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Induced Technical and Institutional Change and the Future of Agriculture†

THE summer of 1973 is an uncertain time in which to discuss the future of agriculture. In less than a decade perspectives have shifted from a sense of impending catastrophe engendered by the world food crisis of the mid-1960's, to the euphoria of the new potentials opened up by the 'Green Revolution,' to the crunch in grain supplies resulting from the poor harvests in South Asia and the USSR in 1972 and 1973.

Renewed uncertainty regarding the longer term prospects for the growth of agricultural production, and for the economic welfare of rural people stems, however, from more fundamental concerns than the recent dramatic behavior in agricultural commodity markets. There has been a convergence of scientific opinion and ideological perspective to the effect that the world is fast approaching both the physical and cultural limits to growth. The theme that 'progress breeds not welfare, but catastrophe' has again emerged from the underworld of social thought as a serious theme in scientific and philosophical inquiry.

ECONOMIC GROWTH

The tools of the economist are relatively blunt instruments with which to confront the grand theme of epochal growth and decline. Until a few decades ago comparative statics was the most powerful theoretical tool available to the economist as a guide to empirical knowledge. Even modern neoclassical growth theory is based primarily on an application of the tools of comparative statics to the analysis of alternative steady growth paths. Growth of output is narrowly determined by the growth of the labor force, the state of technology, and the stock of human and tangible capital. Technical change has, with few exceptions, been treated

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as exogenous to the economic system. Institutional change has not been formally incorporated into growth theory.

The story that can be revealed to us through the application of modern macro-economic growth theory is dull indeed compared with historical experience. It can be considerably enriched, however, by a more flexible application of the tools of micro-economics with which agricultural economists are most familiar.

The last two decades have been highly productive in advancing both our analytical capacity and our empirical knowledge of the role of technical change in agricultural development and of the sources of productivity growth in agriculture. In the now 'conventional' model or paradigm of agricultural development the dating of 'modern' agricultural growth begins with the emergence of a period of sustained growth in total productivity—a rise in output per unit of total input, including the inputs supplied by the agricultural sector itself and by the industrial sector.

It is now generally conceded that as long as growth is based on simple factor accumulation few growth dividends become available to improve the well being of rural people or to be transferred to the rest of the economy. There are few growth dividends to be realized by simple resource reallocation within farms, communities, or regions in the absence of technical change embodied in less expensive and more productive inputs. Only as the constraints on growth imposed by primary reliance on indigenous inputs—inputs produced primarily within the agricultural sector—are released by new factors whose productivity is augmented by the embodiment of new technology is it possible for agriculture to become an efficient source of growth in a modernizing economy.

During the initial stages the growth in total productivity has typically been accounted for by growth in a single partial productivity ratio. In the United States, and the other developed countries of recent settlement, growth in labor productivity has typically 'carried' the initial burden of growth in total productivity. In countries characterized by relatively high man/land ratios at the beginning of the development process, Germany and Japan for example, growth in land productivity—output per hectare—was largely responsible for growth in total productivity during the initial years of modernization. As modernization has continued there has been a tendency for total productivity growth to be fed by a more balanced growth in the partial productivity ratios—on growth in output per worker and per hectare (Fig. 1). The effect, in the case of those countries which have experienced the longest history of productivity growth as in Japan and the United States, is for a convergence in the patterns of partial and total productivity growth (Fig. 2).

SOURCES OF PRODUCTIVITY DIFFERENCES

For a number of countries, however, the model outlined above has little meaning. The 20th century has been characterized by a massive, and continuously widening, disequilibrium in the efficiency of resource use and

the welfare of rural people between rich and poor countries. Since World War II, output per hectare has been growing at approximately the same rate in the less developed countries (LDC's) as in the developed countries (DC's)—at about 2·0 percent per year. But output per worker in the LDC's has been growing at only one-third as fast as in the DC's—at about 1·5 percent per year in the LDC's and about 4·5 percent per year in the DC's. And for large numbers of LDC's, and for the lagging regions

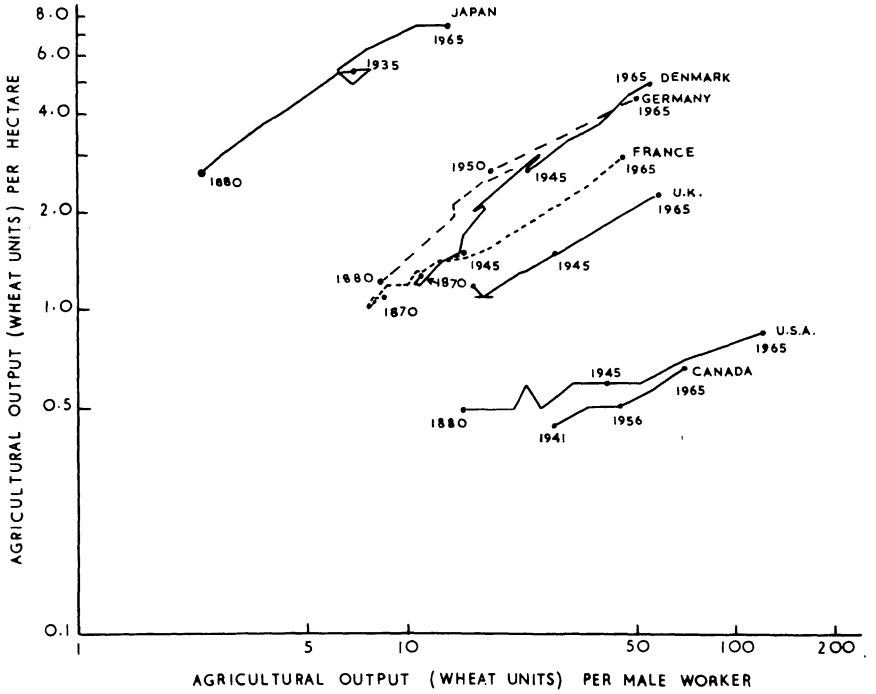

FIG. 1. Historical growth paths of agriculture development in the United States, Japan and Germany, 1880–1965, and Denmark, France, and the United Kingdom, 1870–1965, and Canada, 1941–65.

in many other LDC's, even those rates remain outside the personal experience of most farm families. Output per hectare is growing at rates that are barely perceptible and output per worker has experienced no measurable change, not only between years but between generations.

An empirical characterization of the sources of differences in labor productivity among countries is presented in Tables 1–4.* The sources of productivity differences are classified into three broad categories: *(a)*

* The accounting for inter-country differences in labor productivity utilizes coefficients obtained from estimating an inter-country 'meta-production function' of the Cobb-Douglas form. The percentage differences in output per worker can be expressed as the sum of percentage differences in conventional and nonconventional factor inputs per worker, weighted by their respective production elasticities.

resource endowments; *(b)* technical inputs; and *(c)* human capital. Land and livestock serve as proxy variables for resource endowments; machinery and fertilizer for technical inputs; and general education and technical education in agriculture for human capital.

Land and livestock represent a form of long term capital formation embodying inputs supplied primarily from within the agricultural sector. In traditional systems of agriculture internal labor intensive capital

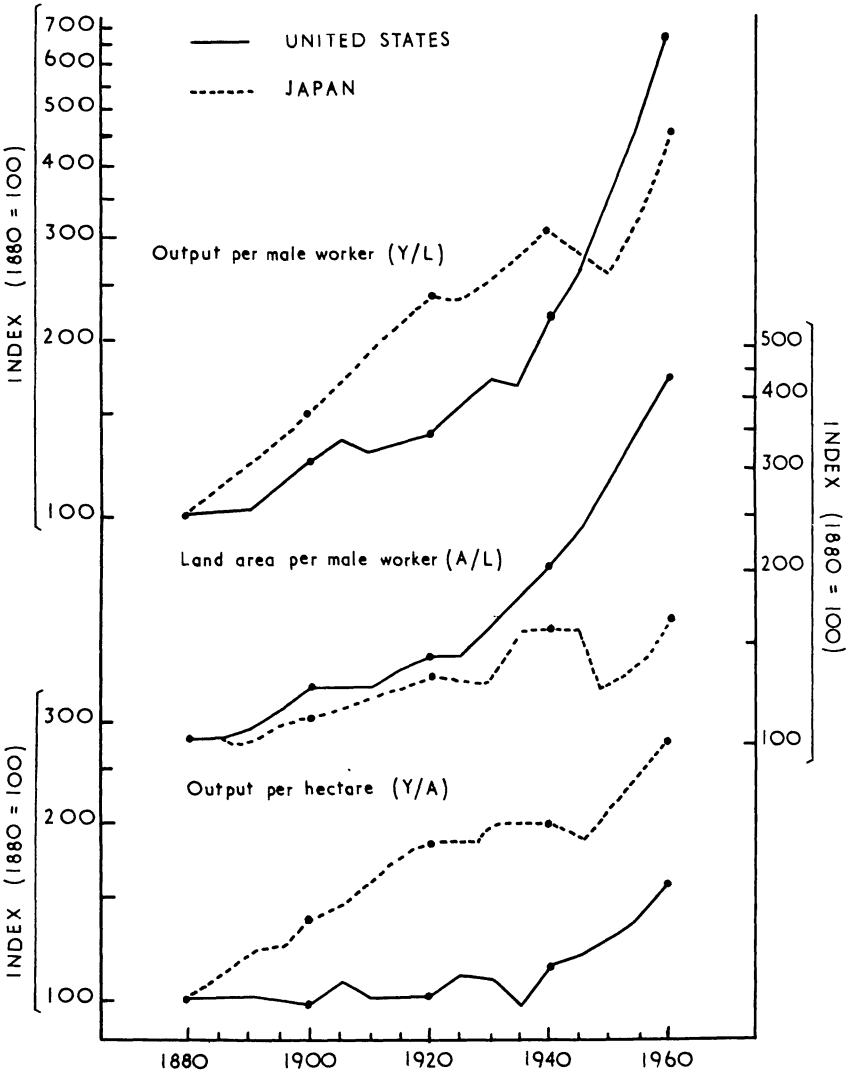

FIG. 2. Changes in labor productivity, land-labor ratio, and land productivity (1880 = 100), the United States and Japan, 1880–1960.

