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TECHNICAL CHANGE IN AGRICULTURE

A Report on the Ninth International Conference of Agricultural Economists

by

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The Conference, which was held in Helsinki from August 19 to 26, 1955, brought together approximately 280 agricultural economists from 37 countries. This report can of course give only a sample of the wealth of ideas and research results which were presented.

1. CAUSES OF AND CONDITIONS FOR THE MECHANISATION OF AGRICULTURE

The Concept and Meaning of Technical Change

The fact that the conferences are held only every three years—the last one took place in 1952 in Michigan—makes it important to select a subject of world-wide interest and considerable importance. The advantage of doing this is that the scientists from all parts of the world who participate are likely to be very familiar with the subject and can work actively for the solution of the problems discussed. Also, the breadth of the theme usually involves collaboration with other disciplines, which in turn leads to the inclusion of new and valuable viewpoints and permits of a more complete discussion of the problem.

Both these factors were present in last year's Conference theme, the title of which was "The Implications of Technical Change in Agriculture". This theme was chosen not only because of the well-known existence of world-wide changes in production techniques in agriculture, but also because of the recognition that technical changes are becoming increasingly important in the whole development of agricultural policies and the economic and sociological phenomena which are related to them.

Factors Causing Higher Incomes in Agriculture

In the last few decades a trend towards a growth in the income per head of the population engaged in agriculture has been observed in many countries, especially in Europe and North America. According

*This article is a translation of two reports which appeared originally in *Agrarwirtschaft*, Vol. 5, Nos. 2 and 3 (February and March, 1956) published by Alfred Strothe Verlag, Hanover, Western Germany. The article has been slightly condensed and adapted for Australian readers.

to Schultz[1], this is attributable less to the additional input of land, labour and capital than to the achievement of higher yields per unit of input. In the case of North American agriculture, 90 per cent of the increase in real income per head in the last 80 years is attributable to higher yields per unit of input in agriculture, and only 10 per cent to an *increased use* of land, labour and capital.

The increased yield per unit of input cannot be attributed solely to greater technological progress in agriculture as is commonly assumed. The other factors which have to be considered are, firstly, the increased amount of capital investment per person working in agriculture, (i.e. expenditure of better general and technical education for the rural population) which leads to qualitative improvements in the work of the human agent, and, secondly, general economic progress which is characterised by such concepts as the growth of the market, increasing division of labour and the growth of more indirect methods of production.

These three positive factors whose influence singly has not been measured so far, operate to counteract the law of diminishing returns in agriculture. Economists have so far relied too much on this law in their support of the thesis of a growing real cost of agricultural commodities in relation to non-agricultural commodities. They seem to neglect the growing importance of technology which tends to delay the effectiveness of this law. Every improvement in seed-bed preparation, fertilisation, control of noxious weeds and pests in the field of plant and animal production, delays the operation of this law for many years, if not for decades.

Knowledge, Incentive and Technological Change

Although the development of new agricultural techniques is an important cause of the growth of productivity, and therefore of income in agriculture, the existence of such techniques alone is not a sufficient condition for the achievement of an improvement in the income status of agriculture. These new techniques must also be made available to, and be used by, the great mass of farmers. This spread of technological knowledge depends not only on economic but also on non-economic factors, and there is no doubt that among the latter category the most important is the level of education and technical skill of the rural population.

In this respect differences are still enormously great not only in the world as a whole, but even within one country, and this lends importance to attempts to raise the level of education and technical skill of the rural population. The technique of spreading agricultural knowledge is, however, still in its infancy.

Since World War II the problem of spreading technical knowledge in agriculture has been attacked from two angles; from the highly developed agricultural countries, and especially from the United States,

[1] T. W. Schultz (U.S.A.), *The Contribution of the Economist to Programs of Technical Development.*

(This and other footnote references, except where apparent, are references to papers submitted at the Conference.)

advisers, technicians and scientists have been sent to less developed areas to advise and give assistance in developmental programmes. On the other hand, the less developed countries are also developing initiative in this regard. They are sending their students and technicians to various countries for study so as to build up a teaching and advisory staff. The great international agencies, such as the United Nations and the Food and Agriculture Organisation may be regarded as co-ordinating institutions where requests for help and indications of willingness to supply such help, meet, so that effective aid can be given in developmental plans.

