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Introduction

Growth in agriculture output can be viewed from many perspectives. The focus may be on an examination of the dynamics of growth; the sources of growth; the stability of growth; technical change and productivity growth; the factors affecting technical change; and so on. The purpose of this paper is to sketch a simple model highlighting some primary factors that influence both the growth in supply of and demand for agricultural output, and which in turn characterize a "balanced" path of agricultural growth. Balanced growth is defined by Malasis as "internal growth" (Malasis, 1975). The model will be cast in terms of readily observable parameters and variables so that testable hypotheses may emerge from the analysis. The text circles around a number of definitions that have been written in formulas.

It is well known that in developed countries such as the U.S. or the countries of western Europe, the growth of demand for food is fully and continually balanced by growth of supply of those products based on a country's agricultural output. Rising per capita income and Engel's Law ensure low rates of growth of the domestic demand for food. Moreover, limited export possibilities act as a further constraint on the potential growth of agricultural output. This contrasts with the situation found in many socialist and developing countries. The realized rate of growth of agricultural output is in many cases insufficient to meet the actual and potential domestic demand for food products. When coupled with a high rate of growth in domestic demand for food products in these countries, there are clear difficulties in achieving equilibrating growth in agricultural output.

These differences create pressure, or at the least political rhetoric, to stimulate the rate of growth of agricultural output.

The attainment of high and stable rates of growth of agricultural output encounter numerous constraints related to the level and changes in domestic factor endowments, their use in production, and the realized level of technical change. The equilibrium level of agricultural growth in turn impacts the production techniques (technology) employed, the pattern of agricultural development, realized productivity gains, and, in many countries, the selection of agricultural policy 'targets'.

The first part of this article describes those factors affecting the rate of growth of demand for food. We distinguish retail food demand from farm-gate product supply. There are substantial and systematic differences in the retail-farm price ratio and the farmer's share of retail food expenditures among countries. These relate to the level of development and associated differences in the level of marketing services. We maintain there is a more-or-less direct link between changes in the domestic demand for food at the retail level and the growth of agricultural output at the farm level. This link is one of the major determinants of the observed pattern of growth in agricultural output.

In the second part of this article, factors affecting the rate of growth of agricultural output are discussed. Particular attention will be devoted to the process of land productivity growth and the role of technical change as a source of agricultural output growth. Significant cross-country differences in the contribution of productivity changes to output growth form a central construct of this model.

Growth Rate of Aggregate Demand for Food

The rate of growth of retail food demand at the national level can be derived from the following identity

$$D = N \cdot D/N \tag{1}$$

where N is population and D/N is the per capita consumption or demand for food. This is essentially the same relationship which was used by Yotopoulos (1985) and Hallett (1987). Differentiating (1) over time gives[1]

$$d = n + d^* \tag{2}$$

where n is the annual growth rate of population; and d* is the rate of growth of per capita demand for food (in real terms).

Although there are various fallacies of aggregation implicit in this formulation, it is a convenient specification for our purposes.[2] It shows the consequences of population growth as well as the effects of growth in per capita demand on the overall rate of growth in demand for food at the national level. It is well known that changes in per capita demand for food are a function of changes in economic factors such as income (income elasticities), price (price elasticities) and other substantially measurable factors such as urbanization, changes in habits, tastes and the like (Mellor, 1966; Raunikar and Huang, 1987). Several cross-sectional studies of consumer behavior have sought to suppress the role of prices and explain changes in quantity demanded simply by the variation of income. Over the extended time period needed for economic development, income (not prices) may well be the principal determinant of changes in food consumption patterns (Marks and Yetley, 1987). Therefore, following Yotopoulos (Yotopoulos, 1975) and ignoring prices, we can assume the per capita demand for food depends simply on per capita income, y, such that

$$d^* = f(y) \tag{3}$$

The change in per capita demand for food over time is then obtained by totally differentiating (3) and converting to (proportional) rates of change such that

$$\frac{\partial d^*}{\partial t}\ \frac{1}{d^*} = \frac{\partial d^*}{\partial y}\ \frac{y}{d^*} \cdot \frac{\partial y}{\partial t}\ \frac{1}{y}$$

which can be rewritten as:

$$d^* = y^* \cdot E_y \tag{5}$$

where $y = \partial t \cdot 1/y$ is the rate of growth of per capita income; and $E = \partial d^*/\partial y \cdot y/d^*$ is the income elasticity of demand for food. Substituting (5) into (2) we can describe the rate of change in total demand as

$$d = n + (y^* \cdot E_y) \tag{6}$$

Considering total demand D and its derivative with respect to population and per capita demand for food, we can rewrite (1) as

$$\frac{\partial D}{\partial t}\ \frac{1}{D} = \frac{\partial N}{\partial t}\ \frac{1}{N} + \frac{\partial d^*}{\partial y}\ \frac{y}{d^*} \cdot \frac{\partial y}{\partial t}\ \frac{1}{y} \tag{7}$$

where

$$\frac{\partial D}{\partial t}\ \frac{1}{N} = d, \qquad \frac{\partial N}{\partial t}\ \frac{1}{D} = n$$

and knowing that

$$\partial d^*/\partial y \cdot y/d^* = Ey \text{ and } \partial y/\partial t \cdot 1/y = y^*$$

we have equation (6). The same equation is presented by Mellor (1966), Ruttan (1978), and Ghatak (1986), while Yamaguchi and Binswanger (1974) take a

similar approach but introduce relative price effects to yield the following relationship (in our notation)

$$d = a + n + pE_p + y\,E_y \tag{8}$$

where a represents a demand shifter that captures changes in tastes which cannot be linked to relative prices, income, or population; p is the rate of growth in agricultural relative to non-agricultural prices; and, Ep is the price elasticity of demand for agricultural products.

Rearranging equation (6) we can examine the population and income effects on the demand for food where

$$1 = n/d + yE_y/d \tag{9}$$

where n/d represents population effects on the growth of demand for food while yE_y/d shows the income effect on the growth of demand for food.

Mellor (1966) pointed out that at certain stages of development the income effect on demand for food may be more important then the population effect. He examines various conditions of the relative importance in population and per capita growth upon growth in the demand for food. Assuming high rates of income growth, the income effect is "estimated to be nearly as great as the population effect in Asia and the Far East. In the middle income countries of Europe and Japan, the income effect is considerably more important than the population effect. It is only in very high-income countries such as the United States that income diminishes to relative unimportance as a determinant of the rate of growth in the demand for food."

We can assume that the income effect in centrally planned economies is substantially more important than the population effect. In Poland in the period 1970-1984, for instance, the population rate of growth was around 0.8%

annually while the demand growth due to income increase per capita was estimated at 4.5% to 5%. It is generally accepted that low-income countries can expect a rate of population growth of 2% to 3% per annum during the early stages of development, and that concurrently the effect of growth in per capita income on the demand for food will be substantially due to relatively high income elasticities of demand for food of 0.6 to 0.9. Thus, growth of per capita income of 2% per year, which is often set as a minimal goal, would result in a rate of growth for demand of over 4.5% per year if we assume a population growth rate of 3% and an income elasticity of 0.8. (Mellor, 1966). Since few countries have experienced sustained growth in agricultural production in excess of 3% per annum, such growth in demand, when juxtaposed against stagnating growth in agricultural output, contributes to a "disequilibrium" in agricultural growth.

A similar situation is found in the centrally planned economies of Eastern Europe. The population rate of growth is, however, lower--ranging between 0.2% to 1.0% per year--while the income effect on the demand for food is high due to income elasticities which are excessively high in relation to per capita national income levels. This, among other factors, is the effect of a spillover of the unsatisfied demand from markets other than the food products, especially from the advanced industrial consumer goods market where a disequilibrium is observed, to food markets, which are relatively more balanced. This situation is additionally aggravated by faulty price relativities. For instance, in Poland the price of consumption goods of industrial origin is abnormally high in relation to wages and the price of food. This is an indirect impact of the outdated structure of national economies in the countries in question. The structure of the economy and the

pattern of production are not market oriented with the share of heavy industry producing capital goods being abnormally high. This can be linked to the centralized planning process which essentially ignores market instruments. In the case of developed countries the rate of growth of both population and per capita demand for food is generally lower than in the case of developing and centrally planned economies.

