# Agricultural Growth and World Developments

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## INTRODUCTION

To deal with the determinants of agricultural growth within the framework of world development subject to a budget constraint of 12 pages (albeit single space) is like organizing a twelve day world tour. Hopefully, aside from recovering from the flights, we will have an opportunity to appreciate some of the main monuments. Much of the landscape was visited by others before. A list of all visitors will leave no space for discussion. Is it thus prudent to use our own guide book to the subject and advise the reader to place his or her collected impressions in an appropriate perspective.

It is useful to set up a point of departure. Ignoring some technical details, neoclassical growth theory, as formulated by Solow, tell us that an economy producing an aggregate output with labour and capital using a constant returns to scale concave production function with constant technology converges to a dynamic equilibrium where output and capital grow at the same rate as population. This implies constant output per caput or simply stagnation. Thus, the key to growth is a change of technology.

In what follows we distinguish between available technology and implemented technology. At the cost of some oversimplification, it is asserted that the available technology constitutes a major constraint to the developed economies, whereas developing countries are unable to fully utilize the available technology because of existing constraints of which the most important are capital and not fully adjusted factor markets. The latter is particularly important in the discussion of agriculture–non agriculture growth. Developing economies can grow without a change in the available technology through intersectoral factor mobility and capital accumulation. This can produce considerable growth in the intermediate term, which is the relevant time horizon for our discussion.

The foregoing comment emphasizes the supply side. In neoclassical aggregate growth, the demand side plays only a secondary role, since behaviour affects only the *level* of income and not its *rate of growth*. When dealing with a sectoral economy, the demand plays an important role in that it constitutes a constraint to agricultural growth. It is very clear that the growth of output cannot exceed the growth of demand. This is the first point of our tour to which we now turn.

## DEMAND CONSTRAINT

Changes in supply which are unmatched by changes in demand cause variations in price. Hence, a compact and efficient way to start the discussion of world agricultural growth is to observe the long-term trends in agricultural prices. Table 1 presents data on the average annual percentage change in the prices of some primary agricultural products deflated by US wholesale prices. Two things immediately emerge. First, a deterioration at an average annual rate of 0.5–0.7 per cent in the relative prices of agriculture. This implies a deterioration by a factor of one half over the period 1900–83. Second, the degree of fit of the trend regressions, as measured by $R^2$, is relatively low. This reflects wide annual variations in supply and demand conditions over this period covering two world wars, energy crises and other shocks. As such, the trend is a poor predictor for *short-term* price variations. Yet, considering the length of the period, these numbers are suggestive as to the long-term trend.

Over this period world population increased by a factor of 3, from 1.6 in 1900 to nearly 5 billions in 1984.[2] Add to this the increase in income per caput and we obtain an increase in food demand by a factor of 4 or more. The decline in world prices indicates that production increased more than demand. Since the supply function is positively sloped, it is clear, as it is well known, that there were some big changes in supply that made it profitable to expand production in spite of the decline in the relative price. Taking such a long-term view, changes in supply make it possible to identify empirically the demand function. That is, the deterioration in prices implies that the growth in supply could only be absorbed at some price decline. In turn, the decline in price had a depressing effect on the growth of output. This implies that the demand has acted as one of the determinants of the agricultural growth.

TABLE 1: *Time trend of agricultural prices deflated by US wholesale prices 1900–83*

| | Coefficient (per cent per annum) | | $R^2$ |
|---|---|---|---|
| Sugar | -0.7 | (3.7) | 0.14 |
| Wheat | -0.7 | (7.2) | 0.39 |
| Maize | -0.6 | (6.1) | 0.31 |
| Rice | -0.6 | (5.5) | 0.27 |
| Cotton | -0.5 | (5.4) | 0.26 |
| Wool | -0.1 | (8.9) | 0.49 |

*Note:* The coefficients are obtained from the semilogarithmic regression: $\ln P_t = a+bt$. The slope, b, representing the rate of growth, is multiplied by 100 to be expressed in per cent. The numbers in parentheses are the ratios of the coefficients to their standard errors (t-ratios).

*Source:* Binswanger *et al.* (1985).

