ACCELERATED GROWTH IN AGRICULTURAL PRODUCTION AND THE INTERSECTORAL TRANSFER OF RESOURCES

by

John W. Mellor

January 1972 No. 72-3

Table of Contents

Accelerated Growth in Agricultural Production and the Intersectoral Transfer of Resources*

John W. Mellor

Accelerated growth in the agricultural production of low-income countries may sharply increase the transfer of resources between agriculture and other sectors of the economy. Such changes affect relative rates of capital formation and income growth in various sectors, the structure of growth, and overall rates of growth. Recent technological breakthroughs in agriculture give current relevance to these relationships.

This paper deals with conceptual and empirical aspects of (a) the magnitude of resource flows between the agricultural and non-agricultural sectors under various conditions of economic growth; (b) the changing role of economic and institutional devices in transferring resources among sectors; and (c) the relationship between such resource flows and technological change in the agricultural sector. Detailed comparisons are made for Taiwan and India, while brief note is taken of the experience of Japan, Britain and France.

There is controversy as to the timing and direction of net resource flows between agriculture and other sectors in early stages of economic development. One argument holds that net capital transfers to agriculture are needed so that agricultural production may be increased to meet the greater demand for food which accompanies industrial development. It is further argued that these capital transfers are large because of the high capital output ratios associated with the agricultural sector--perhaps due to the diminishing returns traditionally associated with agriculture.[1]

A contrasting argument calls for a squeeze on agriculture, transferring resources to other sectors, presumably on the assumption that the rate of return to investment is higher in the non-agricultural than the agricultural sectors.[2] This position is buttressed by the common assumption of diminishing returns in a technologically stagnant agriculture and rising returns through external economies in the non-agricultural sectors.

A much more complex and interesting case arises when technological change in agriculture sharply increases returns to investment in agriculture and consequently sharply reduces the capital output ratios. In these circumstances there will be at least a short-run net inflow of resources to agriculture unless (a) the incremental capital-output ratio is less than one or (b) consumption in agriculture declines.[3] As we shall see

later this ratio may well be less than one in the case of recent agricultural technologies. Consumption in agriculture may decline if higher returns to investment associated with technological change cause a shift in the savings function or if increased production combined with inelastic demand causes a reduction in gross income.

Thus, the magnitude and direction of resource flows between agriculture and other sectors depends on the relationship between values in the two sectors for a complex of factors including: the rates of return on capital, the capital-output ratios, the savings rates and the demand for agricultural output. Each of these forces and hence the balance among them is likely to be substantially influenced by the nature and pace of technological change in agriculture.

Once these forces are determined, whether or not the optimal transfer of resources occurs is a function of the effectiveness of the institutional arrangements for such transfers. A number of peculiarities of the agricultural sector with respect to the way income is earned, consumed, and invested may impede optimal transfers.

The next section will examine the historical evidence for various countries with respect to the size and direction of intersectoral resource transfers and the changing role of various institutional devices in facilitating these transfers.

T. H. Lee has provided unusually detailed and complete data on intersectoral resources transfers for Taiwan over a period of time that includes at least one period of relative technological stagnation in agriculture and at least two periods of highly dynamic technological development.[4] The rate of technological change in the agriculture of Taiwan during the two dynamic periods was much more rapid than during comparable periods for Japan. The rate of population growth, at over 4.6 percent for 1951-55, is one of the highest ever experienced by any nation.

India represents a contemporary low-income country which initially attempted development with a technologically stagnant agriculture but which is currently developing a technologically dynamic agriculture.[5] Comparison of India and Taiwan provides insights into sharply different policies for resource transfers from agriculture. Reference is made to limited data from Japan and Europe to illustrate conformity and contrast with the cases of India and Taiwan.

I. An Historical View of Intersectoral Resource Flows

Taiwan

There were large, continuous net transfers of resources from the agricultural sector of Taiwan throughout the period from 1895 to 1960. Table 1

Table 1 Intersectoral Flows Between the Agricultural and the Nonagricultural Sectors, Taiwan, 1895-1960