Although the problems of technological change are often similar, every country has a unique economic, social and cultural pattern which frequently presents great barriers to the spread of technological knowledge. In many cases the lack is one of elementary education. The proportion of illiterates in the total population may be very high, and the level of health and nutrition may be so low as to make it impossible for the human agent to operate effectively. Sometimes religious beliefs may also prevent the introduction of new practices. Advice and help must not start, in these cases, at the level of mechanising agriculture, but with an attack on fundamental problems such as the level of education, public health and nutrition. Here the co-operation of governments is essential. Unfortunately, governments—especially when they change frequently—are not always interested in long-term schemes such as the development of education and public health services.[2]

It is therefore seldom possible to limit efforts to improve the efficiency of agriculture to the spreading of mere technological knowledge. It is much more important to incorporate technological improvements in agriculture in the existing social and economic conditions of the country, and to improve these latter conditions at the same time.[3]

Knowledge of technological improvements in agriculture must be accompanied by the incentive to adopt them. Incentives can be assumed to exist where there is an active desire for higher incomes and better living standards on the part of the rural population. Such a desire is sometimes awakened as a result of the example of more fortunate neighbouring rural populations.

However, there are cases where existing technological opportunities are not fully used, not only in less developed, but also in more highly developed agricultural countries. Higher incomes are often used to satisfy demands for higher personal consumption, rather than for productive investment in the farm enterprise. Even in countries where governmental assistance is given to encourage technological improvements—with the aim of raising productivity—a part of the increased income is often used to increase consumption and this reduces the possible growth of future incomes.[4] Although such developments are

[2] J. O. Morales (Costa Rica), *The Meaning of Technical Change in the Context of the Agricultural Economy in South America.*

[3] R. Colon-Torres (Puerto Rico), *The Sociological and Cultural Problems Associated with the Technical Change in Agriculture.*

[4] K. L. Robinson (U.S.A.), *Political Obstacles Tending to Retard the Increased Economic Welfare Offered by Technical Change in Agriculture.*

by no means to be condemned once a certain income level has been attained, a more desirable situation is reached when increased income is freely invested in order further to raise incomes and leisure in the future.[5]

Technological Progress and the Structure of Agriculture

If the two conditions of a reasonable level of education and incentive for entrepreneurs to adopt technological improvements are met, it does not by any means follow that technological progress can take place without further hindrance. Technological development of rural production is influenced by a vast range of other factors which may either obstruct or assist its growth.

To these factors belongs the institutional structure of agriculture in its widest sense. In most countries the structure of agriculture is the result of historical developments and as such can be changed only in the long run and by means of legislative or other governmental intervention.

The type of land tenure prevailing in a country has a great influence on its economic development, and on the share of agriculture in the national product. In most cases, as the total area of land used for agriculture cannot be increased, the tenure pattern must be changed, if necessary, to conform to modern requirements. The institutional framework in which farm operations are carried out should include the following features:

(1) The proceeds of the soil must be secured to the operator for a sufficiently long period to enable the planning and execution of investments such as drainage, improvement of soil fertility, irrigation and the breeding of better livestock.

(2) The risks of production must fall on the actual operator.

(3) The proceeds of investment must flow to the persons undertaking it.

These three points, in particular, affect tenure relationships which are often fixed by law and which should be framed so as to permit optimum technological change. Other necessary measures are:—

(4) Means should be found to enable the best farm operators to obtain land.

(5) Real estate prices and rents should be influenced directly or indirectly so that they are kept at a reasonable level.

(6) Collective measures must be taken which will improve productive possibilities on individual farms, e.g., maintenance of rural roads, stream regulation, communal drainage, etc.[6]

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[5] Colin Clark (Oxford), *The Relation Between the Pace of Technical Change in Farming and the Level of Agricultural Prosperity.*

[6] J. Horring (Netherlands), *The Adequacy, from the Point of View of Technical Development, of Contemporary Institutional Systems: Land Tenure.*

The adoption of new techniques, the size of farms and the tenure pattern are all part of a relationship of interaction which tends to obey the law of least resistance.