TABLE 2: *Rates of growth (per cent per annum), 1965–84*

| | GPD (1) | Agri. Output (2) | Population (3) | Per caput GDP (4) | Per caput Agri. (5) | Agriculture GDP (6) |
|---|---|---|---|---|---|---|
| *Low Income* | 5.5 | 3.3 | 2.3 | 3.15 | 1.0 | 0.32 |
| China & India | 6.0 | 3.55 | 2.15 | 3.80 | 1.4 | 0.36 |
| Others | 3.6 | 2.45 | 2.65 | 0.95 | –0.2 | 0.00 |
| *Middle Income* | 5.9 | 3.15 | 2.45 | 3.45 | 0.7 | 0.20 |
| Oil exporting | 6.2 | 3.20 | 2.65 | 3.55 | 0.55 | 0.15 |
| Oil importing | 5.7 | 3.05 | 2.30 | 3.40 | 0.75 | 0.22 |
| Lower Middle | 5.5 | 3.00 | 2.50 | 3.00 | 0.5 | 0.17 |
| Upper Middle | 6.1 | 3.25 | 2.35 | 3.75 | 1.9 | 0.24 |
| *Industrial Markets* | 3.6 | 1.45 | 0.85 | 2.70 | 0.6 | 0.22 |
| *World* | 4.9 | 1.80 | 1.16 | 2.83 | 0.63 | 0.22 |

*Notes*: Last line is a weighted average for the world. The weighs are the shares of the three groups in GDP in 1984. These values in billions of dollars and the weights, in parentheses, are: Low income economies, 621 (0.058), Middle income economies, 1485 (0.142) and Industrial Market economies (0.80)

*Source*: Columns (1) – (3) are taken from the *World Development Report 1986*. The source report date for the subperiods 1965-73 and 1973-84. These were averaged in Table 2. Column (4) = (1) less (3), Column (5) = (2) less (3), Column (6) = entries in (5) divided by respective entries in (4).

The effect of demand on growth is related to Engel's law the empirical validity of which is well established (Cf. Houthakker, 1957). Consequently, for prices to remain constant, agricultural output per caput should grow at a slower rate than that of total output. Table 2 summarizes pertinent information on rates of growth for the period 1965–84 provided in the World Development Report 1986. The data are reported by low income economies (LIE), middle income economies (MIE) and industrial market economies (IME). It is seen that agricultural output per caput grew at a much smaller rate than GDP. This is also the case for subgroups of the LIE and MIE. Aggregating over the three subgroups, with GDP weights it is obtained that the ratio of the two rates of growth for the world is approximately 0.22. This value is so small, that total growth (rather than growth per caput) in agriculture was only 0.47 of total growth in GDP for the world. This ratio of 0.22 is not quite an implicit income elasticity for a variety of obvious reasons. Still, to make all the necessary refinements would not change the picture that faster growth in agriculture is concomitant with a faster growth in non agriculture. This is simply the reflection of consumers preference and nothing else.

## THE RELEVANCE OF WORLD PRICES

A question often asked is What is the relevance of world prices for domestic prices? After all, the domestic prices of a traded commodity reflect government interventions through tariffs, taxes, subsidies, or in brief, commercial policy. In addition, variations in the nominal exchange rates affect domestic prices without corresponding changes in world prices. This is a legitimate question and I know of no way of answering it except by consulting the data.

The point of departure for the empirical analysis is the law of one price, relating the domestic price (P) to world price (P*), $P \equiv P^*TE$, where $T=(1+\theta)$ represents the commercial policy and E is the nominal exchange rate. Obviously, as a matter of definition, varying T and E will cause variations in P, for any given level of P*. This implies intercountry variations in P. However, the question raised above is somewhat different. Do changes in P* generate changes in P? Obviously, if changes in P* do not generate changes in T and E, then it is expected that P will vary proportionally to P*. Thus, our attention is shifted to relative changes in prices. Using lower case letters for logarithms, the identity is $p \equiv p^* + e + t$. To the extent that t and e are independent of world prices, a regression of p on p* would have a coefficient of 1. On the other hand, if countries follow a policy of completely isolating the domestic prices from world prices, a strong negative correlation between p* and t will drive the coefficient toward zero. In a recent study such regressions were obtained for 58 countries for the period 1968–78.[3] For each country, the observations were annual prices of individual commodities. The number of commodities varied around 50. The regression coefficients varied between 0.72 and 1.21 with a median value of 0.945. This result indicates very clearly that domestic prices vary with world prices and, as such, world prices are indeed relevant.