TABLE 1. *Accounting for differences in labor productivity between eleven less developed countries (LDC's) and four recently developed countries (RDC's)*

	Percent		Index	
Difference in output per male worker		93·6		100
Difference explained:				
Total		90·0		96
Resource endowments		32·6		35
Land	9·7		10	
Livestock	22·9		25	
Technical inputs		24·5		26
Fertilizer	14·6		16	
Machinery	9·9		10	
Human capital		32·9		35
General education	19·5		21	
Technical education	13·4		14	

LDC's: Brazil, Ceylon, Colombia, India, Mexico, Peru, Philippines, Syria, Taiwan, Turkey, United Arab Republic.
RDC's: Australia, Canada, New Zealand, United States.

TABLE 2. *Accounting for differences in labor productivity between eleven less developed countries (LDC's) and nine older developed countries (ODC's)*

	Percent		Index	
Difference in output per male worker		83·5		100
Difference explained:				
Total		71·1		85
Resource endowments		17·5		21
Land	1·8		2	
Livestock	15·7		19	
Technical inputs		24·3		29
Fertilizer	14·5		17	
Machinery	9·8		12	
Human capital		29·4		35
General education	17·6		21	
Technical education	11·7		14	

LDC's: Brazil, Ceylon, Colombia, India, Mexico, Peru, Philippines, Syria, Taiwan, Turkey, United Arab Republic.
ODC's: Belgium, Denmark, France, Germany, Netherlands, Norway, Sweden, Switzerland, United Kingdom.

TABLE 3. *Accounting for differences in labor productivity between nine older developed countries (ODC's) and four recently developed countries (RDC's)*

	Percent		Index	
Differences in output per male worker		61·5		100
Difference explained:				
Total		50·5		82
Resource endowments		29·1		47
Land	9·7		16	
Livestock	19·4		31	
Technical inputs		10·4		17
Fertilizer	3·9		6	
Machinery	6·5		11	
Human capital		10·9		18
General education	3·3		6	
Technical education	7·6		12	

ODC's: Belgium, Denmark, France, Germany, Netherlands, Norway, Sweden, Switzerland, United Kingdom.
RDC's: Australia, Canada, New Zealand, United States.

formation represents almost the only source of growth in labor productivity. Fertilizer, as measured by nutrient consumption in commercial fertilizer, and machinery, as measured by tractor horsepower, are employed as proxies for the whole range of inputs in which modern mechanical and biological technologies are embodied. The proxies for human capital include measures of both the general educational level of the rural population and specialized education in the agricultural sciences and technology. General education is viewed as a measure of the capacity of a population to utilize new technical knowledge. Graduates in the agricultural sciences and technology represent the major source of scientific and technical personnel for agricultural research and extension.

TABLE 4. *Accounting for differences in labor productivity between the United States and selected countries*

	India	Japan	United Kingdom	Argentina	Canada
Difference in output per male worker					
Percent	97·8	89·2	55·8	60·0	24·0
Index	100	100	100	100	100
Difference explained:					
Total index	104	74	89	76	98
Resource endowments index	33	38	33	−8	20
Technical inputs index	26	25	24	40	51
Human capital index	45	10	33	44	28

The difference in average agricultural output per worker between the eleven LDC's and the nine ODC's was 83·5 percent. Differences in human capital investment alone accounts for over one-third of the difference. Differences in land resources per worker account for only 2 percent of the difference. It seems apparent that in spite of the limitations of land resources in the LDC's they could achieve levels of output per worker comparable to the European levels of the early 1960's through a combination of investment in human capital, investment in the experiment station and industrial capacity to make modern technical inputs available to their farmers, and investment in the labor intensive capital formation characterized by livestock (and perennial crops).

The difference in average agricultural output per worker between the nine ODC's and the four RDC's was 61·5 percent. The results are quite different from the comparison between the LDC's and the ODC's. Technical inputs and human capital account for only slightly more than one-third of the difference. Resource endowments account for close to half. It appears that output per worker in the ODC's would have great difficulty approaching the levels of the RDC's in the absence of substantial adjustments in labor/resource ratios. However, the ODC's have clearly failed to take full advantage of the growth opportunities available to them through greater investment in technical manpower and in agricultural science capacity. The individual country comparisons tend to reinforce the inferences based on the group comparisons. Failure to take full advantage of the potential growth from human capital and technical inputs are significantly more important than limitations in resource endowments in accounting for differences in output per worker.

It is clear that a fundamental source of the widening disequilibrium in world agriculture has been the lag in shifting from a natural resource based to a science based agriculture. In the developed countries human capital and technical inputs have become the dominant sources of output growth. Differences in the natural resource base have accounted for an increasingly less significant share of the widening productivity gap among nations. Productivity differences in agriculture are increasingly a function of investments in the education of rural people and in scientific and industrial capacity rather than natural resource endowments. Indeed *the one inescapable implication of the results of our cross country analysis is the importance of literacy and schooling among agricultural producers and of technical and scientific education in the agricultural sciences.*

INDUCED TECHNICAL CHANGE

The embodiment of advances in science and technology in the inputs available to farmers clearly represents a second necessary condition for releasing the constraints on agriculture imposed by inelastic supplies of traditional factors. Yet for a country in the early stages of economic development technical innovations are among the more difficult products to produce.

TABLE 5. *Estimated area planted in high-yielding varieties (HYV) of rice and wheat in west, south, and southeast Asia*

	Rice					Wheat				
Country	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, February 1972), pp. 48, 49.

Within the last decade significant steps have been taken to narrow the agricultural technology gap among countries. A new set of international research centers have been institutionalized to generate new knowledge and new technology and to serve as an infrastructure for international communication in the agricultural sciences and technology. The initial impact of these developments on maize production in a number of countries, on wheat production in Mexico, Pakistan, and India, and on rice production in the Philippines and Indonesia contributed, in the late 1960's and early 1970's to a new and highly optimistic perspective on the possibilities of agricultural development in the tropics. Evidence is now accumulating that indicates that the momentum of the 'green revolution' has slackened (Table 5). Furthermore the newer institutes (CIAT, IITA) are having greater difficulty in achieving an impact on production as dramatic as the two older centers (CIMMYT and IRRI).

There is also considerable evidence that while the returns to investment in agricultural research have been exceptionally favorable for some commodities and in some countries the general experience has been much less favorable, and that many national research systems have been relatively unproductive. The capacity to produce the scientific and technical knowledge necessary to generate new growth opportunities in agriculture has clearly not yet been successfully institutionalized in most countries. It is not sufficient to simply build new agricultural research stations. In many countries existing research facilities are not employed at full capacity because they are staffed with research workers with limited scientific and technical training; because of inadequate financial, logistical, and administrative support; because of isolation from the main currents of scientific and technical innovation; because of ideological commitment to research or development strategies; and because of failure to develop a research strategy which relates research activity to the potential economic value of the new knowledge it is designed to generate.

One of the more difficult elements to introduce into the design of an agricultural research strategy is a clear perspective of the interrelationships between technical and economic change. Technical change has been treated by economists as largely exogenous to the development process. Little attention has been given until recently to the role of resources endowments, or of relative factor prices, on the choice of an efficient path of technical change. Among agricultural scientists, even biological scientists, the perception of a labor intensive path, based predominantly on modern biological or biological and chemical technology designed to augment land resources, as an alternative to the more familiar capital intensive path based predominantly on mechanical technology designed to augment labor resources, has not been clearly perceived. As a result economists have tended to view strategies of technical change primarily within a short run resource allocation or 'choice of technology' perspective. And agricultural science administrators have seldom been able to provide their staffs with clear cut guides to research strategy which related the potential productivity of their

research effort to differences in factor endowments among countries or regions or to changes in the economic and social environment over time.

The history of the role of technical change in the agricultural development of Japan and the United States is particularly useful in examining the implications of alternative resource endowments on the choice of an efficient path of technical change in agriculture (Fig. 1). Japan and the United States have been characterized by extreme differences in factor endowments and relative factor prices. Furthermore these differences have widened over time (Table 6). In spite of these differences both countries have achieved comparable roles of growth in output over the period since 1880. Output per hectare increased more rapidly in Japan and output per worker increased more rapidly in the

TABLE 6. *Changes in output, productivity, and factor–factor ratios in agriculture: the United States and Japan, 1880–1960* [a]

	1880	1900	1920	1940	1960	Annual compound rate of growth 1880–1960
						percent
United States						
Output index (1880 = 100) [b]	100	155	180	232	340	1·5
Productivity index (1880 = 100)						
Total productivity [c]	100	112	105	128	179	0·7
Output per male worker	100	125	141	217	680	2·4
Output per hectare of arable land	100	91	72	94	143	0·4
Factor–factor ratios						
Arable land area per male worker (hectare)	10	13	18	22	46	2·0
Power per male worker (horsepower) [d]	1·8	2·2	3·0	6·7	40·9	3·9
Fertilizer per hectare (kg. in $N+K_2O_5+P_2O$)	1·4	3·0	4·6	8·6	37·8	4·2
Japan						
Output index (1880 = 100) [b]	100	149	232	264	358	1·6
Productivity index						
Total productivity [c]	100	142	195	208	229	1·0
Output per male worker	100	152	238	326	453	1·9
Output per hectare of arable land	100	135	184	205	280	1·3
Factor–factor ratios (1880 = 100)						
Arable land area per male worker (hectares)	0·61	0·68	0·79	0·96	0·97	0·6
Power per male worker (horsepower) [d]	0·15	0·16	0·17	0·29	1·01	2·4
Fertilizer per hectare (kg. in $N+K_2O_5+P_2O$)	13	17	63	115	260	3·8

[a] Flow variables such as output and fertilizer are five year averages centering on years shown. Stock variables such as land and labor are measured in years shown.

[b] Gross output net of seeds and feed.

[c] Output divided by total input.

[d] Sum of draft animal power and tractor power.

United States. Furthermore, in Japan gains in output per worker were, until relatively recently, primarily associated with gains in output per hectare whereas in the United States they were associated primarily with growth in the land area cultivated per worker (Fig. 2).