For the most part predominant farm size has been established prior to the introduction of modern technology. However, farm size must in the long run adjust itself to new technological requirements Optimum size will of course vary according to the level of techniques used and the geographical location of the enterprise. Meanwhile the introduction of new techniques tends to take place on the larger farms because of the risks associated with such innovations. However, nowadays more and more small farms are profiting from technological improvements.

In Europe the smallest farm capable of benefiting from technological developments is approximately 12 acres. Holdings which are smaller than this must develop either into part-time farms or become very highly specialised in order to survive. However, even larger farms, say between 12 and 30 acres, are unable to mechanise operations completely, and it is here that there is the greatest need for an adjustment in the size of farms.[7]

The advantages and disadvantages of farms of different sizes should be carefully considered when planning agricultural settlements. Furthermore social considerations should not be allowed to result in the settlement of small uneconomic units. No settlement should be planned to-day without consideration of current technology.

Migration of Cause and Effect of Technological Change

A very important factor in the trend towards mechanisation in agriculture and one of great influence on the incomes of all those occupied in agriculture is the changing number of rural workers. Pedersen has made investigations covering various European countries (Denmark, Sweden and Great Britain) and the United States, the results of which are relevant for similar types of rural economies.[8]

Until the outbreak of World War II, a general development in the Western World was the shrinkage of the proportion of the population engaged in agriculture. However, the place of change was comparatively slow. It is only in the last 15 years that it has accelerated, so that in some countries a reduction in the labour force in agriculture of 20 to 30 per cent can be observed since pre-war. (Certain exceptions can be noticed as a result of war-induced actions).

This spectacular post-war decline in the rural labour force is usually explained in terms of mechanisation, which reduces the demand for rural labour. However, mechanisation was not the dominating influence

[7] H. Niehaus (Germany), *The Adequacy, from the Point of View of Technical Development of Contemporary Institutional Systems: Size and Layout of Farms.*

[8] J. Pedersen (Denmark), *The Impact of Technical Change on the Employment Situation within Agriculture and on the Occupational Structure of the Population.*

in pre-war migration from agriculture, as tractors existed even before World War I, and combines reached a fair level of efficiency during the twenties.

The major factor explaining pre-war migration from agriculture is to be found on the supply side of the rural labour market, and is illustrated by the existence of a negative correlation between total unemployment and relative wages in agriculture (i.e. rural wages relative to wages in industry). Unemployment serves as a barrier to migration from agriculture, thus increasing the supply of rural labour and lowering its wages. This is reinforced by the relative fall in agricultural prices during depressions, together with the introduction of more advanced technical devices, these factors combining to reduce the demand for rural labour. Full employment, on the other hand, provides the opportunity for migration from agriculture, and thus induces a relative increase in rural wages.

Since the war, however, in the countries observed this relationship seems to have been reversed. A fall in unemployment is associated with a fall in relative incomes in agriculture.

Pedersen draws the conclusion from this that we are here concerned with a change in demand in the rural labour market, and not as before with a change in supply. The mechanical innovations have led to a freeing of rural labour, which tends to change the causal relationship. This reversal of the causal relationship does seem, however, to be restricted to a few relatively progressive rural economies, because the condition for its existence is the attainment of a relatively high level of income so that the substitution of machines for labour becomes economically attractive.

The Motive Force in the Mechanisation of Agriculture

The diminution of the rural labour force is one of the most important conditions for successful mechanisation and the raising of rural incomes, irrespective of whether mechanisation is the effect or the cause of the migration of labour from agriculture.

Technological progress in agriculture is possible without a diminution of the rural labour force (e.g. improvements in the breeding and feeding of plants and livestock and pest extermination). However, the effect of such improvements on the level of rural incomes is likely to be smaller than the effect which can be achieved through a reduction in the rural labour force with the same level of total production. An improvement in rural incomes without a reduction in the rural labour force is possible only if the increased product resulting from technical progress can be sold at prices not too far below the level previously in existence. In other words, the assumption is that technical progress does not produce large price-depressing surpluses. This in turn pre-supposes a rising demand from the non-agricultural population—either at home or abroad. Such an increase in demand may be the result of population growth or of increased *per capita* incomes.