The relationship between a domestic and a world price is more immediate, and more obvious, when the product is actually traded. However, the relation is expected to exist also for products which are not traded. In principle, all agricultural products are tradables, and if they are not traded, it is because the domestic price lies in the interval formed by export and import prices of the given product, where the width of the interval reflects the cost of transportation, broadly interpreted. Variations in world prices may convert a product not traded to be traded, or vice versa.

On the other hand, the effect of the price of the traded products on those of a non traded product is indirect, through the factor prices. An increase in the price of cereals increases the prices of inputs in agriculture, and particularly the price of specific inputs such as land quality. The empirical relationships may therefore be somewhat more intricate than those suggested by Samuelson's factor price equalization. This however does not alter in a substantive way the basic underlying premise that the prices of the main primary products do affect the prices of the remaining products.

This is the mechanism through which the world market affects the individual economies. Thus, even though agriculture produces a traded product, to understand the *long-term* developments, it is useful to refer to the world as a unit of analysis, and for this purpose the relevant framework is that of a closed economy.

## INTERSECTORAL ALLOCATION OF INPUTS

### *Introduction*

The foregoing evidence indicates a considerable growth of agriculture in spite of a decline in its relative price. This immediately raises the question of how relevant, if at all, are prices in affecting growth. This is not a trivial question, neither from the point of view of the analysis (theory and measurement) nor for its implication for drawing policy conclusions. More importantly, it is related to a major link between the country and world economies. The echo that local events (such as development for a new productive variety, drought, energy crises) generate around the world, is reflected in world prices. The effect of such developments depends on the degree of transmission of world prices to the countries and on the supply response.

It is much easier to analyse supply response with respect to agricultural growth (or more generally sectoral growth) than with respect to overall growth. It is only natural to do the easy things first and therefore we will turn our attention to agriculture, thereby also building a base for reflecting on overall growth. Prices affect sectoral growth by affecting intersectoral resource allocation, overall employment and technology. Overall employment will be largely neglected here.

### *Labour*

It is well known that the share of agriculture in the total labour force declines along the growth path. As a reminder of orders of magnitude, the percentage averages for the period 1968–78 were 2.5 for the UK, 3.1 for the US, 72.5 for India and 88.2 for Malawi. To get a time dimension, the farm labour force in the US was 9 .1 million in 1939, constituting 20.3 per cent of the total labour force. It was 3.2 million in 1987, constituting 2.8 per cent of the total labour force. Simple arithmetic will tell us that the rate of decline in the share of agriculture in the labour force is equal to the off-farm migration as a proportion of the agricultural labour force. The mean off-farm migration rate for the US in the period 1939–87 was 3 per cent.

The choice of occupation is a decision made by the individual in which he takes into account the income differences of the various alternatives. This is where the profitability of agriculture comes in. Other things being equal, the lower the price of the agricultural product, the larger is the income differential between agriculture and non agriculture.

To be more precise and closer to reality, it is clear that other elements enter in the decision on occupational choice such as the cost of changing occupation (cost of migration), the prices of consumption goods, the stability of income and alike. Let the vectors of such determinants be denoted as a and n for agriculture and non agriculture respectively. Denote the indirect utilities for this individual by V(a) and V(n) for agricultural and non agricultural occupations respectively. The choice can then be described by the function $h_i(a,n)$ defined as:

$$\left[V_i(n) - V_i(a)\right] h_i(a,n) \geq 0$$

$$\begin{matrix} + & & 1 \\ -,0 & & \end{matrix}$$

Thus, $h_i(a,n)$ takes on a value of 1 when the indirect utility in non agriculture exceeds that in agriculture and zero otherwise. Consequently, the rate of off-farm migration is negatively related to the relative price of agriculture. Summing $h_i(a,n)$ over all individuals and dividing by the agricultural labour force gives the migration rate as a function of the intersectoral income differential, as well as other variables.

This approach was formulated for an empirical analysis of off-farm migration and was applied to cross country data as well as to time series for Argentina, Chile, Japan and USA.[4] In all these studies, the intersectoral income differential has a positive effect on the migration rate.

The agricultural labour force in any year can be written as $L_a(t) = L_a(t-1)$ $(1+g-m)$ where g is the rate of natural growth in the labour force and m is the migration rate. Since m is a function of the expected intersectoral income differential as evaluated at time (t-1), it is clear that the agricultural labour force in any year t depends, among other things, on the *history* of the expected intersectoral income differentials. Under this formulation, a more favourable history of terms of trade for agriculture would result in a larger agricultural labour force.

