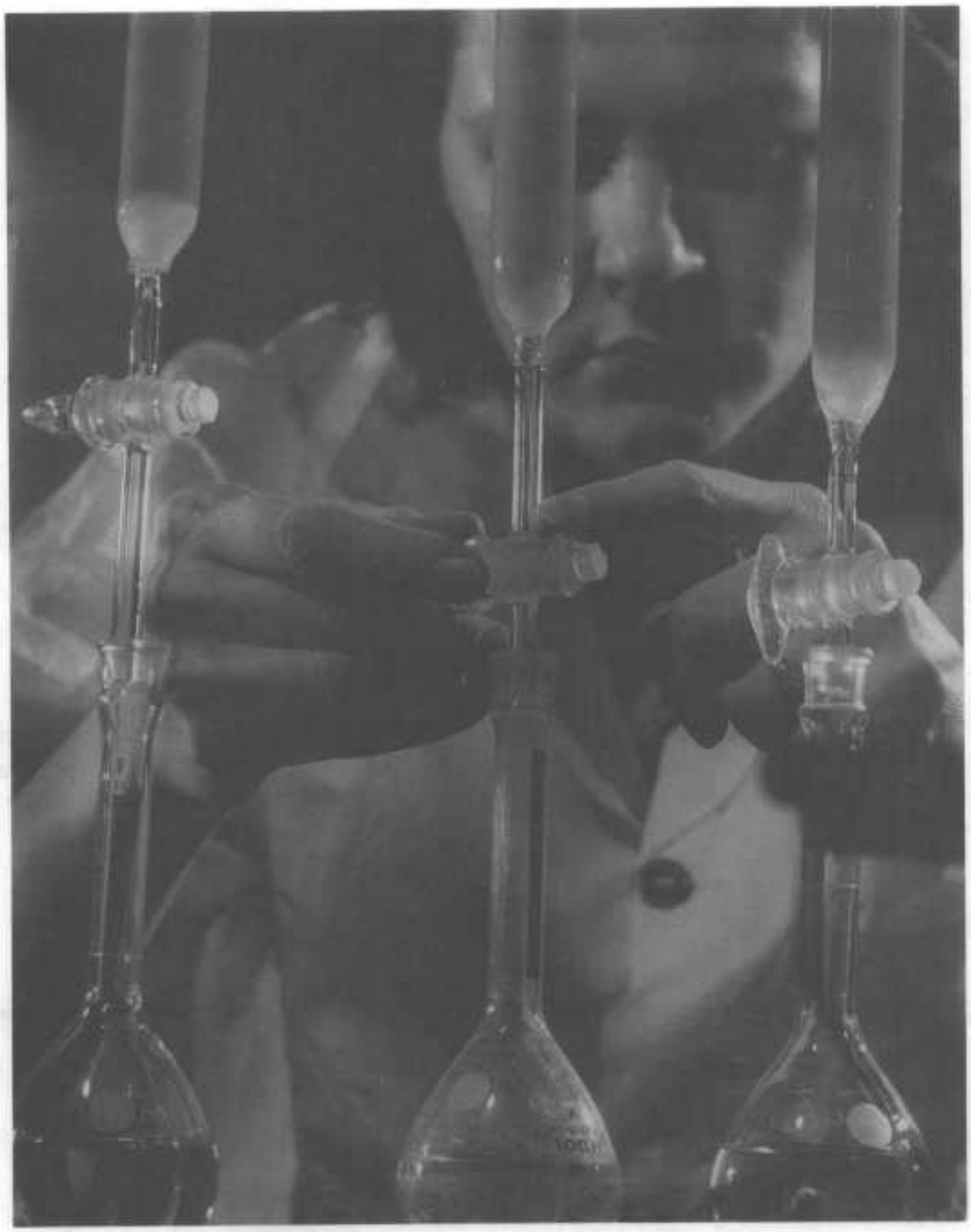
United States
Department of
Agriculture

Economic
Research
Service

Agricultural
Economic
Report
Number 644

Differences in Agricultural Research and Productivity Among 26 Countries

George B. Frisvold
Eugene Lomax



It's Easy To Order Another Copy!

Just dial 1-800-999-6779. Toll free (in the United States and Canada). All other areas please dial 301-725-7937.

Ask for *Differences in Agricultural Research and Productivity Among 26 Countries (AER-644).*

The cost is $8.00 per copy. For non-U.S. addresses (including Canada), add 25 percent. Charge your purchase to your VISA or MasterCard, or we can bill you. Or send a check or purchase order (made payable to ERS-NASS) to:

ERS-NASS
P.O. Box 1608
Rockville, MD 20849-1608.

We'll fill your order by first-class mail.

Differences in Agricultural Research and Productivity Among 26 Countries. By George B. Frisvold and Eugene Lomax. Resources and Technology Division, Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No. 644.

Abstract

Public investment in agricultural research is one of the major factors accounting for differences in agricultural productivity among countries. Research in agriculture measurably raises agricultural productivity. Research investment and productivity increase as a country's level of economic development increases. This report examines the contribution of research and other policy factors on agricultural productivity in 26 countries at various stages of economic development. It also explores differences among these countries in their willingness to make public investment in agricultural research.

Keywords: Agricultural research, total factor productivity, interest groups, public investment

Acknowledgments

We received valuable comments from Bruce Larson, John Reilly, and Jet Yee. We would also like to thank Florence Maupin for editorial suggestions.

Washington, DC 20005-4788 May 1991

Contents

Summary

Public investment in agricultural research is one of the major factors accounting for differences in agricultural productivity among countries. Research in agriculture measurably raises agricultural productivity. Research investment and productivity increase as a country's level of economic development increases. This report examines the contribution of research and other policy factors to agricultural total factor productivity in 26 countries at various stages of economic development. It also explores differences among these countries in their willingness to make public investment in agricultural research.

Growth in agricultural productivity, whether brought about by improvements in technology, education, or market efficiency, is vital to a country's economic development. It reduces the input requirements for a given level of output, and so conserves a country's natural resources. Reduction in per unit costs of production also increases international competitiveness and reduces domestic food prices.

Agricultural productivity in developed countries (those with per capita gross domestic product (GDP) of more than $5,000 in 1980 constant dollars) has grown about 2 percent a year. The rate of growth has been similar in countries in intermediate stages of development (per capita GDP of $1,500-$5,000; for example, Spain, Argentina, and Chile). But, in the developing countries (per capita GDP of less than $1,500), there is little evidence of growth since 1960.

This study shows that growth in agricultural productivity is affected by:

- Public investment in agricultural research.
- Technical education in agricultural sciences.
- Demographic pressure (population growth) on land resources.
- Improved infrastructure in communications and transportation.
- Investment to improve land quality.
- Export orientation in agricultural input markets.

Together, these factors explain over 80 percent of the differences in agricultural productivity among the countries studied.

In the developing countries, too little public investment in agricultural research takes place to compensate for such negative effects as those of demographic pressure. Consequently, the gap in agricultural productivity between the richest and poorest nations continues to grow, and many poorer nations face higher food prices and insecure supplies of food. For that reason, continued increases in productivity by developed countries will be necessary to maintain the global availability of food.

Because of the importance of agricultural research, this report also develops a model to identify those factors which encourage or constrain public investment in such research. The study finds that funding for agricultural research per farm increases as:

- The number of farms declines.
- The output per farm increases.
- The availability of trained research personnel increases.
- The area of agricultural land declines.

