PROCEEDINGS OF THE NINTH INTERNATIONAL CONFERENCE OF AGRICULTURAL ECONOMISTS

HELD AT
TEEKKARIKYLA, OTANIEMI
FINLAND
19–26 AUGUST 1955

THE IMPLICATIONS OF TECHNICAL CHANGE IN AGRICULTURE

LONDON
OXFORD UNIVERSITY PRESS
NEW YORK TORONTO
1956

THE INTERACTION BETWEEN TECHNICAL CHANGES IN AGRICULTURE AND THE PATTERN OF INTERNATIONAL TRADE

ERIC ENGLUND[1]

Foreign Agricultural Service, U.S. Department of Agriculture, U.S. Embassy, London

THIS topic offers wide opportunity to indulge in definition of terms; but it would be unnecessary to do so before this assembly and in the light of the papers already presented. At the risk of appearing to offer definitions, however, I shall deal with the topic as if it read, 'the interaction between technological advance and international trade, with special reference to agriculture'. I shall use the term 'technological advance' to include research, invention, and education, in their broader sense, related to the task of achieving a more effective utilization of resources.

I do not choose the resulting latitude for mere convenience, but for three principal reasons: technological changes in agriculture and in the rest of the economy are closely interrelated; trade in agricultural products cannot be disentangled from trade in other products and services, in their relation to patterns of trade or economic balance among nations; and technological change and trade are interrelated in their economic effects.

Notwithstanding these complexities, we shall consider certain tendencies that may have special significance to agriculture and to international trade in its products, even if some of the tendencies are more clearly discernible in theory than in the practical affairs of the day.

These tendencies, and some aspects of public policy related to them, may be suggested by a few topical phrases: technology and margins of comparative advantage; technology and the size of the market; expansion of the market and inducement for technological improvements; technology and curtailment of international trade; and prospects and hopes for greater benefits of technology and international trade.

[1] I am indebted to Dr. Sherman E. Johnson and Mr. Raymond P. Christensen, Agricultural Research Service, U.S.D.A., for helpful suggestions and references, but the views expressed are my own.

Technology and Margins of Comparative Advantage

Differences in resources among nations have long been recognized as a basic reason for international division of labour and trade. Differences in agricultural resources seldom if ever give one nation superiority over another in all major lines of agricultural production, but only in some lines, with inferiority in others. Upon the *relative* advantage of resources, quite as much as upon absolute differences, to recall another familiar concept, depends the tendency toward regional and national specialization and stimulus to trade in response to market requirements expressed through price.

If the better land responds more abundantly than the poorer to additional increments of input and to technology, it follows that technological progress tends to widen the margins of comparative advantage. But as tendencies, however valid in theory, are not usually permitted to function without practical hindrances, technology may not always expand international trade and may even be used to curtail it. Nevertheless, the question of technology in relation to margins of comparative advantage appears fundamental to our subject.

The greater response of the better land to input and to technology results from certain specific characteristics of the land itself. About thirty-five years ago I was a member of Professor Richard T. Ely's seminar in land economics, in the University of Wisconsin. I remember the emphasis he put upon the economic contents of the term land as a factor of production in agriculture. He included in land not only the ground we walk upon and the depth, structure, and fertility of the soil, but also such natural accompaniments as topography, rainfall, temperature, hours of sunlight, and length of growing season. Upon these depend in large measure not only superior productivity 'at a given state of the arts', but also the additional productivity attributable to the improvement in 'the arts' due to technological advance. We pass over the factor of location.

Assume, for illustration, an area of land in the corn belt of the United States, well endowed with fertile soil and other natural elements which Professor Ely stressed, and assume also two technological improvements,—hybrid corn (maize) and the corn picker, a machine for harvesting the crop.

The most important of the many characteristics already developed in hybrid corn is that it increases the yield, by at least 20 per cent., with little additional cost. The amount of this increase is greater on the superior land, with at least correspondingly larger net returns over the small additional cost. Conversely, the increased yield would

tend to be less than proportionate on land with fertility and rainfall below requirements for the potential increase from hybrid seed. Where land is fertile, rainfall ample, and temperature and length of growing season favourable, hybrid vigour has a better chance to produce the highest yield of which it is inherently capable.

Similarly, land that is level or gently rolling is better suited to mechanized operations including picking by machine. The success of the corn picker is in large part dependent on another hybrid characteristic, namely, a strong root system. By greatly reducing the likelihood of lodging, compared with open pollinated corn, the hybrid facilitates harvesting by mechanical corn pickers of which nearly 700,000 are in use on our farms in the United States compared with 120,000 in 1941.