A more detailed examination of the Japanese and the US experience clearly supports the hypothesis that the alternative paths of productivity growth were induced by the differential factor endowment and relative price differences and trends. In the United States it was primarily the progress of mechanization which facilitated the expansion of agricultural production and productivity by increasing the area operated per worker. In Japan it was primarily the process of biological technology, represented by seed improvements which increased the yield response to fertilizer and thus permitted the rapid growth in agricultural output in spite of severe constraints on the supply of land. Subsequent investigations of agricultural productivity growth in Denmark, France, and Great Britain (by Bill Wade), in Germany (by Adolf Weber), in Pakistan (by Hiromitsu Kaneda) and in Brazil (by John Sanders) provide further empirical support for the induced innovation hypothesis.

It seems clear that the development of a continuous stream of new technology, which alters production opportunities to conform to long term trends in factor and product prices, is key to the success in achieving relatively rapid rates of agricultural productivity and output growth in any country. An important element in the success of such a strategy appears to be a system of market and non-market institutions which accurately reflect the economic implications of factor endowments to agricultural producers, to public institutions, and to private industry.

INDUCED INSTITUTIONAL CHANGE

The model of induced technical change which has been so fruitful in understanding historical processes of technical change does not imply that agricultural development can be left to an 'invisible hand' that directs either technical change, or the total development process, along an 'efficient' path determined by 'original' resource endowments. The model does thrust the issues of resource allocation and institutional change back into the center of the stage in attempting to understand, or design policies for, agricultural development.

Research resource allocation

It was argued earlier in this paper that in the absence of technical change attempts to achieve growth in agricultural output through greater efficiency in resource allocation or through simple factor accumulation was a relatively expensive route to agricultural development. Once the direction of technical change can be treated as endogenous rather than exogenous to the economic system the efficient allocation of relatively scarce research resources to open up new sources of growth becomes central to the development process.

As long as the economics of technical change was cast primarily in terms of the choice of technology—to the selection by the individual firm or the agricultural producer of the 'appropriate technology' from the shelf of available technology—it was easy to assume that the effects of errors in judgment at the firm level or the effects of biases resulting from public policy could be corrected over a relatively short time. If, however, the choice of research priorities by scientists and the research resource allocation decisions of research administrators is guided by a perception of economic opportunities, distortions in the inducement mechanism affect not only current choices among available technical alternatives but the technical alternatives that will become available to producers in the future. A distorted incentive system will have the effect of biasing the direction of technical change in a non-optimal direction and dampening the productivity of resources devoted to the development and diffusion of new technology.

Yet even in the absence of distortions in the incentive system it is clear that our knowledge of the research 'production function' or of how to successfully institutionalize public sector research and development capacity is relatively limited. There is some evidence to the effect that a substantial proportion of existing facilities are too small and too poorly endowed to take advantage of the economies of scale in the research process. There is also evidence that a decentralized research system that is at least partially dependent on local funding and responsive to local commodity and development interests is more likely to be productive than a highly centralized system. The capacity of a centralized system to plan and manage the research program of a country characterized by substantial regional differences in resource endowments and productivity, Mexico for example (Fig. 3), is severely limited.

Evidence is also accumulating that an agricultural research center that is not integrally associated with a major research oriented university is, under today's conditions, an 'inefficient location.' An agricultural research institute or experiment station whose staff does not engage in training as well as research activities loses its capacity for self regeneration. Innovation gives way to filling in the gaps in the literature. The appropriate articulation of public and private sector research and of centralized and decentralized research functions are continuing issues in most national systems. And perhaps most disturbing of all we have little knowledge of the process of successful generation of capacity for research management.

Institutional change

Institutional innovation has, like technical change, typically been treated as exogenous to the economic system. The firm behavior or public policy implications of institutional change have, when considered at all in formal economic analysis, been introduced in the form of exogenous constraints. Extension of the induced innovation perspective to include the process of institutional innovation represents a potentially useful

approach to analytical insight into the complex process of the interaction between economic, technical, and institutional change. *It seems consistent with historical experience to view institutional change as resulting from efforts of economic units (households, firms, bureaus) to internalize the gains and externalize the costs of economic activity and of efforts by society to force economic units to internalize the costs and externalize the gains.*

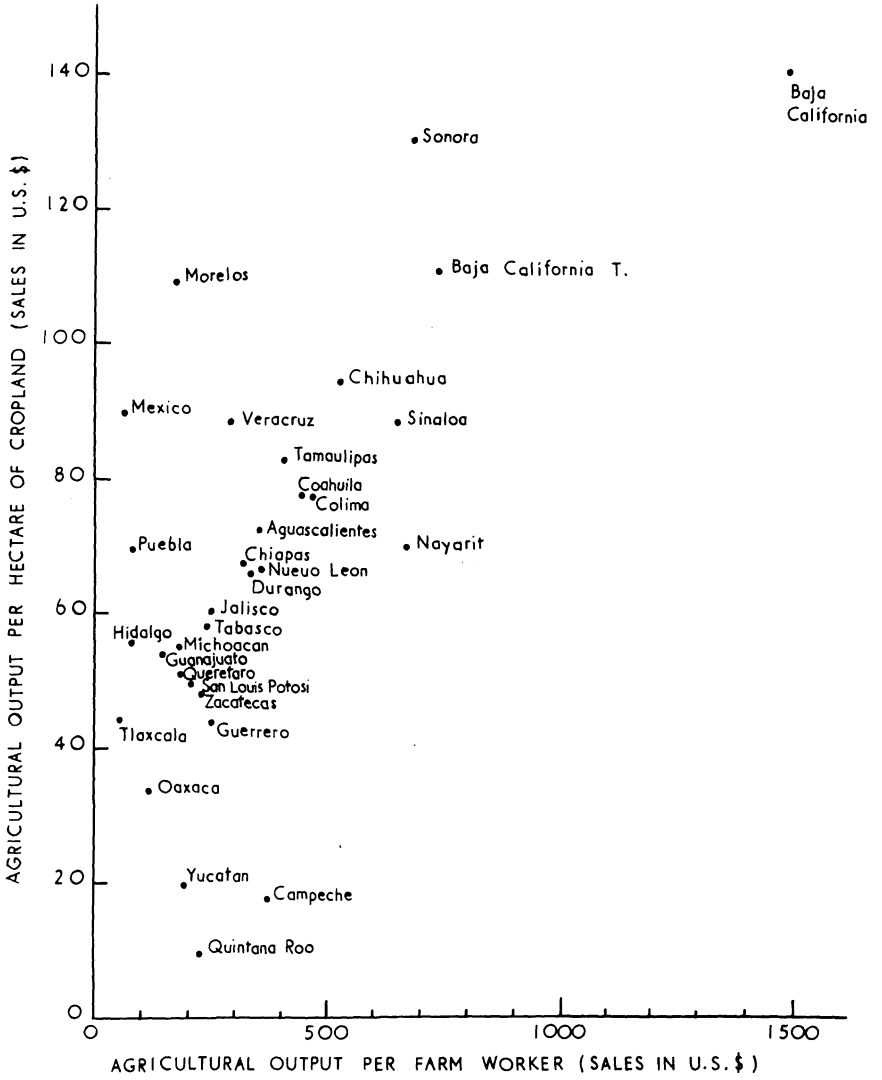

FIG. 3. Comparisons of agricultural output per hectare and per worker among states in Mexico, 1960.

The Second Enclosure Movement in England represents a classical illustration of this process. It facilitated the conversion of communal pasture and farmland into single, private farm units, thus facilitating the introduction of an integrated crop-livestock 'new husbandry' system. 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. Similarly the 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 gains of entrepreneurial innovation by individual farmers.

The socialization of much of agricultural research, particularly the research leading to advances in biological technology, represents an example of public sector institutional innovation designed to realize the potential gains from advances in agricultural technology. In the United States the political and legislative history of farm price programs, from the mid-1920's to the present, can be viewed as a struggle between agricultural producers and society generally regarding the partitioning of the new income streams resulting from technical progress between agricultural producers and consumers.

Profitable opportunities, however, do not automatically lead to institutional innovations. The gains and losses from technical and institutional change are typically not distributed neutrally. There are, typically, vested interests which stand to lose and which oppose change. There are limits on the extent to which group behavior can be mobilized to achieve common or group interests. The process of transforming institutions in response to technical and economic opportunities generally involves time lags, social and political stress, and in some cases, disruption of political and social order.

The capacity of a society to generate a continuous stream of institutional innovations in response to technical and economic opportunities is clearly essential to the development process. The capacity to organize voluntary associations, outside of the hierarchical bureaucratic organization of government—the organization of rural people around the particular commodity, resource, or development interests for example—appears to be an essential element in generation of institutional change.

Clearly the attempt to extend the induced innovation perspective to the process of institutional change does not yet possess formal elegance. It provides no guidance at all as to why many relatively sophisticated societies have demonstrated so little capacity to generate the institutional changes that would give them access to the new income streams that might be obtained from the application of scientific and technical knowledge in agricultural production. Yet it does add significantly to our capacity to interpret the process by which such institutions have evolved, in some countries, in response to technical and economic opportunities.

And it suggests areas of research which should receive relatively high priority in the allocation of social science research resources.

PERSPECTIVE

The empirical support for the induced innovation hypothesis has been generated primarily from the examination of historical growth processes. It seems useful, therefore, to raise the question of whether, under modern conditions, the forces associated with the international transfer of agricultural technology and the exercise of economic and political power are so dominant as to vitiate the induced development model as a guide to agricultural development strategy.

International technology transfer

It might be argued, for example, that the dominance of the developed countries in science and technology raises the cost, or even precludes the possibility, of the invention of location-specific biological and mechanical technologies adapted to the resource endowments of a particular country or region. This argument has been made primarily with reference to the diffusion of mechanical technology from the developed to the developing countries. It is argued that the pattern of organization of agricultural production adopted by the more developed countries—dominated by the large scale mechanized systems of production employed in both the socialist and non-socialist economies—precludes an effective role for an agricultural system based on small scale commercial or semi-commercial farm production units. Yet the labor force explosion anticipated in rural areas of the LDC's in the 1970's implies that failure to design agricultural technologies consistent with higher population densities in rural areas will be extremely costly. It is possible to provide at least a partial response to this concern.