Also, the study examines collective action and the behavior of interest groups to explain why research expenditures vary positively with the absolute importance of agriculture in an economy, but negatively with its relative importance.

Differences in Agricultural Research and Productivity Among 26 Countries

George B. Frisvold and Eugene Lomax*

Introduction

This report has two major objectives. The first is to examine the contribution of research and other policy variables to agricultural total factor productivity in 26 countries at various stages of economic development. The second is to explain differences in public investment in agricultural research among countries. Total factor productivity (TFP) is the ratio of output to inputs, such as land, labor, and capital. Productivity growth reflects improvements in technology, human capital, and market efficiency. Economists use indexes of productivity to make comparisons, across time, region, or industry, of the relative efficiency of input use.

Growth in agricultural productivity serves a number of important functions in economic development. First, by reducing the input requirements for a given level of output, productivity growth allows a country to conserve natural resources. Second, reduction in per unit costs also increases international competitiveness and reduces the price of food (Kendrick),[1] a major issue in most developing countries. Since the poor in developing countries spend much of their income on food, the reduction in food prices alleviates poverty and reduces income inequality (Pinstrup-Anderson).

David Ricardo and other early classical economists believed that demographic pressure on limited natural resources, specifically land, continually threatened growth in agricultural productivity. Ricardo argued that because of population growth, diminishing returns to agricultural production were inevitable because either (1) land of decreasing quality would be brought into production, or (2) more labor and capital would be applied to fixed amounts of land. In the dynamics of the Ricardian model, demographic pressure on limited land resources implied a reduction in total factor productivity and an increase in the cost of food production. Food price inflation would generate pressure for higher wages, choking off capital accumulation and growth in the economy. Working against this tendency toward stagnation were improvements in agricultural science and technology, which allowed the economy to produce a given amount of food with fewer inputs. Technological change could postpone economic stagnation for a time, but diminishing returns to land resources would ultimately slow economic development.

Today, Ricardo's predictions of agricultural stagnation appear overly pessimistic. Vast areas of land in the Western Hemisphere, Australia, and New Zealand have been settled and brought under modern cultivation. Technological innovations have substituted for land, while investments in irrigation, soil conservation, land shaping, and consolidation have increased the effective quantity of arable land stock in many areas. In developed countries (those with per capita GDP of more than $5,000), the rate of technological progress and productivity growth has continued to outpace population pressure on land. Even among countries at middle stages of development (per capita GDP of between $1,500 and $5,000), Kawagoe and Hayami found steady increases in total factor productivity between 1960 and 1980. Despite such gains by middle-stage countries, Kawagoe and Hayami report that "no sign of significant absolute gain in total productivity of less developed countries for the past two decades is evident" (p. 91). Moreover, the findings of these authors suggest that productivity has declined in many developing countries (those countries with per capita GDP of less than $1,500). The possibility that a number of developing countries are caught in a Ricardian trap has alarming implications for the rural poor of those countries. It is crucial, therefore, to identify specific factors that significantly contribute to the growth of productivity.

One such factor, frequently cited in the economics literature, is the development of improved technologies through public investment in agricultural research. Studies of various types of public research have consistently found that the rates of return on this type of investment are relatively high. Although such studies give only rough approximations, annual rates of return of 30-50 percent are quite common (Pinstrup-Anderson). These rates are higher than market interest rates and the rates of returns

* George Frisvold and Eugene Lomax are agricultural economists with the Resources and Technology Division, Economic Research Service, U.S. Department of Agriculture.

[1] Names in parentheses refer to authors cited in the References at the end of this report.

for other public investments, suggesting that there is an overall underinvestment in public agricultural research.

It would be useful, therefore, to identify those factors which either encourage or constrain investment in agricultural research. This report examines productivity differences among countries for the years 1970 and 1980. A total factor productivity index is constructed as a ratio of an index of total agricultural output to an index of total input. The results of statistical analysis of the determinants of agricultural productivity suggest that the main factors that explain cross-country productivity differences are:

- Public research investment.
- Technical education in agricultural sciences.
- Demographic pressure on land resources.
- Communications and transportation infrastructure.
- Investment in land expansion/improvement.
- Trade orientation of agricultural input markets.

The report also develops a conceptual supply and demand model for agricultural research. The model is used to derive an expenditure equation for public agricultural research, following the approach of Huffman and Miranowski, and Judd and others (1986). The effective demand for research depends on the willingness of agricultural interest groups to lobby for increased research funding. Some major findings are that agricultural research funding per farm increases when:

- The number of farms decreases.
- Output per farm increases.
- The availability of agricultural scientists increases.
- Agricultural land area declines.

Land expansion (through irrigation projects and other investments) and scientific research, as methods of increasing agricultural output, compete with each other for limited government funds. Countries that can cheaply increase their output through land expansion invest less in scientific research. Conversely, countries with a binding land constraint are induced to invest more in research and development of new technologies.

The ability to carry out research projects depends crucially on the availability of personnel trained in agricultural sciences. Shortages of such trained personnel are particularly acute in developing countries. This suggests that the research potential of the poorer nations may be greatly enhanced by improving domestic agricultural education programs and by providing incentives for repatriation of agricultural scientists educated abroad.

Sources of Productivity Differences Among Countries

In the following section, a total factor productivity index is derived for selected countries. Factors explaining productivity differences among countries are discussed and econometrically estimated.

A Total Factor Productivity Index

Following Hayami and Ruttan, we assume the existence of an intercountry or "meta-" production function which relates the ith country's output, Q, in a given year, t, to levels of the following inputs: land (A), labor (L), machinery (M), fertilizers (F), and livestock (S), which gives us:

$$(1)\quad Q_{it} = E_{it} \cdot F(A_{it}, L_{it}, M_{it}, F_{it}, S_{it}),$$

where F is a standard neoclassical production function and E_{it} is an index of total factor productivity. Each E_{it} is an indicator of how efficiently a country can use a given set of inputs at a particular time. An increase in the value of E due, for example, to technological advance means that a country can obtain more output from a given level of inputs than it could have done previously. An assumption is made that the function $F(A_{it}, L_{it}, M_{it}, F_{it}, S_{it})$ takes on a constant returns to scale, Cobb-Douglas form, so that:

$$(2)\quad F = A^{\alpha}_{it}\, L^{\beta}_{it}\, M^{\gamma}_{it}\, F^{\delta}_{it}\, S^{\eta}_{it},$$

where the terms α, β, τ, δ, and η are constant output elasticities. By rearranging equation (1), the total factor productivity (TFP) index for country i at time t is then expressed as a ratio of an output index to a weighted geometric average of inputs:

$$(3)\quad Eit = Q_{it}/(A^{\alpha}_{it}\, L^{\beta}_{it}\, M^{\gamma}_{it}\, F^{\delta}_{it}\, S^{\eta}_{it}).$$

Kawagoe and Hayami used econometric estimates of output elasticities from previous empirical studies to construct a cross-country TFP index using the weighting scheme: $\alpha = 0.45$, $\beta = 0.10$, $\gamma = 0.20$, $\delta = 0.15$, and $\eta = 0.10$. For the present study, we employ the same weights to construct a TFP index for 26 countries for the years 1970 and 1980. Data for the input and output variables come from Hayami and Ruttan, appendix A.

