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AGRICULTURAL DEVELOPMENT IN GREECE, MEXICO AND TAIWAN

Wade F. Gregory, Chief
Economic Development Branch
Foreign Development and Trade Division

> There is one quality more important than "know-how ..." This is "know-what" by which we determine not only how to accomplish our purposes, but what our purposes are to be ... Whether we entrust our decisions to machines or metal, or to those machines of flesh and blood, bureaus and vast laboratories and armies and corporations, we shall never receive the right answer to our questions unless we ask the right questions.
>
> Norbert Wiener

The above quotation appears at the beginning of the chaper entitled "Organizing for the Task" in the recently released report on The World Food Problem by the President's Science Advisory Committee. The Economic Research Service of the U.S. Department of Agriculture, under AID sponsorship, has been carrying out a long-range research project on Factors Associated with Differences and Changes in Agricultural Production in Underdeveloped Countries. In this research, we have tried to seek answers to the right questions and my task today is to discuss the findings with you for three countries which are often referred to as success stories: Greece, Mexico, and Taiwan. The point of this discussion being, I presume, to try to understand the factors responsible for their rapid growth and to determine their applicability for your countries.

The development pattern in each of these countries is similar in some respects and different in others. In all three countries, actions by the respective governments were important motivating forces.

Greece, the first country discussed, relied considerably on profit motivation and regulated market forces to bring about increased output of the products in shortest supply. Government programs manipulated factor and product prices for selected inputs and products to insure that the production of the most

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Paper presented at the CENTO conference on Agricultural Development Policy, Istanbul, Turkey, September 11-16, 1967.

The paper draws heavily on the work done by Lawrence H. Shaw in Greece, Reed Hertford in Mexico, and David H. Spaeth in Taiwan as part of a larger AID sponsored research project being conducted by the Economic Research Service, U.S. Department of Agriculture.

needed crops would be profitable. In addition, integrated credit, input, supply and management programs were developed to encourage and enable farmers to obtain the necessary inputs for increased output. Underlying these programs were research and extension activities to develop new technology and to help speed the rate of adoption of the new technology.

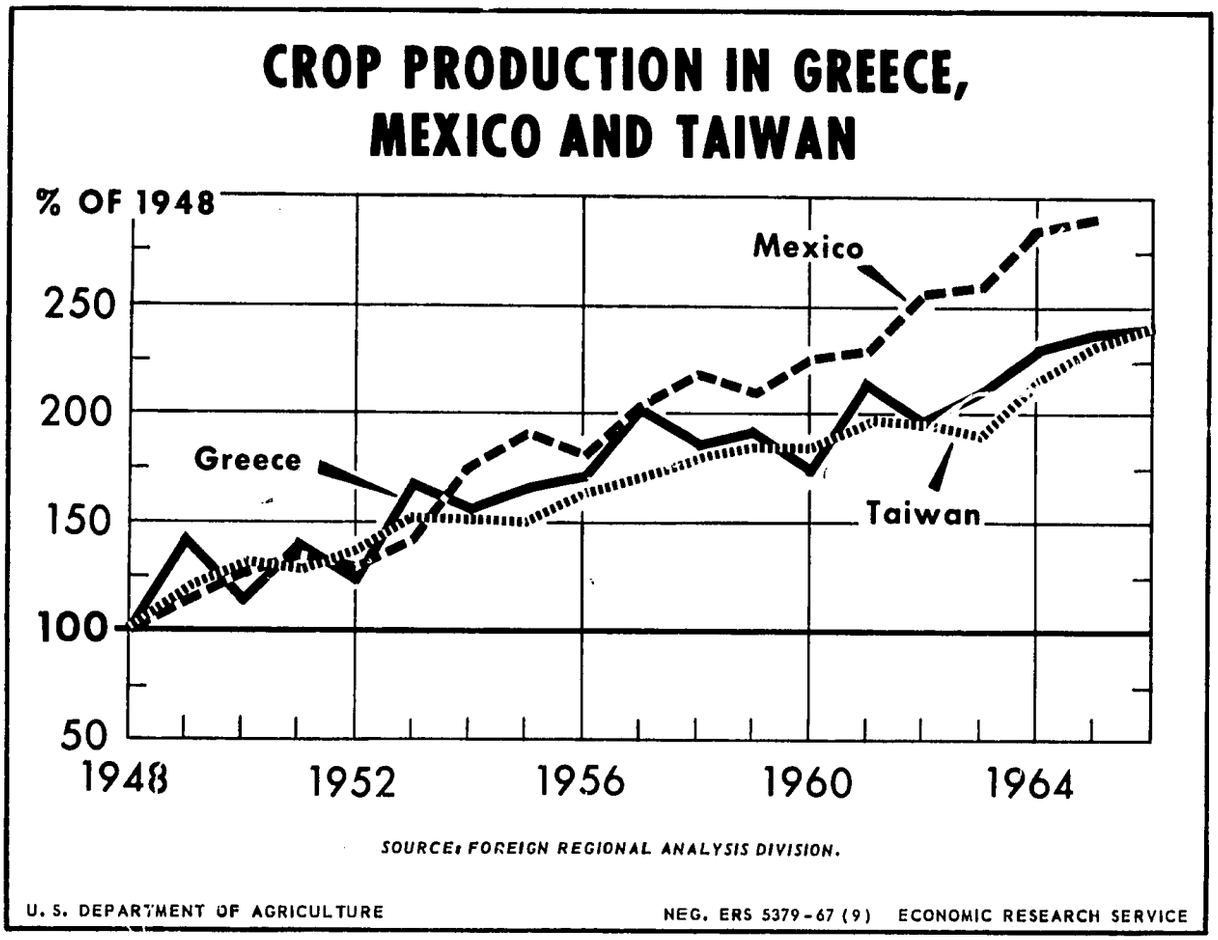
In Mexico, where there was much unused land, the initial increase in output came largely from an expansion of cropland area. Later, as research results produced improved varieties and production practices, yields increased rapidly and became the major component of increased agricultural output. Favorable factor and product prices, which made the adoption of the new technology profitable, appear to be one of the major factors explaining the rapid adoption of yield increasing technology in Mexico.

Taiwan's development departs somewhat from that of Greece and Mexico in that development in Taiwan was much more purposeful, planned and deliberate. As with the case of both Greece and Mexico, research pointed the way for program formulation and execution, and increased income was the motivating force that prompted Taiwan farmers to adopt output increasing technology emanating from the research stations. However, one of the great differences was that development plans in Taiwan were two-edged. Programs were so structured that farmers were rewarded through higher profits if they adopted output increasing practices, but were penalized through lower incomes if programs were not carried out. To accomplish this, rather comprehensive planning was required which involved a cross-section of all groups in the process--from top level government policy-makers down to individual cultivators. It also meant that agricultural sectoral plans had to be developed and corrdinated with overall national development plans to insure complementarity of efforts between the several sectors of the economy.