This incidental reference to hybrid corn and mechanization illustrates important technological contributions by the plant breeder, not only in higher yield, greater disease resistance, improved quality, &c., but also in better adaptability to mechanization.

If the increased outlays of capital, ordinarily associated with technological advance, were pressed against the tendency of diminishing returns, to the point where 'the last increment' yielded the same additional returns on all grades of land, the greater total response of the better land to technology would become even more apparent. In theory this seems clear enough; in practice it is reflected in farm income, rent, and market value of land.

In a direct comparison of grades of land, and in terms of relative advantage as well, it appears certain in principle that technological advance tends to widen the margin of advantage between the higher and the lower grades of land. To the extent that other forces permit this tendency to prevail internationally, it should stimulate increased specialization or division of labour among regions and countries and greater international trade in agricultural products. The significance attributed to this tendency, if well founded, need not detract from our concern over obstacles in its way, but should help to focus research and practical action on problems of scope, and guidance for the economic forces which the tendency implies.

Technology and the Size of the Market

The pattern of international trade is a maze no less bewildering than technological change; and the complexity before us is not diminished by the fact that our subject concerns the interaction between these two labyrinths. We shall, therefore, resort to another generalization.

The two-dimensional enlargement of the market—in *depth* through greater productivity, larger income, and higher standard of living of the people, and in *width* through expansion of the trading area—affords greater inducement for more effective utilization of resources through technological improvement. We shall pass over the evident tendency of enlargement of the market in depth to require things of different kinds and higher degree of refinement than required as a result of enlargement in width, although this tendency has far-reaching significance in relation to technology.

In the more advanced industrial countries, technological progress in agriculture as in other fields appears to have taken place at an accelerated rate. This tendency probably will continue, for several reasons: the widening horizons of science; the cumulative results of research and their practical application; the ability and willingness of a society with increasing wealth and income to support research and to finance education in the application of research results; and the ability and apparent readiness of such a society to reward the primary producer and thereby still further induce him to bear the capital costs ordinarily associated with technological improvement.

Technological progress in the processing and distribution of agricultural products may have a brighter future than commonly realized; and it may afford examples of comparative advantage in relation to the scope and pattern of international trade.

This point may be illustrated by 'recombined milk' for which strong claims have been made.[1] Until recently the distance from Wisconsin, Minnesota, and the Pacific States, to central Mexico, Bombay, Cairo, Tokyo, Karachi, and other parts of Asia, surely seemed too long a 'milk route'. Yet, technological development appear to have spanned the distance in a considerable volume, with possibilities of further expansion.

Butterfat and non-fat solids of fresh milk are processed separately to avoid a cooked flavour. The fat is packed as a solid, and other solids are dried to powder by removing about 90 per cent. of the water. At the other end of the 'route' the fat and the powder are recombined with suitable water, the supply of which, incidentally, presents a difficult but not insurmountable problem. The product is palatable, wholesome, and nutritious.

A promise for the future may lie in that milk is almost unknown to large parts of the human family but capable of meeting important requirements in their diet. Not without relation to comparative advantage is the probability that large regions in Asia and elsewhere

[1] Henry Schacht, 'New Customers for Milk', *Better Farming*, Philadelphia, June 1955.

could hardly become more self-sufficient in the milk their people would consume—if they could get it clean, tasty, and within their means—than could Denmark, Holland, or Wisconsin become self-sufficient in bananas, coffee, and tea.

Technology and Market in a Continental Setting

Interaction between technological advance in agriculture and size and pattern of the market has the best chance to become apparent in countries of expanding economy, large territory of varying natural conditions, and absence of internal trade restrictions.

The United States, perhaps, affords an example of such a setting. Our conditions are continental. We are a relatively young nation, recently emerged from under-developed territory. Agricultural research and education have received increasing public encouragement and support, especially in recent decades and since 1862 when Congress passed and President Lincoln approved the Land-Grant College Act which established a nation-wide system of higher education in agriculture and the mechanic arts. Technology as a field of professional training and research has long enjoyed full economic and social recognition along with other fields and professions. Popular sanction and competitive reward have encouraged innovation and invention.

Referring to the circumstance that the United States affords a favourable setting for the study of comparative advantage in inter-regional competition, with evident implications for the international field, Mighell and Black have this to say:

> The principle of unimpeded commerce among the States was established in this country with the adoption of the Constitution (1787). Farmers and manufacturers have been relatively free to produce wherever conditions seemed most favourable and to sell anywhere in the national market. The result has been intensive inter-regional competition on a continental scale for more than a century. Moreover, the rapid growth of population and the opening of new lands and other natural resources have made agricultural adjustment unusually easy.[1]

It is unnecessary for me to elaborate on inter-regional competition in the United States or on changes taking place in our agriculture in response to comparative advantage within our country. These have been referred to in an earlier paper on technological progress in North America by my colleague of many years, Dr. Sherman E.

