems plausible to argue, however, that the demand for new knowledge in the social sciences is derived primarily from the potential contribution of new knowledge in the social sciences (and professions) to the process of institutional change.

This perspective opens up the possibility of measuring the returns to investment in social science capacity in terms of the contribution of social science knowledge to institutional change--or in terms of the new income streams made available to society as a result of institutional changes resulting from new knowledge produced in the social sciences and professions. This perspective implies that a primary rationale for public investment in the development of capacity in the social sciences and professions is to produce institutional innovations which result in more efficient institutional performance. This means, for example, the development of market institutions which are more efficient in conveying information among producers and consumers and that reduce the resource costs of intersector commodity and service flows; the development of land tenure institutions which induce more efficient use of factors and embodied technology; and the

development of credit institutions which are more efficient in linking and transferring credit between savers, central money markets, and borrowers.

An implication of this perspective is that the returns to public investment in social science research capacity--the contribution of social science research to economic growth and development--can be enhanced if more explicit attention is devoted, in the allocation of social science resources, to the potential value of new knowledge in the social sciences to institutional change.

FOOTNOTES

* Minnesota Agricultural Experiment Station Miscellaneous Journal Series Article No. 1496. Prepared for presentation at a Conference on Agriculture in Development Theory, Villa Serbelloni, Bellagio, Italy, May 23-29, 1973. The research on which this paper is based was supported by grants to the University of Minnesota Economic Development Center from the U.S. Agency for International Development (AID/csd-2815) and by The Rockefeller Foundation. The author is indebted to the members of the UM Trade and Development Workshop for helpful criticism of an earlier draft of this paper. Suggestions by Barbara Miller, Joseph Fitzharris, John Sanders, and Paul Schultz have been particularly helpful.

** Vernon W. Ruttan is Professor in the Department of Agricultural and Applied Economics and in the Department of Economics, University of Minnesota.

1/ See Carl O. Sauer, Agricultural Origins and Dispersals: The Domestication of Animals and Foodstuffs (2nd ed.; Cambridge: Massachusetts Institute of Technology Press, 1969), pp. 113-134; N. I. Vavilov, The Origin, Variation, Immunity and Breeding of Cultivated Plants, trans. from the Russian by K. Starr Chester, Chronica Botanica, Vol. 13, Nos. 1-6, 1949-50. See also David R. Harris, "New Light on Plant Domestication and the Origins of Agriculture: A Review," Geographical Review, Vol. 57 (January 1967), pp. 90-107; Folke Dovring, "The Transformation of European Agriculture," The Cambridge Economic History of Europe, VI, The Industrial Revolution and After, Part II, H. J. Habakkuk and M. Postan (eds.) (Cambridge: Cambridge University Press, 1966), pp. 604-672; Ping-Ti Ho. "Early-Ripening Rice in Chinese History," Economic History Review, Vol. 9, Series 2 (December 1956), pp. 200-218.

2/ Nelson Klose, America's Crop Heritage: The History of Foreign Plant Introduction by the Federal Government (Ames: Iowa State College Press, 1950); also Wayne D. Rasmussen, "Diplomats and Plant Collectors: The South American Commission, 1817-1818," Agricultural History, Vol. 29 (January 1955), pp. 22-31; and Knowles A. Ryerson, "History and Significance of Foreign Plant Introduction Work of the United States Department of Agriculture," Agricultural History, Vol. 7 (July 1933), pp. 110-128.

3/ E. C. Stakman, Richard Bradfield, and P. C. Mangelsdorf, Campaigns Against Hunger (Cambridge: Belknap Press, 1967). At a more general level see the comment by Tom Burns, "... the mechanism of technological transfer is one of agents, not agencies; of the movement of people among establishments, rather than of the routing of information through communication system" (p. 12): Tom Burns, "Models, Images, and Myths," Factors in the Transfer of Technology, William H. Gruber and Donald G. Marquis (eds.) (Cambridge: The M.I.T. Press, 1969). See also Warren C. Scoville, "Minority Migrations and the Diffusion of Technology," The Journal of Economic History, Vol. 11 (Fall 1951), pp. 347-360; Fritz E. Redlich, "Ideas--Their Migration in Space and Transmittal Over Time," Kyklos, Vol. 6 (1953), pp. 301-322; Robert Solo, "The Capacity to Assimilate an Advanced Technology," The American Economic Review, Vol. 56, Papers and Proceedings (May 1966), pp. 91-97; Derek J. de S. Price, "The Structures of Publication in Science and Technology," Gruber and Marquis (eds.), Factors in the Transfer of Technology, pp. 91-104.