Since agricultural production is essentially a biological process, it can proceed no faster than the development of improved varieties of plants and animals and accompanying improved cutlural practices permit it to proceed. Therefore, the development, either through original or adaptive research, of a body of improved practices is of great importance. The discussion on Mexico partially emphasizes the role of research in Mexican agricultural development.

While essential, the availability of a body of improved practices is not a sufficient condition for rapid increases in output. The other necessary ingredient is the ability of a society or economy to provide the organization and incentives to get the improved technology used. The Taiwan case is noteworthy for the manner in which it was able to bring about change in various aspects to enable and to encourage farmers to adopt improved practices.

To briefly summarize agricultural development in each country, output changes are presented, Figure 1.



Index of Crop Output

Year	Greece	Mexico	Taiwan
1948	100	100	100
1949	142	115	118
1950	115	127	130
1951	138	133	129
1952	125	129	137
1953	167	142	152
1954	156	175	152
1955	165	190	150
1956	171	181	163
1957	200	200	171
1958	185	217	180
1959	192	210	184
1960	173	225	184
1961	213	229	196
1962	196	256	196
1963	210	258	189
1964	229	285	216
1965	237	290	232
1966	240	---	239

GREECE

Agricultural output in Greece increased at the annual rate of 5 percent since 1948. As such, the agricultural sector was responsible for nearly one-fourth of the total increase in economic growth since World War II. Immediately after the war, agricultural output increased at the rather rapid rate of 6.0 percent per year, but slowed down to around 4.5 percent after the mid-fifties.

Increases in output were the result of increased quantities of inputs used as well as a change in the relative composition of the inputs. Twenty-one percent of increased crop output was the result of increased cropland; 73 percent, the result of increased productivity (interaction accounted for the remaining 6 percent).

The growth in agricultural output occurred with only moderate increases in the use of land or labor. Labor inputs increased only 9 percent and land inputs 28 percent in the postwar period. Capital inputs, however, increased substantially as agricultural production became increasingly dependent on the nonagricultural sector of the economy. Among the capital inputs, the fastest rate of increase occurred in fertilizer which increased nearly four times from 1948 to 1963, growing at the rate of 11.0 percent a year. In 1948/50, 80 percent of total inputs were land and labor, inputs in large part owned by agricultural producers. By 1961/63, these inputs represented only 69 percent of total inputs, for the use of purchased inputs (fertilizer, machinery, etc.) had increased more than 50 percent.

As a result of this changed input mix, agricultural productivity increased 49 percent from 1948/50 to 1961/63 or 3.1 percent a year. Labor productivity increased at the rate of 4.9 percent a year, and land productivity at 3.7 percent. In the case of land, increased fertilizer use allowed substantial increases in output without expanding the land area. Similarly, output increases did not depend on increased use of labor as machinery inputs were substituted for labor.

Increases in cropland productivity were primarily a function of the use of inputs other than land, and about four-fifths of the change was associated with increased use of fertilizer and associated inputs. A change in the kind of crops grown--switch from low to higher value crops--as well as geographic changed in production--from less productive to more productive regions--also accounted for improved productivity of resources.

As more and more non-land, non-labor inputs were used, the productivity of capital inputs declined. The decline in capital productivity indicates that Greek farmers were moving in the direction of allocating their land, labor and capital resources more efficiently.

Action by the government of Greece was the primary motivating force for output change. Actions taken by the government were aimed directly and indirectly at affecting the cost of farm inputs and the price of farm products as well as in

making farmers aware of these changes. These actions can be grouped into three areas: (1) price support and subsidy programs, (2) agricultural credit programs, and (3) research and producer educational programs.

Greece's import position with respect to food provided an opportunity for establishing stable and profitable price relationships. Price support and subsidy programs were established to provide price incentives for producers to expand the production of selected agricultural products which were judged to be in most critical short supply at the end of the war. Credit programs were simultaneously developed to enable farmers to obtain purchased inputs that came from outside the agricultural sector. Thirdly, programs were developed to provide farmers with knowledge needed to enable them to change from traditional farming methods to new methods of production. This required both the development of new practices (research) and extending the new knowledge to farmers through the extension activities and through more formal means of education such as schools.

At the end of World War II, Greece was faced with the problem of feeding her population. Food needs greatly exceeded domestic production. As food production expanded and critical food shortages were overcome, the demand for agricultural products still remained strong as the result of both population growth and increased per capita income. Once critical domestic food needs were met, incentive programs were redirected away from grains to other crops in order to improve the foreign exchange position by encouraging the production of export crops such as fruits or import-substitution crops such as cotton and rice.

While price support programs provided an incentive for farmers to grow more food, principally wheat, subsidies for fertilizers and other yield-increasing inputs encouraged farmers to increase their use of these inputs and thus expand production through higher yields as well as through expanded crop area. The main subsidy, in terms of increased wheat production, was a fertilizer subsidy of roughly 10 to 30 percent of the purchase price which was granted to all farmers. In addition, transportation costs were also subsidized so that farmers in remote areas paid the same price for fertilizer, including delivery charges, as did farmers close to the source of supply. The subsidy program for fertilizer resulted in not only a uniform fertilizer price to all farmers, but also a fairly stable, though decreasing, price through time.

The support price for wheat coupled with the fertilizer subsidy resulted in a favorable fertilizer-wheat price ratio--both in economic terms and relative to other countries. Compared with other countries, the fertilizer-wheat price ratio in Greece was favorable to high use of fertilizer. Greek farmers needed only 1.7 pounds of wheat to pay for a pound of fertilizer in 1964. For the few countries for which comparable data were readily available, Greece has an enviable position, exeeded only by Pakistan, and Japan, Table 1.

Table 1.--Wheat and fertilizer prices, and kilos of wheat required to purchase a kilo of fertilizer at the farm level, selected countries, 1964

Country	Price of		Kilos of wheat needed to buy a kilo of fertilizer			
	Wheat	N-P-K	Nitrogen (N)	Phosphate (P_2O_5)	Potash (K_2O)	Average (N-P-K)
	Cents per kilo		Kilos			
U.A.R.	6.1	28.4	5.1	2.8	1.9	4.6
India	12.2	34.3	3.0	2.5	1.1	2.8
United States	7.8	18.6	3.4	2.6	1.3	2.4
Spain	10.8	22.9	2.7	1.9	0.7	2.1
Greece	9.6	16.0	2.5	1.5	1.2	1.7
Japan	12.5	20.2	2.1	1.8	0.8	1.6
Pakistan	9.9	15.5	1.8	1.3	0.6	1.6

Source: Computed from data in Production Yearbook, Food and Agriculture Organization, United Nations.