The productivity indexes E_{it} are presented in table 1. Countries are categorized by stage of development, where developing countries are those countries with a per capita GDP of less than $1,500 and developed countries are those with a per capita GDP of over $5,000. The countries in the middle stage of development are those with intermediate per capita GDP's. The productivity levels are normalized so that the U.S. TFP equals 100 for 1980. To partially control for periodic fluctuations due to such factors as weather, Hayami and Ruttan constructed their 1970 values as averages of data from 1967 to 1972 and the 1980 values as averages from 1975 to 1980.

The developing countries, as shown in table 1, experienced negative productivity growth between 1970 and 1980, with the notable exception of the Philippines, which posted a rate of growth double that of Japan for the same period. Note also in table 1 that although Mexico is semi-industrialized, its agricultural productivity is very low. However, Mexico did experience a small productivity increase. Also, the Philippines and Mexico have been the focuses of research and development of Green Revolution technologies for rice and for wheat, respectively.

Table 1--Indexes and average annual growth rates of agricultural total factor productivity for selected countries by stage of development, 1970 and 1980

Country	Total factor productivity level 1970 [1]	Total factor productivity level 1980 [2]	Average annual growth rate, 1970-80
	Index	Index	Percent
Developed:			
Australia	61.67	79.83	2.61
Austria	51.65	63.57	2.10
Belgium	83.25	106.48	2.49
Canada	70.53	82.24	1.55
France	59.97	73.20	2.01
West Germany	63.21	74.88	1.71
Japan	48.03	51.10	.62
Netherlands	69.91	95.94	3.22
New Zealand	89.77	95.80	.65
Norway	49.89	54.78	.94
Sweden	64.33	75.72	1.64
Switzerland	57.00	73.59	2.59
United Kingdom	63.59	73.74	1.49
United States	75.27	100.00	2.88
Middle stage:			
Argentina	59.49	74.54	2.28
Chile	28.24	31.87	1.22
Ireland	34.26	43.95	2.52
Israel	94.50	113.30	1.83
Mexico	17.66	18.21	.31
Spain	40.34	59.76	4.01
Venezuela	29.26	30.82	.52
Developing:			
Egypt	30.72	29.09	-.54
India	17.89	15.93	-1.15
Pakistan	18.95	16.40	-1.43
Peru	33.10	25.27	-2.66
Philippines	28.48	32.73	1.40

[1] 1967-72 averages.
[2] 1975-80 averages.

Factors Affecting Agricultural Productivity

The TFP measure E_{it} is not a fixed parameter. Rather, it is a function of a country's resource endowments as well as the level of investment in agricultural research, education, infrastructure, and technological knowledge borrowed from other countries. The relationship can be expressed as follows:

(4) E = [demographic pressure, land expansion, research, education, infrastructure, technology transfer].

Demographic Pressure

Yamada has identified three phases of economic development. In phase I, expansion of agricultural land outpaces the growth of the agricultural labor force, and the land/labor ratio increases as the number of agricultural laborers increases. Developing countries with extensive land frontiers, such as Thailand or Brazil in the 1950's and the United States in the last century, are representative of phase I countries.

Demographic pressure characterizes phase II countries, which face decreasing land/labor ratios in agriculture due to increased population growth and a relatively closed land frontier. Phase III countries are characterized by a falling absolute level of agricultural workers and by a rising land/labor ratio, brought about by farm mechanization and by the movement of the labor force out of agriculture and into industry.

Table 2 presents indicators of demographic pressure for selected countries. The developing countries and Mexico are phase II countries, while the other middle-stage countries and the developed nations have moved on to phase III. The general tendency among phase III countries is to show a decrease in the number of farms and an increase in the average size of farms. Among phase II countries, however, this tendency is reversed. Population pressure in phase II implies increased fragmentation of holdings as the number of farms increases and land per farm decreases.

Land Infrastructure

The stock of arable land can be increased and improved through public investment in irrigation, soil conservation, and other measures. Such investment relaxes the resource constraint on agricultural productivity. Moreover, in developing countries, the increased yield potential of improved seed varieties requires the reliable and controlled use of irrigation. Thus, investment in land quality complements investment in new agricultural technologies. The Food and Agriculture Organization (FAO) of the United Nations has estimated that land expansion will account for over 25 percent of the growth of agricultural output by the year 2000.

Research and Education

The ability of a country to develop and encourage adoption of new technologies is directly related to public investment in agricultural research and education. Table 3 presents cross-country comparisons of agricultural research and education. The stock of research knowledge may be approximated by the past decade's average of research investment. The research stock per farm may then be interpreted as an indicator of research intensity. Not only is research intensity higher among developed countries than among those still developing, but it is also growing at a faster rate. The same pattern holds with respect to agricultural education. The number of agricultural graduates per farmworker is also greater and is increasing faster in developed countries than in the still-developing ones.

Transportation and Communications Infrastructure

Following Antle (1984), infrastructure is here defined as "capital which has an effect on the cost of transportation and communication services" (p. 166). Reduction in transport costs improves the flow of agricultural inputs and outputs. Also, it improves extension contact. Improved communications, as well, increase farmers' information about new technologies and economic trends that can affect their management decisions.

Technological Borrowing and Agricultural Input Markets

The successful transfer of modern technologies from developed to still-developing countries has often been cited as a key to the economic development of the latter. A country may be thought of as having three methods of obtaining advanced technologies (Evenson and Binswanger). The first is direct transfer, achieved by the direct importation of modern agricultural inputs. The second is to modify imported technologies to suit local conditions through adaptive research. Finally, countries can undertake their own indigenous research programs.

Many developing countries rely heavily on the direct transfer of technologies through the importation of agricultural inputs. Evenson and Binswanger note that extreme dependence on imports may lower agricultural productivity. Imported technologies are often more suited to the resource endowments and production conditions of the country of origin than to those of the importing country. For example, capital-intensive technologies developed for agriculture in colder climates may be less

efficient in tropical agricultural regions of labor-abundant countries.

Dependence on imports is further increased in developing countries by the overvaluation of domestic currency, which makes imports relatively cheap. This type of market distortion can discourage indigenous research programs in favor of direct imports of technology and adaptive research, leading to a suboptimal allocation of research resources. Supply uncertainty, difficulty in obtaining spare parts, and monopoly control by trading companies can also lessen the gains of direct technology transfer.

This does not mean that developing countries do not obtain longrun benefits from direct technology transfer. However, heavy dependence on importation of inputs may be the sign of weak internal development of agricultural input industries and of market distortions. Such factors are fundamental barriers to productivity growth.