4/ This typology was first outlined in Yujiro Hayami and Vernon W. Ruttan, Agricultural Development: An International Perspective (Baltimore: The Johns Hopkins Press, 1971), pp. 174-182.

5/ This section is based on material developed by R. E. Evenson and reported in R. E. Evenson, J. P. Houck, Jr., and V. W. Ruttan, "Technical Change and Agricultural Trade: Three Examples—Sugar Cane, Bananas, and Rice," The Technology Factor in International Trade, Raymond Vernon (ed.), (New York: Columbia University Press, 1970), pp. 415-480. See also J. J. Ochse, M. J. Soule, Jr., M. J. Dijkman, and C. Wehlburg, Tropical and Sub-Tropical Agriculture (2 Vols.) (New York: Macmillan, 1961), pp. 1197-1251.

6/ For a review of these several traditions see Elihu Katz, Herbert Hamilton, and Martin L. Levin, "Traditions of Research on the Diffusion of Innovation," American Sociological Review, Vol. 28 (April 1963), pp. 237-252; Everett M. Rogers, Diffusion of Innovations (New York: The Free Press of Glencoe, 1962); Allan Pred, "Postscript," in Torsten Hägerstrand, Innovation Diffusion as a Spatial Process (Chicago: University of Chicago Press, 1967), pp. 299-324; Everett M. Rogers (with F. Floyd Shoemaker), Communication of Innovations: A Cross Cultural Approach (New York: The Free Press, 1971) (2nd ed.)), pp. 44-97.

7/ Zvi Griliches, "'Hybrid Corn:' An Exploration in the Economics of Technological Change," Econometrica, Vol. 25 (October 1957), pp. 501-522; "Hybrid Corn and the Economics of Innovation," Science, Vol. 132 (July 29, 1960), pp. 275-280; Edwin Mansfield, "Technical Change and the Rate of Imitation," Econometrica, Vol. 29 (October 1961), pp. 741-766; "The Speed of Response of Firms to New Techniques," The Quarterly Journal of Economics, Vol. 77 (May 1963), pp. 291-311; "Size of Firm, Market

Structure, and Innovation," The Journal of Political Economy, Vol. 71 (December 1963), pp. 556-576; "Intrafirm Rates of Diffusion of an Innovation," The Review of Economics and Statistics, Vol. 45 (November 1963), pp. 348-359; Edwin Mansfield, The Economics of Technological Change (New York: Norton, 1968); Lawrence A. Brown, Diffusion Processes and Location: A Conceptual Framework and Bibliography (Philadelphia: Regional Science Research Institute, 1968).

8/ Much of this work stems from the seminal article by Raymond Vernon, "International Investment and International Trade in the Product Cycle," Quarterly Journal of Economics, Vol. 80 (May 1966), pp. 190-207. See also the several articles in Raymond Vernon (ed.), The Technology Factor in International Trade (New York: Columbia University Press, 1970). For a case study of the trade impact of diffusion of agricultural technology see Yujiro Hayami and V. W. Ruttan, "Korean Rice, Taiwan Rice and Japanese Agricultural Stagnation: A Economic Consequence of Colonialism," The Quarterly Journal of Economics, Vol. 84 (November 1970), pp. 562-589.

9/ This limitation has been of concern to some of the leaders in the field of diffusion research. Hägerstrand, in summarizing his work, points out: "In the models attention was directed to the processes of change, to how the distribution of g_n generates the distribution of g_{n+1}. The location of the starting point of the diffusion process was stated among the assumptions. However, we observe that when agricultural indicators and agricultural elements are involved, the same small areas within the region seem repeatedly to be the starting points for new innovation . . . . The origin of such centers is a problem in itself." Hägerstrand, Innovation Diffusion . . . , p. 293.