When labour moves from low to higher wage occupation, it has a positive effect on total output. In this sense, the long-term reduction of the farm labour force has contributed to growth. However, note that this is so only if labour finds employment in non agriculture and this is not always the case. As is well known, off-farm migration takes place even when unemployment exists in non agriculture. This, as explained by Todaro, is a response to expected income when expected income is a product of the wage and the probability of finding employment. Thus, off-farm migration which contributes to unemployment in the cities does not contribute to income but rather subtracts from it. The damage is probably larger if the negative externalities in the big cities on which the migrants converge is taken into account.

Before leaving this subject, it is appropriate to ask the question why the agricultural wage is persistently lower than that in non agriculture over a very long period of time. Part of the difference can be accounted for in terms of variations in human capital. Sectoral wages are averages of wages in various activities requiring different levels of human capital. Aside from this, it is the cost of migration that prevents perfect mobility that would have caused the wage differential to close instantaneously. A more explicit formulation of optimization over the lifetime brings forth the importance of the age factor. It is rational for the younger to migrate and for the older to stay in agriculture. Consequently, demography is driving migration even under constant factor prices. This sometimes gives the wrong notion that the labour supply from agriculture (or the traditional sector) to non agriculture (the modern sector) is perfectly elastic. A long literature, initiated by Arthur Lewis, was developed to rationalize such labour supply and to implement it in growth theory. The difficulty with this literature is not with its spirit but in that it applies a static framework to explain a dynamic phenomenon. There is no need to invent artificially shaped production or utility functions. Our standard conceptual framework is fully adequate. This framework, as well as the empirical evidence quoted above, indicates that the rate of intersectoral allocation is price responsive. As population grows, every year brings new cohorts who can improve their position by migration.

## *Capital*

The intersectoral allocation of capital is done largely through gross investment. Commonsense, as well as theory, tells us that such allocation is determined by the difference in intersectoral expected rates of return, as well as by other variables. The larger is the rate of return in agriculture relative to non agriculture, the larger will be the share of agriculture in total investment.

The time path of the sectoral capital stock is, as a matter of definition: $k_j(t+1) \equiv K_j(t)(1-d_j) + I_j(t)$ where $I_j(t)$ and $d_j$ are the gross investment at time t and the rate of depreciation respectively. Sectoral investment is related to total investment. The share of the sector in total investment is related to the expected intersectoral differential returns, as well as other variables. Such a function can be formulated for empirical analysis. Studies for Argentina, Chile, USA and Japan show a definite positive relationship between the share of agriculture in total investment

TABLE 3: *Share of agriculture in GDP ($\pi$) and labour force ($\lambda$) (per cent)*

| | Share in GDP ($\pi$) 1965 | Share in GDP ($\pi$) 1985 | Share in Labour ($\lambda$) 1965 | Share in Labour ($\lambda$) 1980 | Average Annual rate of change $\hat{\pi}$ | Average Annual rate of change $\hat{\lambda}$ | Average Annual rate of change $\hat{\pi}-\hat{\lambda}$ |
|---|---|---|---|---|---|---|---|
| *Low income* | 41 | 32 | 77 | 72 | −1.31 | −0.48 | −0.83 |
| China & India | 41 | 31 | 77 | 72 | | | |
| Others | 41 | 36 | 79 | 71 | | | |
| *Middle income* | 20 | 14 | 56 | 43 | −1.90 | −1.90 | 0 |
| Lower Middle Income | 29 | 22 | 65 | 55 | −1.46 | −1.20 | −0.26 |
| Upper Middle Income | 15 | 10 | 45 | 29 | −2.16 | −3.20 | 1.04 |
| *Developing economies* | 29 | 20 | 70 | 62 | −1.97 | −2.70 | +0.73 |
| Oil exporters | 22 | 17 | 61 | 49 | −1.37 | −1.58 | +0.21 |
| Exporters of manufacturing | 34 | 21 | 71 | 66 | −2.57 | −0.52 | +2.05 |
| Highly Indebted | 18 | 15 | 51 | 40 | −0.96 | −1.75 | +0.79 |
| *Sub-Sahara Africa* | 39 | 34 | 79 | 75 | −0.72 | −0.37 | −0.35 |
| *Industrial Market* | 5 | 3 | 14 | 7 | −2.73 | −5.08 | +2.35 |

*Source*: World Bank, *World Development Report 1987.*

and the rate of return in agriculture relative to non agriculture.[5] Hence, the sectoral decomposition of the capital stock is affected by the history of the expected sectoral rates of return.