Several factors lead us to expect that a nation that pursues a strategy of expanding its exports in agricultural input markets can indirectly improve the productivity of its farms. First, international competition induces suppliers of inputs to develop improved technologies (Feder). This is

Table 2--Average annual growth rates of number of farms, land per farm, and land-labor ratios for selected countries by stage of development, 1970-80

Country	Number of farms	Agricultural land per farm	Land-labor ratio
		Percent	
Developed:			
Australia	-1.14	1.13	2.00
Austria	-.43	-.19	3.17
Belgium	-3.82	2.88	3.92
Canada	-1.43	1.53	3.87
France	-2.27	2.12	3.53
West Germany	-2.89	2.70	2.88
Japan	-1.38	.82	3.70
Netherlands	-2.54	1.83	1.79
New Zealand	1.03	-.36	.57
Norway	-1.97	1.42	.82
Sweden	-2.69	2.70	2.09
Switzerland	-3.72	3.85	3.52
United Kingdom	-1.56	1.36	1.31
United States	-2.02	1.99	3.87
Middle stage:			
Argentina	-.32	.36	1.22
Chile	1.80	-.90	1.65
Ireland	-.54	.71	3.10
Israel	-2.68	2.79	2.69
Mexico	1.49	-1.72	-1.72
Spain	-1.85	1.69	4.87
Venezuela	-1.06	1.59	2.62
Developing:			
Egypt	.44	-.42	-1.51
India	2.35	-2.09	-.36
Pakistan	1.23	-.88	-.88
Peru	6.21	-5.65	-5.65
Philippines	.64	.16	-.62

shown by the strong linkage between export levels of inputs and the patenting of new technologies in agriculture (USDA, 1989; Evenson, 1988). Orientation toward input exporting is thus an indicator of private sector investment in research and development. Also, farmers in the input-exporting country will themselves use the improved inputs, since new technologies are usually test-marketed locally. Economies of scale in distribution may also be present. Moreover, the sales and marketing divisions of the local input industries act as a form of private extension service, increasing the use of their products and helping producers learn how to use new inputs more efficiently.

Data and Estimation Procedure

TFP for country i at time t, E_{it}, is modeled as a function of investment in agricultural research, infrastructure, education, and economic structure as follows:

$$(5)\quad \log(E)_{it} = a_0 + a_1\log(RD/FARM)_{it} + a_2\log(GRAD)_{it} + a_3\log(IN)_{it} + a_4\log(AREXP)_{it} + a_5(NETEX)_{it} + a_6\log(DFARM)_{it} + e_{it},\ t = 1970, 1980,$$

Table 3--Agricultural research and education for selected countries by stage of development, 1970 and 1980

Country	Research investment per farm 1970	Research investment per farm 1980	Agricultural college graduates per 10,000 farmworkers 1970	Agricultural college graduates per 10,000 farmworkers 1980
	Dollars[1]		Number	
Developed:				
Australia	616.29	1,130.24	4.91	40.43
Austria	26.33	51.20	5.79	12.41
Belgium	97.66	317.59	10.75	54.11
Canada	428.89	851.53	9.35	75.81
France	42.86	171.57	2.11	4.81
West Germany	144.69	397.11	7.39	31.98
Japan	86.47	206.36	12.63	57.52
Netherlands	397.92	1,563.37	10.31	42.05
New Zealand	474.26	845.99	16.28	58.67
Norway	158.51	403.98	9.32	47.50
Sweden	188.45	623.72	6.55	34.02
Switzerland	105.73	306.02	5.26	17.03
United Kingdom	382.35	963.85	7.49	35.60
United States	246.75	536.97	21.21	135.14
Middle Stage:				
Argentina	42.76	60.32	2.75	9.43
Chile	41.55	38.70	1.08	14.65
Ireland	71.53	103.10	3.91	11.06
Israel	147.17	457.30	7.56	36.33
Mexico	4.39	14.82	.11	2.59
Spain	6.45	19.59	.79	5.53
Venezuela	82.24	133.59	.68	10.48
Developing:				
Egypt	3.99	4.39	2.14	10.79
India	.91	1.18	.39	.95
Pakistan	.81	1.06	.43	.87
Peru	3.09	5.95	1.63	4.61
Philippines	4.17	7.11	1.26	8.92

[1]In constant 1980 dollars.

where RD/FARM is the research stock per farm. The research stock, RD, is approximated by the past decade's average of public investment in agricultural research. This variable was constructed from data from the International Service for National Agricultural Research (ISNAR) by Pardey and Roseboom and from data reported in Boyce and Evenson, and Judd and others (1983). Decade averages rather than individual years were used because of data limitations and also so that research may be modeled as a stock variable. Since the results of a research project are generally not known until several years after the initial expenditures, research stock measures are more relevant in terms of effects on productivity than are single-year measures.

Following Antle, the variable for infrastructure, IN, is here measured as the GDP of a country's transportation and communications industries per square kilometer of land area. [2] Data for this variable come from the United Nations *Yearbook of National Accounts Statistics*. The variable NETEX is an index of net exports in agricultural input markets. It is equal to net exports of agricultural inputs divided by the aggregate input index. Data for imports and exports come from the USDA publication *World Agricultural Trends and Indicators, 1970-88, SB-781*.

Data for the variables GRAD, DFARM, and AREXP come from Hayami and Ruttan, appendix A. The variable GRAD, the number of agricultural college graduates per 10,000 farmworkers, reflects the potentially available locally trained research and extension personnel specific to agriculture in a country. Data collected at 5-year intervals during 1960-80 are used to approximate the decade averages. The variable DFARM, the ratio of the number of farms in the current year to the number of farms a decade earlier, captures the effects of demographic pressure on limited land resources. For developing countries, increased fragmentation of individual land holdings would imply a positive value for DFARM. For developed countries, a reduction in the number of farms implies the exit of less efficient farmers from agriculture. Both effects suggest a negative relationship between DFARM and agricultural productivity.

The variable AREXP is a measure of the rate of the expansion of arable land and is defined as the ratio of arable land at the end of the decade as compared with that 10 years earlier. AREXP serves as a measure of investment in land infrastructure and would thus be expected to have a positive effect on productivity. The public sector is often responsible for the increase (or for preventing the decrease) of arable land by direct investment in large-scale irrigation, by soil conservation programs, or by subsidizing private investments in land improvement. The net expansion of arable land may therefore serve as an indicator of the amount and efficacy of public sector investments in land infrastructure.

Empirical Results

The results of linear regression analysis of determinants of TFP in 26 countries are presented in table 4. Observations for the years 1970 and 1980 were pooled in a single equation. The stock of research per farm, RD/FARM, is positively and significantly associated with higher productivity. There are numerous reasons to expect that a given level of research investment would be more effective in countries with a relatively small number of large farms (the number of farms in a country is inversely related to average farm size). The cost of disseminating information about new technologies will increase with the number of farmers to be reached. Also, countries with fewer farms tend to have more homogeneous cropping patterns and agroclimatic conditions. Such countries can avoid the fixed costs of separate research centers for particular crops or regions. Research results from one center can also more easily be carried over to other regions in the same country. Lipton has stressed the importance of establishing a "congruence" between the agendas of public research agencies and farmers' technological demands. A small group of large farm owners in homogeneous agroclimatic regions could presumably articulate their demands for particular technologies at relatively low organization costs. Conversely, larger groups of small farm owners operating in diverse production environments would face greater costs in lobbying for new technologies.

The results also strongly support the hypothesis that investment in transportation and communications infrastructure is an important determinant of agricultural productivity. This finding is consistent with Antle's earlier regression estimation, based on international cross-section data from 1965, on the role of infrastructure. However, here the elasticity of total factor productivity with respect to infrastructural expenditures is less than 0.08, while Antle estimated it to be over 0.20. The discrepancy may be because the present study includes relatively fewer developing countries. Antle found the elasticity to be higher for a subsample of developing countries than for his combined developed and developing countries' sample.