10/ Zvi Griliches, "Hybrid Corn . . . ," 1957. The Griliches study is also of interest because subsequent discussions helped to clarify the role of economic and socio-cultural factors in the diffusion process. See Lowell Brandner and Murray A. Straus, "Congruence versus Profitability in the Diffusion of Hybrid Sorghum," Rural Sociology, Vol. 24 (December 1959), pp. 381-383; Zvi Griliches, "Congruence versus Profitability: A False Dichotomy," Rural Sociology, Vol. 25 (September 1960), pp. 354-356; A. Eugene Havens and Everett M. Rogers, "Adoption of Hybrid Corn: Profitability and the Interaction Effect," Rural Sociology, Vol. 26 (December 1961), pp. 409-414; Zvi Griliches, "Profitability Versus Interaction: Another False Dichotomy," Rural Sociology, Vol. 27 (September 1962), pp. 327-330; Everett M. Rogers and A. Eugene Havens, "Rejoinder to Griliches' 'Another False Dichotomy,'" Rural Sociology, Vol. 27 (September 1962), pp. 330-332; Jarvis M. Babcock, "Adoption of Hybrid Corn: A Comment," Rural Sociology, Vol. 27 (September 1962), pp. 332-338; Gerald E. Klonglan and E. Walter Coward, Jr., "The Concept of Symbolic Adoption: A Suggested Interpretation," Rural Sociology, Vol. 35 (March 1970), pp. 77-83; Kenneth J. Arrow, "Classificatory Notes on the Production and Transmission of Technological Knowledge," The American Economic Review, Vol. 59 (May 1969), pp. 29-35. Arrow points out "the economists are studying the demand for information by potential innovators and sociologists the problems in the supply of communication channels" (p. 33).

11/ Zvi Griliches, "Hybrid Corn . . . ," 1957, p. 502.

11a/ In a forthcoming article Robert E. Evenson and Yoav Kislev, "Research and Productivity in Wheat and Maize," Journal of Political Economy (forthcoming),

have succeeded in partitioning the contribution of international diffusion and indigenous research to the growth of yield of wheat and maize.

12/ In the 1950's and early 1960's discussion focused primarily on the "choice of technology" problem. See Amartya K. Sen, "The Choice of Agricultural

Techniques in Underdeveloped Countries," Economic Development and Cultural Change, Vol. 7 (April 1959), pp. 279-85; Amartya K. Sen, Choice of Techniques: An Aspect of Planned Economic Development (London: Basil Blackwell, 1960); W. E. G. Salter, Productivity and Technical Change (London: Cambridge University Press, 1960).

13/ There are two major variants of the theory of induced innovation. In the Hicks-Ahmad version non-neutrality is induced by changes in relative factor prices. In the Kennedy-Samuelson version non-neutrality is induced by shifts in factor shares. The basic references are: J. R. Hicks, The Theory of Wages (London: Macmillan, 1932), pp. 124-25; Syed Ahmad, "On the Theory of Induced Invention," Economic Journal, Vol. 76 (June 1966), pp. 344-357; Charles Kennedy, "Induced Bias in Innovation and the Theory of Distribution," Economic Journal, Vol. 74 (September 1964), pp. 541-547; Paul A. Samuelson, "A Theory of Induced Innovation Along Kennedy-Weisäker Lines," The Review of Economics and Statistics, Vol. 47 (November 1965), pp. 343-365. These papers were followed by an extended discussion among Ahmad, Fellner, Kennedy, and Samuelson. For an excellent review and assessment of this literature see Hans P. Binswanger, "Induced Innovation: A Critical Review of the Theory and Conclusions from New Evidence," University of Minnesota Department of Agricultural and Applied Economics, Staff Paper P72-29, December 1972.