[1] R. L. Mighell and J. D. Black, *Interregional Competition in Agriculture*, Harvard University Press, 1951, p. 5.

Johnson. Much of our research in this field has been done by him or under his direction.

The expanding market for our farm products is due largely to our growing population, increasing national productivity and rising consumer buying power, and partly to exports which were considerably stimulated after the last war by our foreign aid programmes. This market has widened the margins of comparative advantage within our country not only in agriculture but also in the industries that produce fertilizer, insecticide, machinery, and other farm supplies. Our agriculture, in turn, provides an expanding market for the products of these supporting industries, and this undoubtedly has resulted in their costing relatively less.

The size of the market and the unrestricted trade within a large area, together with improvements in transportation, communications, and market intelligence, have stimulated specialization in agricultural production. A few examples will suffice. The production of market potatoes in the east is concentrated in particularly suitable areas and moves with the seasons from Florida to Maine. Market apples are supplied chiefly by areas of comparative advantage, from the eastern to the western side of the Continent. Citrus fruit is concentrated in Florida, southern California, and south-west Texas. Dairy production, although found throughout the country, is concentrated principally in the north eastern and the Great Lakes States. Range livestock is moved from its 'breeding-ground' in the West to the middle States and other areas where the land is highly productive of feed and forage, there to be finished for the market. This specialization does not necessarily result in a single enterprise system of farming, as the most advantageous use of resources often requires two or more complementary enterprises.

It is apparent in practice, as suggested in theory, that technological progress results in increased external and internal economies, and greater specialization. The resulting increase in trade and in returns to the producer encourages further technological advance with additional widening of the margin of comparative advantage. The limits of this tendency—spurred on by research, invention, and education—are not discernible even in theory. Who can predict developments on the frontiers of science and technology? It is their function to see to it that 'a given state of the arts' does not remain static very long.

The contribution of technology to the increase in production (output) in the United States, apart from the increase attributable to cost factors (input), has been analysed quantitatively by Professor

Schultz,[1] covering the period 1910 to 1950. Refinements of this analysis, including certain differences due to technical questions of index-number construction, speak best for themselves. It will suffice here to give only his main conclusion, namely, that the ratio of output to input increased 53 per cent. from 1910 to 1950; in other words, more than one-half of the increase is due to technology alone. Of this increase, four-fifths occurred in the last fifteen years.

After acknowledging that 'external economies' also have made important contributions to the gains in the efficiency of agricultural production, Schultz concludes: '. . . the revolution in agricultural production will continue; fewer inputs will be required in farming to produce a given output. The gains from new techniques during the next several decades are likely to be fully as great as they were during the period on which this analysis has concentrated.' He finds also that the value of this gain *in one year* is more than the total expenditures by all the States and the Federal Government for agricultural research and extension work since 1910.

Another benefit to society at large—and further evidence, if any were needed, of the inter-relation between agriculture and the economy as a whole—lies in the fact that technological advance in agriculture has released from our farming communities a large supply of labour for the industrial expansion upon which our economic progress so largely depends.[2]

Technology and Possible Curtailment of Trade

Research, technology, and education have advanced 'the state of the arts' with increasing rapidity in many parts of the world, but have done so unevenly in the world at large. This uneven advance probably has a strong influence on the pattern of international trade in agricultural products. Many of the less advanced areas have little buying power and little or no contact with markets for a variety of reasons, some of which may be technological. It follows that an accelerated technological advance in under-developed countries may for a time restrict international trade and thereby significantly change its pattern.

Each of the more advanced countries has borrowed freely from its

[1] W. Schultz, *The Economic Organization of Agriculture*, New York, McGraw-Hill Book Co. Inc., 1953, chap. 7.

[2] An excellent study, compact and well illustrated, of the agriculture of the United States came to hand as this paper was nearing completion but in time to be consulted on several points: R. L. Mighell, *American Agriculture, Its Structure and Place in the Economy*, New York, John Wiley & Sons, Inc., 1955 (a volume of the Census Monograph Series, prepared for the Social Science Research Council in co-operation with the U.S. Department of Agriculture and Commerce).

predecessors in progress. We of the New World have gained much from research and practical experience in the Old. The light of agricultural research on either side has not been hidden under a bushel.

The movement for technical assistance to under-developed countries is designed to help redress the imbalance in technological progress. It includes the pooled effort of many nations through F.A.O., the Colombo Plan, the Point IV Programme of the United States, the co-operative work between the United States and the Latin American Republics, and technical assistance projects under our Marshall Plan agencies. It is all based upon a broad philosophy of common interest among nations.