However, the increase in population tends normally to fall short of the growth in agricultural production which is possible with a stable rural labour force. Nor are increasing export markets likely in a world where technical progress in agriculture is world-wide.[9]

An expanding economy, especially an expanding industrial economy, coupled with a steady increase in incomes therefore offers the best conditions for an expanding demand for agricultural products, and consequently for the stabilisation of prices of farm products. If such a favourable economic climate exists—and that would hold for many parts of Europe and North America—a particularly strong incentive is given to agriculture to increase production. However, even in these cases, it will normally be necessary for the rural labour force to decline gradually. The expansion of industry, trade and administration will require more labour and will tend to attract labour with higher wages and salaries. As a result of these factors a tendency for the rural population to be attracted to industrial centres and cities becomes noticeable in all highly developed economies. This migration is at the same time the most important cause of mechanisation in agriculture.[10]

To reduce the labour force in agriculture is the great problem confronting all countries with open or disguised rural under-employment. This under-employment can result from insufficient labour mobility or from a lack of employment opportunities in other branches of the economy. Lack of employment opportunities presents serious difficulties to many governments in Central and South America, Eastern Europe and Asia. The sudden introduction of labour-saving techniques would produce extraordinarily great social and economic tension in those countries because it would free a large number of workers for whom no employment opportunities could be found. Such a situation can lead to a refusal to adopt any labour saving techniques in agriculture. In such countries help for the rural population is possible only through large scale emigration which is hardly practicable, or through the active promotion of development in the economy as a whole. This is widely recognised by the governments concerned, but the possibilities of development are often severely limited by shortage of capital and lack of education. Technical progress in agriculture and especially mechanisation can take place only very slowly under these circumstances, and the improvements in real incomes achieved so far are extremely small.[11]

2. EFFECTS OF TECHNICAL CHANGE IN AGRICULTURE

As a result of the example of the intensive agriculture of Western Europe, technical progress in agriculture is often identified with high productivity per acre. Although higher productivity per acre can be

[9] Englund (U.S.A.), *The Interaction between Technical Changes in Agriculture and the Pattern of International Trade.*

[10] E. C. Young (U.S.A.), *The Interaction between Technical Change on the Farm and Technical Changes in Marketing and Distribution.*

S. E. Johnson (U.S.A.), *The Meaning of Technical Changes in the Context of the Agricultural Economy of North America.*

[11] S. Krasovec (Yugoslavia), *The Meaning of Technical Change in the Context of the Agricultural Economy of South Eastern Europe.*

obtained by means of thorough seed bed preparation, drainage, plant breeding, use of fertilisers, pest extermination, etc., this is the result of only one branch of technical change. It must be supplemented by other technical means to achieve an increase in the productivity per unit of labour so as to improve the cost-income relationship in agriculture.[12]

There are sufficient examples in the world (North America, Australia and New Zealand) where high productivity of labour coupled with low productivity per acre produces far greater real incomes than are at present possible in the intensive agriculture of Western Europe.

The Measurement of Increases in Productivity

Investigations regarding the agriculture of the United States which were carried out by Schultz showed an average annual increase in productivity per unit of input of .8 to 1.35 per cent (for the years 1910-50).[13]

The greater part of this increase can be attributed to the increased productivity of labour. This is probably not peculiar to the United States. The following table by Clark (Table I) gives the average annual increase in productivity per man in agriculture for various countries. (Productivity is measured in terms of gross money income from agriculture less costs of seed and feedstuffs.[14]) To obtain the real *net* productivity of agriculture it would be necessary to deduct other inputs by the farming community, e.g., fertilisers, weedicides and farm machinery, but unfortunately, the relevant statistical information is not available. This deficiency is, however, not large, as in most areas farm operators' purchases of production requisites from the industrial sector of the economy are approximately 25 per cent of the "gross" product (i.e., gross product minus seed and fodder). Important exceptions exist in the United Kingdom and the United States where farmers pay considerably more (up to 50 per cent) for goods and services from the non-agricultural sector.