14/ Yujiro Hayami and V. W. Ruttan, "Factor Prices and Technical Change in Agricultural Development: The United States and Japan, 1880-1960," Journal of Political Economy, Vol. 78 (September/October 1970), pp. 1115-1141; William W. Wade, Institutional Determinants of Technical

Change and Agricultural Productivity Growth: Denmark, France and Great Britain, 1870-1965, Minneapolis: University of Minnesota Graduate School Ph.D. thesis, June 1973; Hans P. Binswanger, "The Measurement of Biased Technical Change in the Many Factors Case: United States and Japanese Agriculture," University of Minnesota Department of Agricultural and Applied Economics, Staff Paper P72-28, December 1972.

15/ John R. Sanders, Agricultural Mechanization and Employment in Brazilian Agriculture, 1950-1971, Minneapolis: University of Minnesota Ph.D. thesis, June 1973; Harry W. Ayer and G. Edward Schuh, "Social Rates of Return and Other Aspects of Agricultural Research: The Case of Cotton Research in Sao Paulo, Brazil," American Journal of Agricultural Economics, Vol. 54 (November 1972), pp. 557-569; Hiromitsu Kaneda, "Mechanization, Industrialization and Technical Change in Rural West Pakistan" (Paper presented at 28th International Congress of Orientalists, Canberra, January 1971).

16/ The material in this section is presented more completely in Yujiro Hayami, "Elements of Induced Innovation: A Historical Perspective for the Green Revolution," Explorations in Economic History, Vol. 8 (Summer 1971), pp. 445-472 and in Yujiro Hayami and Vernon W. Ruttan, Agricultural Development . . . (1971), pp. 169-237.

17/ Eikichi Iso, Horaimai Danwa (Discourse on the Ponlai Rice) (Yamaguchi: Udokukai, 1964), p. 18.

18/ Peter R. Jennings, "Plant Type as a Rice Breeding Objective," Crop Science, Vol. 4 (January/February 1964), pp. 13-15; E. A. Jackson, "Tropical Rice: The Quest for High Yield," Agricultural Science Review, Vol. 4 (Fourth

Quarter 1966), pp. 21-26. The Jennings article represents the classic statement of the new crop breeding strategy focusing on models of biologically efficient plant types.

19/ The role of material transfers on the initial impact of the new grain varieties on production has been documented in a series of country papers prepared for the 1969 spring review at the USAID. The material presented in the country papers have been summarized in two papers: Wayne A. Schutjer and E. Walter Coward, Jr., "Planning Agricultural Development--The Matter of Priorities," Journal of Developing Areas, Vol. 6 (October 1971), pp. 29-38. The contribution of material inputs is also emphasized in Wayne Schutjer and Dale Weigle, "The Contribution of Foreign Assistance to Agricultural Development," American Journal of Agricultural Economics, Vol. 51 (November 1969), pp. 788-797. The results obtained by Schutjer and Coward in the AJAE article do not reflect the significance of capacity transfer. It was only after the new production functions characterized by a higher response to material inputs were developed that the material transfer became profitable.

20/ The environmental constraint on diffusion was anticipated at the time the new varieties were first being released. See S. C. Hsieh and V. W. Ruttan, "Environmental, Technological and Institutional Factors in the Growth of Rice Production: Philippines, Thailand and Taiwan," Food Research Institute Studies, Vol. 7, No. 3 (1967), pp. 307-41.

21/ There is usually a distinction, in the literature on institutional change, institutional development, and institution building between institutions and organizations. Institutions are usually defined as the behavioral rules that govern patterns of action and relationships; organizations are the decision making units that exercise control of resources. For some purposes more elaborate classifications are employed. Lance E. Davis and Douglass C. North, Institutional Change and American Economic Growth (New York: Cambridge University Press, 1971), distinguish among (a) the institutional environment - "the set of fundamental political, social, and legal ground rules that establishes the basis for production, exchange and distribution" (p. 6); (b) institutional arrangement - "an arrangement between economic units that govern the ways in which these units can cooperate and/or compete" (p. 7); (c) primary action group - "a decision-making unit whose decisions govern the process of arrangemental innovation" (p. 8); (d) secondary action group - "a decision making unit that has been established by some change in the institutional arrangement to help effect the capture of income for the primary action group" (p. 8); institutional instruments - "documents or devices employed by action groups to effect the capture of income external to the existing arrangemental structures" (p. 9). In this paper the term institutional innovation (or change, or development) is used to refer to a change in the actual or potential performance of existing or new organizations (households, firms, bureaus); in the relationships between an organization and its environment; or in the behavioral rules or possibilities that govern the patterns of action and relationships in the organization's environment.

