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INDUCED INNOVATION AND THE ROLE OF AGRICULTURE IN ECONOMIC DEVELOPMENT : A CASE STUDY OF EGYPT AND SYRIA

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Induced Innovation and the Role of Agriculture in Economic Development : A Case Study of Egypt and Syria

Syed Ahmad and Atif Abdallah Kubursi

I. Introduction

Until recently the development of the industrial sector of any economy has been considered the prime source of, and the instrument for, the development of the economy as a whole. This view has essentially been based upon a comparison of the relative contributions of the industrial and agriculture sectors to national income in developed and under-developed countries. It is only in recent years that development economists have begun to argue that the proper lesson to be learned is not by comparing the underdeveloped and developed countries as they are now, but by comparing underdeveloped countries when they themselves were at the threshold of modern economic development. Once such comparison is made, agricultural development comes into its own. The initial economic development of U.K., U.S. and Japan, for instance began with the initial development of agriculture, which in due course provided the marketable agricultural surplus of raw materials for their industry and of food for their industrial workers, as well as the purchasing power to their agriculturists for buying the industrial goods produced.

The realisation of this historical role of agriculture in the process of modern economic development has not only made the development of agriculture a respectable initial strategy for developing an economy, but has also made the reasons for the successful development of agriculture a matter of serious consideration.

In a number of recent influential studies Hayami and Ruttan (1971, 1973) have shown, with the help of the theory of induced innovation, using the concept of the 'innovation possibility curve' (Ahmad, 1966, 1967A, 1967B), that the success of the U.S. and Japan's initial as well as later development of agriculture can be attributed to their success in 'inducing' innovation in response to the relative factor scarcity in the two economies.

Our purpose in this study is to examine the extent to which the experience of the U.S. and Japan has been duplicated in the underdeveloped world, which would take us beyond the rather sketchy treatment of some South and South East Asian countries by Hayami and Ruttan (1971). As a first step we intend to study two countries in the Middle East : Egypt and Syria - the former with a relative scarcity of land similar to Japan's and the latter with a relative 'abundance' of land similar to the U.S. We wish to examine among other things : (1) the extent of induced innovation which has taken place in agriculture in these countries, (ii) the extent to which these countries have been successful in their agricultural development, and (iii) whether (i) can explain (ii). On the basis of this examination we present certain tentative views on some of the basic approaches to the problem of underdevelopment in general and of Egypt and Syria in particular. As mentioned earlier, before proceeding with the analysis we shall need the concept of "induced innovation", to which we now turn.

II. The Theory of Induced Innovation

The theory of induced innovation, defined as the response of the character of innovation to the relative factor scarcity, first developed by Hicks (1932), remained unused, but generally accepted, until the late fifties when Salter (1960) criticized it for having no analytical foundation. His position was supported by a number of other writers including Fellner (1961), Mansfield (1962) and later by Arrow (1968). Ahmad (1966) attempted to provide this missing analytical basis, by developing the concept of the 'innovation possibility curve'[1], which has since been used, particularly in the influential work on economic development, by Hayami and Ruttan (1971, 1973) for analysing empirically the role induced innovation has played in the development of agriculture in Japan and the U.S. Before we summarize their findings, we should briefly examine the nature of induced innovation, and the innovation possibility curve underlying the concept.

The idea of induced innovation is essentially an extension of the idea of factor substitution in response to changing factor prices (scarcity), when such a change does not only cause factor substitution given the production function, but also determines the choice of the new production function to be developed through the process of invention. The idea will become clearer and its various remifications more easily observed with the help of the diagram of the following page.

In Figure 1, the two axes represent two factors: capital and labour. Now let I_{t-1} to be isoquant representing one unit of output produced in period t-1. This isoquant was developed in response to the price ratio of the factors

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[1] The parallel development of the "theory of induced innovation" by Kennedy (1964, 1966, 1967), Samuelson (1965, 1966), and Dradekins and Phelps (1966) was not about 'induced innovation' as defined above or by Hicks, as it was conceived at the response of innovation to relative income shares rather than to relative prices, or the relative factor scarcities.