Item	1895-1900	1901-1905	1906-1910	1911-1915	1916-1920	1921-1925	1926-1930	1931-1935	1936-1940	1950-1955	1956-1960
(All figures in millions of Taiwan dollars unless otherwise stated in row heading)											
1. Total agricultural production	45	56	66	97	188	243	297	291	508	7,210	16,028
2. Total outflow of agricultural products	-	-	-	55	105	155	204	208	362	4,184	9,665
a. To nonagricultural production	-	-	-	28	56	78	106	88	164	2,013	4,926
b. To nonagricultural household	-	-	-	18	105	41	48	48	82	1,942	4,177
c. To foreign countries	-	-	-	9	20	36	51	72	117	229	562
d. Total flow at 1935-37 prices	-	-	-	92	116	152	198	259	302	298	389
3. Sales (outflow) as percent of production	-	-	-	56	56	64	69	72	71	58	60
4. Total inflow of nonagricultural products	-	-	-	31	63	105	143	146	261	3,268	8,716
a. Working capital goods	-	-	-	6	17	29	45	47	82	1,053	2,594
b. Fixed capital goods	-	-	-	*	2	8	11	8	9	107	1,196
c. Consumer goods	-	-	-	24	44	68	87	91	169	2,108	4,926
d. Total flow at 1935-37 prices	-	-	-	42	53	92	140	170	202	185	293
5. Net commodity outflow, row 2-4	-	-	-	24	42	50	61	63	102	916	948
6. Gross outflow of fund	15	20	23	29	53	68	76	76	135	1,337	2,616
a. Land rent and interest	13	17	19	22	43	52	59	56	98	532	739
b. Taxes and fees	1	3	5	6	9	15	16	17	30	712	1,453
c. Transfer of fund through financial institutions	-	-	-	*	*	1	*	3	6	94	425
7. Gross inflow of fund	*	2	2	4	10	18	15	13	33	421	1,668
a. Public investment and subsidy	*	*	*	2	1	3	4	1	2	26	71
b. Investment by nonagricultural sector in agriculture	-	-	-	*	1	3	6	3	5	12	44
c. Income received from the nonagricultural sector	*	*	1	2	8	12	5	9	26	383	1,552
8. Net outflow of fund, row 6-7	14	18	21	24	42	50	61	63	102	916	948
9. Relative agricultural prices (1935-37 = 100)	-	-	-	121	130	112	100	107	102	126	120
a. Agricultural price index (1935-37 = 100)	-	-	-	60	92	102	103	80	120	1,405	2,484
b. Nonagricultural price index (1935-37 = 100)	-	-	-	73	119	114	103	86	123	1,766	2,975
10. Visible net real capital outflow, 1935-37 price, row 5 ÷ 9a	-	-	-	41	46	49	59	78	85	65	38
11. Invisible net real capital outflow, 1935-37 price, row 4 ÷ 9b	-	-	-	9	16	11	*(-)	12	5	48	58
12. Net real capital outflow, 1935-37 price, row 10 + 11	14	18	21	50	62	60	59	89	89	113	96
13. Row 2 ÷ 9a at 1935-37 price	-	-	-	92	116	152	198	259	302	298	389
14. Row 4 ÷ 9b at 1935-37 price	-	-	-	42	53	92	140	170	212	185	293

* Under 1 million

Source: Compiled from T. H. Lee, Intersectoral Capital Flows in the Economic Development of Taiwan, 1895-1960, Cornell University Press, Ithaca, New York, 1971, p. 20.

shows the magnitude of this net outflow in Row 13. Rows 11 and 12 provide the breakdown of net flow between sectors into, respectively, visible flows facilitated by financial mechanisms and invisible flows facilitated by change in terms of trade from the base period. The various component parts of these measures are shown in the other rows.

For agriculture, the period from 1911 to the mid-1920's was one of rapid expansion in irrigation investment but was otherwise stagnant technologically. From 1911 to 1920, the net resource transfer from the agricultural sector was equal to over half the value of agricultural sales and 30 percent of the value of total agricultural production. These proportions dropped to 40 percent and 25 percent for the period 1921-25.

Compared to the period 1911-26, the rate of technological change in agriculture, measured as a residual as in the Solow model, was twice as fast for the period 1926-40 and two-and-a-half times as rapid for 1950-60.[6] The real value of the net resource outflow increased by nearly 25 percent from 1911-15 to 1916-20. It remained at about that level throughout the technologically dynamic period in the last half of the 1920's and then increased to a 50 percent higher level in the 1930's and increased by another 27 percent for the period 1950-55.

In the technologically dynamic period of the 1920's when, for example, the new Ponlai rice varieties were introduced and fertilizer use was increasing rapidly, purchases of commodities from non-agricultural sectors by the agricultural sector more than doubled. Nevertheless, the net outflow of resources from agriculture rose and maintained a high level. The value of net resource transfers as a percent of production and sales declined from the earlier period, but increased production allowed larger absolute net transfers which were concurrent with agriculture's increased use of industrially produced capital and consumer goods.

In the 1950-55 period of extraordinarily rapid population growth, economic development, and technological change in agriculture, the net real resource transfer from agriculture increased to a new high. In this period, net resource transfer recovered to nearly 40 percent of agricultural sales and over 20 percent of total agricultural production. By 1956-60, the net transfer had begun to decline slightly in real absolute terms and was equal to only 15 percent of production and 24 percent of sales of agricultural products. The decline in net resource transfers from agriculture has continued subsequent to 1960.

Just as revealing as the large net transfers from agriculture are the dramatically changing roles of various transfer mechanisms. In the post-World War II period the transfer of resources was achieved primarily by a sharp turn in the terms of trade against the agricultural sector (Table 1, Row 10) so that over 40 percent of the transfer was represented by invisible items in 1950-55. The most important mechanisms of this change were a barter exchange of rice for fertilizer and the compulsory purchase programs. In addition, technological change provided more than compensating production incentives in agriculture through greatly improved physical input-output relationships.

In the pre-World War II period fiscal measures and land rent payments were vital in the transfer. In the latter part of the pre-war period and in the post-war period outflow through financial institutions was also substantial. The importance of particular methods and institutions for financing resource flows changed substantially from time to time according to economic and political factors. The choice was not necessarily the most efficient by economic criteria alone. For example, the heavy reliance in the post-war period on what was in effect a tax on fertilizer presented to farmers one of the most unfavorable fertilizer-rice price ratios in the world.[7]

Other Developed Countries

It is generally agreed that Japan provided a major portion of the capital for early stages of its economic development by resource transfers from the agricultural sector.[8] The mechanisms of transfer differed from those mentioned above.