Turning from wheat, which accounted for half of all fertilizer used in Greece, to total fertilizer use nearly a 10-fold increase in use of fertilizer occurred from before the war to 1964 with a slight decrease in use from 1964 to 1965. The increased use of fertilizer resulted primarily in a larger number of hectares being fertilized than in an increase in the amount used per acre. In 1950, only about one crop acre out of six was fertilized, but by 1962 over half the area in crops received fertilizer. In the process, however, the average amount of fertilizer used per fertilized hectare decreased from 108 to 94 kilos, Table 2.

Table 2.--Extent and amount of fertilizer used, Greece

Year	Percent of area receiving fertilizer	Nutrients used per hectare	
		Total area	Fertilized area
	Percent	Kgs/ha	Kgs/ha
1950	15	17	108
1955	32	24	74
1962	53	49	94

In addition to favorable price ratios, credit and management services (provided by the credit agency) were made readily available to Greek farmers to encourage and facilitate their use of fertilizer and other yield increasing inputs. Loans granted to farmers increased about two and one-half times during the 1950's; and, in 1960 over 80 percent of the producers used credit from the Agricultural Bank of Greece, (A.B.C.).

The case of institutional agricultural credit is large in Greece relative to other developing countries. Of 15 countries for which data are readily available, there were only two countries in 1955 and four in 1961 which used more institutional credit per ton of agricultural output than Greece, Table 3.

Table 3.--Amount of institutional credit per ton of agricultural output measured in wheat equivalents, Greece and selected countries

Country	Amount of institutional credit per ton of output in			
	1955	1957	1959	1961
	U.S. Dollars			
Israel	33.8	42.2	41.8	42.2
Turkey	19.2	22.8	----	7.7
Greece	16.0	21.9	22.9	24.0
Japan	15.8	21.7	27.2	42.0
Philippines	14.1	17.6	30.7	34.7
Mexico	12.7	13.8	17.6	21.5
Colombia	10.5	6.4	7.8	7.8
Chile	9.8	16.0	19.7	39.0
Venezuela	5.9	5.7	32.0	22.2
Brazil	4.8	5.8	5.1	7.4
U.A.R.	2.7	3.7	5.1	7.7
Spain	1.7	1.4	1.3	1.8
India	1.5	2.9	3.4	3.7
Pakistan	1.5	1.9	1.8	----
Thailand	0.2	0.3	0.2	----

Source: FAO and FAER No. 27, page 89.

Research efforts in Greece have been focused primarily on adaptive research. Emphasis has been given to adaptation of varieties and practices from the United States and Western Europe to Greek conditions.

Education at the producer level became a reality in Greece at the end of 1950 with the establishment of an Extension Division in the Ministry of Agriculture, and this also helped to speed up the adoption of improved practices. Producer educational services were also provided to the agricultural sector by the Bank, which also operated a technical service division in conjunction with its lending operations. About 1,000 loan applications are processed per annum by each professional member of the division. 1/ In addition, they supervise agricultural building loans and give advice on the use of fertilizers, seeds,

1/ World Bank report.

new cultivation methods and animal feeding. Under this program, the credit provided by the Bank is largely supervised credit and farmers receive only the amount of fertilizer that the Bank's agriculturalists deem appropriate.

The role of the Agricultural Bank in providing fertilizer to producers, as a part of its credit activities, has been especially significant in providing the motivation needed for increased agricultural output in Greece. The program of the Bank satisfied three needs of producers, each of which would appear to be a necessary condition for the successful adoption of fertilizer use.

1. The Government of Greece granted a price subsidy for fertilizer through a direct appropriation to the Agricultural Bank to allow it to sell fertilizer to producers at low prices. As the relative price of fertilizer declined, producers responded and increased their use of fertilizer. A 10 percent decrease in the price of fertilizer relative to crop prices resulted in a 17 percent increase in fertilizer use. (The fertilizer subsidy plus the relatively high, stable support price for wheat made the use of fertilizer quite profitable.

2. The credit program facilitated the purchase of fertilizer. No matter how profitable a new input may be, producers cannot use it if they do not have the funds to invest in its purchase. In capital-scarce Greece, producers would have been unable to purchase fertilizer without a credit program and producers would have had to place more reliance on non-purchased inputs--land and labor--and therefore forego the growth in output associated with inputs available only through cash purchases.

3. No matter how much fertilizer a producer might buy, his output will not be affected unless he has sufficient knowledge about its proper use. The Agricultural Bank again provided the necessary instructions with the results that, in general, producers were allowed to buy only the amount of fertilizer deemed appropriate by the agriculturalist of the Agricultural Bank.

The above discussion is not meant to suggest that a government credit agency is essential for rapid development and that the credit agency have broader responsibilities than the granting of credit. Rather, attention is meant to focus on the services that the Agricultural Bank of Greece performed. The three aspects mentioned are essential and must be provided, but whether they are provided by the credit agency or some other institution or institutions is a problem that must be determined by each country. In all probability, the uniqueness of each country's situation will dictate that different arrangements be made for assuring that these services are adequately provided.

Looking at the programs and policies that were developed to increase agricultural output in Greece, we note a strong relationship between the rate of credit expansion and the rate of increased agricultural output--49 percent of the change in gross agricultural output was associated with increased credit. The major role of credit in crop production was associated with increased fertilizer consumption and change in the organization of production--from low to higher value crops and from less productive to more productive regions (the more productive regions also used more credit). Over four-fifths of the change in fertilizer consumption can be related to availability of short-term credit. The Agricultural Bank was the main source of both credit and fertilizer and, in fact, most of the short-term credit was granted directly in the form of fertilizer.

While credit appears to be closely associated with the rapid increase in output of food crops in Greece, the other factors associated with the increased use of credit appear to have been of great underlying importance. First, sufficient knowledge existed for the development of profitable fertilizer recommendations. Second, the fertilizer-product price ratios were such that the increased output from using fertilizer more than paid for the extra cost of using fertilizer. Third, there was an assured market for the increased output. Finally, advice and demonstrations were provided on the proper use of fertilizer.