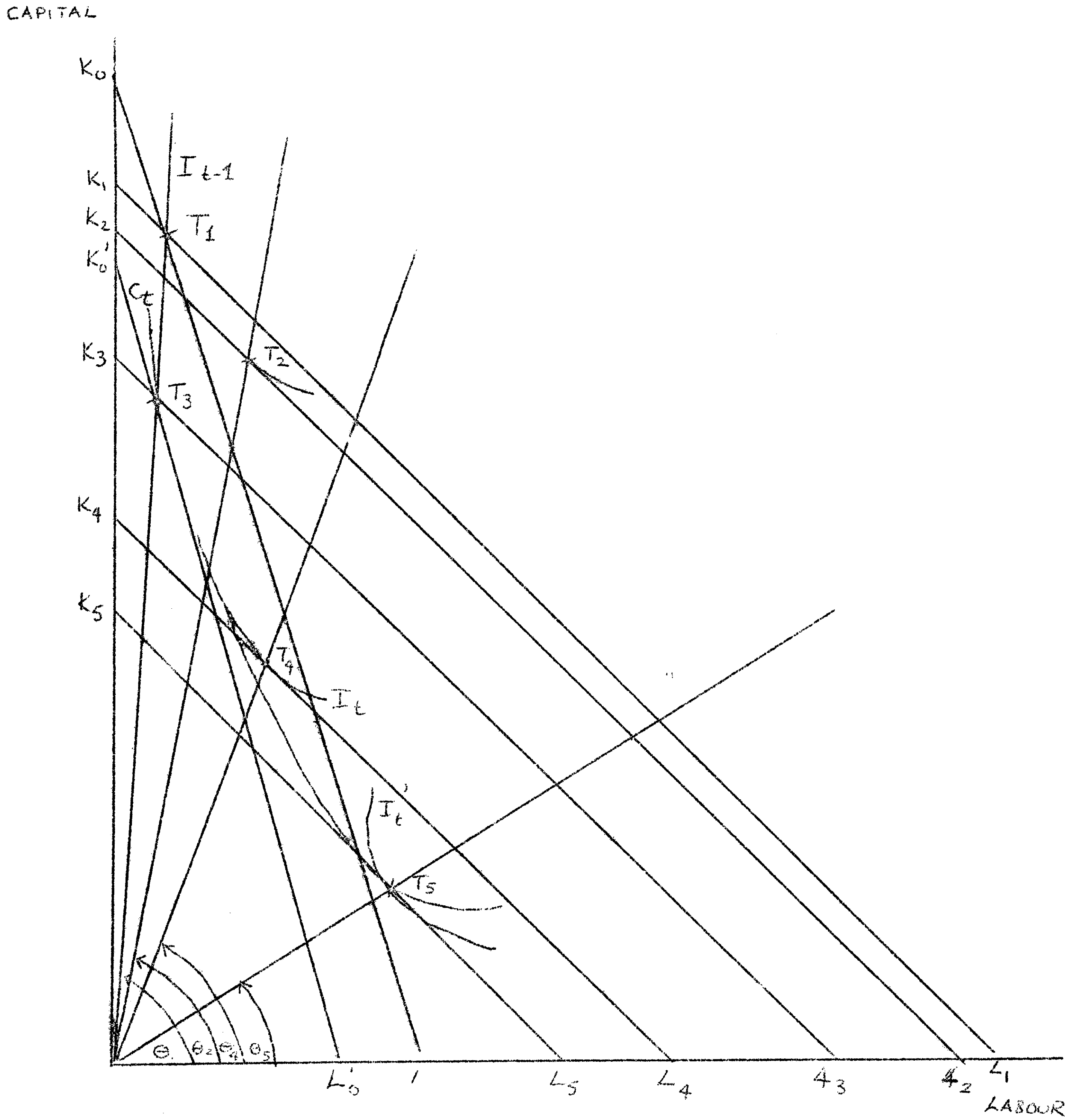

FIGURE 1. The Innovation Possibility Curve and Induced Innovation.

represented by the slope of the K_0L_0. (The meaning of 'response' will become clear as we go along). If the factor price ratio of the economy is represented by the slope of the K_1L_1 (or K_2L_2, etc.), and the economy is technically free to choose its factor proportion, then, it will choose the point on I_{t-1} where K_2L_2 is tangent to it. However, if for some reason this freedom is unavailable to the economy, it will be on K_1L_1 and producing at T_1 rather than the T_2 combination. The cost of being unable to substitute would have cost the economy K_1K_2 (measured in capital) per unit of output. The saving of cost from being able to move from T_1 to T_2 is the result of factor substitution and not due to innovation.

But now let us assume that in the next period, t, there exists the possibility of developing new production functions (isoquants) through innovation. There are a number of such possibilities represented by I_t, I'_t, etc., and an envelope (which although drawn as smooth and twice differentiable, need not in fact be so) of these is represented by C_t. This C_t is the innovation possibility curve. The choice of one of the isoquants, such as I_t or I'_t on C_t, which takes account of the relative factor scarcity, is "induced innovation". Thus the choice of innovation in response to the price ratio K_0L_0 will be I_t, given the traditional assumption of cost minimazation; and similarly the choice of innovation in response to the price ratio K_1L_1 will be I'_t.

The benefits of cost reduction through substitution and induced innovation will depend on whether the economy is innovating or is importing innovation (imitating) or doing neither, and whether the country is importing physical factors (e.g. tractors) which fixes the ratio of factors used, or whether there exists the possibility of factor substitution.

Let us take an innovating country which has a factor price ratio of K_1L_1 at time t, while it had a factor price ratio K_0L_0 in period t-1, when the choice of the production function I_{t-1} was made. For the sub-period for which no substitution can be made after the change in price, the cost per unit of output, measured in terms of capital will be OK_1. Later on, when substitution becomes possible, the cost will go down to OK_2. As the country is the innovating country in period t, it can choose the isoquant on C_t curve which minimizes cost. The choice will be that of I'_t. The cost per unit, when this choice has been made, will be OK_5. Thus K_5K_1 will be its full reduction in cost per unit. Its factor ratio will change from tan θ_1 to tan θ_5.

Let us now take an imitating country, which has the price ratio K_1L_1, but the innovation is made by an economy which has factor price ratio K_0L_0, hence the choice of isoquant in period t is now not I'_t, but I_t. The total reduction in the cost of this country, if it is free to substitute once innovation has been made, will be cut from OK_1 to OK_4 and not to OK_5. Thus K_4K_5 is cost of non-innovation. The factor ratio will change from tan θ_1 to tan θ_{24}* If this imitating country also has to import physical factors which make factor substitution untenable, the additional cost for the imitating country will be K_5K_3, and increase of K_4K_3, per unit of output. The factor proportion would not change and remains at θ_1.

Finally, let us take a country which does not imitate innovation, nor does it itself innovate, but does still substitute factors. The additional

* and not to tan θ_5

cost for this economy will be K_5K_2. Finally, if the non-imitating non-innovating country also imports physical factors which make factor substitution untenable, then the additional cost to this economy, as compared to a country with all the advantages, will be K_1K_5 --there being no possibility of reduction in the cost of production. The last case is approximated by countries which keep on importing outdated equipment, which they themselves have been using for sometime.

It is obvious that all these steps cannot be easily (or profitably) traced in the present empirical study. But the general drift of the argument is clear. Success in reducing cost depends on the degree of adjustment through factor substitution and innovation. In what follows we shall examine the extent of this adjustment in agriculture of the countries under discussion.

III. The Induced Innovation Hypothesis : Empirical Evidence from the Experience of the United States and Japan 1880-1960[2].