Investment in communications and transportation infrastructure can enhance agricultural productivity in many ways. First, the transmission of information about prices, innovations, weather, and so forth is facilitated, thereby improving farmers' abilities to allocate resources

[2] Australia and Canada both have large areas of uninhabited land. For these countries, infrastructural services were measured per unit of agricultural land.

and adopt new technologies. Especially in developing countries, improved transportation infrastructure makes more efficient the agricultural marketing system, allowing farmers more timely access to scarce modern inputs (von Oppen and others) and reducing farm-to-market spoilage losses (Pinstrup-Anderson). Also, where adequate transport and storage facilities are lacking, local intermediaries often monopolize agricultural marketing in developing countries. This noncompetitive structure further restricts the flow of agricultural inputs and outputs (Pinstrup-Anderson). Moreover, lack of a sufficient transportation infrastructure can limit extension agents' access to farmers (USDA, 1976).

Economic theory suggests that the increase of both demographic pressure and of land fragmentation would have a negative impact on productivity for several reasons. First, faced with a dwindling amount of land, farmers may be pressed into using intensive techniques which eventually lead to soil depletion, or such farmers may move on to less productive lands. Second, many factors limit the adoption of modern technologies on smaller farms. For example, adoption of modern Green Revolution technologies often require lump-sum capital investments in irrigation wells or in other equipment. Since fixed costs per acre decline with farm size, such investments are relatively more costly for small farms and are therefore less likely to be adopted. Moreover, access to credit is proportional to land ownership if the land is held as collateral.

We have attempted to capture the negative impacts of demographic pressure on scarce land by the rate at which the number of farms increases, represented by DFARM. As predicted, the sign of the coefficient of DFARM is negative, which suggests that demographic pressure is a major barrier to productivity growth. The coefficient of AREXP is positive and highly significant (at the 0.1 percent level), which supports the arguments of Hayami and Ruttan, and Lipton that expansion of the amount of arable land stock is a major precondition for agricultural development. As noted above, productivity in agriculture also appears linked to the trade position of a country's agricultural input markets. The empirical evidence

Table 4--Linear regression analysis of the determinants of agricultural total factor productivity in 26 countries, 1970 and 1980[1]

Explanatory variable [Definition]	Estimated coefficient	Standard error	t-ratio[2]
log(RD/FARM) [research stock/number of farms]	0.06886	0.030615	2.2493
log(IN) [GDP of transportation and communications industries/total land area]	.07534	.027609	2.7288
log(AREXP) [arable land at end of decade/ arable land at beginning of decade]	.89143	.254090	3.5084
log(DFARM) [number of farms at end of decade/ number of farms at beginning of decade]	-.68291	.175500	-3.8911
NETEX [value of net exports of agricultural inputs/aggregate input index]	.02449	.006501	3.7675
log(GRAD) [number of agricultural college graduates/10,000 farmworkers]	.10869	.040391	2.6909
Constant	4.02750	.147510	27.3040

R-square = 0.8406 R-square adjusted = 0.8193 Log of the likelihood function = 5.68540

[1]The dependent variable is log(TFP), the logarithm of the total factor productivity index for agriculture.
[2]Forty-four degrees of freedom.

suggests that, all else being equal, nations that export inputs have higher productivity than countries that rely on imported inputs. The position of exporter here is closely linked to local patents activity and private sector research and development. This conclusion is consistent with the argument made by Feder that export orientation in one sector of the economy can benefit other sectors of an economy.

The stock of agricultural graduates, GRAD, had a significant, positive impact on productivity. Recent agricultural graduates make up the pool of available extension and research workers that directly influences the development and adoption of new technologies. Such a group may also reflect the level of advanced training obtained by some farm operators themselves.

Kawagoe and Hayami found that TFP rankings among countries at similar stages of economic development are sensitive to the output elasticity parameters employed in equation (2), although they are robust among groups of countries at different stages of development. These authors cautioned that great care should be taken in using the geometric TFP index to make comparisons among countries at the same stage of development. We therefore ran the TFP regressions using alternative sets of factor weights. Our basic results were not qualitatively changed when different factor weights were employed.

Supply and Demand for Agricultural Research

In this section, we present a conceptual supply-demand model for public investment in agricultural research. The demand for research is modeled as a function of the pressure exerted by interest groups. Agricultural producers are assumed to be the primary interest group affecting agricultural research. The demand for research, thus, is a function of those factors which influence farmers' desire and ability to lobby effectively for research investment. In this respect, the model is in the tradition of earlier work by Guttman, Huffman and Miranowski, Rose-Ackerman and Evenson, Huffman and McNulty, and Judd and others (1986).

The actual supply of research is determined by the availability of trained scientific personnel, with the number of researchers acting as a capacity constraint that limits how many projects can be carried out in a given year.

Demand

Economic theories of collective action argue that the effectiveness of an interest group in obtaining government assistance will increase with the size and degree of organization of that group (Olson, Stigler, Guttman). However, the degree of group organization is inversely related to group size (Olson, Huffman and McNulty). This relationship occurs because of economic "free riding." A free rider is someone who benefits from a funded activity without contributing to its cost. Individuals will not join a collective action, such as lobbying for research, if they believe that their own participation will have little effect on the government's action.

Olson has argued that free riding is easier to control in small groups because each individual's marginal contribution to overall lobbying effectiveness is greater. Nonparticipation significantly reduces the probability that the action will be taken; it reduces the expected gain. Smaller groups are also usually more homogeneous, which reduces the organization costs of obtaining a policy consensus. It is therefore possible for the overall lobbying effectiveness of the farm sector to be maintained (or to increase) even when the total farm population is declining. Numerous reasons explain why a country's demand for research should increase as output per farm increases. Huffman and Miranowski point out that absolute cost savings from new technologies would be greater for larger farms. Larger farms would therefore have greater incentive to share in group lobbying for public research investment. Interest group power is positively related to the wealth of group members, with output per farm being a fairly good indicator of wealth. Thus, the farm sector becomes a more efficient lobbying force as productive capacity of each farm increases.

Conversely, in developing countries, population pressure on limited land and the fragmentation of land holdings combine to make a farm sector composed of many smaller operational units. Most of the small peasant producers relate to agriculture more as consumers of food and suppliers of labor than as producers. To this group, the benefits of improved technologies may be far less obvious and the absolute gains of research will be relatively small. This will be especially true if credit constraints or other factors limit these farmers' access to the new technologies. For small landowners, migration out of agriculture altogether may be preferable to lobbying for new technologies (Nugent).

Agricultural research to obtain greater output for each level of inputs is just one method of gaining increased agricultural production. Agricultural growth can also come from increasing the availability of conventional inputs (Judd and others, 1986). Specifically, investment in land infrastructure can increase the amount of arable land through drainage, irrigation, or terracing. The soil quality of existing land may also be preserved or enhanced. Public investments in land infrastructure and scientific research often complement each other to increase output. For example, improved seed varieties may require reliable

irrigation or superior soil quality. However, these types of investments can also compete with each other because they compete for limited public funds for agriculture. In addition, countries with sizable land frontiers or countries for which expansion of the arable land is relatively inexpensive may invest relatively less in scientific agricultural research. It is the countries which have reached the margin of their land frontiers that may most profitably increase their investment in land-saving technologies. One might, therefore, expect to find an inverse relationship between possible arable land expansion and agricultural research.

