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THE MECHANICS OF AGRICULTURAL PRODUCTIVITY AND ECONOMIC GROWTH

by

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Increases in agricultural productivity contribute to national economic development and income growth in two major ways: (1) by releasing labor resources for nonagricultural occupations and (2) by supplying an economic output above that consumed or used for further production in the agricultural sector -- an "economic surplus" that can be transferred out of agriculture and provide capital for economic growth in the nonagricultural sectors.

This paper suggests ways of measuring the contribution increases in agricultural productivity can make to national income growth and changes in agricultural output, input, and productivity. It considers in a general way conditions influencing improvement in agricultural productivity.

Hypothetica, the country referred to for illustrative purposes, is unique with respect to data available for analysis. It is a developing country with characteristics similar to many in the "real world." Data have not been thoroughly checked for internal consistency and reasonableness.

Agricultural Output

Part 1 of table 1 shows that total agricultural output doubled from 1940 to 1960. All value data are in 1957-59 prices.

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Table 1.-- Agricultural output, input, and productivity in Hypothetica

Item	1940	1960	Change
	Million dollars	Million dollars	Percent
I. Agricultural output, total	10,000	20,000	100
A. Products, total	8,000	16,000	100
1. Subsistence	5,000	8,000	60
2. Marketed	3,000	8,000	167
a. Domestic	2,000	5,500	175
b. Export	1,000	2,500	150
B. Capital improvements, total	2,000	4,000	100
1. Land clearing, drainage, etc.	1,000	2,000	100
2. Buildings	500	1,000	100
27. Livestock and draft animals	500	1,000	100
II. Agricultural input, total	9,000	15,000	67
A. Inputs from within agriculture, total	7,000	11,000	57
1. Land	4,000	6,250	56
2. Fixed capital improvements in land	1,000	1,500	50
3. Working capital (seed, livestock, etc.)	500	1,000	100
4. Labor of rural people	1,500	2,250	50
B. Inputs from outside agriculture, total	2,000	4,000	100
1. Fixed capital improvements	500	1,500	200
2. Working capital (fertilizer etc.)	1,500	2,500	67
III. Net agricultural output, total output less inputs from outside agriculture	8,000	16,000	100
IV. Productivity measures	Dollars	Dollars	Dollars
A. Total agricultural output per unit of total input	1.11	1.33	20
B. Net agricultural output per unit of input from within agriculture	1.14	1.45	27
C. Agricultural products per acre	80	100	25
D. Agricultural products per worker	400	533	33

Agriculture in Hypothetica is shifting gradually from subsistence to commercial production. One-half of the products produced in 1960 were marketed as compared with under 40 percent in 1940.

It is customary only to include products in measures of agricultural output. Such measures are meaningful and important. But land has been cleared, drained, and irrigated and farm buildings have been constructed in Hypothetica. The total acreage under cultivation has gone up by 60 percent. Resources employed in the agriculture, especially labor used to make land improvements, have added to the capital stock of the country. Therefore, net capital additions to land and fixed capital reproducers are included in total agricultural output.

Products are "end-products" -- those made available for consumption by farm people, marketed, or added to farm stocks. Crops fed to livestock are included in livestock products so there is no double counting.

Obviously, most countries do not have data for measuring precisely agricultural output in all the above categories but it is important to be aware of the different categories and to know at least approximately the relative importance of each.

Subsistence products are valued by farm prices of marketed products. Capital improvements or additions are physical quantities multiplied by prices of their annual services in 1957-59.

Agricultural Input

Part II of table 1 shows agricultural input in 1940 and 1960. In the case of land and capital goods, inputs refer to the value of annual services of these items. This also is true of labor.

Again, it may be noted that agriculture in Hypothetica is chiefly subsistence. A small but slowly increasing proportion of the input used annually comes from outside the agricultural sector.

Even in Hypothetica where detailed data are available, it is difficult to decide what are the appropriate values to place on inputs from within agriculture (land, fixed capital improvements on land and labor) because there are few market sales of these inputs. We will return to problems of valuing inputs and outputs later.

Agricultural Productivity

Part III of table 1 shows net agricultural output (agricultural sector output) in 1940 and 1960. Total agricultural output less inputs from outside agriculture is the contribution of agriculture to the gross national product (GNP). GNP from agriculture or agricultural sector output doubled from 1940 to 1960.

Part IV of table 1 shows changes in agricultural productivity. Total agricultural output per unit of total input increased 20 percent. But net agricultural output per unit of input from within agriculture increased 27 percent.

Most of the expansion in agricultural output resulted from the use of more inputs, mainly from within agriculture (labor, land and capital improvements on land by labor of rural people). However, purchased capital inputs have become relatively more important. They have been necessary for applying new technology and achieving increased output of agricultural products per worker and per acre.