Japan and the United States are characterized by extreme differences in factor endowments. In 1880, the total agricultural lamd per male worker was thirty-six times larger in the United States than in Japan. This difference has widened over time with the western extension of the area of agricultural land in the United States. By 1960, total agricultural land area per male worker was ninety-seven times in the United States than in Japan. The relative prices of land and labour also differed in the two countries. In 1880, in order to purchase a hectare of arable land, a Japanese farm worker had to work nine times

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[2] This section here simply summarizes the work of Hayami and Ruttan (1971), on this subject.

as many days as a U.S. farm worker. This difference has also widened over time, particularly between 1880 and 1920 when the wages of labour rose sharply relative to the price of land in the U.S. By 1960, a Japanese farm worker had to work thirty times as many days as his U.S. counterpart in order to acquire a hectare of arable land. These figures are displayed in Table 1 below.

TABLE 1

LAND-LABOR ENDOWMENTS AND RELATIVE PRICES IN AGRICULTURE: UNITED STATES AND JAPAN, SELECTED YEARS

	1880	1900	1920	1940	1960
United States:					
1. Agricultural land area (million ha)	202	319	363	411	435*
2. Arable land area (million ha.) .	76	129	189	187	181*
3. Number of male farm workers (thousands)	7,959	9,800	10,221	8,487	3,973
4. (1)(3) (ha./worker)	25	32	36	48	109
5. (2)(3) (ha./worker)	10	13	18	22	46
6. Value of agricultural land ($/ha.)	47	49	171	78	285*
7. Value of arable land ($/ha.)	163	129	352	180	711*
8. Farm wage rate ($/day)	0.90+	1.00+	3.30	1.60	6.60
9. (6)(8) (days/ha.)	52	49	52	49	43
10. (7)(8) (days/ha.)	181	129	107	113	108
Japan:					
11. Agricultural land area (thousand ha.)	5,507	6,031	6,957	7,100	7,043
12. Arable land area (thousand ha.)	4,748	5,200	5,997	6,121	6,071
13. Number of male farm workers (thousands)	7,842	7,680	7,593	6,365	6,230
14. (11)(12) (ha./worker)	0.70	0.79	0.92	1.12	1.13
15. (11)(13) (ha./worker)	0.61	0.68	0.79	0.96	0.97
16. Value of arable land (yen/la.)	343	917	3,882	4,709	1,415,000
17. Farm wage rate (yen/day)	0.22	0.31	1.39	1.90	440
18. (16)(17)(days/ha.)	1,559	2,958	2,793	2,478	3,216

Despite these differences in factor endowments and factor prices, both countries have experienced rapid rates of growth in agricultural productivity throughout the entire 80 years period between 1880 and 1960. This is perhaps why the United States and Japan are frenquently identified as alternative models of agricultural development.

The factors accounting for their rapid rate of growth of agricultural output per worker despite their sharp difference in factor endowments and factor prices according to Hayami and Ruttan lie in their remarkable adaptation of their agricultural technology to suit their contrasting factor endowments. In Japan, they emphasize that their innovations were primarily biological and chemical, whereas in the United States they were primarily mechanical, in both cases the objective being to increase the efficiency of the ralatively scarce factors through the process of innovation. Only in the last several decades has there been technological convergence in the two countries with the U.S. introducing biological innovations and Japan experiencing a rapid assimilation of mechanical technology.

The evidence supporting H-R contentions is of two types. First, they have been able to show strong correlation evidence linking changes of land area per worker and agricultural productivity in Japan[3]. Figure 2 displays the evidence. In the U.S., land area per worker (A/L) rose much more rapidly than in Japan, whereas in Japan land productivity (Y/A) rose much more rapidly than in the U.S.

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[3] In agriculture it is claimed that conditions of production permit the treatment of growth in land area per worker (A/L) independently from output per hectare (Y/A). If this view is accepted the major source of increase in (A/L) would be mechanical innovations which facilitate the substitution of other sources of power for labour. Similarly, increases in (Y/A) would be explained by biological innovations.

It is significant to point out that increases in power per worker and in fertilizer input per hectare were associated with declines in (a) the price of machinery relative to the wage rate and (b) the price of fertilizers relative to the price of land.

The second test of the hypothesis that variations of factor proportions, as measured by the land-labour, power-labour, and fertilizer land ratios are explained by variations in factor price ratios was attempted through the use of multiple regression analysis. The regressions were specified in log-linear form with little claim for theoretical justification given the lack of adequate a priori knowledge. The results of the regressions are summarized in tables 2-5.