In order to extend the dynamics of the demand for food commodities at the national level we add, to the right-hand side of equation (6) a term which captures the rate of growth in the export demand for food so that

$$d = n + yE_y + xE_x \tag{10}$$

where xE_x represents the growth rate of food for exports, x, multiplied by the export elasticity of demand for food. Again, in the developing countries as well as in the centrally planned economies, an increase of the export of agricultural products is essential. This is due to existing difficulties in the balance of payments which is strictly related to foreign debt. It also happens very often that agricultural and food products are tradable goods while it is not true in the case of many of the industrial goods. Pressure to extend export of food creates the additional difficulties in achieving balanced growth in the countries in question.

All factors effecting the rate of growth of demand for food at the national level may be considered independent variables. They are difficult to control by economic policy with the possible exception of (E_x), such that their rate of growth is a function of economic development.

Growth Rate of Food Supply at the Retail Level

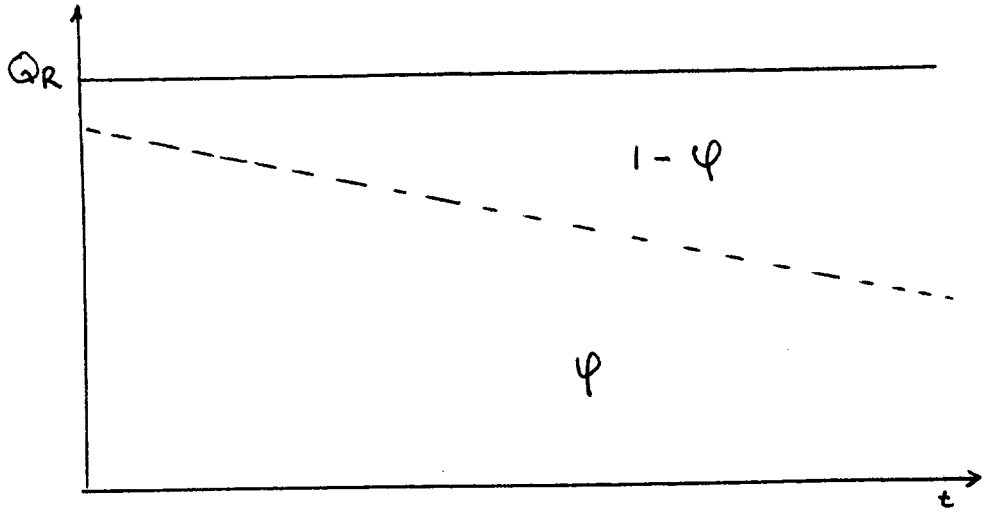
For many commodities there is no direct link between farmers and consumers. As development proceeds farmer consumer linkages are gradually eroded such that agriculture essentially becomes no more than a supplier of raw materials to the food processing and distributive sectors. (Riston 1982). So, analysis of the integration between the growth of consumer demand at the national level and the growth of agricultural output at the "farm gate" has to take this deteriorating linkage into account. The relationship between the farm-gate value of food produced and the value purchased by the final consumer at the retail level--otherwise known as the farm-retail price spread, or marketing margin--has been extensively investigated (Cochrane, 1958; Gardner, 1975; Hein, 1980; Fisher, 1981; and Riston, 1982). The share of marketing and processing services in the retail value of food grows consistently with economic development.[3] This phenomenon--i.e., the retail-farm spread--can be expressed in several ways. It can be measured by the difference between the retail and farm price, by the ratio of these prices, by the farmer's share of the food dollar, or by the percentage marketing margin. Assuming that markets operate on only two levels, that is the farm level and the retail level, this paper focuses on agriculture's share of retail food expenditures. The following formula describing the growth rate of all food supply at the retail level (manufactured food) can be introduced

$$f \approx q + (1-\psi)f \tag{11}$$

where f is the rate of growth of food supply at the retail level; $q = \psi f$ is the rate of growth of agricultural output (assuming that it represents the supply of raw material to the food processing and distributive sector); $\psi = Q_F/Q_R$ represents the ratio of the value of farm output (at the farm gate

level) to the value of food production (at the retail level); and $(1-\psi) = (Q_R - Q_F)/Q_R$ is the marketing service share in the retail value of food supply.