The failure to effectively institutionalize public sector agricultural research can result in serious distortion of the pattern of technical change and resource use. The homogeneity of most agricultural products and the relatively small size of the farm firm, in both the capitalist and socialist economies of the west, make it impossible for the individual agricultural firm to either bear the research costs or capture a significant share of the gains from scientific and technical innovation. Innovation in mechanical technology, however, has been much more responsive than biological technology to the inducement mechanism as it functions in the private sector. It has typically been more difficult for the innovating firm to capture more than a small share of the increased income stream resulting from innovation in biological than in mechanical technology.

Failure to balance the effectiveness of the private sector in responding to inducements for advances in mechanical technology, and in those areas of biological technology in which advances in knowledge can be embodied in proprietary products, with institutional innovations capable of an equally effective response to inducements for advances in biological

technology, leads to a bias in the productivity path that is inconsistent with factor endowments—particularly with the factor endowments of the more labor intensive LDC's. It seems reasonable to hypothesize that the failure to invest in public sector experiment station capacity is one of the factors responsible in some developing countries for the unbalanced adoption of mechanical relative to biological technology. Failure to develop adequate public sector research institutions has also been partially responsible, in some countries, for the almost exclusive concentration of research effort on the plantation crops and, within the plantation sector, on export crops such as sugar and bananas.

The distribution of economic and political power

Agricultural protectionism in the developed countries has been, and remains, a major factor contributing to disequilibrium in world agriculture. The distortion of factor and commodity prices, and of commodity flows, resulting from this protectionism act to lower the return to human and material resources in both the developed and developing countries. The protectionist constraints on the functioning of international commodity markets limits the potential gains which developing countries can realize from productivity growth in agriculture.

The domestic development policies pursued by many developing countries have also dampened incentives and opportunities for agricultural development. A major objective of political leadership in many developing countries, whether impelled by a nationalist or a socialist ideology, has been an attempt to substitute new forms of economic organization for the 'capitalist' form inherited from the period of colonial dominance and economic dependence. An important component of this strategy was the replacement of the traditional 'explosive' raw material and commodity producing sectors with an industrial sector that would reduce 'dependency' on the metropolitan economies. A further reaction to the earlier dominance of the metropolitan economies was a strong skepticism with respect to the role of the market mechanism in the allocation of resources and the direction of income flows.

There was also a general failure to adopt policies consistent with rapid growth in output in the agricultural sector. In some cases these policies were directed to shifting income streams away from the traditional political elite whose economic base rested in the agricultural and plantation sectors. In other cases, it was based on a presumption of low growth potential in the agricultural sector because of institutional constraints on the response of peasant production to economic incentives. Industrialization was viewed as an effective means of breaking down the constraints on economic growth in economies where 'too many peasants' were viewed as a major obstacle to economic growth.

The effect was typically to redirect income flows away from both the traditional elite and the peasantry and toward the middle class—particularly the educated middle class and organized labor. It is

now clear that these policies have been costly when evaluated in terms of the effect on agricultural development and on national economic growth. Discrimination against agriculture in both factor and product markets has depressed production incentives. Price policies have been directed toward extracting an economic surplus from both the peasant and the plantation sectors. At the same time there has been a general failure to make the investments necessary to maintain and expand the surplus—in the capacity to produce and market the new biological, chemical, and mechanical inputs and in the agricultural research capacity to improve the efficiency with which inputs could be transformed into outputs.

The effect, in many countries, of the development policies of the 1950's and 1960's was to tilt the income distributions in the direction of a new urban rentier class of industrial workers and managers. The agricultural surplus—the income streams generated in the agricultural sector—has frequently been used to purchase a nonviable industrial sector or a non-productive military or administrative bureaucracy.

CONCLUSION

If the intersector income transfers resulting from the growth in technical change in agriculture are to result in a cumulative contribution to economic growth, the new industrial sectors purchased by these transfers must also be capable of generating intersector transfers. They must be capable of producing the industrial materials needed to sustain the process of agricultural development. They must be organized to increase the demand for labor in the industrial sector.

The test of the next decade for many of the developing countries will be whether they are prepared to use the relatively inexpensive source of growth opened up by the 'green revolution'—by the transformation of agriculture from a traditional to a modern science-based sector. If these potential gains are to be realized, policies will have to be designed which result in the sharing of these gains with rural people. It is unlikely that it will be possible to achieve modern rates of productivity growth if rural people are excluded from modern levels of commodity, service, and amenity consumption.

BIBLIOGRAPHIC NOTE

The data and analysis in this paper draws very heavily on research conducted with Professor Yujiro Hayami of Tokyo Metropolitan University. The results of this research are presented most fully in two publications:

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Mário Pereira, *Portugal*

It is an honour for me to open the discussion on the excellent paper by Dr Ruttan. It constitutes an important contribution to the analysis of situations concerning economic growth. The analysis he has produced about differences in factor productivities, based on research that deserves an especial reference, and the conclusions that follow from it, provide excellent material for reflexion and debate at this Conference.

I am delighted to say that on the whole I support the main theses contained in this paper. Thus my comments will be mainly directed towards what the author has not said, rather than towards what he has explicitly stated.

The title of Dr Ruttan's paper is 'Induced Technical and Institutional Change and the Future of Agriculture'. However, after defining ably,

clearly—and with some originality, too—the sources of the differences in factor productivities among selected countries, and their relationships with the stage of economic development, as well as the impact of technological innovations on the inducement of institutional change, the author does not show us how his results can be applied so as to provide us with a picture of agriculture in the future in the context of technical and institutional change.

It is obvious that in order to reason scientifically about the future of agriculture one has to move outside the scope of agricultural economics and into the domain of rural sociology and other disciplines. Hence, it is understandable, as I have pointed out, that Dr Ruttan says little about the future of agriculture. He is the first to state that 'the tools of the economist are relatively blunt instruments with which to confront the grand theme of epochal growth and decline'.

Dr Ruttan provides us with an analysis of labour and land productivities in different groups of countries concluding that, in the initial stages of growth, it is the increase in labour productivity that gives the greatest impetus to increases in total productivity in the RDCs, whereas in the ODCs it is land productivity that constitutes the main source of increase in total productivity. As the process of growth continues, there is a tendency for the influence of these two factors to balance out. This all goes to show that this behaviour is rational in following the economic principle that one should aim at obtaining the highest return from the scarcest (and thus most expensive) resource.

In old agrarian countries land has been, and for some still continues to be, the scarcest resource, whereas for younger countries it is labour. The last column in Table 6 shows precisely this: the rate of growth of output per hectare is much higher in Japan (where land is the scarcest resource) than in the U.S. In the latter country (where labour is the scarcest resource) the rate of growth of output per worker is higher than in Japan. In some regions, machinery is the most expensive factor of production; thus there is a logical concern about increasing its productivity.

In the agriculture of the future, what will be the scarcest resource?

Probably the 'brain power' capable of producing technological innovations and new management techniques. Thus it is this ability that will have to be utilized in the most profitable manner. Research, experimentation and extension services will be, as Dr Ruttan points out, key factors in the agriculture of the future.

One statement made by Dr Ruttan (p. 41 of his paper) gives rise to comment. According to him the ODCs have *failed* to take full advantage of the development opportunities opened up by technical inputs and human capital. Now, I do not believe that they have *failed*, nor do I believe that such opportunities were always within their reach, since there is one adverse factor exerting a decisive influence on the process of agricultural transformation which the author does not consider. This factor is the agrarian structure. In old agrarian countries, the historical evolution of the land structure is strongly conditioned by traditional factors, which are not

easy to remove. In the absence of some profound change—in the way of agrarian reform—the traditional structures are a bottleneck to a more efficient use of production factors produced by technological innovations. Hence, the land/labour ratio and the productivities of labour and land (particularly the former) cannot attain the levels they reach in younger countries where the land structure emerged free from conditioning factors resulting from high population pressures in agriculture.

I therefore consider correct but incomplete the conclusion that 'productivity differences in agriculture are increasingly a function of investments in the education of rural people and in scientific and industrial capacity rather than natural resource endowments'. The land structure must also be considered an important factor in those differences. In old Europe there are many examples to substantiate this proposition.

In the section 'Induced technical change', Dr Ruttan calls attention to the importance of technological and scientific knowledge in the growth of nations. I fully agree with this. One can say that differences in natural resources among nations are less responsible for the differences in agricultural development than human and technological factors.

The agriculture of the future will certainly be highly scientific and the businessman-farmer will have to be highly competent in his profession. Thus he will have the right to demand that his business shall provide him with a reasonable income. One can then predict that the farms of the future will be larger whether they are of the family, capitalist or co-operative type. One can also foresee that as a consequence of technological innovations, the proportion of peasant farms will decline substantially.

I would further add that agricultural change will depend more on scientific and technological innovations in other sectors, such as in the fields of electronics, automation, transportation and community infrastructures—which will determine new forms of behaviour for societies—than on specific innovations in agriculture.

With regard to the impact of science and technology on the progress of agriculture, I would stress the role of the extension services. It is not enough to implement a research programme that will lead to the discovery of new technologies; it is also necessary to pass on to the farmer the results of this research and the practical means to apply them. On the other hand, it is also necessary to make known to laboratories and research stations the problems that farmers would like to see studied and resolved. Bad extension services can also be held responsible for slow progress in the adoption of techniques long used in similar regions elsewhere.

I strongly agree with Dr Ruttan's ideas about personnel training for research activities, as opposed to the creation of new research units. I am glad to see that he shares my personal convictions about the usefulness of having people with responsibilities both in teaching and in research. Besides the advantages he mentions, it also seems to me that the general cultural background that the teacher-researcher must possess in order to educate his students helps research to the extent that it enlarges the area of knowledge in which the research is carried out. On the other hand,

teaching benefits from the process of self-regeneration that the researcher-teacher acquires in the course of his research activities.

With regard to induced institutional change, Dr Ruttan seems in my view to put too much emphasis on the impact of technological change in the inducement of institutional modifications. It is true that there are causal relationships between technical and institutional change but they work in both directions. Technological change may induce institutional transformations but new institutions may also give rise to new technologies adapted to them or may influence the degree of adoption of techniques already known.

On the other hand, we cannot forget that the major institutional changes in agriculture are dictated by socio-political factors and not merely economic ones. The history of agrarian institutions in older countries tells us that major changes have been mainly motivated by socio-political considerations, in terms of the behaviour of societies and their administration.