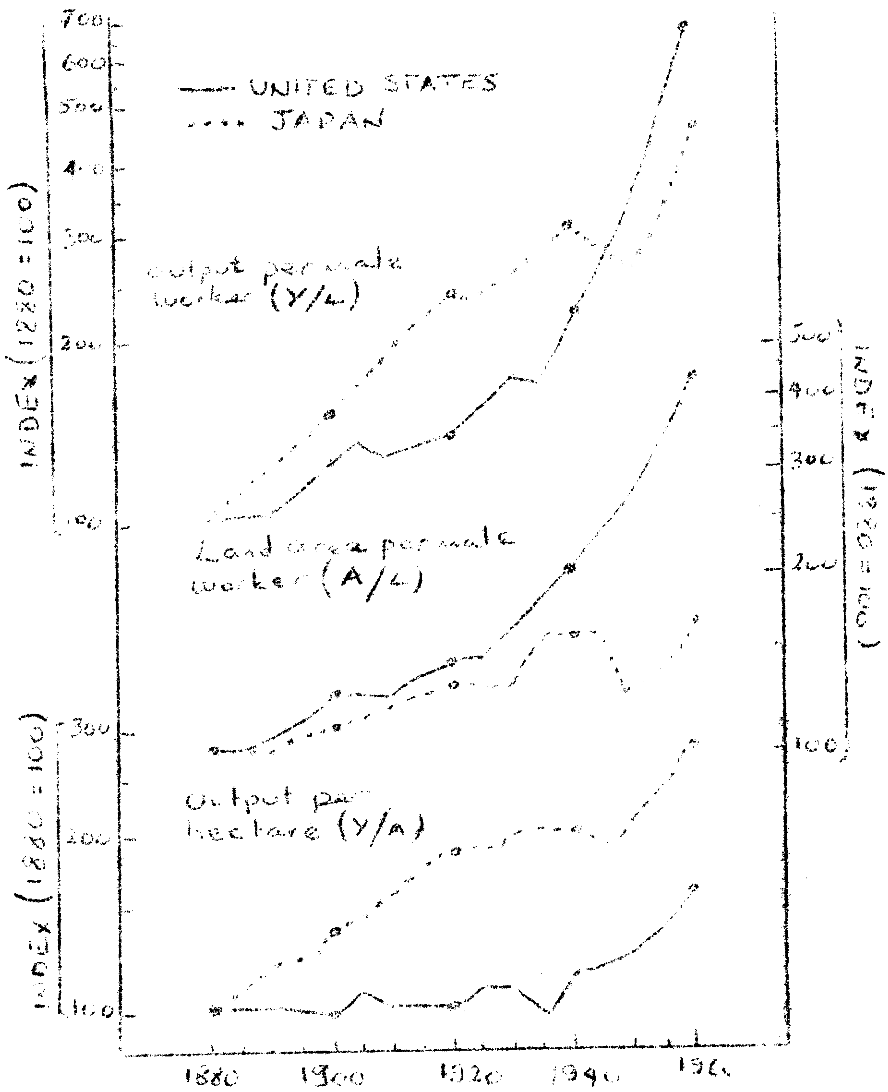

TABLE 2

REGRESSIONS OF LAND-LABOR RATIO AND POWER-LABOR RATIO ON RELATIVE FACTOR PRICES: UNITED STATES, 1880-1960 QUINQUENNIAL OBSERVATIONS

REGRESSION NUMBER AND DEPENDENT VARIABLES	COEFFICIENTS OF PRICE OF: Land Relative to Farm Wage	COEFFICIENTS OF PRICE OF: Machinery Relative to Farm Wage	$\bar{R}^2$	S	d
Land-labor ratio:					
1. Agricultural land per male worker	-0.451 (0.215)	-0.486 (0.120)	.828	.0844	1.29
2. Arable land per male worker	-0.035 (0.180)	-0.708 (0.101)	.882	.0706	1.37
3. Agricultural land per worker	-0.492 (0.215)	-0.463 (0.120)	.828	.0789	1.34
4. Arable land per worker.	-0.077 (0.182)	-0.686 (0.102)	.879	.0713	1.41
Power-labor ratio:					
5. Horsepower per male worker	-1.279 (0.475)	-0.920 (0.266)	.827	.1865	1.33
6. Horsepower per worker	-1.321 (0.474)	-0.898 (0.265)	.828	.1863	1.36

Note: Equations are linear in logarithms. Standard errors of the coefficients are in parentheses.

TABLE 3

REGRESSIONS OF LAND-LABOR RATIO AND POWER-LABOR RATIO ON RELATIVE FACTOR PRICES: JAPAN, 1880 - 1960 QUINQUENNIAL OBSERVATIONS

REGRESSION NUMBER AND DEPENDENT VARIABLES	COEFFICIENTS OF PRICE OF: Land Relative to Farm Wage	COEFFICIENTS OF PRICE OF: Machinery Relative to Farm Wage	$\bar{R}^2$	$\bar{S}$	d
Land-labor ratio:					
7. Arable land per male worker	0.159 (0.110)	-0.219 (0.041)	.751	.0347	1.17
8. Arable land per worker	0.230 (0.049)	-0.155 (0.019)	.914	.0156	1.71
Power-labor ratio:					
9. Horsepower per male worker	-0.665 (0.261)	-0.299 (0.685)	.262	.2191	0.60
10. Horsepower per worker	-0.601 (0.236)	-0.228 (0.620)	.266	.1982	0.61

Note: Equations are linear in logarithms. Standard errors of the estimated coefficients are in parentheses.

TABLE 4

REGRESSIONS OF FERTILIZER INPUT PER HECTARE OF ARABLE LAND ON RELATIVE FACTOR PRICES: UNITED STATES, 1880-1960 QUINQUENNIAL OBSERVATIONS

REGRESSION NUMBER	COEFFICIENTS OF PRICE OF: Fertilizer Relative to Land	Labor Relative to Land	Machinery Relative to Land	R^2	S	d
11 . . .	-1.622 (0.200)	1.142 (0.275)	0.014 (0.286)	.950	.1042	2.08
12 . . .	-1.615 (0.134)	1.138 (0.255)	...	.954	.0968	2.09
13 . . .	-1.951 (0.166)	...	...	.895	.1406	0.77
14 . . .	-1.101 (0.184)	1.134 (0.173)	-0.350 (0.214)	.969	.0816	1.38
15 . . .	-1.357 (0.102)	1.019 (0.168)	...	.970	.0832	1.15
16 . . .	-1.707 (0.154)	...	...	.884	.1481	0.84

Note: - Equations are linear in logarithms. Standard errors of the estimated coefficients are in parentheses.

TABLE 5

REGRESSIONS OF FERTILIZER INPUT PER HECTARE OF ARABLE LAND ON RELATIVE FACTOR PRICES: JAPAN, 1880-1960 QUINQUENNIAL OBSERVATIONS

REGRESSION NUMBER	COEFFICIENTS OF PRICE OF: Fertilizer Relative to Land	Labor Relative to Land	Machinery Relative to Land	R^2	S	d
17 . . .	-1.437 (0.238)	0.662 (0.244)	0.236 (0.334)	.973	.0865	2.45
18 . . .	-1.274 (0.057)	0.729 (0.220)	...	.974	.0810	2.45
19 . . .	-1.211 (0.071)	...	...	.953	.1036	1.52
20 . . .	-1.248 (0.468)	1.217 (0.762)	-0.103 (708)	.878	.1820	1.76
21 . . .	-1.313 (0.131)	1.145 (0.556)	...	.888	.1670	1.79
22 . . .	-1.173 (0.126)	...	...	.860	.1794	1.52

Note: Equations are linear in logarithms. Standard errors of the estimated coefficients are in parentheses.