Direct investment by landlords in the non-agricultural sectors was relatively more important than in Taiwan. Also, Japan depended largely on land taxes while Taiwan emphasized taxes on crop output (sugar cane in the pre-war period and rice in the post-war period). During the 1920's when her agriculture was technologically relatively stagnant Japan relied on imports of rice and other agricultural commodities from the colonies to depress relative agricultural prices.[9] In post-World War II Japan, in which landlords had been largely eliminated and there were high support prices on rice and low fertilizer prices, the net flow of resources must have been channelled toward agriculture. By that time, however, the relative size of agriculture had declined sufficiently that the impact on capital formation and growth rates was less than that of compensating variables.

Scattered historical evidence for early stages of industrial growth in Great Britain suggests substantial net transfers of resources out of agriculture which were financed by rent payments to landlords, taxes, and, after repeal of the corn laws, by cheap food imports which turned the terms of trade against agriculture.[10] Economic historians suggest that the slow growth rate in the French economy during comparable periods was due in part to net transfers of resources into a low productivity agriculture, largely through favorable terms of trade for the agricultural sector.[11]

The experience of the Soviet Union is consistent with the pattern described, although the Soviet Union relied heavily on compulsory deliveries facilitated by collectives for financing resource transfers from agriculture.[12] It is likely that the Soviet Union had unusually large transfers from agriculture relative to the amount of technological change in the agricultural sector.

India

The recent experience of India, in contrast to the evidence above, illustrates the special problems of development in contemporary low-income countries. Although we do not have a single comprehensive study of India comparable to Lee's work on Taiwan, we can piece together a number of parts which suggest that there were net resource flows into the agricultural sector during the first three five-year plans (1950-1965). It is interesting to note this fact in view of the prevailing criticism that India's economic policy neglected agriculture during this period.[13]

Ved Gandhi provides an authoritative set of estimates of the direct and indirect tax burden on agriculture and government expenditures for agriculture.[14] Gandhi shows that in the period 1950-60 tax revenue attributable to agriculture was substantially less than government expenditures on agriculture, and that rural people in the same income class were taxed at substantially lower rates than their urban counterparts.[15] The discrepancy was particularly large in the upper income brackets. In Taiwan, by contrast, the tax burden on agriculturalists, in any individual income class, was heavier than on those not in agriculture.[16]

Simple lagged correlations of government expenditures on agriculture show little relation to growth in agricultural output in India, whereas in Taiwan government expenditures induced large complementary investment by farmers and increased output.[17] The effectiveness of expenditure on agricultural development depends very much on how close to optimum is its composition and the technical environment within which allocations are made. Both appear to have been unusually favorable in Taiwan and much less favorable in India, at least up to the mid-1960's.[18]

The relative prices of agricultural and non-agricultural commodities fluctuate substantially in India according to the weather. Thus it is not surprising that some observers of short periods erroneously note a change in the terms of trade against the agricultural sector.[19] For India in the period 1952-53 to 1964-65 there is no statistically significant evidence of a movement one way or the other of relative prices of food grains and non-agricultural commodities. If we compare prices of all agricultural commodities (including industrial raw material crops, fruits, vegetables, and livestock products) the terms of trade clearly moved toward the agricultural sector in this period and thus produced a significant invisible transfer of resources.[20] Extension of the period of analysis to the present would show an increase in this transfer.

Large fluctuations in relative prices arising from changes in weather make it possible to observe the effects of changing relative agricultural prices on growth of savings and investment in the non-agricultural sectors. The nature of the fluctuations, the complexity of the lag factors, and the short period of time for which data are relevant limit the usefulness of statistical analysis. It appears, however, that large crops and consequent relative decline in agricultural prices were associated with increased rates of domestic saving and investment. The converse relationship also

seemed to occur.[21] In fact, a notable example is the sharp drop in savings, investment, and industrial growth following the disastrously poor crop years and sharply rising relative agricultural prices of 1965-66 and 1966-67. Similarly, the sharp decline in relative agricultural prices from 1953-54 to 1955-56 was associated with a sharp rise in domestic savings, which peaked in 1957. Relative agricultural prices rose for the three years ending 1958-59 and domestic savings dropped sharply to a trough in 1958. Relative agricultural prices again declined from the 1958-59 peak and domestic savings again resumed their upward trend in 1959.[22]

These observations appear to indicate that the slight upward trend in relative agricultural prices over the past two decades has resulted in net resource transfers to agriculture and in slower rates of growth in the non-agricultural sectors. Without major technological change in agriculture the resources transferred to agriculture were subject to diminishing physical returns and low physical response. They provided attractive economic returns only because of relative increase in agricultural prices.

It is likely that the net flow of resources on private account in India has also been to the agricultural sector. There may have been a single permanent transfer away from agriculture after the Indian land reforms of the early 1950's. Subsequently there has not been a large wealthy land-owner class as in the early stages of development of Taiwan, Japan, or Great Britain. In addition, during the two decades up to the late 1960's there has not been an economic environment favorable to direct investment by landed classes in small-scale manufacturing. Resources have been largely directed toward large-scale industry. Savings rates in the agricultural sector have at least until recently been low, perhaps largely because of relatively unattractive investment opportunities.[23] Finally, there have been substantial remittances to the rural sector by urban wage earners, which have gone largely to consumption.[24] As will be suggested below, these relations may now be changing as a result of the new highly profitable grain varieties.

In conclusion, then, we find that in the case of India all the three mechanisms--government account, price relationships, and private account--have transferred resources to the agricultural sector. This situation differs from that in Taiwan, Japan, Great Britain, the Soviet Union, and perhaps with most successful cases of development. The successful cases of net transfer of resources from agriculture have either had a basis for repressive extraction of a surplus from agriculture through a wealthy landowner class, a strong state operating through collectives, easily taxed major agricultural exports, a technologically progressive agriculture which generated large additional surpluses, or a combination of these. For most contemporary low-income countries the route of technological change in agriculture may be the only feasible one.