Obviously, the rate of return to capital in agriculture is positively related to the price of agriculture relative to non agriculture. Note however that the rate of return is also determined by the level of technology, a concept discussed below. Hence, it is quite possible to observe declining agricultural prices, an increase in the expected rate of return and, therefore, an increase in the agricultural capital stock.

Although capital plays a key role in the growth process, data on the sectoral composition as well as on the level of capital are not part of the standard international statistics and are therefore more difficult to come by for the purpose of cross country comparisons. This also makes it difficult to compute the rates of return in agriculture. Some indirect observations can be made using national accounts. It can be shown that $\pi \equiv \sigma_w S_L \lambda + \sigma_r (1-S_L) \rho$ where $\pi$, $\lambda$ and $\rho$ are the shares of agriculture in total output, the labour force and the capital stock respectively whereas $\sigma_w$ and $\sigma_r$ are the ratios of the agricultural wage and the rate of return to the respective values for the economy as a whole, $\lambda = L_a/L$, $\rho = K_a/K$ $\sigma_w = W_a/W$, $\sigma_r = r_a/r$, $S_L = WL/PY$. By definition, $\rho/\lambda = k_a/k$ where $k = K/L$. Thus, $k_a/k$ is positively related to $\pi/\lambda$, a ratio that can be computed from available data. Table 3 reports summary results for $\pi$ and $\lambda$ taken from the WDR 1987. It is seen that for all reported groups, both shares decline with time. For LIE, lower MIE and Sub Sahara Africa, the decline of the share of agriculture in total output was stronger than that of its share in the labour force. This can be caused by a decline in the capital labour ratio in agriculture relative to that of the economy as a whole. That is, for the low income countries, agriculture might have become more labour intensive. The reverse is observed for the richer countries, and specifically, the ratio of $k_a/k$ increases most rapidly for the industrial economies and the developing countries which are classified as exporters of manufacturing.

Inspection of data for 33 countries on the share of agriculture in total investment (not shown here) reveals no strong trend in this share. For some countries, the share shows a positive trend. For instance, in India the ratio increased from about 13 per cent in the early 1960s to a level of 20 per cent at the end of the late 1970s. But note that even the latter ratio is considerably lower than the relative share of agriculture in output or the labour force. This is the case for most countries. It thus appears that where the capital labour ratio in agriculture increased relative to non agriculture, it was largely done through the decline in the agricultural labour force.

The changes in factor intensity have two important implications which are related to two measures of factor intensity. The two measures become identical only when factor prices are identical across sectors. The physical measure compares the capital labour ratios in the two sectors. It is relevant for our discussion below on technology, as well as for deriving the effect of capital accumulation on factor prices. The cost intensity measure is related to the share of labour in the total cost. A sector is cost-labour intensive if the share of labour in the unit cost is larger than in the other sector. This measure is relevant for deriving the effect of factor prices on product prices. For instance, if wages increase less than the return to capital, the relative price of the labour intensive sector declines. Or alternatively, if the relative price of the labour intensive sector declines, that will have a depressing effect on wages relative to the return on capital.

Is agriculture labour intensive? From the above discussion and from Table 3 it appears so, in that its share in the labour force is considerably larger than its share in total output. Our discussion indicates that this difference might be declining as capital accumulates. Will there be a reversibility of factor intensity? Calculations done for the US indicate that there was a reversibility in the factor intensity of agriculture with respect to non agriculture around 1965 and that the capital labour ratio in agriculture grew considerably faster than in non agriculture.[6] In some countries, like Argentina, agriculture has always been more capital intensive.

## *Technology*

A major difficulty in fully understanding the generation of technical change stems from the fact that technology is an abstract concept. The evidence on it is largely circumstantial.

Traditionally, technology is characterized by a production function. But the production function is a micro concept. There is no unique production function for agriculture; there is more than one for each crop. Recognizing that at any time the economy employs many techniques, each identified with a production function we can define technology as the collection of all techniques. Only a subset of such techniques is implemented at any one time. The collection of all implemented techniques is the implemented technology. Our empirical observations on outputs and inputs are limited to the implemented technology.[7]

The choice of the implemented technology from the available technology is an economic decision. This decision is taken simultaneously with the decision on the level of inputs to be allocated to the various techniques. The analytic similarity to the familiar linear programming should help in clarifying this approach. The only deviation here is that our techniques are represented by concave production functions. With this analogy, it is clear that the solution for the implemented technology depends on the prices of the inputs and outputs in question and on the constraints faced by firms, an important one of which is capital. By capital we mean resources diverted from present consumption in order to generate larger consumption in the future. By definition, resources are limited to the economy as a whole and therefore to firms. When dealing with the industry, prices are replaced by product demand and factor supply functions.