It is true that 'the capacity of a society to generate a continuous stream of institutional innovations in response to technical and economic opportunities is clearly essential to the development process'. But it is also true that such a capacity frequently goes beyond the economic sphere and into the area of socio-political motivations. These, particularly when linked to a fixed traditional system, are precisely the reason that explain why, as Dr Ruttan states, 'many relatively sophisticated societies have demonstrated so little capacity to generate the institutional changes that would give them access to the new income streams that might be obtained from the application of scientific and technical knowledge in agricultural production'.

Many old agrarian countries provide examples of socio-political constraints on development. On the other hand, agrarian reforms that have taken place in certain countries provide arguments for the contention that institutional change can stimulate technological development. There are moreover, examples which show that technological change can be inspired by the difficulty, even the impossibility, of modifying institutions. The development of machines suitable for regions of minifundia is a case in point.

I do not entirely disagree with Dr Ruttan when he says that institutional change has resulted from the efforts of firms to internalize the gains and externalize the costs, and of societies to do the opposite. In order to substantiate this assertion he mentions the cases of the Enclosure Acts in England and of the modernization of land-tenure relationships. It seems to me, however, that this conclusion cannot be made general; there are cases in which technical opportunities have produced different reactions in institutions. As an example, I can mention from Portugal the case of the expansion of tomato growing for processing. This expansion has brought about a change in the contractual basis of production exactly the opposite of what has happened in England: from the owner-operator system to share tenure to lease tenure.

All these considerations serve only to emphasize the complexity of the relationships between technological and induced institutional changes and their dependence on extra-economic factors.

Agricultural development policies and the type of institutions which will give effect to them will result from the impact of technical change on the socio-economic utilization of natural and human resources in conjunction with the reactions of undertakings to the constraints imposed by a production discipline at international level.

After these comments, it seems to me appropriate to bring together a few considerations about some of the problems of agriculture in the future not mentioned in Dr Ruttan's paper. Speculation about the agriculture of the future belongs more to the field of sociology than to economics. As I do not consider myself a sociologist, I will base my reasoning on some of the ideas already put forward by the experts who have been considering society in the year 2000.

It is hard to prove, but everything seems to indicate that the future of agriculture will depend more on the socio-political institutional organization that societies will ultimately adopt than on the technological changes taking place within the sector. What forms will that institutional organization take? To what extent will present-day economic concepts survive in that system? That is to say; will societies continue to gauge their behaviour only by the material benefits offered by the various alternatives? What will be the significance for future societies of indicators such as GNP and income per capita? Can we go on thinking only in terms of productivity? These are just a few points on which we must begin to reflect.

I do not intend to answer those questions since I do not feel them to be within my competence. I merely wish to present some of the hypotheses put forward by the already numerous group of experts concerned with this problem.

Among the several predictions on this theme, the first commonly made is that there is a strong tendency towards the elimination of the specific characteristics that make agriculture unique among economic activities. The spread of urbanization, the diffusion of community infrastructures and the occupation of so-called leisure time will eliminate the differences between rural and urban populations. A general improvement in the conditions and ways of living will approximate farmers' behaviour to that of people engaged in other activities. Certain technological innovations (hydroponics, industrial fruit production and factory livestock production, etc.), the improvement of means of communication (telephone, radio and TV), and new management techniques will make the farm closer in nature to a unit of production in any other sector.

The second type of predictions in which we are interested has to do with the use of natural resources, whose potential is threatened by their uncontrolled and discriminative utilization. The alarm spread by some scientists, in particular those of MIT, has brought about an increasing concern on the part of societies to accept a collective discipline for the

control of a system that will guarantee in perpetuity a stable way of life to all mankind. If this comes to pass, agricultural production will be co-ordinated on a world scale and oriented towards a more equitable distribution of wealth. International collaboration will attempt to reduce the growth differences between nations; hence, factor use and product prices will be controlled by social values.

If these predictions come true, we shall stop thinking in terms of higher rates of growth. Instead, we shall start to think in terms of stable rates of growth, the present concept of productivity will certainly be modified, and technological and economic research will perhaps pursue different objectives.

As a logical consequence of this, the legal systems of property and land tenure will change. The right to property will be severely limited, giving place to private temporary use of land, and there will be a trend not only towards the consolidation of family farming but also towards an increase in co-operative and semi-public farming under the control of the State.

It must also be recognized that the attempts made up to the present to eliminate the gap between the developed countries and the so-called 'third world' have failed. This will bring about friendship movements among nations directed towards a more equitable distribution of wealth.

The crises of food shortages and surpluses will be controlled by the adjustment of production to world consumption, which will imply a change from the market economy system to that of a more or less planned economy.

The world of the future will be dominated by the discipline of co-operation: at regional, national and world levels.

To sum up: if mankind wants to build a world where self-interest will give way to friendship between peoples, a new morality must emerge, and the behaviour of societies will alter the significance of present-day economic indicators. Profit may cease to be the prime mover of business; productivity may perhaps lose its present importance in the economy, and GNP will be replaced by what is already being called Gross National Welfare.

I will end my comments on Dr Ruttan's paper by saying that I am in total agreement with his critiques of the way developed countries have thought to 'help' the less developed countries. They substantiate some of the comments I have made above.

Finally, I should like to congratulate Dr Ruttan on this brilliant and stimulating paper.

Dusan Tomic, *Yugoslavia*

Modern techno-technological progress during the past decade has given a positive characteristic to the great success achieved in agricultural development in the whole world.

As far as forecasting the future development of world agriculture is

concerned, it will be necessary to continue examining and evaluating the effects of new technology and the techniques applied. In my opinion, the efficiency of new technique and technology in agriculture generally depends on two conditions. The first, is the amount of new technique and technology applied. The second, is how large is the part of agricultural production covered by the new processes.

Agriculture in many countries is getting more and more the characteristics of capital intensive production. This means that modern technology is accepted and introduced with the aim of achieving better results. Investigation of volume and efficiency of modern technique and technology introduced in Yugoslav agriculture show that correlations between production results and various production factors are different for individual groups.

A high degree of correlation exists between the total agricultural production achieved and consumption of fertilizers and usage of reproduction material of high biological value, mechanized transport, manner of land utilization, etc.

There is a moderate degree of correlation between total agricultural production and fixed assets. With this the questions of volume, dynamics and structure of investment are becoming topical and are worth further detailed investigation.

There is a moderate degree of correlation between the entire agricultural production and the socialized sector of large-scale production. This reveals a complex of problems which still exist in building up large-scale production units.

A very low degree of correlation has materialized between total agricultural production and the structure of production, regional component of agriculture, irrigation and some other production factors.

Even though Yugoslav agriculture, during the starting phase of its intensification, realized very effective results, it has to be said that the efficiency of technical and technological progress applied is not yet satisfactory.

A lower degree of efficiency is achieved when modern technique and technology are applied partially, covering only certain phases of the production process of important agricultural products. In contrast, higher efficiency is assured when modern technique and technology is fully applied for all production processes of an agricultural product, or groups of products on agricultural holdings, and in specific areas. The highest degree of efficiency is reached when modern techno-technological progress is applied in the whole agricultural sector and in the entire economy.

The choice of adequate up-to-date techno-technological treatment has to be combined with optimal use of other production factors and full utilization of the available material base. It is my firm opinion that a high intensive and economic production is possible only when modern technique and technology is combined with the up-to-date work organization.

Harold F. Breimyer, *U.S.A.*

My first comment is pedagogical. It is unfortunate that we adhere to the traditional listing of four factors of production. It would be better to recognize two categories. The first is composed of man and natural resources. The second comprises factors that man in his ingeniousness has designed. These are four: physical capital, management, technical education, and the institutional structure of governance. All these are integral.

My second comment relates to the uncertainty of present assessment of world-wide resources and productivity in agriculture. There is reason for apprehension that the developed world, whose agricultural 'development' has rested so heavily on utilization of industrial materials, will be handicapped henceforth by gradual depletion of mineral resources, including petroleum and natural gas. If this be the case, the paradox will arise that more emphasis will be placed on the factors of man and land, but also the role of education will be enhanced as ways will be sought to adjust to the more limited supplies of chemical fertilizer, petroleum, and natural gas.

Henri de Farcy, *France*

I will begin the discussion by examining only one of the points made in Dr Ruttan's perceptive paper: passing from an agriculture based on natural resources to one based on science; a science which would permit a new technology and also new institutions.

The development of this most prodigious human faculty—science—seems to me often to have been neglected because its role is not always apparent at first sight. It reminds me of the drunkard whom someone meets on all fours in the street under a street light. He is asked 'What are you doing?'—'I'm looking for my keys.' The other man helps him to look, and then asks: 'Are you sure you lost them here?'—'No, I lost them farther down the road.'—'Well then, why are you looking here?'—'Because there's more light here.' How often we too look for solutions where there are none, because we think we have the methods to find them!

Also, I wonder if we should not link what Dr Ruttan says to the recent theory of what are called 'growth economies'. Emphasis has long been laid on 'economies of scales' which are based on known production factors which can easily be identified and measured.

The theory of 'growth economies' is based on an established fact which has taken a long time to be integrated into economic thought. There exist in every enterprise as in every society, a certain number of factors which could be called dormant, which are not developed. It is by developing them, which in fact may be done at little cost, that we shall be able enormously to improve results.

Is not the typical example of these growth economies the development of man himself? What a difference there is between two workers or two company directors who both have the same tools but of whom one is motivated and competent, and the other indifferent and incompetent! It is for this reason that I would congratulate Dr Ruttan on the final distinction between production factors:

— Man
— Means.

But how should man be developed? It is with this point that I should like to open the discussion. It seems to me that he must have economic power, that is to say, means and a framework in which he is not prevented from utilizing them: economic knowledge; an economic will.

I will not dwell on the idea of power because it requires in itself a very lengthy discussion.

Dr Ruttan mentions the fact that many relatively sophisticated societies have shown little capacity to effect the institutional changes necessary to prepare for the future. There are in the final analysis two sorts of science, and therefore two sorts of education: the first is simply the communication of a certain number of notions, the other is the profound assimilation of a tool for studying and transforming the world. Dr Samuel Johnson used to say to his son: 'Your intelligence is limited, hasten to learn to make use of that of others.'