II. Technological Change[25] and Intersectoral Resource Flows

It is difficult to achieve continuous net resource transfers from a technologically stagnant agriculture if those resources are invested productively in the non-agricultural sector. Growth of the non-agricultural sector increases the demand for food. Relative agricultural prices will then rise in the face of the inelastic aggregate supply characteristic of technologically stagnant agriculture. As a result, resources will be transferred back to the agricultural sector--where they will of course be subject to diminishing, and eventually to low returns. In these circumstances, the greater the increase in demand for food, the greater the increase in agricultural prices, and the greater the resource transfer to agriculture. If increased food imports prevent increases in agricultural prices, growth of the non-agricultural sector may then be halted by scarcity of foreign exchange.

It is likely that policies which provide a net flow of resources out of agriculture will have their incidence particularly on high-income rural people who have relatively inelastic demand for agricultural commodities.[26] Simon's data for Senapur, India show income elasticity of expenditure for all food of the petty landlord class at about 0.2, while it was about 0.9 for the landless labor class.[27] Thus if resource transfers from agriculture foster increased employment and income of low-income laborers, there will be a net increase in the demand for food and an upward pressure on food prices.

Increased demand for agricultural commodities incident to industrial growth may arise from increased incomes that accompany expanded employment per worker and per family and does not necessarily indicate higher real wage rates. Thus we see in Japan a long period of essentially constant real wages, while per worker, per capita, and per family real incomes rose rapidly.[28] Similarly the real agricultural wage rate in Taiwan was quite constant from 1911 to 1960 but, owing largely to increased employment per family, per capita consumption rose over 50 percent.[29]

In order to prevent increased industrial investment from increasing the demand for food and thereby raising relative agricultural prices and transferring resources back to agriculture, either the increase in employment must be relatively small or the real wage rate must be reduced sufficiently to balance the aggregate income effect of increased employment. Both are difficult to accomplish and both have unfavorable implications for income distribution.

In contrast to the situation of a stagnant agriculture, continuous technological change in agriculture permits some expansion in demand for agricultural production to be met without higher relative agricultural prices. In these circumstances net transfers of resources from agriculture which

cause expansion of employment in the non-agricultural sectors are not fully reversed by changes in the terms of trade toward the agricultural sector. In practice, technological change in agriculture also increases the elasticity of aggregate supply by increasing the relative importance of more demand-responsive inputs such as chemical fertilizers.

Technological change in agriculture directly accelerates growth in real national income. It is also likely to influence relative prices so as to encourage industrial development. Because, however, such technological change normally induces increased use of inputs from the non-agricultural sector it may not induce increased net resource transfers to that sector. What actually happens will depend on (a) the capital-output ratios associated with the technological change, and (b) the changes in consumption in the agricultural sector resulting from the technological change.

Significantly higher returns to investment associated with new agricultural technologies, may shift the savings function and reduce consumption. Thus, an increase in the flow of production goods to agriculture may be balanced by a decrease in the flow of consumption goods. Alternatively, an incremental capital-output ratio less than one will allow immediate concurrent increases in agricultural production and increased resource transfers from agriculture. More generally the lower the incremental capital-output ratio associated with technological change the sooner net resource transfers may resume. Reduction of the rate of technological change will also shorten the period of accelerated net resource transfers--although at the cost of lower rates of growth.

The Effect of High-Yield Crop Varieties

In the case of Taiwan, the net outflow of resources increased during the two periods of most rapid technological change--1920-35 and 1950-60. The rate of technological change apparently did not slacken during these periods and the level of per capita consumption in agriculture increased. The incremental capital-output ratio, as defined in this paper, was apparently less than one. The process was accompanied by high incremental savings rates within the agricultural sector.[30] The technological change in agriculture which produced these results was embodied in the introduction of improved seed, chemical fertilizer, and pesticides; land improvements made by agricultural labor; and improved, labor-using cultural practices. The increased labor used on farms was drawn from within the agricultural sector. Most of the resources drawn from other sectors were for items of working capital. If we assume, conservatively, that this capital turned over in one year and provided a rate of return of 25 percent, the capital-output ratio would have been 0.8.[31] If we assume a faster turnover and alternative opportunities for the financial resources during the rest of the year, or a higher rate of return, the capital-output ratio would have been even lower.

Ohkawa's evidence shows that in Japan capital-output ratios for agriculture declined sharply from 1885 to 1919 and ramained low until after World War II.[32] Using a capital measure which excluded residential buildings, but which still included resources from within the agricultural sector, his data showed the capital-output ratio near 1.0 for the total period 1885 through World War II.

These relationships are consistent with current micro data for new high yield crop varieties in India. In areas where they are well adapted the increase in gross value of output of dwarf wheat and rice varieties is typically four times as great as the increase in cost of inputs purchased from the non-agricultural sectors.[33] Preliminary studies in India also show that farmer's behavior with regard to savings is similar to that noted in Taiwan under similar circumstances. That is, a very high proportion of the increments to income from new technology are saved. The high incremental savings rates presumably reflect much higher returns to investment when new technology is applied.

The Irrigation Problem

Particularly in the tropics and in rice areas generally, water supplies must be well controlled if high yield crop varieties are to be grown successfully. Because irrigation may require large investment, the capital-output ratios may be greater than one. It is here that conflict develops between increasing net resource flows from agriculture and growth of agricultural production. This need not be the case if irrigation is provided largely by an agricultural labor input.