Supply

The primary factor that influences the supply of agricultural research is the availability of trained agricultural scientists and researchers. Shortages of trained scientific personnel would bid up salaries and increase the cost per scientist for research projects. Because of shortages of scientific labor, developing countries often resort to the importation of relatively expensive foreign researchers from more developed countries. These researchers, often placed at international institutes, are paid salaries more comparable to those in their home countries than those at the host agricultural research centers. The labor costs of research are thus a function of the extent (or lack) of technical education in a country.

The government's willingness to fund agricultural research will also depend on the size and organization of nonfarm interest groups who compete for public funds. Studies have tried to assess the effect of nonfarm interest groups by modeling agricultural research funding as a function of the proportion of the farm population to total population (Rose-Ackerman and Evenson, Judd and others, 1986). The empirical results are somewhat mixed, however.

Data, Variables, and Model Specification

The stock of agricultural research for country i for decade t is modeled as a function of the following variables:

$$(6)\quad \log(RD/FARM)_{it} = b_0 + b_1\log(SY/FARM)_{it-1} + b_2\log(LAL)_{it} + b_3\log(FARM_{it}) + b_4\log(AREXP)_{it} + b_5\log(OUT/FARM)_{it-1} + b_6DYR_{it} + u_{it}.$$

The dependent variable (RD/FARM) is defined as in equation (3), where RD is the decade average of expenditures for public research. The variable SY, the number of scientist-years devoted to public agricultural research at the beginning of the decade, is a measure of the availability of trained research personnel. Data for this variable come from Boyce and Evenson. The remaining variables have all been derived from data published in Hayami and Ruttan, appendix A. The variable LAL is the ratio of nonagricultural labor to the total labor force, and FARM is the number of farms (agricultural holdings). Both variables are decade averages.

The variable AREXP, the ratio of arable land at the end of the decade to arable land at the beginning of the decade, again is meant to capture the effects of irrigation and other land improvements. Judd and others (1986) argue that a low value of this ratio implies that the cost of land expansion is relatively high and that countries will then invest more to gain technological improvements through research. A high value, conversely, implies that investments in land expansion is a relatively cheap substitute for research. Implicit in this argument is the notion that land expansion and scientific research are competing for limited public funds.

The variable OUT/FARM is the level of aggregate agricultural output per farm at the beginning of the decade. Inclusion of output as an explanatory variable acknowledges the positive feedback effect between research and output (Pardey and Craig). The beginning-of-decade value was chosen because it is largely exogenous to the decade average of research investment.

The variable DYR is a dummy variable which takes on the value of 1 if the decade of observation is 1970-79 and zero if it is 1960-69. The term u_{it} is a normally distributed random error term with mean zero.

Empirical Results

Table 5 presents the results of linear regression analysis of the determinants of expenditures for public agricultural research in 26 countries. The model explains expenditure levels remarkably well, with an R^2 coefficient of over 0.93, which is quite high for an intercountry study of this type.

The availability of trained research scientists at the beginning of the decade has a strong positive effect on future research expenditures. Research expenditures also increase as the productive capacity per farmer (measured by OUT/FARM) increases. As discussed above, larger farms are better able to appropriate absolute gains from agricultural research. This also means that, holding the number of farms constant, the research stock is increasing with the absolute level of output. In other words, research investment is increasing with the absolute importance of agriculture in an economy.

The regression coefficient for log(FARM) is the elasticity of the research stock per farm (RD/FARM) with respect to

the number of farms. The negative value of this coefficient implies that research expenditures per farm increase as the number of farms decline. The elasticity of the research stock (RD) with respect to the number of farms can be calculated from the regression coefficients as $1 - (0.61532 + 0.22422 + 0.17293) \approx 0$.

These results are consistent with the thesis of countervailing forces in the determination of farm lobbying power. As group size increases, more farmers appear with an economic interest in agricultural research, but the costs of organizing these people also increase. At the same time, the expected payoff from taking part in lobbying efforts declines. Our estimate that the elasticity of research expenditures with respect to the number of farms is approximately zero suggests that these countervailing forces cancel each other out, at least for the countries in the sample.

Research expenditures also rise with the level of industrialization, measured by the ratio of nonagricultural labor to the total labor force (LAL). This finding is consistent with the regression results of Judd and others (1986, table 9) but at odds with the argument that an increasing nonfarm population should be able to divert funds from agriculture. What could explain this result? First, industrialization may cause changes which dampen resistance to investment in agricultural research. Developing countries have relatively heterogeneous farm populations and small, organized urban populations. In more developed countries, the pattern is reversed. The farm sector is relatively small, homogeneous, and organized compared with the multitude of nonfarm interest groups. Also, the costs of agricultural research in industrialized countries are relatively small compared with overall government expenditures, even though they are large in absolute terms. The variable LAL may also

Table 5--Linear regression analysis of the determinants of public agricultural research expenditures in 26 countries (decade averages 1960-69 and 1970-79)[1]

Explanatory variables [definition]	Estimated coefficient	Standard error	t-ratio[2]
log(SY/FARM) [agricultural research scientist-years per number of farms]	0.61532	0.10670	5.7684
log(LAL) [ratio of nonagricultural labor to total labor force]	2.51640	.46586	5.4017
log(OUT) [agricultural output at beginning of decade]	.22422	.11119	2.0165
log(AREXP) [ratio of arable land at end of decade to arable land at beginning of decade]	-1.16100	.48396	-2.3989
log(FARM) [number of farms]	-.17293	.06602	-2.6193
DYR [binary variable; = 1 if period = 1970-79, = 0 if period = 1960-69]	-.22491	.14295	-1.5734
Constant	-12.61400	1.98950	-6.3403

R-square = 0.9417 R-square adjusted = 0.9339 Log of the likelihood function = -39.1064

[1]The dependent variable is log(RD/FARM), the logarithm of the average public expenditure on agricultural research per farm for decades 1960-69 and 1970-79 in 1980 U.S. million dollars.
[2]Forty-five degrees of freedom.

represent an income effect on the demand for agricultural research. Since LAL is highly correlated with per capita income, it is possible that agricultural research (or, for that matter, any scientific research) is a normal good.

The sign of the coefficient of the land expansion variable AREXP is negative and significant, which is consistent with the hypothesis put forth by Judd and others (1986) that land expansion is a substitute for scientific research.

Conclusions

The empirical analysis of the first section of the report indicates that productivity differences among countries can be largely explained by differences in (1) public research investment, (2) technical education in agricultural sciences, (3) demographic pressure on land resources, (4) communications and transportation infrastructure, (5) investment in land expansion or improvement, and (6) trade orientation of agricultural input markets. Public investments in research, education, and infrastructure are necessary not only to increase agricultural productivity but, particularly in developing countries, to counteract the negative effects of population pressure.

Investments in irrigation increase both the amount and the quality of arable land and also increase adoption of modern seed-fertilizer packages in developing countries. Evenson and Kislev, in agreement with this study, found at the national level no evidence of an increase in agricultural productivity in India between 1970 and 1980. However, their analysis at the State level revealed that those areas with relatively rapid adoption of Green Revolution technologies, with controlled use of water, made marked gains in productivity. In contrast, dryland areas suffered rather large productivity losses. Research by international centers such as the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and International Rice Research Institute (IRRI) have as yet had only modest successes at increasing yields of dryland crops. This suggests that future investment in irrigation and water management in such dry areas remains essential to productivity growth.