MEXICO

Mexico's rate of growth of agricultural production over the past 25 years finds few equals, and in Latin America it had none. Her 5.4 percent rate of growth of crop production between 1940 and 1962 was a quarter higher than Venezuela's and Brazil's for the same period and fully twice as high as the growth rates experienced by Argentina, Chile, and Colombia. Preliminary data indicates that this exceptional record has been sustained or bettered since 1962, for the preliminary figures indicated that Mexican crop output has increased at the rate of 8.8 percent between 1963 and 1965. Therefore, looking at the period 1940 to 1965, total Mexican agricultural production increased 4.7 percent a year. Crops and livestock performed quite differently during this period. Crop production increased at the rate of 6.2 percent a year, but meat production increased at the slow rate of 2.9 percent, and milk production at 4.2 percent a year. In conformity with the objectives of this conference, the remaining remarks will deal primarily with changes in crop production.

While Mexico's growth in agricultural output has had few peers in the world over the past 25 years, her present level of agricultural productivity, as contrasted to output, places her somewhere in the middle of developing countries. For example, crop output per hectare in 1960 was only about $100, a level easily exceeded by many of the developing countries including Turkey and Pakistan.

All parts of Mexico did not share equally in this rapid increase in crop production. Rather, growth rates varied among the five regions of Mexico: from a low of 3.5 percent in the Central Region to 9.2 percent in the Pacific North Region. Other breakdowns also show unequal growth: production of export crops increased much more rapidly than subsistence food crops, 8.7 percent compared to 3.6 percent; output from irrigated areas also increased at a high rate of 10.3 percent; and the private sector had much more rapid growth than the ejido sector, 2/ Table 4. As might be expected, these are not mutually exclusive categories: the slow growth Central Region, predominately a region of dryland farming, was the center of the ejido sector and produced primarily subsistence food crops. In contrast, the Pacific North, a region largely of irrigated private farmland, produced mainly export crops.

The difference between Mexico's rapid increase in output as contrasted to her somewhat slower growth in productivity can be partially explained by the fact that almost half of the increased output between 1940 and 1953 came from an expansion of land area, with yield increases accounting for the other half. However, the agricultural productivity picture changed sharply during the 1950's. Yields jumped during the decade of the 1950's and after 1953 over three-fourths (77 percent) of the change in crop production was attributable to changes in yields with about three-fourths of this yield increase due to the increased use of fertilizers.

This suggests two somewhat different periods of growth in Mexican agricultural development. The period between 1940-50 and the period from 1954 to the present. Growth was slightly higher in the earlier period than the later one, 5.4 percent compared to 5.2 percent, and the causes of growth were also different.

Coming out of the 1930's, crop production had increased only slightly with little change in the amount of land labor used, with some indication that the amount of labor actually decreased during the decade of the 1930's.

During this time, the supply-price of land also fell sharply. This coupled with rising crop prices during the 1940's, provided the Mexican farmers with extra purchasing power. With the exception of labor, purchased inputs were not yet in general use: fertilizers, improved seeds, insecticides, etc., generally were not part of the farming picture of the 1940's. The increased purchasing power was, therefore, largely used to purchase land, whose price was almost falling as a result of the Agrarian Reform program. The area of cropland harvested increased at the rate of 2.6 percent a year from 1940 to 1953. As indicated, almost half the total change in crop production was the

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2/ The ejido sector refers to the land area expropriated from the private sector and transferred to farmer peasants, under Article 27 of the Mexican Constitution and the Agrarian Code. Occupants of ejido lands, called "ejiditarios", have perpetual rights to work the land and pass it on to their heirs, but legally the land cannot be sold or rented. If the land is not farmed, it reverts to the State for redistribution to other qualified people. Ejiditarios, however, can buy or rent land in the private sector to operate in addition to their ejido land.

Table 4.--Rates of growth of crop production by region for selected crop aggregates, Mexico, 1940-62 1/

Crop aggregate	North	Gulf	Pacific North	Pacific South	Central	Mexico	1960 share of total crop production
	Percent						Percent
37 Principal crops	4.8	5.2	9.2	5.2	3.5	5.2	85.9
Subsistence crops	2.7	3.7	4.9	5.0	3.2	3.6	34.5
Export crops	8.4	6.4	12.9	7.5	5.9	8.7	26.4
Irrigated production 2/	4.2	23.1	15.5	18.3	9.3	10.3	23.6
Ejido sector 3/.....	4.0	4.4	6.1	5.3	3.7	3.3	35.0
Private sector 3/.....	5.3	5.7	9.8	6.5	2.6	8.2	50.9
1960 share of total crop production	23.0	17.0	17.9	14.9	27.2	100.0	----

1/ Based on yearly data adjusted to Mexican Census year which begins on April 1.
2/ Thirty-seven principal crops over 1947-1962 period. Earlier data not available for the S.R.H. irrigation districts.
3/ Thirty-seven principal crops.

result of increased area of cropland harvested with increases in output per unit of land contributing the other half. Much of the increased value of output per hectare was the result of a change from low to higher value crops. The average value of output per hectare (in terms of 1960 prices) increased from 619 pesos in 1940 to 800 pesos in 1953. Cotton was one of the crops farmers turned to after 1940 and cotton production increased at the average rate of 8.6 percent a year since 1940. If cotton and the resources used in its production were eliminated from the calculations, the growth rate of Mexican crop production would have dropped from 5.4 percent a year to 4.3 percent.

Some of the increased purchasing power was also used to purchase machinery, and apparently there was a substitution of machinery for labor, for while cropland area was expanding at the rate of 2.6 percent a year, labor increased only at the rate of 1.8 percent, implying a decrease in labor used per harvested hectare. At the same time, however, tractors (measured in terms of effective horsepower without adjustment for days worked) increased at the rate of 22 percent a year. Light tools and cottage-type implements increased 9.5 percent a year and the overall stock of farm machinery 6.1 percent.

The development process changed after 1953, for in this period yield increases, not land area harvested, accounted for the major share of increased crop production--77 percent. Likewise, changes in cropping pattern accounted for less of the increased output than in the earlier period.

Fertilizer use increased greatly and was the single most important factor accounting for increased yields. Total fertilizer use increased at the rate of 11.9 percent a year which, with only a slight increase in land use, amounted to an increase of 10.3 percent a year in the amount used per hectare of harvested cropland. The basic element in this rapid increase in fertilizer consumption was a decline of one-third in the relative price of fertilizer. This was largely the result of rising crop prices while the government dominated fertilizer industry largely kept its prices constant.