In Table 2 it seems that more than 80% of the variations in the land-labour ratio and the power-labour ratio are explained by variations in their price ratios. More interesting is the fact that almost all of the coefficients in the various equations depicted in Table 2 are negative and statistically significant. The results suggest that the marked increases in land and power per worker in the U.S.'s agriculture over the past 80 years are closely related to the declines in the prices of land and machinery relative to the price of farm labour.

In Japan, the regression results of Table 3 suggest similar trends and patterns to those operating in the U.S. over the same period of time. However, the statistical fits for Japan are of lower statistical qualigy than those inTable 2. This is probably because the ranges of the observed variation in the land-labour and power-labour ratios are too small in Japan to reveal a significant relationship between the factor proportions and factor prices.

A comparison of Table 5 results with those of Table 4 indicates a remarkable similarity in the structure of demand for fertilizers in the U.S. and Japan. For in spite of sharp differences in climate, factor endowments, pattern of development, farmers in both countries show similar responses to economic variables.

The same techniques used to identify and measure the responsiveness of factor proportions to factor prices in the U.S. and Japan will now be used on data collected for Egypt and Syria. The data admittedly is of poor quality and the time span is limited -- the maximum range is 25 years, but for most of the series it is for 12-16 years.

IV. The Induced Innovation Hypothesis: Empirical Evidence from the Experience of Egypt and Syria 1950-1974

In this section we will attempt to show that Egypt and Syria's factor endowments are such that the former is labour intensive and the latter is land intensive. These factor endowment differences are likened to the differences between Japan and the U.S.'s factor endowments in the early stages of their agricultural development. Since induced innovations are singled out as the most important determinants of Japan and U.S.'s high agricultural productivity (response of factor proportions to factor prices), it is useful to see whether Syria's and Egypt's agricultural experience conforms in this respect to Japan and the U.S. Along the lines of the objectives enumerated in the Introduction we shall examine the following:

(i) Whether or not Syria's and Egypt's agricultural factor proportions have responded to their relative factor prices.

(ii) Whether or not the pattern of response, if it exists, is similar to Japan's or to the U.S.'s.

(iii) Whether or not their responsiveness has led to increases in agricultural productivity.

(iv) What lessons, if any, can be learned from our answers to (i) - (iii).

Broad Perspective

Syria and Egypt are characterized by extreme difference in relative endowment of land and labour. From Tables 6 and 7, it is evident that both Syria and Egypt seem to have, by 1963, responded fairly well to their relative factor endowments. Syria, with 34 times land per worker as compared to Egypt, also had about 3 times tractors per worker, while it had 1/50 of use of fertilizer per hectare. The process and pattern of adjustment seems to have continued till 1974, at least in fertilizer, in which the decline in the ratio of land to labour in Syria as compared to Egypt was accompanied by a rise in the ratio of fertilizer use per hectare from 1/50th to 1/20th. There was no change in the ratio of hectare to worker however.

Looking at this broad picture, one cannot but conclude, that it is fully consistent with the view that both Syria and Egypt have made appropriate induced adjustments in response to their relative factor scarcity. However, a more complete study of adjustment through induced innovation would require a more detailed analysis. Following H-R, we use regression analysis for this purpose.

Regression Analysis

In following Hayami and Ruttan's approach, we are faced with two sets of problems: one of data and the other of method. So far as the data is concerned the first problem is that we have been unable to obtain a suitable series of land prices. Therefore, we cannot obtain results which require land/labour prices for their calculation. The second problem in data is more general. While Hayami and Ruttan use data covering a period of over 80 years, and thus have been able to work with five year averages without loosing the significance of their results, our data cover too short a period to allow us to use even two year averages. The special significance of averaging in agriculture lies in the fact that most of its variables can be significantly affected by weather conditions, and particularly by the rainfall. An averaging

TABLE 6 (A)

Land-Labour Endowments in Agriculture

Egypt and Syria, 1963-1974

	1963	1964	1965	1966	1967	1968
EGYPT						
1. Agricultural Land Area (1000 hectares)	2548.	2506.	2672.	2780.	2801.	2835.
2. Arable Land Area (1000 hectares)	2470.	2422.	2582.	2683.	2694.	2687.
3. Economically Active Population in Agriculture (1000 persons)	3632.	3673.	3751.	3877.	3864.	3892.
4. (1)/(3) (ha/worker)	.702	.682	.712	.717	.725	.720
5. (2)/(3) (ha/worker)	.680	.659	.688	.692	.697	.690
SYRIA						
1. Agricultural Land Area (1000 hectares)	12727.	12762.	12211.	11542.	11542.	11325.
2. Arable Land Area (1000 hectares)	6280.	6410.	6342.	5873.	5876.	5577.
3. Economically Active Population in Agriculture (1000 persons)	517.	556.	718.	784.	959.	1092.
4. (1)/(3) (ha/worker)	24.6	22.9	17.0	14.7	12.0	10.4
5. (2)/(3) (ha/worker)	12.1	11.5	8.8	7.5	6.1	5.1

Source : Data Appendix

TABLE 6 (B)

Land-Labour Endowment in Agriculture

Egypt and Syria, 1963-1974

	1969	1970	1971	1972	1973	1974
EGYPT						
1. Agricultural Land Area (1000 hectares)	2835.	2843.	2852.	2855.	2855.	2855.
2. Arable Land Area (1000 hectares)	2725.	2725.	2725.	2725.	2723.	2724.
3. Economically Active Population in Agriculture (1000 persons)	3964.	4120.	4471.	4650.	4400.	4198.
4. (1)/(3) (ha/worker)	.715	.690	.638	.613	.649	.680
5. (2)/(3) (ha/worker)	.687	.661	.609	.585	.619	.649
SYRIA						
1. Agricultural Land Area (1000 hectares)	11321.	11350.	11357.	11967.	12371.	12420.
2. Arable Land Area (1000 hectares)	5600.	5642.	5647.	5612.	5542.	5682.
3. Economically Active Population in Agriculture (1000 persons)	1307.	768.	891.	907.	850.	874.
4. (1)/(3) (ha/worker)	8.7	14.8	12.7	13.2	14.5	14.2
5. (2)/(3) (ha/worker)	4.3	7.3	6.3	6.2	6.5	6.5