22/ Suggestions for the development of an endogenous or induced theory of institutional change have been made by T. W. Schultz, "Institutions and the Rising Economic Value of Man," American Journal of Agricultural Economics, Vol. 50 (December 1968), pp. 1113-22 and by Douglass C. North and Robert Paul Thomas, "An Economic Model of the Growth of the Western World," Economic History Review, Vol. 23, No. 1 (second series) (1970), pp. 1-17. Schultz regards institutional innovation as a lagged response to the growth of productivity and the rising economic value of man associated with economic growth. North and Thomas regard technical change and productivity growth as a lagged response to institutional changes induced by long run changes in relative factor and product prices and changes in the size of the market. Both regard institutional innovation as induced primarily from the demand side rather than the supply side.

23/ The institution building literature is largely a product of two major efforts: (a) The Interuniversity Research Program on Institution Building, involved staff members from Indiana, Michigan State and Syracuse Universities, and the University of Pittsburgh, headquartered at the Graduate School of Public and International Affairs at Pittsburgh. The guiding concepts for this effort have been outlined in Milton J. Esman and Hans C. Blaise, "Institution Building Research--The Guiding Concepts" (Pittsburgh: Graduate School of Public and International Affairs, University of Pittsburgh, 1966 (mimeo)) and (b) The Committee on Institutional Cooperation--Agency for International Development Rural Development Research Project involved staff members from the Universities of Wisconsin, Minnesota, Illinois, Missouri, Indiana, North Carolina, Ohio, Utah State, and Purdue. The objective of the project was to review and evaluate the results of AID--university cooperation in assisting the development of agricultural education

and research institutions in developing countries. For a review and evaluation of the results achieved by the two research programs see William J. Siffin, "The Institution Building Perspective: Properties, Problems and Promise," Institution Building: A Model for Applied Social Change, D. Woods Thomas, et. al. (eds.) (Cambridge: Schenkman, 1972), pp. 113-148. For an annotated bibliography of the institution building literature see Melvin G. Blase, Institution Building: A Source Book (Michigan State University, East Lansing: Midwest Universities Consortium for International Activities, Inc., 1973).

24/ The seminal work in this body of literature is Anthony Downs, An Economic Theory of Democracy (New York: Harper, 1957), pp. 3-35. See also James M. Buchanan and Gordon Tullock, The Calculus of Consent (Ann Arbor: University of Michigan Press, 1962); Mancur Olson, Jr., The Logic of Collective Action: Public Goods and the Theory of Groups (New York: Schocken Books, 1968); Anthony Downs, Inside Bureaucracy (Boston: Little, Brown, 1966); William A. Niskanen, Jr., Bureaucracy and Representative Government (Chicago: Aldine-Atherton, 1971).

24a/ In the more recent institution building literature there is a good deal of rhetoric to the effect that technical assistance involved more than the simple transfer of resources, or knowledge or institutions and that emphasis should be placed on institution building activities which have a greater experimental content. See for example, Milton J. Esman and John D. Montgomery, "Systems Approaches to Technical Cooperation: The Role of Development Administration," Public Administration Review, Vol. 29 (September/October 1969), pp. 507-539.

25/ William J. Siffin, "The Institution Building Perspective . . . ," pp. 123-127. Siffin's perspective on the role of technology in institution building draws very heavily on James D. Thompson, Organizations in Action (New York: McGraw-Hill, 1967). The Thompson perspective can be summarized--the design,

structure and behavior or organizations will vary systematically with (a) differences in technologies and (b) variations in task environments.