In the case of Taiwan, large investment in irrigation occurred prior to the period of rapid technological change in agriculture. Thus, by 1925, 60 percent of the cropped acreage was irrigated in Taiwan so that capital-output ratios during the period of technological change were very low. Of course, the returns to irrigation investment were low prior to the period of technological change in Taiwan.[34] But when new crop technologies emerged in the 1920's the availability of irrigated area made their application relatively easy, cheap, and quickly productive. Investment in the irrigation system prior to the 1920's was financed by savings in the agricultural sector or revenues otherwise raised in that sector. Net transfer of resources from agriculture then increased when technological change was imposed on the already expanded irrigated acreage.

In contrast, in 1965, only 20 percent of the cropped acreage in India was irrigated. Because of the lack of investment in irrigation prior to the period of rapid technological change in agriculture, India should have been able to provide a greater net outflow of resources than Taiwan in its comparable periods. On the contrary, however, high rates of savings in the non-agricultural sector and net flows of capital from abroad permitted a relatively rapid rate of growth in the non-agricultural sector, which turned the terms of trade toward the agricultural sector and added to the net inflow of resources to agriculture.

The increase in returns to irrigation from new high yield varieties of crops may encourage the allocation of increased funds for irrigation development in India and Pakistan. The capital-output ratios for minor irrigation schemes such as tube wells plus the improved technology may in practice be very low. A recent calculation for Aligarh District, India, showed this ratio to be 1.5:1.[35] Similar results have been noted for central India.[36] Investments in such small-scale irrigation schemes have been largely self-financed by the farmer.[37] Although it is not clear precisely what transfers of assets occurred, it is likely that some reduction of consumption or sale of assets from the agricultural sector provided the financing. This may have avoided the net flow of resources into agriculture otherwise required for the irrigation investment.

Large-scale irrigation schemes not only have higher capital-output ratios but may require much more financing from outside the agricultural sector. The extent of investment in large-scale irrigation depends on comparative rates of return. The optimal investment pattern may call for a net resource flow to agriculture, at least temporarily. In this case, of course, the rate of growth of the non-agricultural sectors and the overall rate of growth will be slower compared to a situation of lower capital-output ratios for technological change in agriculture.

III. Implications of Technological Change to the Means of Resource Transfer

Characteristics of technological change in agriculture suggest some specific means of resource transfer. For example, yield increasing technological change, at least initially, raises dramatically the returns to land, thereby further strengthening the economic case for land taxes. Unfortunately land taxes appear particularly unpalatable politically.

Relative agricultural prices tend to decline as yield increases thereby transferring resources to other sectors. Such price declines may not discourage agricultural production due to the cost reductions accompanying new technology and due to the shape of response curves.[38] Government policy may usefully, (1) facilitate orderly price declines, and (2) help translate the decline in agricultural prices into accelerated growth in industrial investment and employment.

Yield increasing technological change in agriculture is usually accompanied by increased use of purchased inputs, and greatly increases the returns to them. Under these circumstances, it is essential that input supplies be increased rapidly as the demand curves shift. Clearly, the worst possible policy, but one too often followed, is a subsidized price for inputs and inadequate supply. Technological change in agriculture offers potential for large net transfers of resources out of agriculture not because its added input requirements are small--they are in fact very large--but because the rate of return on those inputs is very high.

A tax on variable inputs complementary to technological change, such as on fertilizer, is inefficient on narrow economic grounds as it reduces input use and causes a lower than optimal level of output. Yet, Taiwan used such a tax as a major means of drawing revenue from the agricultural sector. Similarly, a tax on fertilizer was instituted in India following introduction of high yield crop varieties.

In the context of rapid technological change in agriculture a tax on fertilizer is not as inefficient as at first might appear and has some features to recommend it. First, its incidence is somewhat in proportion to the benefits from research and other aspects of technological change with which fertilizer is so closely associated. Second, there is evidence that fertilizer response functions are essentially linear until they reach their maximum.[39] Thus, for a wide range of price relationships the optimal quantity of fertilizer to use appears quite inelastic with respect to price. In early stages of adoption, diffusion of fertilizer use may be accelerated by highly favorable price relationships. This factor, however, diminishes in importance with time.

Both a land tax or a relative decline in agricultural output prices are to be preferred to a tax on an input such as fertilizer.[40] A tax on fertilizer is preferred to loss of investment opportunities which offer high rates of return. It is the political difficulty of effecting economically preferable mechanisms for resource transfer that compels taxes on variable inputs. Fortunately, in a context of technological change such devices may not be markedly inefficient.

IV. Conclusion

Both in concept and in practice it is possible for the agricultural sector to make large net transfers of resources to other sectors. If these transferred resources are used productively the rate of economic growth can be accelerated.

Net resource transfers are possible from a technologically stagnant agriculture. But such transfers are difficult to achieve without either an economically and politically powerful landlord class strongly motivated to invest in the domestic non-agricultural sectors, a powerful unitary government, or major export crops.[41] The first two conditions rarely exist in contemporary low-income countries. Low-income countries with major export crops are among the few that tax agriculture heavily.