In these circumstances, it seems to me that any training might answer the following questions:

(*a*) Is it suited to communicate the results of human thought which are the aim of formal teaching?
(*b*) Is it suited to help the student learn, by experience and self-criticism, the data which science has not yet formalized? When there was a question of forbidding English children to work, Karl Marx said: 'It is a good thing to forbid children work which prevents their physical growth. But it would be a sad thing to forbid them all work, for work is a school where one learns much.'
(*c*) Is it suited to help the student acquire a method whereby he is not content to consider things from the point of view of speculation or indignation, but as problems to be solved?
(*d*) Is it suited to help everyone to work better with others and better to socialize his behaviour?

In short, it seems to me that we could discuss whether we want to develop a science which helps to interpret the world, or, on the contrary, to transform it?

My second point is this. Knowledge should be put into effect by a will. A motivated man can do incredible things. But very strong motivations are necessary for the acceptance of new technologies; they are necessary above all for the acceptance of new institutions. For ultimately, new

institutions upset many people. It is said that 'In order to progress one must determine one's priorities'. I think one must above all determine one's 'posteriorities', that is to say, break with the aims, the techniques, the behaviour, the habits and even the relationships which one has had hitherto.

For this we need a type of men which has thus far been inadequately studied—the enterprising, who are capable, in the sophisticated societies Dr Ruttan talks of, of being the surgeons of progress.

I think we must take the term 'enterprising' in a wide sense of any person capable of risking something for the sake of progress. The industrialist who creates jobs; the agriculturist who dares to modify a tradition several centuries old; but also the militant trades unionist who is prepared to risk his position to create more justice for the workers; the banker who lends money not on material guarantees, but on the personality of men and the quality of their projects; the university teacher who is prepared to stand up to his dean.

Dr Ruttan has shown the dangers of a false system of incentives and motivations which can stifle the enthusiasm of men who were ready to be useful. We must ask ourselves what are the real motivations which invite these men to leave a real security of their own to create new achievements.

It is said to be profit. I was struck by a remark of Henry Ford's: 'I know industrialists who will never make money because they love it too much, and they'll be too scared to risk it in profitable ventures.'

Should we not look farther afield, with method and rigour. And with humour as well. You know that I am a Catholic priest and therefore celibate. A friend of mine, a businessman who has created thousands of jobs, said to me once: 'I am an industrialist. I am the father of a family. I listen with interest, and often with profit, to the advice which you, as a bachelor give me, about my behaviour towards my children. But I'm not always sure that you perfectly understand. I listen with interest and sometimes with profit to what the economists say about my business. But I am very much afraid they don't always understand my motivations. To understand those who take risks, don't you need to have taken risks yourself?

But since we cannot perfectly understand them, can we not respect them? Could this not be the theme of another discussion in which we should ask ourselves how to identify and how to stimulate those motivations which can encourage men of all classes to create new institutions and to adapt to them?

A. B. Lewis, *U.S.A.*

I suggest there are matters more fundamental in their effect on agricultural and economic development than the institutions discussed by Dr Ruttan in his excellent paper. Ideas are the mothers of institutions, and ideas are derived largely from the basic philosophies whereby people live and order

their lives. In turn, these philosophies have come from the influential teachers whose precepts have captured the loyalty of the peoples of the world—such teachers as Confucius, Gautama Buddha, Mohammed, Jesus of Nazareth, the Greek philosophers, the Hebrew prophets.

These philosophies, I suggest, affect economic development in, among other ways, their influence on (*a*) the courage and confidence with which the people face the natural facts of their environment and thus how fully and skilfully they manage these for their benefit and (*b*) their willingness and capacity in co-operating with one another in establishing and running the institutions which carry the economy.

Economists from the West who would grapple with the problem of stimulating economic growth elsewhere in the world should first face and grapple with the question of why—not *how* in the mechanical sense—economic development emerged first in their own nations in the past 500 years, and *why* it still, with a few exceptions, proceeds fastest in those same nations.

In my opinion, economic theory will remain a poor and feeble instrument for understanding economic development, as Dr Ruttan says it now is, until economists realize that motives of profit are not the only economic characteristics of the human personality. But I see no reason why all the characteristics of man which do in fact have economic consequences should not be comprehended in economic theory.

R. N. Tewari, *India*

I congratulate Dr Ruttan and Dr Gulbrandsen for a meeting of minds, and refer you to Dr Ruttan's paper, page 50 and Dr Gulbrandsen's page 26. Both these papers emphasize—*inter alia* presuppose—that the protectionist policies for agriculture adopted by LDCs have led to:

(*a*) Slower growth rate with no possible betterment in the future. Dr Ruttan says: 'The protectionists constraints on the functioning of international commodity markets limits the potential gains which developing countries can realize from productivity growth in agriculture.' Dr Gulbranden is more clear when he states that the 'pessimistic, but unfortunately likely, projection is therefore that the per capita food supply in developing countries will not improve'.

(*b*) That the politics, in LDCs, aiming to redirect flows of income from both the traditional elite and the peasantry toward the middle class—educated middle class—have been costly when evaluated in terms of the effect on agricultural development.

These statements have policy implications and need further examination. Assuming that the situation as listed (*a*) above is true, should we open the agricultural sectors of the LDCs to international competition? In the face of vertical integration and multinational multimillion dollar forms

of western organization will not the, so far protected, agricultural sector get internationally liquidated and/or amalgamated with the disappearance of indigenous production and other grave consequences?

Experience of trade protectionism in most developed countries, like the EEC makes this international synthesis of agro-product markets unreal, if not economically fallacious.

Regarding the second part listed at (*b*) above, Dr Ruttan may like to consider these issues:

(*a*) Is there no place for socio-constitutional obligations to be accounted for in agricultural economics? In India the established elite in agriculture proved a positive hindrance and exploitive.
(*b*) If the emerging body of peasants is more innovative why should not such a policy be effected and be preferred by economists?
(*c*) Finally, the breakthrough in agriculture in India is a very recent phenomenon and any benefit—cost analysis (ref. Ruttan's paper) should give time for technologies to reach fruition. A study limited to 1967–68 and 1971–72 cannot be used for assessing generalized consequences.

Thus, the entire issue of protectionism of agriculture and income transference needs to be examined further.

G. C. Mandal, *India*

As expounded by Dr Ruttan in his paper, the economic logic is, of course, forcefully in favour of adjustment of technique of production to the resource-endowment of the economy. This view is generally accepted nowadays. But the question that remains to be answered is: 'To what extent can labour-intensity be pursued in less-developed countries?' There are less-developed countries where population in the agricultural sector is so vast that probably no other input could be used than labour. Even improved non-mechanical technology based upon seed and fertilizer seems to be capital-intensive. Even a progressive technology based on improved seed and fertilizer is not spreading fast enough in many less-developed countires. Probably there is scope of further elaboration on the degree of labour-intensity or capital-intensity which a less-developed economy can pursue.

Peter von Blanckenburg, *West Germany*

I want to refer to Dr Ruttan's statement that literacy and schooling are among the most important variables responsible for the level of productivity.

I have some doubts whether this thesis is correct with respect to societies in less-developed countries. Could it not be that formal education is only an indicator for another variable behind this phenomenon which I

could describe as open-mindedness for rational, scientifically-based farming? Such an attitude does not come only by formal education.

It seems to be an important point in so far as policy-makers could conclude from Ruttan's statement that increased efforts in alphabetization and primary schooling are among the most effective means for reaching higher agricultural productivity. But informal education, such as extension activities or use of mass media, are possibly more important and, under certain conditions, more economical instruments in the development process as a careful evaluation of recent experiences has shown.

Dr Ruttan (in reply)

Dr Pereira's comments, particularly that on the problem of transforming the structure of agriculture in traditional societies, clearly represents an important contribution to the topic we are dealing with, and goes beyond my paper.

I want to make one comment on the problem of looking at the future. I have done a fair amount of projection work myself, and have certainly come to the conclusion that it is not possible to know or to project the future. What we need to do is not to concentrate on making better projections but on how to design systems that respond to the future and the present—to the new knowledge as it becomes available—rather than to the past. Too many of our systems are responding to knowledge that is obsolete.

I did not intend to focus exclusively on the impact of technical change. Clearly there is a dialectical process going on here, of institutional change generating a technical change, and vice versa.

I see grounds for scepticism, not only about the transfer of technology, but about the transfer of institutions particularly in situations where there is an absence of capacity to invent or adapt institutions, consistent with the resources and the culture endowments of a particular country. The direct transfer almost always results in a less efficient use of either the technology or the institutions than is potentially feasible.

I appreciate Breimyer's comments. My views on this problem of factors is that any aggregation into a few factors does violence to the rich diversity that exists in the rest of the world. The definition of factors has to come down to the particular purpose you want to use them for. I don't like just 'factors'. I don't think that 'education and management' is a factor. I think, man is a factor, and 'education and management' is embodied in him. I do not think, either, that science and technology can be viewed directly as factors of production. They operate only as they become embodied in technical inputs, or in the capacity of the indiviual farmer. So, if I had to select just a few factors, I would select 'man' and 'tools'.

I agree that we now have to begin to look at energy implications. I do

not think that the price of fertilizer is going to continue to decline. I think it can still decline in the many countries that do not yet have the advanced fertilizer technology but fertilizer prices as a result of rising prices of energy will level off or begin to rise. This will have a very important impact on the direction of other technical changes.

It seems to me that we are now at the point where we need to move beyond the industrial revolution, with its emphasis on mechanical technology, into the biological revolution with its emphasis on appropriate biological technologies.

I also appreciate the point that the growth of agricultural productivity depends on the evolution of the non-agricultural sector. I think we still have a difficult problem though, in asking why some countries which clearly have the scientific and industrial capacity to provide those inputs for agriculture have been so slow in doing it. France, for example, had the capacity to provide scientific and technical inputs, why did the applications take so long?

I agree with the point on industrial protectionism; it is worth while to approach the subject by thinking of who owns the country. Let us consider a country in which 70 or 80 per cent of the people are agriculturists. If we assume that they own the country, what kind of a bureaucracy and what kind of an industrial system would they buy?