Agricultural productivity has been influenced by supplies of capital and its use in agriculture by other sectors. In fact, these capital inputs have been essential for increasing agricultural productivity.

Land area in agriculture increased by 60 percent. Despite extension of the cultivated area to poorer lands, agricultural products produced per acre increased by a fourth.

Labor input increased 50 percent. Agricultural products produced per worker increased a third.

Table 2 shows changes in the "input mix" associated with increased productivity.

Table 2.-- Percentage distribution and change in inputs by major categories

Input categories	Percentage distribution		Change 1940 to 1960
	1940	1960	
	Percent		Percent
Land and land improvements	55	52	55
Labor	17	15	50
Capital	28	33	100
Total	100	100	67

Land, including land improvements, is the major input. It accounted for over half of total input in 1940 as well as in 1960. Labor is a relatively minor input measured in value terms. But this reflects the fact that labor has a low price or value per unit.

Since any alternative use of land and labor in agriculture in hypothetical would have had only low value, it is of interest to observe the returns for

the limited amounts of the additional nonagricultural inputs used. In this example, additional inputs of $2,000 have been associated with increased output of $10,000, or a ratio of about 1 to 5 if we were to assume the additional land and labor used was "costless".

Subsistence and market sectors of agriculture need to be considered separately. (See table 3). The market sector, of course, is the source of economic surpluses that can be transferred from agriculture to other sectors.

Table 3.-- Agricultural output and input by sectors

Sector	Items Over Table 1	1940	1950	Increase
		Mil Dol.	Mil Dol.	Percent
Market				
Agricultural products	1-A2	3,000	8,000	167
Purchased inputs	17-A	2,000	4,000	100
Difference		1,000	4,000	300
Subsistence				
Agricultural output	1-A1 & 1-B	7,000	12,000	71
Inputs	17-B	7,000	11,000	43
Difference		---	1,000	---
Total				
Agricultural output	1	10,000	20,000	100
Agricultural input	11	9,000	15,000	67
Difference		1,000	5,000	400

In 1940, value of agricultural products marketed exceeded value of purchased input by $1,000. This $1,000 plus subsistence products valued at $7,000 meant that agriculture's contribution to the GNP was $8,000. Agriculture supplied food and other products for consumption in nonagricultural sectors. In addition, it was an important source of foreign exchange as the value of agricultural exports was much larger than that of agricultural imports.

In 1950, total agricultural output exceeded total input by $[illegible],000, $4,000 more than in 1960. Hypothetically there is no effective taxation program for capturing a substantial part of the increased product resulting from increased agricultural productivity, and a program for using it in nonagricultural sectors. Of the increase in the economic surplus, $3,000 was retained in the agricultural sector. The remaining $1,000 was "leaked" away from agriculture.

Transfer of agricultural income into nonagricultural sectors can, of course, take place in other ways:

1. Real prices of food and other agricultural products may decline. This indirectly reduces production costs in industry and other sectors where wage rates are influenced by food costs.

2. Landlords and others who share in agricultural income may transfer some of this income into nonagricultural uses by making investments in industry.

3. Agricultural people who move into nonagricultural sectors may "take savings" or transfer money from agriculture to other sectors. Agriculture, of course, pays costs of rearing, educating, and training people who migrate to urban areas.

Demand for agricultural products has increased rapidly with population growth and higher per capita incomes, especially in urban areas. Although total agricultural output has increased at a compound annual rate of 3.5 percent a year, it has been necessary to increase imports of food in order to meet increased economic demand and keep the cost of living stable. The capital stock of agricultural products has gone up 21 percent, about 0.8 percent a year. See Table 4.

Table 4.-- Agricultural products available for domestic uses

Items	Unit	1940	1960	Percent Increase
Total production	Mil. Dol.	8,000	16,000	100
Exports	do.	1,000	2,500	150
Difference	do.	7,000	13,500	93
Imports	do.	500	1,500	200
Total available for domestic use	do.	7,500	15,000	100
Total population	Million	100	165	65
Per capita supply & consumption	Dollars	75	91	21

The growth rate in total demand for agricultural products is equal to population growth rate (p), plus growth rate for per capita income (g) times income elasticity of demand (n). The population growth rate for Hypothetica has been relatively rapid, about 2.6 percent a year. Per capita income has increased at about 1.3 percent a year. Income elasticity of demand for agricultural products is relatively high, approximately 0.8. By substituting appropriate numbers in the equation, $D = p + gn$, it can be observed that total demand for agricultural products increased at a rate of 3.64 percent a year. Domestic demand for agricultural products has increased a little more rapidly than agricultural production.