There generally appears to be a continued and important role for productivity-enhancing government investment in agriculture. However, the role of research by the private sector in agricultural input industries also continues to grow. Data on private research and development (R&D) are very incomplete, but what data do exist indicate that levels of private R&D investment in developed countries appear comparable with those of public investment (Boyce and Evenson). In the developing nations, however, the level of private R&D is often much lower. However, one exception is the Philippines, where Pray and Neumeyer have estimated that private R&D accounts for nearly 40 percent of total agricultural R&D. This case is particularly notable considering that the Philippines was the only developing country in our sample to post positive productivity gains in 1970-80 (see table 1). To our knowledge, this paper represents the first attempt to analyze empirically the effect of trade orientation in markets for agricultural inputs on productivity. The econometric findings lend support to the arguments that (1) extreme dependence on imported inputs is a signal of structural barriers to the growth of productivity and (2) that orientation toward exports of such inputs can indirectly improve farm productivity. Further study of these linkages between input trade patterns and agricultural productivity seems warranted.

The results of the second section of this report suggest that economic theories of collective action can be highly useful in explaining those differences in agricultural research that exist among nations. Specifically, such theories are able to explain such matters as why countries spend more on agricultural research even as the relative economic importance of agriculture declines. We have argued here that farm groups have become wealthier and more organized as the number of farms declines. Increased wealth and organization compensate for reductions in group size to increase the overall effectiveness of the farm lobby.

The empirical evidence also suggests that investments in land infrastructure, as measured by arable land expansion, compete with scientific research for limited funds. Countries that find it cheaper to increase output through land expansion devote relatively less investment funds to scientific research. Conversely, countries facing a binding land constraint must invest more in research for new, often land-saving, technologies.

The ability to carry out research projects can be constrained by shortages of personnel trained in agricultural sciences. This constraint on research is particularly acute in developing countries, suggesting that the research potential of poorer nations may be greatly enhanced by improved domestic agricultural education and by providing incentives for repatriation of agricultural scientists educated abroad.

References

Antle, J. "Infrastructure and Aggregate Agricultural Productivity: International Evidence," *Economic Development and Cultural Change* 31 (1983): 609-19.

_____, "Human Capital, Infrastructure, and the Productivity of Indian Rice Farmers," *Journal of Development Economics* 14 (1984): 163-81.

Bardhan, P. *Land Labor and Rural Poverty: Essays in Development Economics*. New York: Columbia University Press, 1984.

Boyce, J., and R. Evenson. *National and International Agricultural Research and Extension Systems*. New York: Agricultural Development Council, 1975.

Evenson, R. "Private Sector Agricultural Invention in Developing Countries," *Policy for Agricultural Research*. Eds. V. Ruttan and C. Pray. Boulder: Westview Press, 1988.

_____, and H. Binswanger. "Technology Transfer and Research Resource Allocation," *Induced Innovation*. Eds. H. Binswanger and V. Ruttan. Baltimore: Johns Hopkins University Press, 1978.

_____, and Y. Kislev. *Agricultural Research and Productivity*. New Haven: Yale University Press, 1975.

Feder, G. "On Exports and Economic Growth," *Journal of Development Economics* 12 (1982): 59-73.

Guttman, J. "Interest Groups and the Demand for Agricultural Research," *Journal of Political Economy* 86 (1978): 467-84.

Hayami, Y., and V. Ruttan. *Agricultural Development: An International Perspective*. Baltimore: Johns Hopkins University Press, 1985.

Huffman, W.E., and M. McNulty. "Endogenous Local Public Extension Policy," *American Journal of Agricultural Economics* 67 (1985): 761-768.

_____, and J. A. Miranowski. "An Economic Analysis of Expenditures on Agricultural Experiment Station Research," *American Journal of Agricultural Economics* 63 (1981): 104-118.

Judd, A., J. Boyce, and R. Evenson. *Investing in Agricultural Supply*. Discussion Paper No. 442. Yale University, Economic Growth Center, 1983.

_____, J. Boyce, and R. Evenson. "Investing in Agricultural Supply: The Determinants of Agricultural Research and Extension Investment," *Economic Development and Cultural Change* 35 (1986): 77-113.

Kawagoe, T., and Y. Hayami. "An Intercountry Comparison of Agricultural Production Efficiency," *American Journal of Agricultural Economics* 67 (1985): 87-92.

Kendrick, J.W. *Understanding Productivity: An Introduction to the Dynamics of Productivity Change*. Baltimore: Johns Hopkins University Press, 1977.

Lipton, M. "The Place of Agricultural Research in the Development of Sub-Saharan Africa," *World Development* 16 (1988): 1231-57.

Nugent, J. "Applications of the Theory of Transactions Costs and Collective Action to Development Problems and Policy." Paper prepared for the conference on "The Role of Institutions in Economic Development," Cornell University, Ithaca, NY, Nov. 14-15, 1986.

Olson, M. *The Logic of Collective Action: Public Goods and the Theory of Groups*. New York: Shocken Books, 1968.

Pardey, P., and B. Craig. "Causal Relationships between Public Sector Agricultural Research Expenditures and Output," *American Journal of Agricultural Economics* 71 (1989): 9-19.

_____, and J. Roseboom. *International Service for National Agricultural Research Indicator Series: A Global Data Base on National Agricultural Research Systems*. Cambridge, England: Cambridge University Press, 1989.

Pinstrup-Anderson, P. *Agricultural Research and Technology in Economic Development*. New York: Longman Group Ltd, 1982.

Pray, C., and C. Neumeyer. "Problems of Omitting Private Investments in Research when Measuring the Impact of Public Research," *Methods of Diagnosing Research System Constraints and Assessing the Impact of Agricultural Research*. The Hague: International Service for National Agricultural Research, 1990.

Ricardo, D. *The Principles of Political Economy and Taxation*. London: Dent and Son, 1937.

Rose-Ackerman, S., and R. Evenson. "The Political Economy of Agricultural Research and Extension: Grants, Votes, and Reapportionment," *American Journal of Agricultural Economics* 67 (1989): 1-14.

Stigler, G. "Free Riders and Collective Action: An Appendix to Theories of Economic Regulation," *Bell Journal of Economics* 5 (1974): 359-65.

United Nations, *Production Yearbook*. Various years.

_____, *Yearbook of National Account Statistics*. Various years.

_____, Food and Agriculture Organization. *Agriculture: Toward 2000*. Rome, 1979.

U.S. Department of Agriculture, Economic Research Service. *Egypt: Major Constraints to Increasing Agricultural Productivity*. FAER-120. 1976.

_____, Economic Research Service. *World Agricultural Trends and Indicators, 1970-88*. SB-781. 1989.

Von Oppen, M., P. Parthasarathy Rao, and K.V. Subba Rao. "Impact of Market Access on Agricultural Productivity in India," *Agricultural Markets in the Semi-arid Tropics: Proceedings of the International Workshop*. Patancheru, India: International Crops Research Institue for the Semi-Arid Tropics, 1983.

Yamada, S. "Agricultural Growth and Productivity in Selected Asian Countries," *Productivity Measurement and Analysis: Asian Agriculture*. Tokyo: Asian Productivity Organization, 1987.