Now if we change viewpoint and suppose that the modernized elite owns the country, then do they capture the market? and how? It seems to me that these two ways of looking at modernization have different implications as to the kind of industrial sector which will emerge, and the kind of person the industrial sector will produce for.

On the issue of literacy and schooling, I agree that we need to look for more productive ways to provide literacy than schooling now provides. Extension is clearly one way. It also seems to me that schooling or literacy or the ability to search the environment and to scrutinize the knowledge provided for the appropriate knowledge to use in your own farm situation does not become important until technical change begins to speed up. But when it does, this capacity of the firm manager to make judgments at micro level becomes extremely important, regardless of what kind of a firm it is. And I do not see how this capacity can be developed without literacy and without higher levels of education, whether it is produced by formal or informal methods.

Further discussion of papers by Dr Gulbrandsen and Dr Ruttan

G. R. Allen, *U.K.*

I find myself in strong disagreement with the emphases in Dr Gulbrandsen's paper which I feel does not get to the more critical factors behind the present international economic crisis, especially in relation to agricultural issues. I support his account of the structure of international trade and I am in complete agreement on the beneficial effects of

multinationals although, as will appear below, I query whether they have the influence or power which he suggests. But I am concerned that his paper touches on too few of the basic causes of the present international inflation, including those which are agriculturally based, that it is too guarded in its concern over present and prospective world food supplies, and that it pays insufficient attention to the inegalitarian tendencies between nations and the measures necessary to remedy them.

Dr Gulbrandsen's analysis of the international economy into five blocks is valid. One must share with him the fear that the stronger blocks will remain firmly protectionist. Towards the less-developed countries it seems that they will remain largely indifferent and exploitative—whether the exploitation starts in Washington, Brussels or Moscow.

Looking somewhat more closely at the multinationals, I am sure that our American colleagues will agree that every barrel can contain one bad apple. But I find it hard to see multinationals in general with either the economic powers or anti-social motives so frequently attributed to them. They generally maintain a low political profile and seek to be accommodating to the national governments of the countries where they invest. It is true that they will move money from one country to another in the face of monetary instabilities and uncertainties. But surely they are doing no more that any individual finding that his own bank is likely to go bankrupt? The multinationals have become the scapegoats of governments which have been unable to manage their own monetary affairs properly.

Like free trade itself, the multinationals are agents for great good in the international economy. They attempt to bypass barriers to trade, although they must all too frequently heed the protectionist demands of national governments. They seek to move capital to regions or countries where labour is most abundant and are, therefore, a force making for the equalizing of incomes about the world. Like Dr Gulbrandsen, however, I fear that they will continue to be constrained, and probably seriously, by economic nationalism.

I cannot see that new structure of international trade and the role of the multinationals provides the basis for a major explanation of inflation. At the best, Dr Gulbrandsen is stressing secondary influences and overlooking a whole series of partly independent and partly interdependent institutional factors and circumstances which have come together to create the present situation. These are:

(1) The recent extreme militancy of the labour monopolies, where in some cases the elasticity of expectation is now so high that wage claims are partly based upon the inflationary consequences which they will themselves create.
(2) The situation in many developed countries where voters have been demanding more in collective expenditures than they seemed prepared to meet in taxation. I frequently recall Colin Clark's prognostication that serious inflation is likely wherever governments take more than

40 per cent of national income in taxation. Certainly, there has been a printing press mentality towards the money supply in several major developed countries in recent years.

(3) The contradictions in economic and social objectives in many developed countries which are now probably more extreme than they have been at any time since World War II. Developed societies still insist on rapid economic growth yet increasingly seem unwilling to accept the structural economic adjustments which such growth demands. For example, so-called regional policies, while unquestionably socially desirable, reduce the overall productivity of capital without any apparent compensating reduction in society's demands for goods and services.

(4) 'The benign neglect' of the United States balance of payments and the outflow of eurodollars which have inflated world monetary supplies.

(5) Finally, and most direct concern to ourselves, the serious mismanagement of world agricultural policies in the last five years, which in the end has culminated in a set of partly avoidable events to produce the recent rise in food prices and the cost–push inflation resulting therefrom. The micro- and macro-economic agricultural cycles, which are a standard part of our teaching, seem to have had little effect in the recent planning of world agriculture. For example, we have had the absurdity of the EEC providing financial subsidies to reduce dairy cow numbers, and so the supply of beef, at a time when cattle inventories were being depleted in most major producing areas and when it was reasonable to foresee the resulting shortage within two or three years. Or again and with more general impact, the reduction in agricultural prosperity in most of the developed agricultures in the latter 1960s pointed to a likely cyclical inadequacy in investment for food production in the early- or mid-1970s. Finally, and this time outside our economic theory, it was possible to see quite clearly by 1970 that the trend of U.S. surpluses was downward, that the odds were for bad weather to reduce agricultural output seriously in some major areas within a few years and that prudent planning therefore required an international grain reserve

The foregoing interpretations may be controversial and, given the time available, contain many rough edges. But I hope that they will be sufficient to support the contention that the present international inflation is not to be explained to any significant degree by reference to multinationals or the present structural divisions in international trading.

In passing, I would query Dr Gulbrandsen's contention that the less developing countries lose from inflation. Inflation exerts many distorting influences but I do not see how it modifies the balance of real factors determining the sharing of the gains of trade between developed and developing countries. Moreover, I find it hard to accept the contention that inflation promotes flexibility. It is more likely to accentuate the protection

of established positions and to increase the ungovernability of nations. There is no such thing as moderate inflation in the long run—unless, of course, there is a periodic deflation deliberately engineered to check the pressures of rising costs and prices.

Dr Gulbrandsen seems to be too guarded in his doubts concerning existing projections of world food supplies and demand and concerning the Green Revolution. This is, of course, an extremely complex subject, but there are a number of reasons for concern.

(1) American surplus capacity in cereal production is trivial in relation to the growing needs of the world.
(2) In North America and Western Europe the pace of new technological advances in agriculture seems to be slowing and the adaptations to the scientific developments of the last 25 years is almost consummated. For example, it seems likely that U.S. feed grain yields will rise at a much slower rate in the 1970s than they did in the 1960s and, maize excluded, a similar situation is probable within the EEC. It is equally hard to believe that livestock/grain conversion rates will be improved at anything like the pace obtained in the 1950s and the 1960s.
(3) The Green Revolution has been much overrated and does not have the potential which has been so widely assumed. We seem to be near the end of the sharp increase in wheat yields associated with the comparatively easy exploitation of underground water. In future irrigation will become increasingly capital intensive. In addition, any radical advance in rice presupposes new varieties, especially adapted to cope with existing irrigation systems, and these are not yet available.
(4) In the U.S.S.R. and some parts of Eastern Europe agricultural planning is constrained by political dogma to the point where farm structure and other policies check the rate of growth of output—perhaps only by one-quarter of 1 per cent annually below what would otherwise be attainable, but in our context that is a critical deficit in the long run.
(5) As Dr Ruttan has already pointed out, the energy shortage will substantially increase the price of fertilizers relative to the value of agricultural output. In my opinion the real cost of nitrogen will increase by around 20 per cent at the farm gate over what it would have been if the energy costs of the mid-1960s had continued to apply.
(6) Finally, there is the possibility that there are long-term weather cycles differentially affecting the northern and southern hemispheres. At least a few serious scientists appear to fear that the northern hemisphere is due for a prolonged period, say more than a decade, of less favourable weather than experienced since the mid-1950s. If this view is correct, the implications are extremely serious.

One recognizes, of course, that there are points of advance which might enable the former rate of growth in food supply relative to that of demand to be maintained, particularly pasture improvement and synthetic proteins. However, there is sufficient evidence for us to consider that a sea change in the terms of trade in favour of agriculture is likely during the 1970s and that, if present policies are maintained, there will be periodic serious shortages of food and, maybe, famine around the world. Clearly, the situation is uncertain. However, it seems to me that there is a 50/50 chance of a pessimistic outcome if current policies are maintained, whereas 10 years ago one would have put the odds at no more that 1/100. (No doubt there will be an over-reaction to the present crisis with unusually low prices in say, 1975 and early 1976. We should make sure that we are better prepared than we were on the last occasion of temporary oversupply of grains and be ready with operational schemes for establishing a world grain reserve.)

The crisis in food supplies in the land-hungry underdeveloped parts of the world is now so serious and the gaps between the haves and the have-nots around the globe is so great that we must return to the battle for free trade, even if we know in our hearts, as I do, that it is almost a lost cause. But, without a rapid freeing of trade barriers in the developed countries, it is hard to see how elsewhere labour-intensive industries can be developed in any sufficiency to employ profitably the teeming urban proletariats.

The principal aim must be to create a situation where over-populated and land-hungry countries such as India can look to North America, Europe, Australia and parts of South America for a substantially greater proportion of their food supplies than is the case presently. In other words, the rich countries—U.S.A., Japan, EEC and U.S.S.R.—must be prepared to reduce or eliminate industrial protection so that the others can get the necessary international purchasing power. Can we not make the farmers of North America, Western Europe and, say Australasia understand that their general interests lie in reduced or eliminated industrial protection? We need an enlarged international division of labour to enable a greater reduction of hunger and malnutrition than is ever going to be possible with present policies.

Against the foregoing background, the present conflict over farm policy between the U.S.A. and the EEC is unimportant, if not totally trivial, in terms of major world issues. Indeed, it may be a false battle in that, with expanded food exports to the Third World, equilibrium between demand and supply in the developed agricultures would be rapidly achieved. In quantitative terms the present disequilibrium in North America and Western Europe are small. But agricultural free trade is also involved. To take but one example, the sugar-beet lobby of Western Europe should be firmly and continually reminded of the plight of most cane producers.

Our President and others have already raised ecological and environmental issues for our consideration. These may be real enough, although by no means as pressing or dangerous as suggested by the Club of Rome, but to me the main issue before us is to see that international

agricultural policies can be devised for the next decade to help the world to survive in some reasonable economic and political order. To this end we need:

(1) to recognize the probable long-term changes in the demand/supply balances for food now confronting us,
(2) to avoid or minimize mismanagement of world food supplies which, in particular means that we promote practical policies which will minimize the chances of inflationary, periodic shortages in the developed countries and which do much more than in the past to reduce the hunger and malnutrition in the developing countries, and,
(3) to reduce, as much as we can, the protection of the richer groups in world society—as much in the factories as in the agricultures of the developed countries—so that income and employment creating opportunities be created for the unemployed or underemployed of the developing countries, especially those which are land hungry.