Progress is encouraging in terms of practical results, including especially the development of local interest and leadership, and in the increasing support by the governments of countries in which the work is being done. For example, in 1943 the cash support of our technical assistance programme in the Latin American Republics was approximately $10,000,000 by the United States and about the same over-all total by the host countries. Their annual contribution had increased more than fourfold by 1955, while that of the United States had declined by about one-third.[1]

These international efforts, and above all the step-by-step progress of individual countries achieved by their own means and under their own leaders, may well have the effect of reducing international trade, for a time and under particular circumstances. This could result, for example, if a country which for some time had depended on imports for a substantial part of its food supply, should become largely self-sufficient through the technological advance of her agriculture. In the long run, however, the record of economic progress encourages the belief that the effort to redress the world's inequalities in technological progress will be rewarding in terms of higher standards of living and a mutually advantageous increase in trade. This belief is based, of course, on the conviction that technology in agriculture must and will advance as part of general economic progress.

Another example, in a potentially long list of exceptions to the apparent tendency of technology to expand trade, may be afforded by an advanced country which aims to achieve substantial self-sufficiency in agricultural products, even in the face of comparative disadvantage. The reasons for doing so may be based on compelling

[1] 'Technical Assistance Programs', *Hearings before a Sub-Committee of the Committee on Foreign Relations, United States Senate, 84th Congress, First Session, between February 17 and March 4, 1955*, Washington, Government Printing Office, p. 32. (This document, a record of hearings on many aspects of the subject, covers 396 pages.)

economic and political consideration, even including the stark necessity of survival. Whatever the reason, our purpose is not to pass judgement upon it, but merely to point out that technology may provide the decisive means of implementing the policy of self-sufficiency.

The same could be said of quite a variety of circumstances in which public policy aims to change the pattern of trade or has the effect of doing so. It may be added, however, that after a national pattern of production has been established, modifications are likely to be slow and difficult even after the basic reasons for the policy have largely disappeared.

Prospect and Hopes

In certain circumstances, including those suggested in the above mention of under-developed countries entering upon a rapidly emerging technology and advanced countries striving for self-sufficiency, technological progress may hinder its own *general tendency* to widen the margins of comparative advantage and expand international trade.

Such hindrances, however, may be temporary and the tendency increasingly effective. This possibility, I believe, lies within the domestic and international context of the inter-relations between agriculture and the rest of the economy. If the tendency is well founded, we should not despair if its practical effects appear slowly. Perhaps Alfred Marshall had this in mind with reference to economic theory in general when he put *Natura non facit saltum* on the title-page of his *Principles of Economics*.

The dynamics of technology may be contributing more than we realize toward a greater awareness of our interdependence, out of which is gradually emerging, I believe, a stronger determination to devise realistic means of improving international economic relations and to create a more favourable climate for their growth.

These means, along with much else, include economic advancement of under-developed areas, maintenance of employment and reasonably stable prices, and liberalization of trade and exchange of which there are hopeful signs. The climate most needed to nourish these prospects and hopes toward their fuller realization is, of course, the *assurance of peace* upon which all else so greatly depends, including technology coupled with mutually advantageous international trade.

O. Aresvik, *Agriculture College, Vollebekk, Norway*

As Dr. Englund hints, the topic offers opportunity to indulge in definition of terms. However, I should like to know more clearly

what he means by the difference between technical changes and technological changes. I agree with Dr. Aziz that technological change is the narrower term. I would say that it occurs when a new input, or a change in characteristics of inputs, becomes known to the enterpreneur and he makes use of it.

Technical change may be defined by referring to the total production function for an industry, as done by Theodore Schultz in his excellent book, *The Economic Organization of Agriculture*. Thus we can say that if we have a different production function, we have a technical change. By technical advance in agriculture we get a higher total production function for the industry. This definition of technical change includes also all the reallocation of resources necessary to make agriculture as profitable as possible. We may perhaps call it improvements in organization, under which many things can be included such as regional specialization and better systems of land tenure. The definition of technological advance given by Dr. Englund is so broad that it appears to be the same as my definition of technical advance. However, in his paper he generally uses it with a narrower meaning.

Before commenting on Dr. Englund's main generalizations I will stress that we have insufficient knowledge about the interaction between technological advance and international trade, and we do not know the degree of independence of the assumed relations. It must be somewhat dangerous therefore to assume general validity for our statements. We need empirical studies to test the theories.