Closely associated with the increased use of fertilizer was a rapid expansion in irrigation with water use increasing from 6.6 billion cubic meters of water in 1950 to 17.2 billion by 1962. Public investment in irrigation started in the 1920's and since 1940, the Secretariat of Water Resources (S.R.H.) has completely underwritten all irrigation projects involving gravity fed water. This turns out to be largely a government contribution to farmers using these facilities, for it is estimated that only 10 percent of the government investment has been repaid through water use charges. In addition, the Mexican government has heavily subsidized current costs of operating and maintaining the irrigation districts. Since 1948, S.R.H. has received only 54 percent of its operating expenses from user charges, the balance coming directly from the Mexican government.

Pesticides represent another complementary input important in the rapid increase in yields. During the 1950's, the need for pesticides began to be understood and their use has greatly increased.

The technological basis for the increased use of fertilizer, pesticides and other inputs that resulted in higher yields can be attributed in large part to the research program underway in Mexico since the mid-Forties. This program, initially started with the help of the Rockefeller Foundation, consisted of both basic and adaptive research directed toward problems of immediate importance as well as those of a longer run nature. The success of this research program in developing new strains and varieties of higher yielding plants and in specifying the bundle of cultural practices that had to be followed in order to realize the higher output potential of the new varieties, formed the basis for the yield take-off. In addition, price support programs were developed for corn, beans, wheat and rice, which assurred farmers of a market for their increased output at fairly fixed and profitable prices.

A few comments on the Rockefeller Foundation program in Mexico may be in order since it is closely linked to the successful research program now underway in Mexico. And it is the results of this research program that provided one of the essential ingredients for the rapid increase in agricultural output that occurred.

The program started with research. A Survey Commission from the Foundation that went to Mexico in July, 1941 to recommend on the establishment of a program of work, reported as follows:

> Research must precede effective extension under the conditions prevailing in Mexico (in 1941) ... Extension alone, and other forms of education, can make great improvement only when there is a great reservoir of potentially useful, but not unused information... Of course, research alone does not alleviate conditions either unless the results are made practically effective through education and extension. 3/

Wheat may be the outstanding success story of the research program. In 1943, the average yield of wheat was 780 kilos per hectare; in 1963 the average was 2,020 with yields of 3,370 to 5,930 kilos per hectare in areas that, prior to the research program, were not even considered part of the Mexican wheat region.

3/ Stakman, E.C.; Bradfield, Richard; and Mangeldorf, Paul C.; Campaigns Against Hunger, The Belknap Press of Harvard University Press, Cambridge, Mass., 1967.

Equally good results were obtained in corn trials and many progressive farmers increased their corn yields from 1,260 to 4,400 kilos per hectare on good, well-watered soils following the recommendations based on research results. These findings were the result of a team of scientists working together on joint problems. They showed the way to improve yields by "selecting superior varieties from the native corns and using them to create more productive varieties. The pathologists helped to incorporate disease resistance into the new varieties; the soil scientists demonstrated the importance of good fertilizers and improved cultural methods; and the entomologists devised better methods for protecting the increased crops against destruction from insects and rodents during storage." 4/

While corn research has been as successful as research on wheat in developing technology to increase yields, farmers have been much slower in adopting the new corn technology than they were the improved practices for wheat. For example, almost all the wheat grown is from improved varieties whereas only about 20 percent of the corn acreage is planted with hybrid seed. (Hybrid seed has been available in Mexico for about 20 years). One partial explanation is that wheat is a relatively new crop and farmers did not have to change their method of production, but rather began with improved technology. Corn, on the other hand, is a traditional crop and change in production practices appears to come slow and hard for traditional crops.

In discussing the slow adoption of hybrid corn, Stakman, et. al. stated,

> for various reasons the Mexican Government preferred to maintain complete control of the production and distribution of improved seed, and private enterprise was excluded. One consequence has been that, once hybrid corn became established on the larger farms managed by the more progressive farmers, the expansion slowed down. Hybrid seed is not yet reaching the small farmer in Mexico in substantial amounts... Other countries can learn from Mexico's experience that government monopoly has not proven to be successful in getting hybrid corn into the hands of small farmers. 5/

A final comment on the research program refers to the pay off on investment in research. A study of the returns to the Mexican research program indicates that

> the financial value of Mexico's increased wheat and corn production that has been contributed by research is the equivalent of about 400 percent annual interest or return on the total amount of money spent for all research in the cooperative program from 1943 to 1962. The returns to the

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4/ Ibid.
5/ Ibid.

wheat program alone, resulting from comparing wheat research expenditures and benefits, are at least 800 percent per year. 6/

Turning to other parts of Mexican agricultural development, one interesting aspect is the difference in the rates of growth between the ejido and the non-ejido or private farm sector. 7/ The average rate of growth of ejido crop production since 1940 has been 3.3 percent compared to 8.2 percent for the non-ejido sector. The growth of crop production in the ejido sector lagged behind that of the non-ejido sector both because of slower rates of growth in cropland used and in yield increases. If ejido owners had expanded their cropland area at the same rate as the private sector, the differences in growth rates between the two sectors would have largely disappared. Also, differences in yield growth between the two sectors have become less pronounced over time: between 1940 and 1953, yields increased about four times faster in the private sector than in the ejido; but from 1954-1962, yields in the ejido sector actually increased faster than in the private sector, and average ejido yields today are about 90 percent of those in the private sector, while in 1959 they were only 79 percent as high. 8/

One question raised by these data is why the ejido sector lagged behind the private sector and then suddenly began to catch up. The obvious answer is fertilizer. But, this is too quick and easy an answer. More fundamental is why fertilizer was so readily adopted by the ejido sector while other practices were not.

Preliminary evidence from the study in Mexico suggests that basically the ejido farmer may have different values. His tastes and preferences for savings and investments distinguish him as one less willing to expand his area of cropland; likewise, he was much slower in purchasing tractors and farm machinery which, like land, entail long-term commitments. On the other hand, the ejido farmer expanded his use of fertilizer with a speed equal to that of private farmers. The practice of using fertilizer can be distinguished from the purchase of farm machinery and land in at least one basic way: fertilizer is a current production input and implies no long-term commitments; it is purchased, used, and the benefits captured all in one year.

6/ Ardito Barletta, "Cost and Social Return to Agricultural Research in Mexico". Forthcoming Ph. D. dissertation, University of Chicago.

7/ See footnote 2, page 15 for description of ejido.

8/ These comments on the performance of the ejido sector are based on national averages which may be somewhat misleading. A comparison of ejido-private sector performance in that part of Mexico where ejidos predominate shows quite different results. Growth rates of crop production in the Central Region, which is 40 percent or more ejido land, increased at the rate of 3.7 percent a year in the ejido sector compared to 2.6 percent in the private sector, Table 4.