Equation (11) presents the growth of food supply at the retail level as a function of the rate of growth in agricultural output ($q = \psi f$) and the rate of change in the marketing margin $[(1 - \psi)f]$. The coefficients (ψ) and $(1 - \psi)$ can be graphically shown as follows:



It can be hypothesized that the larger is the share of the marketing margin $(1 - \psi)$ the lower is the rate of growth of agricultural output (q) for a given rate of growth of demand for food (g) expressed in equation (10). This can be supported by the following rearrangement of equation (11) to give

$$1 = q/f + (1 + \psi) \tag{12}$$

The ratio q/f, which be definition is equal to $\partial Q_F/\partial Q_R \cdot Q_F/Q_R$, can be viewed as the elasticity of food supply at the retail level with respect to the growth in farm-level output. Food supply at the retail level is more elastic in relation to farm output growth if the marketing margin $(1 - \psi)$ is growing. The determinants of changes in the marketing margin's share of the retail food

dollar were elaborated by Gardner. The above reasoning, to some extent, is relevant to the analysis of the derived demand for food at retail and at the farm level (Stevans, 1965; George and King, 1971). They examined the relation between demand elasticities at the retail level and derived elasticities at the farm level.

In less developed countries, as well as countries where small-scale, peasant-type farms prevail, a part of farm output is directly consumed by the farm family. This reduces the demand for food at the retail level while simultaneously lowering the marketable surplus at the farm level. Therefore, the rate of growth of demand for food shown in equation (2) can be modified as follows:

$$d^{+} = n + (1 - F)\, d^{*}_{u} + F d^{*}_{f} \tag{13}$$

where d^{*}_{u} is the rate of growth in per capita demand for food by the non-farm (urban) population; (1 - F) represents the share of the non-farm population in total population; F is the share of farm population in the total population; and d^{*}_{f} is the rate of growth in per capita demand for food (at the retail level) by the farm population.

The variable d^{*}_{f} may be explained in the following way

$$d^{*}_{f} = \frac{d - (1 - H) d^{*}_{H}}{H} \tag{14}$$

where (1 - H) is the share of home consumption of farm products by the farm population; d^{*}_{H} the growth rate of home consumption of farm products by the farm population; and d, as defined with respect to equation (2), is the rate of growth of per capita demand for food at the retail level. Comparing equations (2) and (10) with the equation (13), it can be assumed that $d^{+} \leq d$ if $(1 - H) \geq 0$. Thus, in the case where there is home consumption of food

products at the farm level ((1 - H) > 0), the actual rate of demand growth (d^+) is lower than (d). There is a body of literature dealing with the factors determining the level of on-farm home consumption (H) and its impact upon farm output supply.

It is clear that since (1 - H) ≥ 0' the rate of growth of the marketable surplus, q^+, will be lower than the rate of growth in farm output, q, such that (Malassis, 1975)

$$q^+ = \frac{q - (1 - H)d^*_H}{H} \tag{15}$$

There is empirical evidence that there is a secular decline in the home consumption of food produced on farms in response to economic development, increased farm specialization, and improved food marketing and accessibility.

Growth Rate of Farm-Land Output

If "balanced" conditions of growth prevail such that d = f then from equation (10) and (11), we obtain

$$n + y\,E_y + xE_x = q + (1 - \alpha)f \tag{16}$$

If production does not keep pace with the effective demand for food products, incomes will decrease or prices will rise -- if prices and the price elasticity of demand is included on the left hand side of (16). So we have

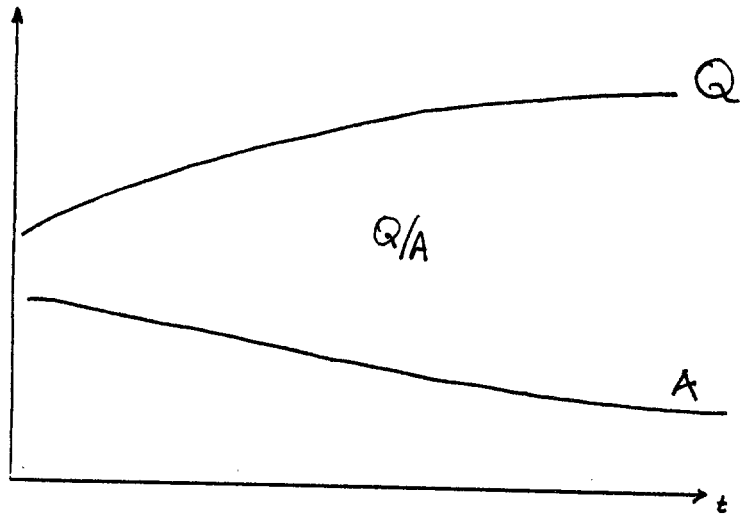
$$y = \frac{[g + (1 - \alpha)f] - (n + x\,Ex)}{E} \tag{16a}$$