The rates of increase in productivity per man are normally fairly constant if one ignores firstly, seasonal fluctuations, and secondly, those countries such as France, Sweden, the United Kingdom and the United States, in which extraordinary changes have led to marked deviations in the rates of increase. In France, for instance, there was a very marked reduction in the length of the working day betwen 1870 and 1920.

For a few countries information is also available about the rate of increased productivity per hour of working time. These rates are approximately one-seventh higher than the rate of increase in productivity per annum. This suggests that part of the increase in productivity is taken out in leisure.

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[12] M. Cépède (France), *The Meaning of Technical Change in the Context of the Agricultural Economy of France.*

[13] T. W. Schultz, *Economic Organization of Agriculture* (New York: McGraw-Hill Book Co. Inc., 1953), p. 374.

[14] Colin Clark (Oxford), *The Relation Between the Pace of Technical Change in Farming and the Level of Agricultural Prosperity.*

TABLE I.

Average Percentage Increases in Annual Labour Productivity in Agriculture

Country	Time Span	Rate of Increase per Annum
		Per cent
Australia	1911–1952	1·2
Austria	1901–1951	2·3
Belgium	1910–1953	2·2
Canada	1929–1952	2·7
Cuba	1935–1951	1·6
Denmark	1880–1952	2·0
Finland	1934–1950	2·5
France	1815–1870	2·4
	1870–1920	0·4
	1920–1952	1·9
Germany	1882–1938	0·9*
Ireland	1867–1952	1·3
Japan	1894–1938	2·3
Netherlands	1934–1950	0·9
New Zealand	1935–1950	2·2
Norway	1890–1951	2·9
Sweden	1860–1925	2·1
	1925–1952	4·0
Switzerland	1890–1950	0·7
South Africa	1934–1951	2·1
United Kingdom	1870–1930	0·5
	1930–1951	3·7
United States	1870–1940	1·3
	1940–1953	5·4

* According to German calculations a higher rate of growth of productivity holds, Cf. *Agrarwirtschaft*, Sonderheft, 1954, Page 10.

Source.—Colin Clark, *op. cit.*

In so far as this is not the result of enforced leisure arising out of lack of opportunity for work, it represents a real gain obtained through technical changes in agriculture.

The Influence of Technical Change on the Terms of Trade

The rise of real incomes in agriculture depends on two factors:

(1) A rise in real terms in the net productivity of rural labour, and

(2) A favourable movement of farm product prices in relation to other prices—the terms of trade. This concept, also known as "the exchange value of farm products", is used here in its widest sense comprising both national and international markets.

With respect to the world market as a whole, there can be little doubt that technical progress in agriculture produces a deterioration in the terms of trade when viewed from the standpoint of the agricultural

producer.[15] It is possible that the agriculture of one country can obtain special economic advantages as a result of undergoing relatively more rapid progress than the rest of the world.[16] However, these advantages will disappear quickly if other areas manage to catch up technologically. The ever-widening application of new agricultural techniques leads to an expansion in the supply of farm products which depresses the exchange value of agricultural commodities. Bellerby gives the following reasons for this pressure of supply on demand:—

(1) A significant degree of flexibility in the expansion of the supply. (The term flexibility is used to denote the rate of expansion in response to a growing demand).

(2) The low income elasticity of demand for agricultural products.

(3) The low price elasticity of demand for agricultural products.

(4) In times of contraction of demand, the almost complete short-term inflexibility of supply.

(5) The low supply prices of rural labour in areas where labour is in over-supply.

This combination of factors is typical only of agriculture and leads to a constant pressure of supply on demand. The low income elasticity of demand would, by itself, be of little consequence if the supply of agricultural products did not constantly tend to increase. This tendency alone would not be of great importance if either the elasticity of demand were such that surpluses could be absorbed at lower prices, or if farmers could restrict production in the short run. Finally it would be possible to restrict supply in the long run if it would not matter so much that the supply price of rural labour is so low in areas with a labour surplus. Nor is an improvement in real incomes made possible by selling the surpluses. The fact that the elasticity of demand is less than one means that the gross income realised from the sale of a larger volume will be smaller than the income which would have accrued from the sale of a smaller volume.