A summary of the Mexican development experiences, somewhat oversimplified, may be as follows: the Agrarian Reform increased the supply of land and caused land prices to fall. This coupled with rising farm product prices in the 1940's provided farmers with increased purchasing power which was partially used to acquire additional crop land. The expanded crop area accounted for around half of the increased output from 1940 to 1953.

During the 1940's, a sound research program was started which resulted in the development of improved varieties of plants and accompanying cultural practices that greatly increased yields. Putting the results of this reseach into practice, crop yields increased rapidly after 1953. Government price support programs were also instituted which provided assured markets at profitable prices for the production of staple food crops. While crop prices in general were rising, fertilizer prices remained constant. The combination of (1) high crop response to fertilizer and the association bundle of practices developed by research, (2) rising product prices, and (3) constant fertilizer prices, all contributed to make the use of fertilizer quite profitable and its use increased rapidly. This in turn accounted for about 75 percent of the increase in yields that occurred after 1953. Coincident with the increased use of fertilizer was an increase in the use of irrigation made possible by earlier government investments in irrigation facilities.

Except for land redistribution under the Agrarian Reform, the role of government in Mexican agricultural development was somewhat indirect. Its chief intervention was to support research, subsidize irrigation, and support prices of basic food crops. Aside from these programs, development occurred more or less from farmers acting individually to improve their own private welfare. Government plans and programs were not long-range and far-reaching, but rather were made to solve immediate problems of the moment.

TAIWAN

To the social scientist who seeks to explain the process of economic and agricultural development, Taiwan is a paradox. Against its limited resource endowment and high population pressure, Taiwan appears as a focal point of adversity; a place where one would least expect to find sustained economic development. But Taiwan has progressed. Over a period of 50 years, its economy has emerged from a relatively backward state--characteristic of much of Asia--to achieve a highly productive agriculture and rapidly expanding industrial capacity.

The dominant feature of the physical environment for agricultural output in Taiwan is that the total land area available for cultivation has been relatively fixed. Therefore, it was necessary to resort to land-substitution methods to increase agricultural output. This was successfully accomplished as the result of increasing capital inputs and intensifying the use of land and labor.

Separating inputs into land, labor, working capital, and fixed capital, it is seen that a relatively fixed land area was combined with slowly increasing amounts of labor and fixed capital and greatly increased amounts of working capital to achieve increases in output, Table 5. Differences between cultivated land area and crop area were the result of increases in multiple-cropping practices. A comparison of the number of agricultural workers with labor input (man-days) indicates that the agricultural labor force worked more days per year as the intensity of fertilizer and water use increased and improved varieties were developed.

Table 5.--Indices of agricultural inputs, Taiwan, 1936-63 (1935-37 = 100)

Year	Land area	Crop area	Labor input		Working capital	Fixed capital	Aggregate input
			Number of workers	Man-days worked			
1936-40 ..	101	100	104	102	100	90	100
1941-45 ..	99	97	---	97	58	81	90
1946-50 ..	101	114	125	99	50	78	90
1951-55 ..	103	133	132	125	117	92	111
1956-60 ..	104	139	130	139	157	112	123
1961 ..	103	143	135	142	173	138	128
1962 ..	103	143	136	144	182	139	130
1963 ..	103	144	139	146	190	149	133

From 1936 to 1960, except for fertilizer, prices of purchased inputs (represented by soybean cake) and interest rates advanced more rapidly than wages and rental rates of land, Table 6. The relationship between the price of capital and labor was such that it was not advantageous to substitute capital inputs for labor. Although the relative decrease in land rental rates provided a price incentive to substitute land for capital, this possibility was limited by the small size of farms and relatively fixed amount of cultivable land.

Table 6.--Indices of real prices of major inputs, Taiwan (1935-37 = 100)

Year	Fertilizer	Rental rate of land	Wage rate	Soybean cake	Interest rate
1936-40..	100	100	100	100	100
1941-45..	63	86	84	64	86
1946-50..	159	86	56	180	1,036
1951-55..	80	70	68	159	608
1956-60..	82	68	76	171	333
1961..	85	n.a.	95	173	299
1962..	80	n.a.	97	181	280
1963..	77	n.a.	91	171	261

Computing input productivities, it is seen that the notable features in Taiwan agriculture were the sharp rise of land productivity accompanied by sharp declines in the productivity of capital. Labor productivity per man-day and crop area productivity both increased at about the same rate, while productivity per farm worker increased at a faster rate than productivity per man-day, Table 7. That is, capital input coupled with intensified land use allowed farmers to work harder and more effectively. Under Taiwan's severe geographic limitations and rapid population growth, additional increases in both labor and land productivity depended heavily on increased inputs of both fixed and working capital.

Table 7.--Indices of resource productivities, Taiwan, 1936-63 (1935-37 = 100)

	Land productivity per		Labor productivity per		Capital productivity	Aggregate resource productivity
	Land area	Crop area	farm worker	man-day		
1936-40...	100	101	98	100	104	101
1941-45...	81	82	--	82	137	89
1946-50...	78	69	62	79	138	87
1951-55...	115	87	90	95	107	107
1956-60...	144	107	114	107	101	121
1961...	160	116	123	116	100	130
1962...	162	117	123	116	97	129
1963...	159	115	118	112	91	124

Since working capital is a measure of the use of things such as improved seeds, fertilizers, irrigation service, and pesticides, attention is drawn to technological innovation rather than increases in labor, land, and accumulated fixed capital as the significant direct cause of increased agricultural output in Taiwan. The development and adoption of improved technology did not just happen, however, rather they were the result of a deliberately planned strategy on the part of the government to increase agricultural output.

The first part of this strategy was to develop improved technology for Taiwan's conditions. This was achieved in three steps: First, the best crop varieties and techniques used by the better farmers in Taiwan were sought out and identified; second, improved plant varieties and animals were sought from foreign sources; third and simultaneously with the first two, basic and adaptive research facilities were started and maintained to supply new technology on a continuing long-term basis.

As improved technology became available, it was passed on to farmers through extension activities, demonstrations, and information programs. These were aimed not only at educating the farmer about the agronomic side of the new practices, but also about the greater economic gains associated with the practices.