Focusing on the right hand side of (16), the factors affecting the rate of growth of farm output (q) are now to be explored. Taking the same approach as used to analyze demand growth rates, we can write

$$Q = A \cdot (Q/A) \tag{17}$$

where A represents land in agriculture; and Q/A is aggregate output per unit of agricultural land.

The above identity expresses the level of farm output as a function of land used for production (A) and land productivity (Q/A) (Malassis, 1975). It can be illustrated graphically as follows:



After differentiating (17) over time the following equation is obtained

$$q = a + b \tag{18}$$

where q is the rate of growth of farm output (as in equation (11)); a is the rate of change of land in farms; and b is the growth rate of land productivity.

Equation (18) shows that the rate of growth of farm output (q) is a positive function of the rate of growth of land productivity (b). It is clear that land expansion ($a > 0$) is no longer the primary source of farm output growth. Instead ($a < 0$) is observed in developed as well as in developing and socialist countries. The impact of land contraction and land productivity increases upon the growth of total farm output can be examined by rearranging (18) such that

$$1 = a/q + b/q \tag{19}$$

where a/q is the impact of land productivity growth upon the rate of growth of agricultural output; b/q measures the impact of decreasing land use upon agricultural output rate of growth.

There is no alternative as far as the strategy of agricultural development in this respect is concern. The only strategy is to aim for increased land productivity as well as to keep the balance between land use decrease and land productivity increase.

The relationships formally described in equation (18) are based on the assumption that land is of a crucial importance for farm output growth. This approach to growth accounting is essentially the same used in a more general analysis by Madison (1987). More complex approaches to account for agricultural output growth are available and are linked with the production function.

Land Productivity Growth Rate

Bearing in mind (18) let us analyze the factors affecting the rate of growth of land productivity. It utilizes the same approach as above which is the formal growth accounts originated from index number approach.

Since the agricultural production function is commonly expressed as

$$Q/A=(C/A)\cdot(Q/C)\cdot(C/C+L) + (L/A)\cdot(Q/L)\ (L/C+L) \tag{20}$$

where Q/A is the level of land productivity

Q/C is the level of capital productivity

C/A measures capital intensity per unit of land

L/A measures labor intensity per unit of land

Q/L is the level of labor productivity

C/C+L is a structural parameter describing the share of capital input in total inputs

L/C+L is a structural parameter describing the share of capital input in total inputs

and where all output and inputs are expressed in real (constant quality) terms. After totally differentiating and rearranging the following equation can be derived (Rembisz and Gemma, 1988)

$$b = \alpha c + \beta \ell + e \tag{21}$$

where b is i.e. the rate of growth of land productivity (as defined for equation (18); c is the rate of growth of capital input per unit of land; ℓ is the rate of growth of labor input per unit of land; α = C/C+L; β = L/C+L; and $\alpha + \beta = 1$; and $e = b - (\alpha c + \beta \ell)$ is the residual of the growth of output per unit of land which cannot be explained by growth in input use, i.e., the rate of technical change.

Equation (21) describes the growth of output per unit of land as a function of the share of each input (in total inputs), the rate of growth of input use, and the rate of technical change (the rate of efficiency use of capital and labor). This form is basically the same as the Cobb-Douglas growth accounting model used by Hayami and Ruttan (1985) and similar to the function used by Paglin (1965) and Yotopoulus et al. (1970). The specific function they derived is as follows (using our notation)

$$Q/A = a' + b' \log (J/A)$$

where J is the sum of inputs per unit and (farm), and a' and b' are parameters.