In many areas the current technological breakthroughs in agriculture offer large increases in output at incremental capital-output ratios of less than one. This facilitates immediate and greatly accelerated net resource transfers. Even if large investment in irrigation is a necessary complement to technological change, increased net resource outflows may occur shortly after rapid technological change in agriculture begins. A wide range of devices may be used to facilitate such resource transfers, including taxes of many types, lower relative agricultural

prices, and direct investment outside of agriculture by wealthy agriculturalists. The change in the structure of demand accompanying the increased agricultural output may well enhance these opportunities.[42]

If a low-income country is to grasp the type of opportunity so well exploited by Japan and Taiwan it must develop the infrastructure of research and related institutions for developing, adapting, and applying suitable high-yield crop varieties. It then must ensure the ready availability of a large quantity of complementary inputs such as fertilizer. A highly elastic supply of inputs complementary to technological change is crucial to the process. The economic incentive for using additional inputs in agriculture is provided by technological change itself, which increases output per unit of input. Under these circumstances, a wide range of devices is available for transferring resources from agriculture. There remain complex political problems of choosing a combination of these devices acceptable in the complex political and institutional framework of a modernizing agriculture.

Footnotes

*The data for this paper is drawn from a series of studies conducted under my direction at Cornell University as part of an AID financed study of agricultural prices as they affect intersectoral resource flows. I am most indebted to T. H. Lee for the intersectoral study of Taiwan which I have used extensively in this paper. In addition, I have made substantial use of the work of Uma J. Lele, G. M. Desai, Ashok Dar, U.S. Bawa and Sheldon Simon. I am particularly grateful to Uma J. Lele for suggesting major improvements in this paper.

[1]This argument is developed in Maurice Dobb, "Some Reflections on the Theory of Investment Planning and Economic Growth," in Problems of Economic Dynamics and Planning, Essays in Honour of Michal Kalecki, (Warsaw: 1964), pp. 107-118; and in A. K. Sen, "An Essay on Economic Growth and Planning," Quarterly Journal of Economics, (Nov. 1957). It receives support from the argument that rapid growth in agricultural production requires massive inflow of resources for water and irrigation, e.g., Vernon W. Ruttan, "Considerations in the Design of a Strategy for Increasing Rice Production in Southeast Asia," (a paper presented at the Pacific Science Congress Session on Modernization of Rural Areas, Tokyo: August 27, 1966); and, T. W. Schultz, Economic Crises in World Agriculture, (Ann Arbor, Michigan: 1967). The argument that agricultural development requires improved price incentives which implicitly involves increased net inflow of resources through the change in terms of trade also supports this position, e.g., Edward Mason, "Economic Development in India and Pakistan," (Occasional Papers in International Affairs 13, Harvard University, Cambridge, Mass.: 1966); and, T. W. Schultz, Economic Crises in World Agriculture, (Ann Arbor, Michigan: 1967).

[2]For a review of this argument, see Wyn F. Owen, "The Double Development Squeeze on Agriculture," American Economic Review, vol. 56, no. 1, (March 1966), pp. 43-70. See also Bruce F. Johnston and John W. Mellor, "The Role of Agriculture in Economic Development," American Economic Review, vol. 51, no. 4, (Sept. 1961), pp. 566-593.

[3]Throughout this discussion of intersectoral resource flows the term "capital-output ratio" refers to the ratio of only that portion of capital represented by a flow of resources to agriculture from other sectors of the economy to increments of total agricultural output. Thus, a capital-output ratio defined in this manner may be low because a substantial portion of the capital more broadly defined arises from direct transformation of unemployed rural labor.

[4]T. H. Lee, Intersectoral Capital Flows in the Economic Development of Taiwan, 1895-1960, (Ithaca, N.Y.: Cornell University Press, 1971).

[5]John W. Mellor, Thomas F. Weaver, Uma J. Lele, and Sheldon R. Simon, Developing Rural India, (Ithaca, N.Y.: Cornell University Press, 1968).

[6]T. H. Lee, Intersectoral Capital Flows in the Economic Development of Taiwan, 1895-1960, (Ithaca, N.Y.: Cornell University Press, 1971).

[7]For comparisons with India and a number of other countries see John W. Mellor, Thomas F. Weaver, Uma J. Lele, and Sheldon R. Simon, Developing Rural India, (Ithaca, N.Y.: Cornell University Press, 1968).

[8]See for example, Bruce F. Johnston, "Agricultural Productivity and Economic Development in Japan," Journal of Political Economics, (Dec. 1951), pp. 498-513; Bruce F. Johnston, "Agricultural Development and Economic Transformation: A Comparative Study of the Japanese Experience," Food Research Institute Studies, vol. 3, (Nov. 1962), pp. 223-76; and Kazushi Ohkawa and Henry Rosovsky, "The Role of Agriculture in Modern Japanese Economic Development," Economic Development and Cultural Change, vol. 9, (Oct. 1960), pp. 43-67.

[9]Kazushi Ohkawa, "Concurrent Growth of Agriculture with Industry: A Study of the Japanese Case," in International Explorations of Agricultural Economics, ed., Roger N. Dixey, (Ames, Iowa: 1964); and Kazushi Ohkawa, Bruce F. Johnston, and Hiromitsu Kaneda, eds., Agriculture and Economic Growth: Japan's Experience, (Tokyo, Japan: 1969).

[10]T. S. Ashton, The Industrial Revolution, 1760-1830, (London: 1962); J. D. Chambers and G. E. Mingay, The Agricultural Revolution, 1750-1880, (London: 1966); and Phyllis Deane, The First Industrial Revolution, (England: 1965).