Since irrigation was the critical factor affecting land utilization and multiple-cropping, early attention was given to increasing irrgation facilities. In addition, irrigation research led to the development of a system of rotational irrigation which resulted in reducing water needs by 20 to 50 percent. In addition to irrigation research, other research was also carried on in areas such as disease and insect control, fertilizer trials, plant breeding, and improved cultivation practices. As multiple-cropping became fairly well established, a system of intercropping was also worked out to further increase output per given area of land.

At the same time that technology specific to Taiwan was being developed, steps were taken to insure that farmers would adopt the new technology that would bring about an increase in the production of crops that were in most critical demand.

In the period 1945-48, food shortages in Taiwan led to immediate steps to restore production of major food crops. As already mentioned, the first step was to restore irrigation factilities and increase the use of fertilizer. The second was to stablize the price of basic foods, especially rice. This was accomplished through compulsory sale of rice to the Food Bureau, the establishment of rice-fertilizer barter programs, and land tax payments in rice rather than money.

Probably the most important of these was the fertilizer-rice barter program. The government controlled all fertilizer supplies and rather than sell the fertilizer, it was bartered for rice at rates that undervalued rice, Table 8. However, even at these prices for fertilizer, Taiwan farmers still found it profitable to use fertilizer and preferred to pay a high price for it rather than go without. As a result of these programs, the government was able to control about 30 percent of the rice supply.

The facility with which the government formed organizations to meet agricultural needs and carryout commitments to reach goals and expectations was an important factor in the development of Taiwan agriculture. These organizations included farmers associations, irrigation associations, and crop associations for all kinds of crops such as tobacco and sugarcane, as well as for fishermen. It is probably safe to say that each individual involved in agricultural production belonged to at least one or more of these organizations.

Table 8.--Rice and fertilizer prices and kilos of rice paddy required to purchase a kilo of fertilizer plant nutrients at the farm level in selected countries, 1964

Country	Price of		Kilos of rice needed to buy a kilo of fertilizer			
	Rice	N-P-K	Nitrogen (N)	Phosphate (P_2O_5)	Potash (K_2O)	Average N-P-K
	Cents per kilo		Kilos			
United Arab Republic	4.4	28.4	7.2	3.9	2.6	6.4
Thailand	4.0	18.2	5.2	4.3	2.2	4.6
India	7.8	34.3	4.7	3.9	1.6	4.4
Taiwan, China	9.6	35.8	4.6	2.4	1.3	3.7
Philippines	10.7	26.8	3.2	2.6	1.4	2.5
United States	10.8	18.6	2.4	1.8	0.9	1.7
Pakistan	9.9	15.5	1.8	1.3	0.6	1.6
Japan	17.5	20.2	1.5	1.3	0.6	1.2

One of the more important structural changes that took place had to do with changes in the credit system. Traditionally, agricultural production credit was proved by the person who later bought the product. Before the farmers associations were reorganized, it was not uncommon for the landlord, money lender, and the buyer to be the same person. This practice was changed when effective credit organizations were placed under government regulation and farmer control. In this new situation, farmers could use their contract with processing firms to get production credit and thus draw on the financial resources of the community as well as the Central Bank for cooperatives. These changes and the institution of new credit agencies were not designed to do away with traditional money-lenders, but rather were used to encourage traditional money lenders to change their practices through competition with the new credit agencies.

Another important change in the structure of agriculture during the 1952-54 period was the formation of an economic planning unit for agriculture within the framework of the national government. This group brought together representative from several agencies: people from top policy-making groups, heads of agencies instrumental in carrying out national plans, and those from the reporting units that gathered statistics on the performance of agriculture.

The market system and farmers associations became flexible instruments to transmit demands to farmers and in this way aasist them in efficiently allocating resources. The heart of the system was forward pricing determined by planners who had become skilled at estimating supply responses and whose estimates were linked to government policy, with respect to foreign exchange needs and inflation control. The general policy was to maintain the greatest control over rice and sugar. Control of rice was achieved by control of

fertilizer supplies and the fertilizer-rice barter program; control of sugar was through Government ownership of sugar manufacturing facilities. With crop plans established, orderly marketing procedures were then established for principal export crops, the remaining domestic demand was left to market mechanisms, which were largely organized into a system of cooperative marketing.

One conclusion that can be drawn from the experience of the interrelated service systems in Taiwan economic development is that an economy can function more effectively when the people affected work together to meet common goals. One of the principal observations to be derived from the Taiwan experience is that the political, social, and economic role of the farmer was not left to accidental arrangement. Organization was pervasive and was designed to align farmers' actions to national policy. Furthermore, where problems of organization or lack of technical skills became barriers to increased agricultural output, other organizations--such as training classes for land tenure committees--were formed to cope with the problem.

One of the notable features of the Taiwan experience was the ability to establish organizations rapidly and in such a manner that they were able to complete the tasks that were started. Behind most of these programs was the Government. But within this system of government guidance and control, a high degree of decision-making was retained by the individual farmer. Government policies and programs were largely intended to align private with public objectives.

Dr. Hsieh and Lee in their study of Taiwan agricultural development comment on this as follows:

> The Taiwan record clearly would have been impossible except for a stable government guided by a strong commitment to use its power in meeting the organizational requirements of technological advance, and also an island of people guided by a long heritage of felt obligations to be as productive as they can for the sake of improving the income and status position of their families from generation to generation.
>
> They further state: The most strategic component of the island's economic development has not been the capacity of its people to generate new farm and non-farm technologies, but their capacity to construct new organizational rules for linking together their economic behaviors so as to more effectively help each other create and put to widespread use the improved technologies which in turm increase their power to manipulate their physical and biological environment more in lime with their work and aspirations. Otherwise expressed, the main secret of Taiwan's development is not merely her ability to meet the technological requirements for increasingly productive gadgets, but her ability to meet the organizational requirements of new combinations and mechanization of

mutually helpful human behavior necessary to achieve the gadgets of progress. 9/

Three conclusions can be drawn regarding the relevance of the Taiwan experience to other countries: (1) Taiwan increased her agricultural output on a relatively fixed cropland base through the development and adoption of a series of improved practices that resulted in increased output per land area, (2) identifying agricultural development with improved technology and high output per unit of land suggests an easy transfer of the Taiwan experience to other countries, but (3) this suggestion is subject to severe qualification, for as pointed out above, it was the ability of the Taiwan society to effectively organize itself in many different ways to meet the various and changing requirements of rapid development that made this growth possible. Without this flexibility and discipline, it is doubtful that the Taiwan record would have been achieved. The main lesson to be learned from Taiwan is not in the technology that was developed and used, but rather how society organized itself to recognize problems and the manner in which problems were developed and carried out to break the status quo and insure that change would, in fact, occur.