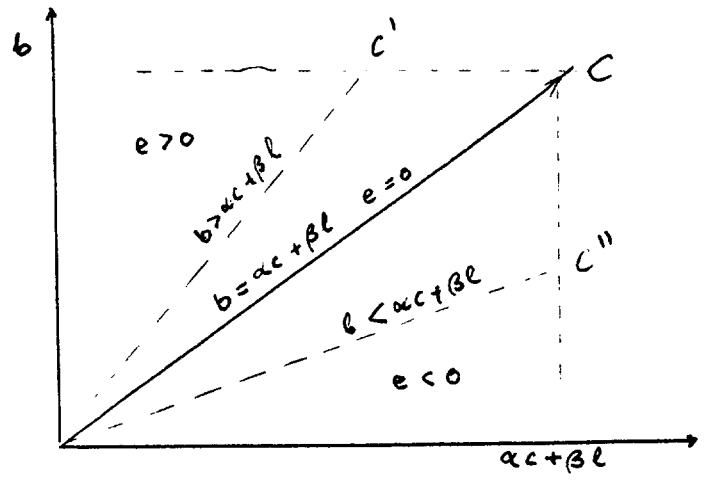
The dynamic relationship describing the growth rate of agricultural

output used by Yamaguchi and Binswanger (1974) was as follows (using our relation)

$$q = e + \alpha\ell + \beta C \tag{23}$$

where α and β are the share of product accruing to labor and capital respectively; and e is the percentage rate of change of output per unit of input. This dynamic relationship corresponds to the production function $Q = TL^{\alpha}C^{\beta}$.

The rate of growth of output (q) in (23) is related to (d) in equation (8)--that is, if d = q equilibrium condition are assumed to prevail. The most important source of land productivity growth in (21) seems to be variable (e). The sense of this term can be illustrated as follows:



The line OC with a slope of 45 degrees represents points where the rate of growth of land productivity is equal to the rate of growth of total inputs per unit of land. Therefore no improvement in output per unit of input has occurred. The other lines, OC′ and OC", describe conditions for e > 0 and e < 0, respectively.

Sources of Land Productivity Growth

Equation (21) can be rearranged to exhibit the following relationship

$$1 = \alpha(c/b) + \beta(\ell/b) + e/b \tag{24}$$

where $\alpha(c/b)$ is the ratio expressing the share (the role) of labor input growth in land productivity growth; $\beta(\ell/b)$ is the ratio expressing the share of capital input growth in land productivity growth; and e/b is the ratio expressing the share of technical change in land productivity growth.

Equation (24) allows us to examine the sources of land productivity growth and therefore, since $a < 0$, to investigate the sources of agricultural output rate of growth. This approach is to some extent similar to Denison's (1985) accounting for the sources of growth. It can be assumed that the most important difference among countries, with respect to sources of agricultural growth, concerns the contribution of technical change to output growth--i.e., (e/b) in equation (24). It can be hypothesized that the contribution of technical change to output growth (e/b) is larger in the agricultural sectors of developed countries compared with socialized and developing countries. In the case of developed countries, there are limits imposed upon the possible rate of growth of agricultural output (q), and therefore upon land productivity growth rates (b) which are derived from the growth rate of demand for food (d). This stimulates a growth path that is oriented towards an input-saving approach through technical change and input substitution effects in order to maintain and improve profitability and income. In countries where the (domestic) demand side does not place binding limits on the rate of growth of farm output, more conventional sources of growth such as capital input increase (for instance, fertilizers, chemicals, machinery, etc.) are likely to prevail.

Ratios (c/b) and (/b) can be considered as coefficients of the production elasticities to capital and labor inputs respectively.

$$c/b = \beta C/C \ / \ \partial Q/Q = \partial C/\partial Q \cdot Q/C$$

$$/b = \partial L/L \ / \ \partial Q/Q = \partial L/\partial Q \cdot Q/L$$

These elasticity coefficients turned upside down in relation to elasticity coefficients derived from Cobb-Douglas production function. The elasticity coefficient (c/b) shows how much production will increase (in percentage terms) while capital inputs are increased by one percent.