Source : Data Appendix

TABLE 7

Tractors/worker and Fertilizers/hectare in Egypt and Syria
1964-1974

	Egypt			Syria		
Year	Hectare/ worker	Tractor/ worker	Fertilizer/ hectare	Hectare/ worker	Tractor/ worker	Fertilizer/ hectare
1964	.682	3.49	1216.	22.9	10.32	25.0
1965	.712	3.71	1263.	17.0	9.09	26.0
1966	.717	3.87	1035.	14.7	9.47	25.0
1967	.725	3.98	1002.	12.0	7.5	39.0
1968	.720	4.00	1147.	10.4	7.43	50.0
1969	.715	4.28	1227.	8.7	6.70	49.0
1970	.690	4.25	1312.	14.8	11.76	67.0
1971	.638	3.93	1306	12.7	10.78	84.0
1972	.613	3.97	1466.	13.2	11.44	84.0
1973	.649	4.55	1418.	14.5	13.62	73.0
1974	.680	5.00	1508	14.2	14.72	70.0

Source: Data Appendix

TABLE 8 (A)

Total Agricultural Production, Labour Productivity and Land Productivity Egypt and Syria, 1961-1974

E G Y P T

(1) Year	(2) Total Production (Index) 1961=100	(3) Economically Active Population in Agriculture 1961=100	(4) Total Agricultural Land area 1961=100	(5) Labour Productivity (2)/(3)	(6) Land Productivity (2)/(4)
1961	100.0	100.0	100.0	100.0	100.0
1962	100.0	100.0	100.0	100.0	100.0
1963	103.0	100.8	100.0	102.2	103.0
1964	106.0	102.0	98.3	103.9	107.8
1965	107.0	104.2	104.8	102.7	102.1
1966	108.0	107.7	109.1	100.2	98.9
1967	106.0	107.3	109.9	98.8	96.4
1968	118.0	108.1	109.9	109.2	107.4
1969	123.0	110.1	111.3	111.7	110.5
1970	123.0	114.4	111.5	107.5	110.3
1971	127.0	124.2	111.9	102.2	113.5
1972	129.0	129.3	112.0	100.0	115.2
1973	130.0	122.2	112.0	106.4	116.1
1974	132.0	116.6	112.0	113.2	117.8

Source : Data Appendix

TABLE 8 (B)

Total Agricultural Production, Labour Productivity and Land Productivity Egypt and Syria, 1961-1974

S Y R I A

(1) Year	(7) Total Production 1961=100	(8) Economically Active Population in Agriculture 1961=100	(9) Total Agricultural Land Area 1961=100	(10) Labour Productivity (7)/(8)	(11) Land Productivity (7)/(9)
1961	100.0	100.0	100.0	100.0	100.0
1962	100.0	103.3	100.0	96.8	100.0
1963	100.0	89.3	100.0	112.0	100.0
1964	108.0	96.0	100.3	112.5	107.8
1965	109.0	124.0	95.9	87.9	114.0
1966	83.0	135.4	90.7	61.3	91.5
1967	105.0	165.6	90.7	63.4	115.8
1968	98.0	188.6	88.9	52.0	110.2
1969	109.0	225.7	88.9	48.3	122.6
1970	85.0	132.6	89.2	64.1	95.3
1971	89.0	153.6	89.2	57.8	99.0
1972	135.0	156.7	94.0	86.1	143.6
1973	84.0	146.8	97.2	57.2	86.4
1974	126.0	150.9	97.6	83.5	129.1

Source : Data Appendix

TABLE 9

Wheat Production and Land Productivity in Egypt and Syria

1950-1974

Year	Egypt: Area of Wheat (1000 Hectares)	Egypt: Production of Wheat 1000 ha	Egypt: Productivity (1)/(2)	Syria: Area of Wheat (1000 hectares)	Syria: Production of Wheat 1000 (M.T.)	Syria: Productivity (1)/(2)
1950	576.	1018	1.767	992.	830.	.837
1951	629.	1209	1.922	1037.	510.	.492
1952	589.	1089.	1.849	1167.	900.	.771
1953	752.	1547.	2.057	1314.	870	.662
1954	754.	1729.	2.293	1347.	965.	.716
1955	640.	1451.	2.267	1463.	438.	.299
1956	660.	1547.	2.344	1537.	1051.	.684
1957	636.	1467.	2.307	1495.	1354.	.906
1858	599.	1412.	2.357	1461.	562.	.385
1959	620.	1443.	2.327	1422.	632.	.444
1960	612.	1499.	2.449	1550.	555.	.358
1961	581.	1436.	2.472	1315.	757.	.576
1962	611.	1593.	2.607	1417.	1374.	.970
1963	565.	1493.	2.642	1559.	1190.	.763
1964	544	1500.	2.757	1476.	1100.	.745
1965	577.	1600.	2.773	1214.	1044.	.860
1966	542.	1465.	2.703	853.	559.	.655
1967	530.	1299.	2.451	1201.	1049.	.873
1968	594.	1518.	2.556	891.	600.	.673
1969	523.	1269.	2.426	1221.	1004.	.822
1970	548.	1516.	2.766	1341.	625.	.466
1971	567.	1729.	3.049	1274.	662.	.519
1972	523.	1618.	3.094	1354.	1808.	1.335
1973	525.	1838.	3.501	1476.	593.	.402
1974	576.	1984.	3.444	1537.	1630.	1.061

Source: Data Appendix

over a number of years helps reduce the influence of such random factors.

The methodological problem, referred to above, is the following. While looking at the question in broader perspective, Hayami-Ruttan's as well as our analysis defines the land/labour relative scarcity as the ratio of land per worker in agriculture in these countries. It is this relative scarcity which is supposed to induce the amount of hectare per worker or fertilizer per hectare used in agriculture. In this way the land per worker is treated as an exogenous variable. The question then is : whether it is methodologically justifiable to try to explain the same land per worker (See Table 1) in agriculture (that is, to turn it into an endogenous variable) with the help of the relative prices of hectares to labour and fertilizer to labour.