Comparisons of Development in the Three Countries

In the 1940-53 period, Mexico's increased output came primarily from an expansion of land area, whereas Taiwan's increased output was achieved on an almost constant land base that was farmed in such a way to produce an ever-increasing amount through multiple-cropping, inter-tillage, and other yield increasing practices. In Greece, cropland expanded until the mid-forties and since then has remained fairly constant. All three countries owe much of their success to research programs that developed improved practices appropriate for each country. In this regard, the three countries were quite similar. Differences in the development process appear in the programs that were developed to encourage the adoption of improved practices that resulted in increased output.

Taiwan probably had the most purposeful programs. Planning was rather complete and comprehensive with involvement from top ranks of government down to individual farmers and back up to top levels of government, whereas Mexico had almost no comprehensive inter-related planning for overall development. Greece was somewhere in between with fairly complete planning for limited aspects, such as programs to assure an adequate supply of wheat through support prices for wheat and subsidies for fertilizer.

9/ Hsieh, S.C., and Lee, T. H., Agricultural Development and Its Contributions to Economic Growth in Taiwan. Economic Digest Series No. 17, JCRR, Taiwan, 1966.

Fertilizer played a key role in all three countries; but the programs related to fertilizer use were quite different in each country. In terms of formal programs, one might say Mexico had no program other than a government monopoly of fertilizer which kept the price of fertilizer almost constant over time 10/ (while farm product prices were rising) and an extension program and series of demonstration and field days to teach the worth of using proper fertilizer practices. Greece had a rather elaborate program centered around the use of credit and subsidies to encourage farmers to use fertilizer. On the other hand, Taiwan farmers were accustomed to using fertilizer and in its desire to gain control over rice supplies, the government, through the high prices set for fertilizer in the fertilizer-rice barter program, taxed fertilizer use rather than granting a subsidy. However, even though the fertilizer-rice price ratio in Taiwan was quite unfavorable compared to those in most other countries, Taiwan farmers continued to increase their use of fertilizer. This suggests that the use of fertilizer (or other input) is a function not only of the factor-product price ratio but also the physical response to an additional unit of input. Taiwan farmers fertilized their rice because the incremental increase in output from using fertilizer was profitable even though the fertilizer-rice price ratio was less favorable than in surrounding countries. For programs to be effective in encouraging farmers to adopt a new practice, farmers must be made aware of the relationship between the amount of the increased output from adopting the practice and the value of the increase output relative to the cost of adopting the practice.

The role of labor was quite different in the three countries. Taiwan maximized the use of labor and many of the output increasing practices--such as intertilled crops--were the result of intensive labor inputs. With little opportunity to expand cultivated land area, increased output had to come from increased output per area of land. Since Taiwan was short of capital relative to labor resources, there was little interest in substituting capital for labor or adopting labor saving practices. The result was high output per unit of land area and high returns to capital, but low labor productivity. Immediately after the war, Greece increased her crop area slightly above the pre-war level, with little change thereafter. However employment opportunities were great in Europe and large number of rural people left Greece to work in Europe, with the result that the agricultural labor force increased only slightly during the decade of the Fifties.

Mexico presents the opposite case from Taiwan. She not only had large areas of uncultivated land, but as the result of the Agrarian Reform program, land prices fell and land became more readily available for purchase during the

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10/ Mexico was developing a domestic fertilizer industry, and during this period the cost of domestic production probably exceeded prices on the world market. Fertilizer, however, was supplied to farmers at more nearly the world price than at the cost of production in Mexico. In this sense, the government subsidized the use of fertilizer.

Forties. Therefore, around half of the increased output came from increased land area. However, at the same time, Mexican farmers were also purchasing machinery at an even faster rate than land area was expanding, which in turn tended to increase output. The absolute size of the labor force continued to increase but at a slower rate than the land base so that labor input per cultivated area decreased.

A final comparison concerns the role of government and control. In all three countries, considerable weight was placed on the market mechanism to affect farmers' decisions relative to their choice of crops and the practices used to produce them. In some respects, Mexico influenced market forces the least. The earliest and perhaps greatest influence was on the land market, but to a large extent, aside from controlling ejido land, this influence ended prior to the yield take-off. Prices of fertilizer and water were also lower than would have been the case without government intervention. The Mexican government controlled fertilizer supplies and appears to have sold fertilizer to farmers below the cost of producing fertilizer in the developing Mexican fertilizer industry. Irrigation was likewise subsidized in that a very high proportion of total public expenditures went into irrigation facilities with revenues from irrigation insufficient to cover costs. On the product side, the government intervened in the market for the main food crops--corn, wheat, rice, and beans--by establishing and maintaining support prices for these commodities.

Greece, like Mexico, had support prices for the main food crop, wheat, as well as some other crops but intervened in the factor market to a greater extent than did Mexico. Whereas Mexico primarily subsidized the price of fertilizer by keeping its price from rising, in Greece not only was the price closely controlled, but the kind and amount of fertilizer bought and the crop on which it was applied were also largely controlled by the government through regulating the allocation of credit. Farmers were free to buy and use fertilizer as they wished if they had money to pay for it. This very few could do in capital-scarce Greece. On the other hand, when credit was granted for fertilizer, control was exercised over the use of it. Aside from this, there appeared to be fairly free play in the market. That farmers reacted to the demand of the market is indicated by the large and rapid shifts made from one crop to another as the demand and, in turn, prices for various commodities rose and fell.

Taiwan presents a contrast that at first glance is not easily recognized, for the market mechanism appears to have largely guided farmers' decisions. However, when free market forced did not produce the desired results, the programs to modify the usual market forces were quickly and effectively instituted. This applied to either or both factor and produce prices and market and to other parts of the economic system as well. The chief characteristic of Taiwan's development was the ability to spot needs, devise and

initiate programs to meet them, and to carry them to completion. However, this was not the end; for as other needs arose, there as sufficient flexibility to abandon ineffective programs and devise new ones to meet the changed conditions.

The focus of the Conference on "Technology" and "Economics" appears to be quite relevant to the factors associated with rapid growth in Greece, Mexico, and Taiwan. All three countries recognized the need for developing improved agricultural technology to replace traditional methods of farming, and they set about to develop new plant varieties and improved cultural practices appropriate for their own situations. In addition, policy-makers were aware that, in most cases, the new technology would not be rapidly adopted unless special programs were instituted to encourage farmers to adopt it. This encouragement took different shapes and forms, both in the three countries and through time, but in all cases, it consisted of economic incentives, improvements in supply conditions of the new inputs, and education of how to apply the new technology as well as the economic consequences of using it.