[11]See for example, Uma J. Lele, "Agricultural Resource Transfers and Agricultural Development: A Brief Review of Experience in Japan, England, and France," (Occasional Paper 33, Department of Agricultural Economics, Cornell University-USAID Prices Research Project, June 1970); Rondo E. Cameron, "Economic Growth and Stagnation in France, 1815-1914," in The Experience of Economic Growth: Case Studies in Economic History, ed., Barry E. Supple, (New York: 1963); J. M. Clapham, Economic Development of France and Germany, 1815-1914, (England: 1921); M. J. Habakkuk, "Historical Experience in Economic Development," in The Problems of Economic Development, ed. E. A. G. Robinson, (London: 1965).

[12]Alexander Erlich, "Preobrazhenski and the Economics of Soviet Industrialization," The Quarterly Journal of Economics, vol. 64, (1950), pp. 57-88.

[13]This position is forcefully argued in Edward Mason, "Economic Development in India and Pakistan," (Occasional Papers in International Affairs 13, Harvard University, Cambridge, Mass.: 1966); see also T. W. Schultz,

Economic Crises in World Agriculture, (Ann Arbor, Michigan: 1967). A contrary view is presented in M. L. Dantwala, "Incentives and Disincentives in Indian Agriculture," Indian Journal of Agricultural Economics, (April-June, 1967), pp. 1-25; and John W. Mellor and Ashok K. Dar, "Determinants and Development Implications of Foodgrains Prices in India, 1949-1964," American Journal of Agricultural Economics, vol. 50, (Nov. 1968), pp. 962-974. For a more complex argument on this point see Uma J. Lele, "Agricultural Price Policy," Economic and Political Weekly, vol. 4, (Aug. 30, 1969), pp. 1413-1420; and Uma J. Lele, Foodgrain Marketing in India, Private Performance and Public Policy, (Ithaca, N.Y.: Cornell University Press, 1971).

[14]Ved P. Gandhi, Tax Burden on Indian Agriculture, Harvard Law School International Tax Program, (Cambridge, Mass.: 1966).

[15]Note that for the period 1950-51 to 1964-65 taxes on the agricultural sector as a percent of income rose from 3.6 to 5.6 percent while they rose from 8.8 to 18.3 percent for the non-agricultural sectors. The ratio of additional taxes to additional income was 7.5 percent for agriculture and 44 percent for other sectors. See Ujagar S. Bawa, "The Relationship Between Agricultural Production and Industrial Capital Formation in India, 1951-52 to 1964-65," (Occasional Paper 25, Department of Agricultural Economics, Cornell University-USAID Prices Research Project, August 1969).

[16]T. H. Lee, Intersectoral Capital Flows in the Economic Development of Taiwan, 1895-1960, (Ithaca, N.Y.: Cornell University Press, 1971).

[17]For the detailed data for India and Taiwan, see respectively, Ujagar S. Bawa, "The Relationship Between Agricultural Production and Industrial Capital Formation in India, 1951-52 to 1964-65," (Occasional Paper 25, Department of Agricultural Economics, Cornell University-USAID Prices Research Project, Aug. 1969); and, T. H. Lee, Intersectoral Capital Flows in the Economic Development of Taiwan, 1895-1960, (Ithaca, N.Y.: Cornell University Press, 1971).

[18]For Taiwan and India, respectively, see T. H. Lee, Intersectoral Capital Flows in the Economic Development of Taiwan, 1895-1960, (Ithaca, N.Y.: Cornell University Press, 1971); and John W. Mellor, Thomas F. Weaver, Uma J. Lele, and Sheldon R. Simon, Developing Rural India, (Ithaca, N.Y.: Cornell University Press, 1968).

[19]V. M. Dandekar, "Agricultural Price Policy," Economic and Political Weekly, vol. 3, no. 11, (March 16, 1968), pp. 454-459; Edward Mason, "Economic Development in India and Pakistan," (Occasional Papers in International Affairs 13, Harvard University, Cambridge, Mass.: 1966); and T. W. Schultz, Economic Crises in World Agriculture, (Ann Arbor, Michigan: 1967).

[20]On the basis of a nonparametric test for the period 1958-1964, at the 15 percent level of significance, terms of trade between agriculture and industry turned toward agriculture. By the same test, the terms of trade between foodgrains and industry only fluctuated, with no discernable trend. The linear trend for all agricultural prices relative to industrial prices is positive, while there is no discernable trend for the ratio of foodgrain prices to industrial prices. Agricultural raw materials, including fibers and oil seeds, have a weight nearly half as large as foodgrains in the consumer price index. Raw materials comprise over 50 percent of the cost structure of the agricultural processing industries, which in this period provided over 50 percent of the value added in all industry in India. A too-literal view of wages goods as food alone should not divert attention from these important parts of the agricultural sector. See John W. Mellor and Uma J. Lele, "Alternative Estimates of the Trend in Indian Foodgrains Production During the First Two Plans," Economic Development and Cultural Change, vol. XIII, no. 2, (Jan. 1965); and Ashok K. Dar, Domestic Terms of Trade and Economic Development of India, 1952-53 to 1964-65, (Cornell International Agricultural Development Bulletin 12, Ithaca, N.Y.: 1968).

[21]See Ujagar S. Bawa, "The Relationship Between Agricultural Production and Industrial Capital Formation in India, 1951-52 to 1964-65," (Occasional Paper 25, Department of Agricultural Economics, Cornell University-USAID Prices Research Project, 1969).

[22]Ujagar S. Bawa, "The Relationship Between Agricultural Production and Industrial Capital Formation in India, 1951-52 to 1964-65," (Occasional Paper 25, Department of Agricultural Economics, Cornell University-USAID Prices Research Project, 1969).