Larger agricultural imports have been financed by Food Aid programs of the United States and other countries. Hypothetica has had difficulty earning enough foreign exchange to finance imports of capital goods required for industrial development. If it had not been for Food Aid programs, industrial growth would have been retarded, more people would have remained in agriculture, and national income growth would have been slower.

National Income Growth

As in the case of other developing countries, and in developed countries too, per capita incomes in Hypothetica average much lower in agriculture than in nonagricultural sectors. See table 5.

Table 5.-- Gross national product, capital investment, and income by sectors

Items	Unit	1940	1960	Percent increase
Agricultural sector				
GNP from agriculture	Mil. dol.	8,000	16,000	100
Capital investment	" "	2,000	4,000	100
Net income for consumption	" "	6,000	11,000	83
Population	Millions	70	105	50
Net income per person	Dollars	86	105	22
Nonagricultural sectors				
GNP from rest of economy	Mil. dol.	8,000	20,000	150
Capital investment	" "	2,000	6,000	200
Net income for consumption	" "	6,000	15,000	150
Population	Millions	30	60	100
Net income per person	Dollars	200	250	25
Total economy				
GNP	Mil. dol.	16,000	36,000	125
Capital investment	" "	4,000	10,000	150
Net income for consumption	" "	12,000	26,000	117
Population	Millions	100	165	65
Net income per person	Dollars	120	157	31

Two things need to be noted with regard to the above data: (1) $1,000 of the increase in net product of agriculture was transferred to nonagricultural sectors; (2) the large percentage rise in per capita income for the total population resulted partly from transfer of people from agriculture, where incomes are relatively low, to nonagricultural sectors where they average relatively high.

The gain in agricultural productivity was large enough to cause incomes per person to rise by about as large a percentage in agriculture as in other sectors even though a part of the gain was transferred to nonagricultural sectors.

A large part of total output (24%) was used for capital investment or new development, one-fourth in 1940 and 23 percent in 1960. These relatively large investments have helped make possible a relatively high national output growth rate of about 5 percent a year.

In 1940 as well as in 1960, one-half of total capital investment originated from output in the agricultural sector and one-half from output in other sectors.

Increases in national income, of course, resulted from increased productivity in other sectors as well as from increased productivity in agriculture.

Transfer of labor resources

In terms of employment, Uruguay was chiefly an agricultural country in 1940 and continued to be so in 1960 although there was a large net migration from agriculture to other sectors. See table 6.

Table 6.-- Distribution of total population and employment by sectors

Sector	1940	1960 actual		1960 with no migration	
	million	million	percent	million	percent
Agriculture	70	105	64	115.5	70
Nonagriculture	30	46	36	49.5	30
Total	100	165	100	165.0	100

The population growth rate was the same in agriculture and in other sectors, namely 2.6 percent. Population in nonagricultural sectors doubled while that in agriculture increased by one-half. Agriculture accounted for 64 percent of total population in 1960 as compared with 70 percent in 1940.

Population and employment in nonagricultural sectors increased 5 percent a year, while that in agriculture increased about 2.2 percent a year.

The movement of people from agriculture to other sectors during the 1940-60 period (10.5 million) was equivalent to 15 percent of the total population in agriculture in 1940 or to about 10 percent of the total population. More than 35 percent of the labor force in nonagricultural sectors in 1960 were people who moved out of agriculture during the 1940-60 period.

The contribution of agriculture to the labor force in nonagriculture sectors was large. But movement of people out of agriculture would have been even larger if employment opportunities in the other sectors had increased at a faster rate. Income levels in nonagricultural sectors average much higher than those in agriculture. However, Hypothetica has done well to increase employment in nonagricultural sectors by 5 percent a year.

In most developing countries population growth rates are higher in agriculture than in other sectors. If the population growth rate for agriculture had been higher and that for other sectors had been lower in Hypothetica, a much larger net migration out of agriculture would have been necessary to achieve the 100 percent growth in nonagricultural population and the 50 percent growth in agricultural population.

Investments made by rural people to improve their education and skills, of course, are transferred out of agriculture when they move to nonagricultural sectors. But even more important is the fact that agriculture pays the costs of rearing rural people who move from rural to urban areas. Agriculture's contributions to increased output of other sectors thus is influenced by capital investments in the "human agent" made by agriculture.

Valuation Problems

Economists are faced with difficult problems in measuring agricultural output, input, and productivity in Hypothetica because of the subsistence nature of agriculture.