Although nowhere explicitly stated, the view taken by Hayami and Ruttan seems to be that although they have taken land/labour ratio as a general measure of relative scarcity, it is the relative price of land to labour which represents the relative scarcity, so far as the response of the economic agents is concerned. As labour could move into and out of agriculture in the U.S. and Japan, in response to price incentives, this procedure would appear to be eminently justifiable. Our problem via-a-vis this approach is two-fold. First, the non-methodological one, has already been noted : we do not have the series for land prices and therefore we cannot use the ratio of the land and labour prices as a measure of the relative scarcity of the two factors. The other, and methodologically more important, aspect of the problem is that due to the possible lack of ability of the sectors outside agriculture to absorb increasing numbers of labourers with increases in population, and given the relative fixity of land in agriculture in Egypt and Syria, we should treat the land/labour ratio as the exogenous variable, while treating the ratio of the price of land to the price of labour as one of the endogenous variables.

As the answer to this question for these 'overpopulated', predominantly agricultural underdeveloped countries is not quite clear, we treat the land/labour ratio, in what follows, as alternatively exogenous and endogenous. However, as we shall see, the results are not significantly different in the two cases.

With land/labour ratio treated as endogenous variable, a la Hayami and Ruttan, we get the following result.

The results are displayed in Tables 10 and 11 for the case where A/L is treated endogenously and in Table 12 when it is treated exogenously. In all the tables, the numbers in parenthesis are student-statistics, R^2 is the coefficient of multiple determination -- a measure of goodness of fit of the results, s is the standard error of estimate and d is the Durbin-Watson statistic -- it indicates whether or not there are serious autocorrelation problems[4].

Table 10 results are those pertaining to Syria, whereas the results in Table 11 pertain to Egypt and those in Table 12 pertain to both countries.

The regression results indicate that almost more than 80 percent of the variation in the land-labour ratio in Syria is explained by the changes

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[4] It should be pointed out that the coefficients in the linear regressions are marginal responses, whereas they are elasticity estimates in the log-linear case.

in the relative prices of power to labour and fertilizers to labour. The coefficients are negative for the relative price of tractors to labour and are statistically significant at the 5 percent level. Such results suggest that the changes in land per worker in Syria over the past decade have been closely associated with relative price changes of tractors relative to labour. The fact that the land-labour ratio is negatively related to the relative price of tractors to labour further suggests that land and power should be treated as complimentary factors. Moreover, this suggests that mechanical innovations which raise the marginal rate of substitution of tractors for labour also tend to raise the marginal rate of substitution of land for labour. In the same view, the positive elasticity estimates of the relative prices of fertilizers to labour suggest that fertilizers can be thought of as substitutes to the extension of land per worker.

The results of the same regressions for Egypt (Table 11) are much inferior in terms of statistical criteria. This is perhaps explainable by the fact that the ranges of observed variations in land-labour ratio in Egypt is too small (See Table 6) in Egypt to detect any significant relationship between the factor proportions and factor prices. However, it may also indicate that mechanical innovations adopted in Egypt were motivated by a desire to increase yield rather than substitute for labour. The closeness to zero of the parameter estimates of the price coefficients of tractors relative to labour may be taken as an indication of this possibility. However, the statistical lack of significance of these parameter estimates make any guess in this regard hazardous.

The regression results of the amount of fertilizer input per hectare of agricultural land in Syria show that relative prices of machinery to

TABLE 10

Regressions of Land-Labour, Tractor-Labour, and Fertilizer-Land Ratios on Relative Factor Prices: Syria 1961-1974

Regression Number and Dependent Variables	Coefficients of Price of Tractors Relative to Labour	Coefficients of Price of Fertilizers Relative to Labour	R^2	s	d
Land-Labour Ratio:					
Linear					
1. Agricultural land per worker	-1.45	54.39	86	2.04	2.11
	(3.23)	(5.8)			
2. Arable land per worker	- .82	25.81	83	1.13	1.92
	(3.32)	(5.00)			
Log-Linear					
1. Agricultural land per worker	-2.07	.84	82	.145	2.20
	(2.33)				
2. Arable land per worker	-2.47	-1.50	79	.162	2.00
	(2.49)	(4.63)			
Tractor-Labour Ratio:					
Linear					
Tractor per worker	.61	13.72	41	1.73	1.35
	(2.46)	(1.75)			
Log-Linear					
Tractor per worker	1.69	-1.46	39	.188	1.44
	(2.33)	(1.76)			
Fertilizer-Land Ratio:					
Linear					
Fertilizer per hectare (P_2O_5/ha)	3.14	-126.23	29	7.54	.60
	(1.38)	(1.58)			
Log-Linear					
Fertilizer per hectare (P_2O_5/ha)	6.19	-1.65	35	.477	.55
	(1.55)	(1.78)			

TABLE 11

Regressions of Land-Labour, Tractor-Labour, and Fertilizer-Land Ratios on Relative Factor Prices: Egypt 1961-1974

Regression Number and Dependent Variables	Coefficients of Price of: Tractors Relative to Labour	Coefficients of Price of: Fertilizers Relative to Labour	R^2	s	d
Land-Labour Ratio:					
Linear					
1. Agricultural land per worker	-.006 (.41)	.45 (.48)	4	.03	.79
2. Arable land per worker	-.006 (.44)	.57 (.63)	7	.03	.78
Log-Linear					
1. Agricultural land per worker	-.16 (.64)	.11 (.74)	8	.44	.89
2. Arable land per worker	-.18 (.70)	.14 (.91)	13	.47	.89
Tractor-Labour Ratio:					
Linear					
Tractor per worker	-.08 (1.12)	-6.67 (2.1)	88	.18	2.17
Log-Linear					
Tractor per worker	-.067 (.33)	-.34 (3.57)	92	.04	2.02
Fertilizer-Land Ratio:					
Linear					
Fertilizer per hectare (P_2O_5/ha)	1.09 (1.88)	-409.17 (2.95)	68	1.18	2.39
Log-Linear					
Fertilizer per hectare (P_2O_5/ha)	3.35 (1.89)	-3.35 (3.00)	67	.31	2.32