Sometimes Dr. Englund draws conclusions with which I cannot fully agree. He regards it as certain that technological advance tends to widen the margin of advantage between higher and lower grades of land. But to me it seems that the reverse is often the case. Theoretical arguments can be designed to support this also. The results depend upon the character of the advance. New varieties of grain, for instance, have enabled cultivation to be extended to the north in Canada and Siberia. This is an advance which does not affect the 'good' land. Again, in Denmark one hundred years ago the value of all land was determined and the land was classified accordingly. But what was then classified as poor land has increased more in value than the good land of that time. The last hundred years are characterized by marked technological advances in Danish agriculture. However, we can perhaps find the most striking examples of this type of change in the United States. In a wide sense the technological advances which made it possible to settle the American prairies were of a type of no direct consequence to the 'good' land.

Earlier, the 'good' land in the United States was to be found in the New England States. Much of the best land today, such as in Iowa and Illinois, was then graded as not suitable for agricultural production. Furthermore, let us for a moment imagine that technological advance in the atomic age might make it possible to produce food more efficiently by photosynthesis in factories than by any form of old-fashioned agriculture. The new margins of comparative advantage would then be quite different from the old and would be more narrow because, owing to atomic power, production could be nearly of the same efficiency in different parts of the world.

Technological advance may change the grading of the land. We have, of course, no absolute grading of land. Also, as Dr. Englund stresses, the effective supply of land is not merely a matter of area, but depends upon fertility, mineral content, climate, topography, and all the factors influencing accessibility. It is highly sensitive, therefore, to technological progress which affects the economic significance of all these qualities. Irrigation enables gardens to be made out of desert, as in Israel. The grading can change considerably, therefore, and changes of that type may result in a widening or in a narrowing of the margins of comparative advantage, and may increase or decrease international trade. In my opinion it is not advisable to generalize. We must examine each individual situation.

The effect of technological advance in agriculture on the margins of comparative advantage will also depend, of course, upon the advance in other industries in different regions. For instance, American agriculture has lost certain comparative advantages owing to essentially domestic influences. This is at least partly due to a greater rate of technological advance in other industries there.

History provides good examples of technical advance on farms and in marketing and of its impact upon international trade. So long as there were no internal transport facilities, specialization in agriculture and international trade in agricultural products were centred mainly in coastal regions and along the banks of navigable rivers. Specialization and trade opened up opportunities to improve techniques. But in the middle of last century, with the construction of railways and steamships, the Middle West of the United States was made accessible. This development had a great influence upon international trade. Many countries in Europe started to protect their home markets. Other countries, such as Denmark, found that dairy and poultry production and supplementary pork production now had comparative advantages. In spite of the strong tendencies towards agricultural protection, several countries developed a sub-

stantial export trade in agricultural produce. Technical advance in marketing, such as the development of canning, refrigeration, and freezing, has been of great importance. I would especially like to suggest for discussion by the Conference the effects of technical changes in marketing upon international trade. I agree with Mr. Marshall that the producer with good marketing facilities can more easily adopt improved techniques.

International trade in agricultural products and agricultural supplies depends upon corresponding international trade in raw materials and industrial products. Mechanization in Norway, for instance, is only possible if we can export industrial products to pay for the importing of tractors, fuel, and oil. Thus, trade in agricultural products cannot be disentangled from trade in other products and services, as stressed by Dr. Englund. Through technological advance in agriculture and non-agriculture each country's pattern of production will change. For instance, manufacturing industry now produces many substitutes for agricultural products, such as synthetic fibres and rubber, as mentioned earlier at this Conference.

A question which is treated more indirectly by Dr. Englund is that of institutional changes with regard to international trade and their impact upon technological changes in agriculture. It is a question which should receive prominent attention. In my opinion the effects of the different restrictions and regulations on international trade may have great influence upon technical changes in agriculture. Under free trade, there would be a tendency for production to fall in line with comparative advantage and for production thus to be maximized. The different trade restrictions disturb this distribution of production and may be a hindrance to technical advance. So, regarding the question of technical advance and the size of markets, it seems to be obvious that a large market with unrestricted trade stimulates specialization both in agriculture and other industries and also, therefore, international trade.

I. A. Butler, *Commonwealth Bank of Australia, Sydney, Australia*

The effect of technical change on international trade is a question which interests us in Australia, and also our neighbours in New Zealand, very deeply. Not only does our agriculture depend on exporting a large portion of what it produces, but the rest of the economy also depends on these exports to pay for a large volume of imports of raw materials and other products. Australia's trade represents a very high proportion of her national income, so that

variations in trade have a decisive effect on the economy. Right now, we have to consider whether we should correct the deficit which is appearing in our balance of payments by seeking to produce and export more agricultural produce, or whether we should extend our already fairly well-developed industrialization and so reduce the need for imports. I understand that our position in this respect is not unique among the countries exporting agricultural products. The solution which we and these other countries adopt must also be of concern to countries which are primarily interested in exporting industrial products and raw materials.