As a matter of observation, technical change on the whole tends to be labour saving or capital using, in the sense that techniques are more capital intensive at the going factor prices. As such, the pace of their implementation depends on the rate of capital accumulation. For instance, if high yielding varieties in dry or semi-dry areas require irrigation, the expansion of output in that area can be expanded by expanding the irrigated area.

Some of the constraints to growth can be removed by farmers, but others are exogenous to farmers. To continue the example above, if there is no water in the region, the farmer is unable to adopt the new variety even if he is able to invest in an irrigation system on his own farm. In this case, if there is a water source that can be developed and the water can be brought to the farm, a new set of opportunities will be opened up to the farmer. To generalize, investments in water, in roads, in communication, or generally in infrastructure open up new opportunities for the farmers.

The discussion can now be extended to cover human capital the importance of which was initially brought out by T.W. Schultz. It is human because it is largely embedded in people, but not exclusively so as knowledge accumulated in the form of books, journals and manuals is also classified in this category. It is capital because it requires resources (time, tuition fees) to acquire. Investing in himself opens up new opportunities to the individual and facilitates increasing his productivity. Such an increase in productivity is carried out largely by shifting to activities which utilize education. A person with a degree in physics does not mix cement by hand faster than the uneducated. He contributes to productivity by engaging in more productive activities or techniques. The level of such accumulation depends on the amount of time invested in learning, on the quality of the training or schools and on the opportunities for using human capital. The quality of local schools is not independent of the scientific and educational infrastructure of the country. Basic scientific knowledge is available to everyone in the form of journals, books and manuals. The translation of this to productivity is the stage that requires resources, part of which are public. These are determinants of the implemented technology.

The role of public investment in applied research, where the general knowledge is converted to technology, is particularly important in agriculture where it is difficult to maintain property rights of innovations and where the innovations have a wide use and thereby generate a considerable amount of consumer surplus. The value of such investment is well brought forth in the survey by Evenson on the returns to agricultural research.

With a concave production function, capital accumulation causes a decline in the rate of return and an increase in the wage rate. A point is ultimately reached where the rate of return does not justify new investment. This is a characterization of the steady state solution. The situation is completely different under the technology described above. Capital accumulation, human or physical, leads to an implementation of more capital intensive techniques under constant wage rental ratio. Thus, the economy can expand without causing a decline in the rate of return, if it expands in the direction of the capital intensive techniques.

All this is conditional on the existence of untapped available technology which is more capital intensive than the utilized one. At this point it is important to emphasize that the capital intensity may refer to human capital or physical capital or both. Thus, in terms of human capital, or more generally knowledge, what is required here is to have new techniques which are more knowledge intensive and which dominate the existing ones. Essentially, we talk of two kinds of knowledge. First is the knowledge required to generate the new techniques and second the knowledge necessary to implement them. These two activities are greatly separated. The latter is the knowledge individuals acquire to increase their productivity. Each individual selects his optimal level. But productivity depends not only on the level of schooling but also on its content. If a person plans to leave agriculture, he will not benefit from learning to operate a milking machine. Instead he is expected to train himself in a direction useful in his new occupation. The idea is that as the technology changes, the content of the investment in human capital changes accordingly.

Analytically, a very similar process takes place in the generation of new knowledge. It is built on the basis of the existing knowledge. Given the time spent on research and development, society moves in the direction of generating the analogous of new techniques. These may be new concepts in science or technology. As long as this is possible, a continuous stream of technical change can be generated that rescues the economy from being locked at a stagnant equilibrium.

The emphasis on progressively more capital intensive technology serves two related purposes. First, this facilitates explaining the increase in capital labour ratios without a corresponding decline in the rate of return. Second, it shows in which sense the technology is endogenous. The production function associated with each technique is concave and therefore is subject to decreasing marginal returns to capital as the capital-labour ratio increases. Thus, entrepreneurs who constitute the demand for new technology would search for new techniques which are more capital intensive than the ones already employed and thereby protect the returns on their investment. Suppliers of new techniques try to meet this demand. The behaviour of the public sector is not very different when it computes the cost-benefit ratios to alternative potential investments. It looks for investments in projects, or we say techniques, with the highest rate of return.