[23]For example see data for India in John W. Mellor, Thomas F. Weaver, Uma J. Lele, and Sheldon R. Simon, Developing Rural India, (Ithaca, N.Y.: Cornell University Press, 1968).

[24]For example, in the period 1954-64 in the village of Senapur, which has a long history of movement to urban employment, per capita agricultural incomes held about constant, while per capita income from non-agricultural sources rose 133 percent to comprise over 40 percent of total per capita income. During this period of technologically stagnant agriculture, increases in savings were small and were used primarily for education. See John W. Mellor, Thomas F. Weaver, Uma J. Lele, and Sheldon R. Simon, Developing Rural India, (Ithaca, N.Y.: Cornell University Press, 1968).

[25]Technological change as used here refers to shifts in the production function at a given level of inputs. The prime example in agriculture is high yielding seed varieties which increase the value of gross output per unit of land and labor. There is of course in practice a large increase in use of certain inputs, such as fertilizer, and a consequent further increase in output.

[26]This is particularly true in the case of transfers accomplished by relative decline in agricultural prices. The incidence on incomes of change in agricultural prices is proportional to sales of agricultural commodities which are normally highly elastic with respect to farm income. See John W. Mellor, "The Functions of Agricultural Prices in Economic Development," The Indian Journal of Agricultural Economics, vol. 23, (Jan.-March, 1968).

[27]John W. Mellor, Thomas F. Weaver, Uma J. Lele, and Sheldon R. Simon, Developing Rural India, (Ithaca, N.Y.: Cornell University Press, 1968).

[28]Kazushi Ohkawa, Bruce F. Johnston, and Hiromitsu Kaneda, eds., Agriculture and Economic Growth: Japan's Expereince, (Tokyo, Japan: 1969).

[29]T. H. Lee, Intersectoral Capital Flows in the Economic Development of Taiwan, 1895-1960, (Ithaca, N.Y.: Cornell University Press, 1971).

[30]From 1911 to 1925 per capita farm household real income rose 48 percent, consumption 38 percent, and savings more than tripled with 25 percent of the increment in income for the period being saved; from 1911 to 1955 income rose 85 percent, consumption 43 percent, and savings over nine times with nearly half of the increment in income for the period being saved. See T. H. Lee, Intersectoral Capital Flows in the Economic Development of Taiwan, 1895-1960, (Ithaca, N.Y.: Cornell University Press, 1971).

[31]The capital-output ratios are of course very high in production of chemical fertilizers. Presumably such products would be imported except where extreme import displacement models are applied, where special circumstances with respect to capital availability prevail, or where non-economic considerations receive substantial consideration.

[32]Kazushi Ohkawa, Bruce F. Johnston, and Hiromitsu Kaneda, eds., Agriculture and Economic Growth: Japan's Expereince, (Tokyo, Japan: 1969).

[33]T. V. Moorti, "A Comparative Study of Well Irrigation in Aligarh District, India," (Occasional Paper 29, Department of Agricultural Economics, Cornell University-USAID Prices Research Project, March 1970); Vishnoo P. Shukla, "An Economic Analysis of Farm Resource Use, Jabalpur District, Madhya Pradesh, India, 1967-68," (Occasional Paper 26, Department of Agricultural Economics, Cornell University-USAID Prices Research Project, Oct. 1970).

[34]T. H. Lee, Intersectoral Capital Flows in the Economic Development of Taiwan, 1895-1960, (Ithaca, N.Y.: Cornell University Press, 1971).

[35]T. V. Moorti, "A Comparative Study of Well Irrigation in Aligarh District, India," (Occasional Paper 29, Department of Agricultural Economics, Cornell University-USAID Prices Research Project, March 1970).

[36]Vishnoo P. Shukla, "An Economic Analysis of Farm Resource Use, Jabalpur District, Madhya Pradesh, India, 1967-68," (Occasional Paper 26, Department of Agricultural Economics, Cornell University-USAID Prices Research Project, Oct. 1970).

[37]T. V. Moorti, "A Comparative Study of Well Irrigation in Aligarh District, India," (Occasional Paper 29, Department of Agricultural Economics, Cornell University-USAID Prices Research Project, March 1970).

[38]For detailed analysis of this see, Gunvant M. Desai, "Growth of Fertilizer Use in Indian Agriculture -- Past Trends and Future Demand," (Cornell International Agricultural Development Bulletin 18, 1969).

[39]Gunvant M. Desai, "Growth of Fertilizer Use in Indian Agriculture -- Past Trends and Future Demand," (Cornell International Agricultural Development Bulletin 18, 1969).

[40]Gunvant M. Desai, "Growth of Fertilizer Use in Indian Agriculture -- Past Trends and Future Demand," (Cornell International Agricultural Development Bulletin 18, 1969).

[41]For these views presented as part of a larger mathematical framework see, John W. Mellor and Uma J. Lele, "A Labor Supply Theory of Economic Development," (Occasional Paper 43, Department of Agricultural Economics, Cornell University-USAID Prices Research Project, June 1971); similar views are presented in a political framework in Uma J. Lele and John W. Mellor, "Jobs, Poverty, and the Green Revolution," International Affairs, (Jan. 1972).

[42]For a full explanation of this view see, John W. Mellor and Uma J. Lele, "Domestic Markets and the Growth of Farm Cash Income," (Paper presented at the Stanford University Conference on Agricultural Strategies for the 1970s: Their Design and Implementation, December 13-18, 1971).