* U.S. G.P.O.:1991-281-091:40049/ERS

A USDA/ERS BRIEFING BOOKLET

THE 1990 FARM ACT AND THE 1990 BUDGET RECONCILIATION ACT

How U.S. Farm Policy Mechanisms Will Work Under New Legislation

This new 40-page booklet, explaining new farm legislation, has just been released by the Economic Research Service of the U.S. Department of Agriculture. This booklet explains the main features of the new 5-year farm law in easy-to-follow pages of illustrative material. These "verbal graphics" act as a self-programmed instruction method, as the reader easily proceeds from one point to another. The booklet works in the same general way as an informal briefing which makes its points step-by-step with overhead transparencies.

The booklet begins with an overview of the goals which motivated changes in farm legislation, accompanied by the most important mechanisms that support them.

Main goals		**Basic Mechanisms**
Reduce the Federal deficit	→	Reduce payment acres
Improve agricultural competitiveness	→	Permit planting flexibility; Maintain market-oriented loan rates
Enhance the environment	→	Implement Agricultural Resources Conservation Program

The booklet then proceeds with definitions and illustrations of basic mechanisms of farm policy for the next 5 years:

- Target Price
- Crop Acreage Base
- Payment Limitation
- Loan Rates
- Zero-92
- Deficiency Payments
- Farmer-Owned Reserve

To order your copy of this timely publication, just dial 1-800-999-6779. Call toll free in the United States and Canada. Other areas, dial 301-725-7937. Ask for "The 1990 Farm Act and the 1990 Budget Reconciliation Act," order # MP-1489.

Cost per copy is $8.00. Non-U.S. addresses (including Canada), please add 25 percent. Charge your purchase to your VISA or MasterCard, or we can bill you. Or send a check or purchase order, made payable to ERS-NASS, to: ERS-NASS
P.O. Box 1608
Rockville, MD 20849-1608

We'll fill your order by first-class mail. We offer a 25-percent discount when you order 25 or more copies to one address.

Get these timely reports from USDA's Economic Research Service

These periodicals bring you the latest information on food, the farm, and rural America to help you keep your expertise up-to-date. Order these periodicals to get the latest facts, figures, trends, and issues from ERS.

Agricultural Outlook. Presents USDA's farm income and food price forecasts. Emphasizes the short-term outlook, but also presents long-term analyses of issues ranging from international trade to U.S. land use and availability. Packed with more than 50 pages of charts, tables, and text that provide timely and useful information.

Economic Indicators of the Farm Sector. Updates economic trends in U.S. agriculture. Each issue explores a different aspect of income and expenses: national and State financial summaries, production and efficiency statistics, and costs of production for livestock and dairy and for major field crops.

Farmline. Concise, fact-filled articles focus on economic conditions facing farmers, how the agricultural environment is changing, and the causes and consequences of those changes for farm and rural people. Synthesizes farm economic information with charts and statistics.

Foreign Agricultural Trade of the United States. Every 2 months brings you quantity and value of U.S. farm exports and imports, plus price trends. Subscription includes two big 300-page supplements containing data for the previous fiscal or calendar year. A must for traders!

Journal of Agricultural Economics Research. Technical research in agricultural economics, including econometric models and statistics on methods employed and results of USDA economic research.

National Food Review. Offers the latest developments in food prices, product safety, nutrition programs, consumption patterns, and marketing.

Rural Conditions and Trends. Tracks rural events: macroeonomic conditions, employment and underemployment, industrial structure, earnings and income, poverty and population.

Rural Development Perspectives. Crisp, nontechnical articles on the results of the most recent and the most relevant research on rural areas and small towns and what those results mean.

☐ Check here for a **free** subscription to *Reports*, a quarterly catalog describing the latest ERS research reports. It's designed to help you keep up-to-date in all areas related to food, the farm, the rural economy, foreign trade, and the environment.

See other side for other periodicals available from ERS!

	1 year	2 years	3 years
Agricultural Outlook (11 per year)	_____ $26	_____ $51	_____ $75
Economic Indicators of the Farm Sector (5 per year)	_____ $14	_____ $27	_____ $39
Farmline (11 per year)	_____ $12	_____ $23	_____ $33
Foreign Agricultural Trade of the United States (8 per year)	_____ $25	_____ $49	_____ $72
Journal of Agricultural Economics Research (4 per year)	_____ $8	_____ $15	_____ $21
National Food Review (4 per year)	_____ $11	_____ $21	_____ $30
Rural Conditions and Trends (4 per year)	_____ $14	_____ $27	_____ $39
Rural Development Perspectives (3 per year)	_____ $9	_____ $17	_____ $24

Complete both sides of this order form.
Single copies of all periodicals available for $8.00 each.

Save by subscribing for up to 3 years!

Situation and Outlook Reports. These reports provide timely analyses and forecasts of all major agricultural commodities and related topics such as finance, farm inputs, land values, and world and regional developments.

	1 year	2 years	3 years
Agricultural Exports (4 per year)	_____ $12	_____ $23	_____ $33
Agricultural Income and Finance (4 per year)	_____ $12	_____ $23	_____ $33
Agricultural Resources (5 per year, each devoted to one topic, including *Inputs*, *Agricultural Land Values and Markets*, and *Cropland, Water, and Conservation*.)	_____ $12	_____ $23	_____ $33
Aquaculture (2 per year)	_____ $12	_____ $23	_____ $33
Cotton and Wool (4 per year)	_____ $12	_____ $23	_____ $33
Dairy (5 per year)	_____ $12	_____ $23	_____ $33
Feed (4 per year)	_____ $12	_____ $23	_____ $33
Fruit and Tree Nuts (4 per year)	_____ $12	_____ $23	_____ $33
Livestock and Poultry (6 per year plus 2 supplements)	_____ $17	_____ $33	_____ $48
Livestock and Poultry Update (monthly)	_____ $15	_____ $29	_____ $42
Oil Crops (4 per year)	_____ $12	_____ $23	_____ $33
Rice (3 per year)	_____ $12	_____ $23	_____ $33
Sugar and Sweetener (4 per year)	_____ $12	_____ $23	_____ $33
Tobacco (4 per year)	_____ $12	_____ $23	_____ $33
Vegetables and Specialties (3 per year)	_____ $12	_____ $23	_____ $33
U.S. Agricultural Trade Update (monthly)	_____ $15	_____ $29	_____ $42
Wheat (4 per year)	_____ $12	_____ $23	_____ $33
World Agriculture (4 per year)	_____ $12	_____ $23	_____ $33
Agriculture and Trade Reports (5 per year) Supplement your subscription to *World Agriculture* by subscribing to these five annuals: *Western Europe*, *Pacific Rim*, *Developing Economies*, *China*, and *USSR*.	_____ $12	_____ $23	_____ $33

For *fastest* service, call toll free: 1-800-999-6779 (8:30-5:00 ET in the U.S. and Canada; other areas please call 301-725-7937)

- Use purchase orders, checks drawn on U.S. banks, cashier's checks, or international money orders.
- ***Make payable to ERS-NASS.***
- Add 25 percent for shipments to foreign addresses (includes Canada).

Name _____

Organization _____

Address _____

City, State, Zip _____

Daytime phone (_____)_____

☐ Bill me. ☐ Enclosed is $_____.

Credit Card Orders:

☐ MasterCard ☐ VISA Total charges $ _____.

Credit card number: ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐ **Expiration date:** ☐☐ **Month / Year**

Complete both sides of this order form and mail to:

ERS-NASS
P.O. Box 1608
Rockville, MD 20849-1608