I think that one of the more important of the points made by Dr. Englund is that technical progress increases the differences in productive capacity between different countries and areas. There are certainly exceptions to this, as Dr. Englund himself pointed out, and as Dr. Aresvik has emphasized. In Australia we have one quite interesting exception in large areas of land which were previously almost valueless but which, when fertilized with minute quantities of trace elements in superphosphate, became highly productive. Australia considers that it has great differential advantages in grazing and wheat-growing, and technical progress has strengthened these advantages.

One important reason why existing advantages have been increased is that a country is likely to have facilities for and interest in intensifying research to help industries which have already been successful. I will illustrate this point briefly with two examples of changes which have recently yielded us very useful results. The first of these is in pasture improvement. Techniques have been worked out, and are at present being applied on a wide scale, for the sowing and fertilizing of pastures under Australian conditions—techniques which have opened up the possibilities of improving millions of acres. As a consequence, this land may yield four or more times the product which it yielded before.

The second example concerns rabbits, which had become one of the worst pests in Australia. They were introduced from overseas, found the grazing conditions ideal, and multiplied by millions. The study of means for eliminating them has been going on for a long while, and recently a virus disease, myxomatosis, was introduced and spread. This, at least for the time being, has proved extraordinarily successful, and a recent responsible estimate is that 90 per cent. of the rabbit population has been destroyed. If this reduction is permanent it will mean that the pastures of Australia will be able to carry tens of millions more sheep, or their equivalent in terms of cattle. The cost

of this particular control measure has been quite negligible so far, in relation to the benefits obtained.

These two examples show how an existing advantage, in our case mainly in grazing facilities, can be strengthened. They also illustrate the point that research aiming at increases in productivity has generally to be conducted or developed locally and directed at the solution of local problems, rather than being the mere adaptation of methods which have been successful elsewhere.

On the question of technical change and international trade, I believe, although it would be difficult for me at the moment to prove it, that techniques for international transport of goods are not advancing as fast as the techniques of agricultural production. If this is true, it means that trade in agricultural products tends to be handicapped since transport cost will remain nearly constant while cost of production is falling. Consequently transport costs would progressively contribute a higher proportion of total costs.

Again the development of substitutes can markedly affect trade in a particular commodity. Trade in butter is a particular example of this. Trade in natural textile materials could also be affected. Or again, a comparative advantage can be eliminated or reduced by technical change. An example of this is an advantage which Australia formerly had in producing eggs for export to the United Kingdom during the season of the year when northern hemisphere production was low. More recently techniques of egg production have extended the season over which eggs are produced. A similar effect could follow from some forms of mechanization. An industry depending for its advantage on plentiful supplies of cheap labour could lose this advantage if machinery were introduced which removed the need for most of the labour. Cotton-growing throughout the world might be affected in this way by the development of cotton-picking machines.

The expansion of production as a result of technical change often leads to international agreements. Wheat and sugar are two examples. Many more products would have been included, probably, had the difficulty of handling them and getting agreement about them been easier to work out.

Professor Pedersen and various other speakers have brought home to us the rapid rate of technical change in Europe and the pressures of population movements which are resulting from it. My interpretation of these changes is that, irrespective of the movement of population from farms, production will increase in these countries and this will mean additional pressure on supplies in both internal and external markets. It is difficult therefore to foresee any reduction in

the trend towards self-sufficiency in agricultural products, or any improvement in the prospects of food production for export.

The special position of meat and other protein foods which has been mentioned by Dr. Booth and Mr. Bellerby would favour agriculture in Australia in that we are meat producers and also have a potential for producing more meat. However, if as a consequence of general market pressure the producers of grain products turn to producing animals, the pressure might increase quite markedly on protein products as well as on grain.

To try to sum up, I am afraid that the implications of the various Conference sessions are not such as to inspire very great confidence in development, or perhaps even maintenance, of international trade in food products. The Conference even opened on a somewhat pessimistic note in the President's address, in which he said, 'the fearful problem of shortage, characteristic of the post-war years, has now, almost overnight, been transformed into one of an apparent unmarketable surplus'. The subsequent discussions have not done a great deal to dispel that rather gloomy but perhaps realistic statement. Irrespective of any widening of advantages, it does look as though the immediate future will not witness much encouragement for expansion of international trade in food. One view might be that technical change has been a sorcerer's apprentice and that we are in process of being drowned with a flood of the products of our ingenuity. Another view might be that a good fairy has been waving a wand, and we will all gain immeasurably as a result so long as we make the necessary adjustments.