Source: Data Appendix

labour and fertilizer to labour account for only 29% of the variation of the dependent variable in the linear case and 35% in the log-linear case. The fact that the coefficient of the price of fertilizer to labour is negative is an indication of an economic response on the part of farmers to price changes of fertilizer relative to labour. The positive price coefficient of tractors relative to labour suggests a substitutionary relationship in Syria between the fertilizers and tractors and fertilizers and labour. The four D-W coefficients, however, indicate serious auto-correlation among the error terms which biases the coefficients estimates. The signs however remain indicative of the nature of association.

In Egypt the same results are far more acceptable according to the statistical criteria. The two relative prices explain more than 2/3 of the variations in the input of fertilizer per hectare. Furthermore the coefficients of the relative price of fertilizer to labour are statistically significant at the 5% level of significance. The D-W statistic is close to two indicating the absence of serious auto-correlation.

Treating the land-labour ratio as an exogenous variable and using it as a proxy variable for the relative scarcity of land seems to have improved the statistical fits for Egypt and worsened them for Syria as one might have expected. The results in Table 12 are all in log-linear form as this form produced better results than the linear specification.

The results suggest that the land-labour ratio in Egypt is indeed exogenous and that land scarcity is a decisive factor in Egyptian agriculture. Furthermore, the success of Egypt's adjustment of factor proportions to factor prices is now all the more apparent. More than 98 percent of the variations in the tractors per worker in Egypt are explained by the relative prices of tractors to workers, fertilizers to workers and the proxy variable for the relative scarcity of land A/L.

In Syria treating the land/labour (A/L) ratio as an exogenous variable worsened the statistical fits. Besides, it (A/L) turned out to be a statistically insignificant variable in both of the regressions.

V. Concluding Remarks

Our findings in the previous sections indicate that in the broader perspective as represented by Table 7 both Egypt and Syria appear to have adjusted their factor use to their relative factor scarcity. The more detailed study however, shows that Egypt has adjusted much better than Syria, particularly in terms of the variables whose endogeneity is in no doubt, viz tractors and fertilizers.

So far as the question of "success" is concerned, the total agricultural output of both countries has increased, again at a somewhat higher rate in Egypt than in Syria, and also at a steadier rater - but the trend has been an increasing one in both cases. However, if achievement is measured in terms of output per worker rather than in the aggregate, as it should be for representing the changes in the welfare of the participants in agricultural sector, then for Egypt we find a slight increase, but for Syria a decline in agricultural output per worker.

Therefore if we were to summarize Egypt's experience, we would say that it has had success in adjustment but a non-success in achievement, while for Syria it had a non-success in adjustment and a failure in achievement.

TABLE 12

Regressions of Tractor Per Worker and Fertilizer Per Hectare on Relative Factor Prices and Land-Labour Endowments: Egypt and Syria 1961-1974

Dependent Variables	Coefficients of Price of Tractors Relative to Labour	Fertilizers Relative to Labour	Land/ Labour	R^2	s	d
Egypt						
Tractor per worker	.191 (1.92)	-.589 (9.89)	.675 (4.28)	98	.017	2.87
Fertilizer per hectare	.098 (.139)	-.302 (.54)	-1.33 (1.30)	46	.106	1.65
Syria						
Tractor per worker	2.79 (2.00)	-.139 (.34)	.649 (1.52)	54	.175	1.02
Fertilizer per hectare	5.85 (1.37)	-.824 (.73)	.019 (.017)	38	.469	.62

Source: Data Appendix

In both cases the success in achievement is lower than the success in adjustment, and in neither case has the adjustment or the achievement been as good as in the U.S. or in Japan. However, the adjustment, particularly in Egypt, has been of the same order of magnitude as that of the U.S. and Japan and so has the achievement in terms of total output. But the achievement in terms of per worker output for either of the two countries cannot be compared either to Japan or to the U.S.

Our conclusion from this somewhat "mixed" result for Egypt and Syria is not that the agriculturists do not respond to economic incentives, as has customarily been assumed for underdeveloped countries, nor that there is a "lagged" reaction in adopting new techniques as seems to have been assumed, without much supporting evidence by Hayami and Ruttan. The overall picture of adjustment represented by Table 7, and Egypt's responsiveness in the more detailed study, are sufficient to preclude either of the above two hypotheses.

In our view, the initial clue lies in examining the differences between Syria and Egypt, by asking the question why has Egypt succeeded better than Syria on both counts ? For answering this even tentatively, we have to go beyond the data included in our study - the difference in the provision of water supply. In our very tentative view, Syria has done less well on both counts mainly because of the overpowering influence of her erratic water supply on the behaviour of other variables. If we compare Egypt and Syria on the one hand and Japan and the U.S. on the other, the major difference, again not covered either by H-R or by us, is between the rate of the growth of population and the possible absence of induced innovation outside agriculture in response to the change in factor proportions. It is this additional factor, and the unresponsiveness of the sector outside agriculture, which, particularly in the case of Egypt, has not allowed output per worker to increase at the rate one would have expected from its fairly successful adjustment as well as its success in achievement measured in terms of aggregate output.

The tenative general conclusion we draw from the above is that even if we agree that the development of agriculture is the key factor in the overall economic development of a country, the "correct" behaviour of agriculturists may not be sufficient to ensure this development. It is quite possible that the absence of appropriate behaviour and responsiveness <u>outside</u> agriculture may thwart the development of agriculture. All this is indeed tentative and will require further study, but it does lead us back to the rather old fashioned view of economic development. Partial solutions to this general problem may succeed, but for this to happen one has to be 'born' with the 'right' endowments and at the 'right' time in history.

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