The foregoing discussion does not preclude innovations which are factor neutral or even labour intensive. Since the common knowledge generated in the process has many applications, it may facilitate changes which are not capital intensive and which pay high returns. This is permitted. The essence of the argument is that these are exceptions and not the rule itself. The endogeneity requires development of techniques which use more intensively the factor which grows fastest and saving the factor which grows at a slower pace, or remains constant, and therefore becomes scarcer in a relative sense. This explains also why technical change in agriculture is on the whole land saving, in the sense that under constant prices the ratio of the aggregate input used per unit of land increases.

The role of prices in the choice of techniques is largely through their effect on the expected rates of return. Higher sectoral prices for agriculture are expected to increase its share in total investment and thereby facilitate the transfer to more productive techniques.

## POLICY IMPLICATIONS

The prominence given here to capital accumulation naturally raises the question: why not increase the country's investment in infrastructure, physical and human, and thereby increase production? Well, by definition, resources are scarce and a policy designed to mobilize resources should indicate not only where these resources are to be used but also where they should come from. This calls for an economic evaluation of the productivity of scarce resources in alternative uses.

It is particularly important when resources are to be mobilized by taxing the productive sector of the economy, such as agriculture. Taxing agriculture in order to finance development is not a new concept but that by itself does not make it attractive. This idea is based on the following premises: (i) that investment in agriculture infrastructure produces high returns; (ii) that taxing agriculture will not affect agricultural output; (iii) that there are no better sources of financing such investment.

The first premise is well supported empirically, as the survey by Evenson shows. The scope of investment in infrastructure is broader in that it also covers physical forms of infrastructure such as irrigations, roads and communications. Their importance is well supported empirically.[8]

The second premise is ill founded. Indeed, the existence of aggregate supply response is not easily apparent. This subject is surveyed elsewhere and we do not have the time to go into it here.[9] Suffice it to say that if the analysis is properly done, prices do matter. To negate this assertion is to say that either individuals do not respond to opportunities or that opportunities do not exist. Obviously, the first possibility is ruled out, not only on general grounds, (the alternative would make economics obsolete) but more specifically by the cumulative empirical evidence on intersectoral resource flow in response to income differentials. The second possibility takes an unnecessary pessimistic view of the world. Agriculture has undergone a very impressive evolution, or revolution — depending on one's temperament. That has opened up opportunities to increase resource use in agriculture, including farmers' and their childrens' time in building their specific human capital necessary to increase production. Such investment, like other forms of investment, increases with the expected returns. Decreasing the expected returns will be self defeating. Such arguments, though based on simple and well accepted principles, might seem too abstract and too detached. It is therefore important to note that they are substantiated by empirical analysis. The paper by Domingo Cavallo on Argentina shows very clearly how taxing agriculture, directly or indirectly through macro and trade policies, affected negatively Argentinian agriculture. Similar results are obtained for Chile. The importance of such studies is not only in their results but also in that they state, very explicitly, the structure and method of analysis as well as provide the data. This facilitates a careful examination of the results as well as testing competing hypotheses. It is through such a process of confronting our assertions with the actual experience that we can perhaps reach a better understanding and, one might hope, agreement, on the scope and cost of policies.

Finally, it is hard to believe that there are no other sources of financing this needed expansion in infrastructure. The question is whether or not they are politically feasible. It seems that the debate should concentrate on the issue of efficient expenditure of public funds.

To sum up this discussion of the obvious, there is no short cut in a way of massive programmes to revolutionize development in or out of agriculture in the short run. It is this realistic view of the feasible set of policies which suggests that we turn our attention to eliminate, rather than increase, distortions caused by policies. Elimination of distortion will increase output and will facilitate more investment and further growth in the intermediate run by moving from a low income to a higher income growth path. Such a strategy definitely affects the time path of income per caput. The growth theorist may question whether this also affects the asymptotic rate of growth. When this question is raised in the literature, it is aimed at the equilibrium or a steady state rate of growth. This criterion is not the relevant one for economies which are far from fully exploiting the technology available to them because of their capital constraint. Thus, for any relevant time horizon that we think of, such economies can move to higher and higher levels of technologies through their capital accumulation.