Myself, I would not like to end on a pessimistic note. I feel that more emphasis could be given to the need of the world for more and better food. Also, I would like to emphasize that so long as conditions of full employment prevail throughout the world, wide changes both in trade and in production can occur in a fairly short period of time without very great hardship. I am inclined to believe, as Dr. Cardon hopes, that the sum of human welfare will increase as a result of technical progress, although perhaps it would grow more rapidly if there were a freer movement of food throughout the world.

F. BAADE, *Institute of World Economics, University of Kiel, Germany*

I am venturing upon a very radical doctrine, and although it is largely in accordance with Mr. Butler's concluding words, mine is an extremely optimistic prognosis concerning world food supplies.

I am of the opinion that the structure of international trade will be completely re-formed within the next two or three decades. The

volume of international trade in agricultural products will probably decrease. The proportion of vital food in international trade will fall, while that of luxury food, such as fruit, will rise. This prediction springs from the conviction that technical progress in world agricultural economy will be so rapid that it will reverse the Malthusian tendency in every part of the globe, including the retarded countries of today.

I can discuss here only one of the contributory factors, namely the quantitative increase and the geographical expansion of the use of commercial fertilizers. I believe that the development of the use of commercial fertilizer is particularly appropriate for measuring technical progress. Whenever the use of commercial fertilizer increases, there is also a corresponding increase in other beneficial factors such as better seeds, pest control, soil cultivation, and, where applicable, irrigation. This does not imply that commercial fertilizer is 'the magic pill' which need only be thrown on the soil to give adequate food supplies. I am using the data concerning commercial fertilizer as a specifically appropriate indicator for measuring the trends of technical progress.

In 1900 the approximate figures for world fertilizer consumption were:

	million tons
nitrogen	0·3
phosphoric acid	0·9
potassium	0·2

These quantities were used almost exclusively in two quite small parts of the world—a strip of the east coast of the United States of America, and a corner of west- and north-west Europe. A quarter of a century later, world use of nitrogen had quadrupled, that of phosphoric acid had trebled and that of potassium had increased sevenfold. Yet, by 1950, world consumption had risen to something between $3\frac{1}{2}$ and 4 times that of 1925. Thus, it has been quadrupled every twenty-five years; in all, it has risen sixteen-fold within fifty years. Now looking at the future, for instance to the year 1975 (that year which can be considered a milestone owing to the Paley Report), we may well assume yet another fourfold rise. This is a conservative estimate, for if we based the presumed increase on the increased ratio of the past few years and on that of the present, we should arrive at quite fantastic figures. Consumption of nitrogen in world economy is at present increasing at a rate of approximately 10 per cent. per annum. If it were to continue at the same rate until 1975, it would by that time have reached something of the order of 30 or 40 million tons, plus

the appropriate quantities of phosphoric acid and potassium. Even though world industry would be able to produce such quantities and the necessary raw materials would also be available—such enormous masses could not be consumed for the simple reason that world population even at the highest conceivable figure for 1975 would be physically incapable of consuming the gigantic quantities of food supplies which would result from the use of these amounts of fertilizer. Therefore, we must assume that the present rate of increase will slow down, and that the increase from 1950 to 1975 will be approximately equal to that which occurred twice in the course of a quarter of a century, that is to say a quadrupled rise for each twenty-five year period. This would be a conservative estimate. Even if the growth of world population were to continue at the present rate, such quantities would suffice to rid the whole world of hunger.