Using equation (24) it is possible to examine the relationship among the sources of land productivity growth. Redefining (24) the following equation is obtained

$$c = (1/\alpha) \quad - (\beta/\alpha) \quad - (1/\alpha)e \tag{25}$$

Equation (25) shows that the level of growth rate of capital inputs is determined by the level of land productivity growth, which is to be achieved, by the rate of decrease of the labor input and the rate of growth of technical change which is possible to attain within the given input composition; i.e., technique of production (∂/β). The required (necessary) growth rate of capital inputs (c) will be larger, if the growth rate of land productivity (b) to be attained is larger as well as labor inputs rate decrease is faster and if the actual rate of growth of technical change is lower. This can be considered as a simple input demand function. It can be assumed that in developed countries, the actual rate of growth of technical change is larger then it is in the case of socialist and developing countries. The same can be said as far as labor decrease rate is concerned. From another hand the rate of land productivity to be attained in developed countries is assumed to be lower than in remaining countries in question. In these conditions the demand

for capital inputs in developed countries is lower than in socialist and developing countries. Hence the necessary rate of growth of capital inputs (c) in former countries will not be so big as in case of latter countries. It can be put forward, the certain rate of substitution of technical change for capital and labor inputs exist and vice versa. There is also an impact of changing in technique of production i.e. (α/β) upon the rate of growth of capital inputs. If $\alpha > \beta$ and this relationship is growing wider, the rate of demand for capital input is diminishing.

The bias of technique of production changes i.e. the bias of changes in relation between (α) and (β), can be examined in the following way. Coefficient (2) is defined:

$$\alpha = C/C + L = C/L/C/L + 1 = U/U + 1 \tag{26}$$

where:

$$U = C/L \text{ - capital - labor - ratio}$$

so:

$$U = \alpha/1(1 - \alpha) \tag{27}$$

having:

$$Ut + 1/U_t = 1 + U \tag{28}$$

and:

$$u = c - \ell$$

the following equation is obtained:

$$U_{t+1}/U_t = 1 + (c - \ell) \tag{29}$$

substituting (28) to (25) the relationship between the rate of change of capital inputs and labor inputs to the change of capital input share in total inputs (α) can be expressed as:

$$\alpha_{t+1} = [1 + (c - \ell)]\ \alpha t/\ [1 + \alpha_t\ (c - \ell)] \tag{30}$$

Simple relation can be derived from (29):

a) for $c - \ell > o$, it is $\alpha_{t+1} > \alpha_t \Rightarrow \alpha > \beta$

b) for $c - \ell < o$, it is $\alpha_{t+1} < \alpha_t \Rightarrow \alpha < \beta$

c) for $c - \ell = o$, it is $\alpha_{t+1} = \alpha_t$

Case (a) indicates a rather typical relationship in the agricultural development. Faster growth of capital inputs then labor input which can be $\ell > 0$, $\ell = 0$, $\ell < 0$, means that technique and technology of production become more capital intensive and less labor intensive. Therefore the share of capital input (α) is larger than the share of labor input (β). The growth of agricultural production is increasingly dependent on the supply of industrial inputs, and research (Hayami and Ruttan). Case (b) shows labor intensive backward type of agricultural production growth. This type of agricultural production growth path occurred in the early stage of economic development. It also may indicate that shortage of industrial input supply is substituted by more labor intensive or consuming technology. The third case (c) shows no structural change in the terms of input composition. This may happen in the most advanced stage of development as well as in the earliest interval.

Conclusion

The theoretical model has been developed. The model allows examination of the factors and conditions having impact upon the equilibrium in agricultural production growth.

If the equilibrium conditions are assumed, the following relationship among the discussed coefficients should be maintained:

$$d = f => q => \ell => e => c$$

The rate of growth of demand for food is more consistent with the food supply growth rate than with the growth rate of agricultural output as a raw material

for food processing. Next, the rate of growth of agricultural output is shaped by the land productivity growth, which in turn is dependent upon the technical change and capital input supply growth rate.

There is a recurrent order of relationships among the equations which have been introduced in this paper:

$$d = p + i\ Ey + xEx \tag{11}$$

$$f = q + (1 - \psi)f \tag{12}$$

$$g = a + b \tag{17}$$

$$b = \alpha c + \beta l + e$$

The final hypothesis is that relationships among these equations and among factors affecting the growth of their left-hand side coefficients are different in developed, socialist and developing countries.

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ENDNOTES

[1]In this paper lower case variables denote the proportional rate of change of the respective upper case variables (e.g., $\partial D/\partial t\ 1/D = d$).

[2]See Yotopoulos (1985: 465-466).

[3]Nevertheless Ahmad (1988) found that marketing margins in African countries are high and that farmers receive only 35 to 50 percent of the retail price of food grains.