## NOTES

[1]The Hebrew University of Jerusalem, University of Chicago and International Food Policy Research Institute.

[2]Rand McNally Co., *The World Almanac and Book of Facts* (1988) p. 522, and CIA Directorate of Intelligence, *Handbook of Economic Statistics* (1987) p. 22.

[3]Preliminary results are reported in Mundlak (1988c).

[4]Cross country: Mundlak (1979), Kislev and Siegel. Country: Mundlak and Strauss, Cavallo and Mundlak, Mundlak, Cavallo and Domenech, Coeymans and Mundlak, Barkley.

[5]Mundlak and Strauss, Cavallo and Mundlak, Mundlak, Cavallo and Domenech, Coeymans and Mundlak, Barkley.

[6]Barkley, *op. cit.*

[7]For more details on the approach and its implications see Mundlak (1988a, b).

[8]Cf. Antle, Binswanger *et al.*

[9]See Mundlak (1985).

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## DISCUSSION OPENING – DANIEL SUMNER

Professor Mundlak has performed a useful service in summarizing some key features of the facts and economic reasoning on agricultural growth. I urge agricultural economists to examine the cited literature in the paper. These comments of mine can be used to clarify and re-emphasize a few significant points and to provide some caution with respect to policy implications.

### *Intersectoral allocation*

Obviously relative output prices affect the allocation of resources across sectors and across nations. In particular, prices relevant to investment (and hence growth) are those that decision makers expect to prevail over the relevant economic horizon. There is no way to avoid price expectations as a driving force and these are affected, to a large degree, by governments.

The capital and labour resources discussed by Professor Mundlak are defined very broadly. Human capital, research and agricultural extension and related investments are all sensitive to the incentives he discussed. Further, in some economies, such as Japan, the intersectoral allocation of land from farming to other activities may contribute to economic progress. Severely distorted product markets and land transfer restrictions seem to have led to a large over-allocation of land to farming.

Part-time farming may be singled out explicitly for its importance to intersectoral allocation in most developed and many less developed economies. Multiple job holding among farm families contributes to the flexibility in responding to incentives to shift resources between occupations and industries. Furthermore, there is evidence that human capital acquired in farming does pay off in terms of higher wages for individuals who also then work in non-farm jobs (Sumner and Frazao, forthcoming).

### *Technology*

Mundlak also uses the term 'technology' very broadly. We must be careful not to think that economic growth in agriculture is mainly determined by some narrow measure of the sophistication of the equipment, purchased supplies or other inputs that are used by farmers. Any innovations that lead to the more profitable use of existing resources can contribute to growth. Such innovations may be in marketing or management or even government regulations. Building a modern factory or planting a new variety of rice may indeed lead to growth. However, many other little-noticed innovations in the way farmers operate their business may contribute more. Allowing appropriate incentives to be felt and encouraging the appropriate knowledge-base allows innovation, in many forms, to expand.

*Policy*

An emphasis on technology may seem to suggest an engineering approach to economic policy. It has been tempting for governments to become heavily involved in attempting to plan and manage the direction of economic innovation. Such an approach often fails because a government has neither the specific knowledge nor the incentives to control the important investments that must and will occur in a multitude of tiny steps. Government management also leads to political control of investment and may be more likely to contribute to growth in the power of politicians than growth of the economy (Council of Economic Advisers, 1988).

The active role of government, then, remains the funding of public goods for which no private incentives are sufficient. A more important role may be the consistent and secure definition and enforcement of property rights so that individuals will perceive incentives to innovate.

In the short term, of course, governments can contribute to higher incomes by reducing distortions and barriers to innovation. Policies such as international trade restrictions channel resources into less productive uses and also channel innovations into activities and industries of lower long-term return. Relaxing controls can lead to an early economic expansion and to long-term growth.

Innovations often require investment, so expected government policy is a crucial factor. If little confidence can be placed in what policies are likely this may dampen incentive to invest in any sector. This sort of policy risk may be a much more severe drag on agricultural innovation than the vagaries of weather. Farmers and markets are well equipped to deal with fluctuations caused by natural phenomena; but futures markets and diversification can do little to protect against major changes in policies. One significant benefit of reducing the active role of government policies and programmes in innovation is reducing the fluctuation of policies (Rausser, 1988).

Professor Mundlak has focused our attention on major features of the economics of agricultural growth. There are both economic research and economic policy implications of his review and other papers in this conference help to develop these themes quite effectively.

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