These very negative effects of technical progress in agriculture on the terms of trade are not necessarily inevitable. If, as a result of the growth of population and the improvements of techniques in industry, the prices of non-agricultural products fall, no deterioration in the terms of trade need take place. Population growth, falling industrial prices and a rise in real incomes have, in the last 25 years, worked in favour of agriculture. In the western world the terms of trade have moved in favour of agriculture since approximately 1930—although not to the extent predicted by Colin Clark in his book *The Economics of* 1960 (Clark estimated an improvement of 90 per cent in the terms

[15] J. R. Bellerby (Great Britain), *The Relative Incidence on Agriculturalists and on other Groups of the Benefits Resulting from Technical Change in Agriculture.*

S. E. Johnson (U.S.A.), *The Meaning of Technical Change in the Context of the Agricultural Economy of North America.*

[16] E. C. Young (U.S.A.), *The Interaction Between Technical Change on the Farm and Technical Changes in Marketing and Distribution: Farm Crops.*

of trade by 1960 as compared with the base of 1925-34). Schultz on the other hand, on the basis of United States experience, believes that a 20 per cent improvement in the exchange value of agricultural products relative to the thirties would be impossible even if the prices of farm products continue to be supported at artificial levels by governmental action.

Is Income Disparity Inevitable?

Different answers were given at the Conference to the question of whether farmers obtain a commensurate reward, in the form of higher incomes, for their pains in adopting new techniques. Commensurate rewards were defined as the achievement of rural incomes which corresponded to the real incomes obtainable in other sectors of the economy.

It cannot be denied that the disparity in incomes between farmers and urban workers has always existed and is world-wide, and although appreciable improvements in the relative incomes of farmers have been achieved in many countries in recent years, complete equality of incomes is, so far, rare. Bellerby concluded from this that, because of the five points mentioned earlier, income disparity can never be completely eliminated. Others supported this contention claiming that some disparity in incomes is necessary to encourage a constant stream of migration out of agriculture.

Although it is important for the improvement of incomes in agriculture that migration to the city is always possible, it is by no means true to say that an income disparity is necessary for this purpose. This disparity can lead to a negative qualitative selection which would do agriculture great harm. If migration is the effect and not the cause of the mechanisation of agriculture (and this seems to be the case in some industrialised countries), there is no reason why incomes in agriculture should be lower than in other sectors of the economy. This destroys *the proof* of the necessity for an income disparity. It is, however, still necessary to demolish the frequent acceptance of this idea. In this connection Schultz instances the North American Corn Belt where technological progress has been very rapid in the last 20 years, and where farmers now obtain a real income which is as high as that of industrial workers in the same area.

This parity can also be attained in other areas if farmers are in a position to adopt the five conditions mentioned by Bellerby in such a manner as to approximate to the conditions usual in industry. Technical progress in its widest sense is making this increasingly possible. Better seed-bed preparation, fertiliser use, harvesting machines, etc. are making it possible to obtain yields less subject to seasonal fluctuations and therefore to predict the supply more accurately than before. The use of new labour-saving machines also gives agriculture a greater influence on the labour market.

In this way the supply of farm products can be varied relatively more in the short run and to some extent adjusted to the demand. A good storage scheme and the mechanisation of conservation will supplement

these measures. Improvements in distribution, marketing and transport can lead to a greater division of labour and thus to fuller utilisation of the natural and economic advantages of any given area.[17] Other measures helpful here could be designed to achieve greater mobility of labour by means of a change in the pattern of tenure and the size of farms. Here we should mention the example of the United States where the size of farms in terms of acreage is constantly increasing, despite the simultaneous increase in the proportion of part-time farmers.

It is evident that this process of achieving income parity is going to be a slow one. The realisation of the goal will depend on agriculture, industry and governments, and will require great effort. The immediate aims—and here the speakers at the Conference were unanimous—should be the better education, training and guidance of rural producers.

[17] E. Englund (U.S.A.) *Interaction between Technical Changes in Agriculture and the Pattern of International Trade.*