It is possible to do a reasonably good job in valuing agricultural products because substantial quantities move to markets and prices are established for them. However, market price making forces operate imperfectly because there are few buyers and many sellers and for other

reasons. Product prices tend to be lower than they would be with "perfect" markets. The contribution of agricultural products to the national income probably is underestimated in most developing countries.

Values placed upon inputs of land and fixed capital improvements (and outputs in the form of land improvements) are based on prices established by relatively few market transactions. These prices, of course, also are influenced by imperfect markets. There is the additional problem of deciding how to value the annual service of land and other fixed investments. Obviously, it is necessary to assume a capitalization or interest rate. Interest rates also are likely to be influenced by imperfect market conditions with "many buyers and few sellers."

Finally, there is the question of how to value labor input when most agricultural workers are self-employed. It is necessary to impute values to labor of the self-employed based chiefly on wage rates of hired workers.

Do difficulties in placing values on inputs and outputs in agriculture mean that development of estimates of changes in agricultural output, input, and productivity is a meaningless exercise? The answer, of course, is no. By going through this exercise country by country, much can be learned about the magnitudes of the various variables affecting agricultural output and productivity, the obstacles to economic progress in agriculture, and the role of agriculture in national economic growth.

The values placed on inputs from within agriculture are imputed values and decisions about these influence estimates of the relative importance of land, labor, and capital in the "input mix." Labor, for example, may account for a small part of total input in less developed

commodities because it has a low value per unit. The reverse is true of capital. Still, it is true that agriculture in less developed countries uses large amounts of labor and small amounts of capital as compared with agriculture in the highly developed countries.

This appears to be no accident from the fact that the physical volume of capital must increase relative to that of labor in order to improve agricultural productivity. However, if additional capital is to be most effective in increasing productivity, it must be in the forms and combinations required for the application of improved technology.

Conditions Influencing Productivity

It is difficult to develop precise measures of change in agricultural productivity and the contributions that gains in agricultural productivity make to national economic growth. But these tasks are simple as compared with measurement of the conditions that cause gains in agricultural productivity to take place.

It is possible to indicate the sources or "proximate causes" of increased agricultural output. For example, agricultural output depends upon level of technology and quantities of land, labor and capital inputs. In the case of Hypotheria the volume of traditional inputs (land, labor, and capital) increased 50 percent, but output per unit of input (technology) increased 33 percent. Moreover, the combination of inputs was changed with the input of additional goods and a substantial part of the additional output might be contributed to change in the input mix.

Perhaps the most fruitful procedure from a conceptual point of view of organizing economic research on the factors or conditions affecting agricultural output and productivity is analysis in the traditional supply and demand framework. On the supply side the following need to be considered:

1. Motivations and attitudes affecting change in farming methods and practices. Are people receptive to change customs and practices? Do people respond to economic incentives?

2. Available technology. Are combinations of improved practices or production techniques adapted for soil and climatic conditions available?

3. Diffusion of knowledge about improved technology. Farmers obviously need to know about improved production practices if they are to adopt them.

4. Supplies of additional inputs including land, labor, and capital. Most improved production methods, even better seeds, involve additional capital inputs. Are these available, and if so, at what price?

5. Finance, credit, taxation, and marketing systems with reference to how they influence production and marketing costs.

On the demand side, the following merit attention:

1. Population and income growth in nonagricultural sectors causing demand for farm products to increase.

2. Export markets for agricultural products. These may expand less than domestic markets, depending upon the product.

3. Subsistence demand resulting with farm population growth.

4. Finance, credit, and taxation and marketing systems with regard to how they affect prices received by farmers and the quantities of products that can be sold at these prices.

5. Transportation, storage, and processing facilities that influence demand and prices of farm products at the farm level.

Finally, a few points deserve emphasis.

First, factors that affect supply and demand for agricultural products are interrelated and often cannot be classified neatly as

falling in the demand or supply category. For example, improvement in prices and expansion in demand for farm products may cause farm people to conserve soil and water resources which in turn leads to lower unit costs of production and adds to the supply of agricultural inputs.

Second, the distinction between additional output resulting from higher levels of productivity and that resulting from the use of additional inputs is important. If agriculture is to contribute to economic growth, it must become more productive as measured by output per unit of input. It is not sufficient to increase agricultural output by employing more inputs from the nonagricultural sectors.

Change in the input mix and a larger agricultural output usually is associated with increased agricultural productivity. In Hypothetica, agricultural output increased 5 percent for each 1 percent increase in total output per unit of total input. Stated another way, real cost per unit of output increased a little less than 1 percent for each 5 percent increase in total output. United States' experience has been similar. In the case of Hypothetica, economic demand for agricultural products kept pace with increase in economic supply. Increased output and productivity did not depress prices of products. But this will not always be true for developing countries.