26/ Anthony Downs, Inside Bureaucracy, pp. 81-84; James M. Buchanan and Gordon Tulloch, The Calculus of Consent, pp. 11-39; William A. Niskanen, Jr., Bureaucracy . . . , pp. 36-42.

27/ William A. Niskanen, "The Peculiar Economics of Bureaucracy," American Economic Review, Vol. 58 (May 1968), pp. 293-305.

28/ For an exception see the analysis of the U.S. Food Stamp Program by W. Keith Bryant, "An Analysis of the Market for Food Stamps," American Journal of Agricultural Economics, Vol. 54 (May 1972), pp. 305-325; "An Analysis of the Market for Food Stamps: Correction and Extension," American Journal of Agricultural Economics, Vol. 54 (November 1972), pp. 689-693.

29/ ". . . there are three separate but cumulative factors that keep larger groups from furthering their own interests. First, the larger the group, the smaller the fraction of the total group benefits any person acting in the group receives, and the less adequate the reward for any group oriented action and the further the group falls short of getting an optimal supply of the collective good, even if it should get some. Second, since the larger the group the smaller the share of the total benefits going to any individual, or to any (absolutely) small subset of members of the group, much less any single individual will gain enough from getting the collective good to bear the burden of providing even a small part of it; ... Third, the larger the number of members in the group the greater the organization cost, and thus the higher the hurdle that must be jumped before any of the collective good can be obtained. For these reasons the larger the group the further it will fall short of providing an optimal supply of a collective good . . . ." Mancur Olson, Jr., The Logic of Collective Action, p. 48. See also James M. Buchanan and Gordon Tullock, The Calculus of Consent, pp. 43-62.

30/ See for example, Lance E. Davis and Douglass C. North, Institutional Change and American Economic Growth (London: Cambridge University Press, 1971); Douglass C. North and Robert Paul Thomas, "An Economic Theory of the Growth of the Western World."

31/ Peter C. Timmer, "The Turnip, The New Husbandry, and the English Agricultural Revolution," The Quarterly Journal of Economics, Vol. 83 (August 1969), pp. 375-395.

32/ Vernon W. Ruttan, "Agricultural Policy in an Affluent Society," Journal of Farm Economics, Vol. 48 (December 1966), pp. 1100-1120.

33/ The literature on which I draw in this section is reviewed in S. C. Hsieh and V. W. Ruttan, "Environmental, Technological, and Institutional Factors in the Growth of Rice Production: Philippines, Thailand and Taiwan," Food Research Institute Studies, Vol. 7, No. 3 (1967), pp. 307-341. See also Yhi-min Ho, Agricultural Development of Taiwan, 1903-1960 (Nashville: Vanderbilt University Press, 1966); Anthony Y. C. Koo, The Role of Land Reform in Economic Development: A Case Study of Taiwan (New York: Praeger, 1968).

34/ John D. Montgomery, Rufus B. Hughes, and Raymond H. Davis, Rural Improvement and Political Development: The JCRR Model (Washington, D. C.: American Society for Public Administration, 1966); T. H. Shen, The Sino-American Joint Commission on Rural Reconstruction (Ithaca: Cornell University Press, 1970).

35/ For an attempt to rehabilitate the contribution of "storytelling" to the development of knowledge in economics, see Benjamin Ward, What's Wrong With Economics (New York: Basic Books, 1972), pp. 179-190.

36/ In addition to the papers presented at this conference see Steven N. S. Cheung, The Theory of Share Tenancy (Chicago: University of Chicago Press,

1969). For a review of the earlier literature see Vernon W. Ruttan, "Equity and Productivity Issues in Modern Agrarian Reform Legislation," Economic Problems of Agriculture in Industrial Societies, Ugo Papi and Charles Nunn (eds.) (New York: Macmillan [St. Martin's Press], 1969), pp. 581-600.

37/ See for example, the papers in Walter L. Fishel (ed.), Resource Allocation in Agricultural Research (Minneapolis: University of Minnesota Press, 1971). Also Robert Evenson and Yoav Kislev, "Research and Productivity in Maize and Wheat."