Ahmad Kamali-Nafar, *Iran*

I would like to make a comment on the question of technical and institutional changes for the development of agriculture.

Experience showed that the technological advances could be brought to a country or region relatively easier than institutional changes. As a matter of fact, I think that institutional machinery should be provided first in a country so that it can absorb the technological changes.

For example, in my country, Iran, we have had land reform, and have provided the institutional facilities, such as co-operatives, credit, extension services, farm corporations, as well as education of farmers, training of managers and accountants, and other facilities. We introduced the technology much easier and faster because of this.

G. Gaetanni, *Italy*

The future outlook for agricultural prices has been brought to our attention by G. R. Allen this morning and we should consider it further. High prices for commodities look to me to be extremely pessimistic but, however, I will only agree that prices for agricultural products can stay higher than other prices of manufactured goods, particularly of the sophisticated ones, because they are more affected by energy restraint, also to fertilizer input and also to land which has become scarcer and scarcer in the world.

The third point I would like to make is that the outlook is different for Canada, U.S. and perhaps, Australia. They have great resources with a different policy. We already see a different approach by President Nixon removing all restrictions to increased production. The prices of 1973 may not stay as high in the future.

However, the outlook is quite bleak for Europe due to the fact that the

high prices of commodities, the restrictions on exports put into effect by Canada and possibly by the U.S.A. are going to strengthen the forces which are in favour of high prices, so that the trend to decrease agricultural prices in Europe may fade away. Furthermore, Europe has not such a good potential, at least for meat, as the other countries.

My conclusion would be that the outlook in the short run is for high prices for agriculture, but not as high as in 1973. The outlook can be better in the longer run also because the technological substitutions between different inputs can be made more favourable by innovation. The rate of innovation changes over time so we cannot say that the possibility of technological progress is subsiding. I do not agree with a previous speaker on this point.

However, the future can only be better with the liberalization of international trade but we all know the difficulties in the way of that.

K. L. Bachman, *FAO/U.S.A.*

Two important developments need to be emphasized.

1. There has been a long-term trend in the developed countries extending over the past several decades towards increasing their self-sufficiency ratios in agricultural products and involving many protected commodities. These trends need to be reversed. The recently completed FAO study indicates that a small decrease in the self-sufficiency ratio of the developed countries could over the next decade have a significant effect on the foreign trade earnings of developing countries while at the same time permitting a continued substantial growth in the agricultural exports of the developed countries.

2. The disappearance of U.S. food reserves and the fact that it consequently no longer serves as the world granary results in a significant new situation. It has policy implications at the national and international levels. Whether or not there is a new higher agricultural price level likely over the next few decades it seems clear that there will be periods and places of scarcity in food supplies. The inelasticity of food demands emphasizes the need for considering means in this new situation for ensuring greater stability in world food supplies and the prevention of hunger. It is in this context that the Director General of FAO recently has proposed the establishment of a system of World Food Reserves.

N. S. Jodha, *India*

The complementary relationship between technological and institutional innovations has covered a substantial space in the debates relating to development economics. But in terms of adoption of these innovations and their impact on agricultural growth, the situation in most of the developing countries hardly inspires confidence. The reason, to my mind, is that the LDCs have blindly imitated the patterns of developed countries

and have tried to foster such innovations with high subsidy. Once the subsidies are dropped, the innovations also collapse, because the latter could not become an integral part of the system.

Hence, unless the innovations stem from within and are guided by the people's motivation, the whole efforts relating to institutional innovations may prove sterile. Moreover, as the new institutions fostered by the governments of the LDC completely ignore the prevailing socio-economic framework of the communities, they prove misfits in the traditional communities. Cases have been noted where new institutions have degenerated into instruments of exploitation of weaker sections by the stronger sections of the community. Hence, the traditional power structure has reimposed itself through the new, formal institutions encouraged by the governments in the LDCs under their target-oriented programmes.

C. Muthiah, *India*

Dr Ruttan correctly emphasized the importance of literacy and schooling on the basis of a cross-country analysis involving a number of developing and developed countries. When I tried this analysis with different regions of a large country like India, I came to the same conclusion. The State of Punjab for wheat, and the State of Madras for rice have been able to register a higher rate of growth than other states. And these are the states which registered the higher rate of literacy and a higher rate of schooling.

But here I would like to introduce a caution: there are a number of educationalists, both from the developed and developing countries who think that a good proportion of the funds spent on education, particularly primary and higher education, is not very productive because of the type of education. The education tends to be of the bookish type which is not relevant to the problems of people or the area concerned.

Again Dr Ruttan carefully emphasized the importance of technical and scientific education. If the technical and scientific education is going to be of the pattern which is mainly available in most parts of the developing countries, that will only add to the problem of the educated unemployed with all its social and other difficulties.

Again Dr Ruttan emphasized the importance of institutional changes. Here I would like to stress one type of institutional change which is highly important, namely organizing rural landless labourers. In India, which is a densely populated country, the landless labourers properly organized, find that they have been able to get at least a small share of the increased productivity and production which have come through the technical changes. But there are some people who differ, they take the case of Kerala, and say the labour is very highly organized and there the development of the higher wheat programme or the Green Revolution is not very perceptible. But they miss the point. In Kerala most of the rice varieties introduced are not suited to the ecological conditions; but if you take the pre-Green Revolution stage, you find that Kerala stood first in rice productivity.

Dr Gulbrandsen (in reply)

Dr Allen wondered if I was correct in my interpretation of the main inflationary forces. He spoke of a number of other forces being at work but from the list he gave I understood that most of the items were referring to national inflation. That was not my point. I was referring to the fact that inflation has become a phenomenon on international markets and the fact that though previously the international market was a buffer against national inflation spreading from one country to another this no longer applies. In this context I think that I am still quite right in my assumption that it is much easier to divert the pull of demand from the domestic market to the international market due to technological advance, faster communication, better contact in which the multinational firms are very important as communicators of information.

I think that this point is still valid. There is a further point he mentioned and that is the question of the supply of money on the world market and there he might have a point, but it is difficult to distinguish between the extra supply of dollars because people do not want to buy American products and a general over-supply of dollars, and he might also be right that the dollar market has been flourishing and may produce more money than is appropriate for a well-functioning market with stable prices.

Regarding my optimism on the future capacity of agriculture, I feel that he is too much bound to the present price situation. I would ask the Latin American representatives here if their farmers were given prices for their sugar production double what they get today, would they not be able to increase the production by, let us say, 50 per cent? And I would pose the question to the economists from U.S., Canada, Australia and Argentina: if their farmers got double the price they get now, would they not be able to increase their production at least 50 per cent? Because the doubled price of sugar and wheat are exactly the prices the European farmers are getting.

In the context of protection I would like to refer to some speakers yesterday from India and from Bangladesh. They asked if it would be right for Indian agriculture to expose itself to the world market prices. Of course, in the present situation, with the world market prices distorted in the domestic markets by heavy protectionism, it would not be right. What they should do is to find out what would be the world market prices under free trade and adapt their policies to that. This is not an easy calculation and we should do more work in this field not only in making calculations but in working towards a freer trade.

I agree on the importance of a food reserve but think that often its size is exaggerated. If you have a well-functioning world market, this should be able to absorb a lot of variation from year to year in the need for food in any particular country of the world. The stress on the need for food reserves is also linked to the fact that we have this very great price distortion due to domestic protection.

Dr Ruttan (in reply)

There are four separate themes on which I will try to respond. In general I agree with most of the formal comments on the paper. The one area that I have some concern about is that of motivation, partly because I am not optimistic about our capacity to change people's motivations. This leads me to place much greater emphasis on building environments, and on changing environments that reward entrepreneurship or reward behaviour. I am concerned not with motivations but with behaviour. I do not trust most of your motivations. I think we have to build institutions which do not dampen latent entrepreneurial behaviour or, in another context, do not force people with good motivations into bad behaviour. And we need to build environments which induce people with poor motivations to act, and that induce socially desirable behaviour regardless of people's motivations.

In the same sense, I am not interested in the motivations of the people who manage the multinational enterprises, only in the behaviour of those enterprises.

On this relationship between technical and institutional changes, the point was made that the institutional conditions often do not exist for the exploitation of the technological changes. My own feeling is that one of the essential conditions for building the institutions that are consistent with development is the political organization of rural people at the local level. And let me put it more frankly: all of us who are trained to work in the area of development, all of us who are technocrats, work for who pays us. Unless rural people develop the political resources to force the bureaucracy to carry out programmes in their interest, the bureaucracy will carry out programmes in the interest of people who do hire them.

I know of many countries that passed perfectly good land reform legislation but the legislation is not implemented, not because the legislation is not good, not because the bureaucrats are not well motivated, but because there are no political rewards. There are no political rewards for implementation, there is no organized political power at the local level.

On another aspect of this, a point was made that often an institutional change requires subsidization and when subsidies are removed the programme collapses. This again goes back to my earlier point that reform must have some gains to be partitioned to generate the political resources necessary to implement the reform. I often look, for example, at the reform in the agriculture credit system in the United States in the 1930s. As I interpret that reform, it enabled local or regional, semi-public credit institutions to achieve lower costs, to tap central money markets at lower costs than the hierarchy of correspondent banks.

It reduced the cost of carrying money from New York to the Great Plains. When I look at the credit reforms in some developing countries, I see that they have increased the cost of carrying credit from the Central Bank to the rural area; and those reforms do not work.

On the issue of literacy and schooling, I agree completely, in spite of the fact that our findings indicate very substantial productivity implications of

literacy and schooling. Careful studies have also been done on health, I think that it is very unlikely that poor societies, societies which will continue to be poor at the end of this century, will be able to provide adequate literacy, schooling and health to poor people unless we can come up with some institutional innovations that enable us to perform these functions much more efficiently than the Western models that have been transferred to the developing countries.

I think that again those of us who work with our colleagues of the developing countries have got to get beyond the idea of being missionaries for our own institutions and collaborate with them in the invention of institutions which are more appropriated to countries that at the end of this century are still going to have a per capita income below 200 dollars.