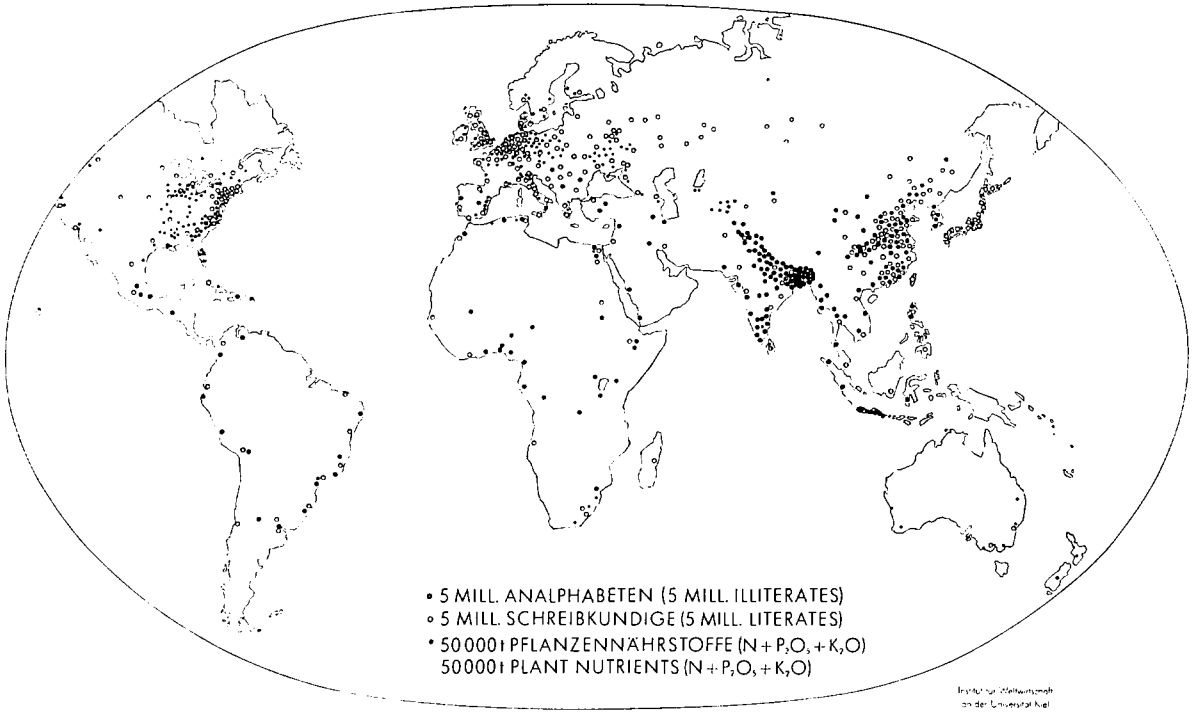
A decisive part of this increase will develop inside those countries which today constitute the Malthusian Belt. The map shows the distribution of the use of commercial fertilizer and also the distribution of literate and illiterate populations. Plant nutrients, in the main, are being consumed only where there are literate people. The Malthusian Belt is, to a great extent, identical with the analphabetic belt of the globe. These areas have the greatest chance of development in the next twenty-five years; for it is where the majorities of the rural population are illiterate that governments (and particularly the young national governments) are making the greatest and most successful efforts to conquer ignorance.

I think it is not too bold a prediction that by 1975 no great masses of illiterate farmers will exist anywhere on this earth. Plant nutrients will then be consumed in quantities compatible with modern agricultural techniques in the retarded territories of the present. But such consumption of plant nutrients is only conceivable if an improvement of agrarian techniques develops simultaneously in the use of better seeds, better soil cultivation, pest control, and irrigation. Here too, the removal of ignorance will be the best pacemaker.

Food production will therefore tend to increase more rapidly than population, even in countries which are today inside the Malthusian Belt. This will, of course, have a restrictive influence on the volume of international food trade. In my opinion, continental Europe will, by 1975, no longer constitute an import market for bread grains, fodder supplies, or animal products.[1] Furthermore, I

[1] For a development of this theme, see Fritz Baade, *Bread for all Europe*, 1953; also, *The Production and Purchase Reserves of European Agricultural Economy and its Meaning for*

BILDUNGSNIVEAU UND HANDELSDÜNGERVERBRAUCH
WELT 1950
EDUCATION AND COMMERCIAL FERTILIZER APPLICATION
WORLD 1950



Institut für Weltwirtschaft
an der Universität Kiel

believe that the Far East, with the exception of Japan, will by then no longer import mass food supplies.

W. H. LONG, *University of Leeds, England*

I should like to refer to what appears to me to be a paradox in comparing technical changes at the national level.

As we have heard several times during the last week, technical changes on the farm are a form of specialization. Farming, at any rate in the developed countries, is no longer carried on by subsistence farmers growing crops and livestock entirely to feed and clothe themselves and their families. Instead, the farmer now relies on the engineer for his tractors and implements, on the feeding-stuffs manufacturer, and in the first instance on the native grower of soya beans and cotton seed, for much of the food for his stock, on the chemist to help him keep his land clean with chemical weed-killer, and on the by-products of industry to help maintain its fertility, as well as on marketing organizations to exchange his surplus produce for the goods and services he and his wife and family require. The further specialization is carried, the more does the role of the farmer change from being a Jack-of-all-trades to one of organizing these many and varied specialists, so that each is made use of in the best proportions for the farm to yield the greatest surplus. And even this function the farmer now often shares with the scientific adviser. Most of this specialization has occurred comparatively recently; it has been said that it was not until 1914 that subsistence farming disappeared from Britain.

But when you consider change on a national scale, in almost every country you find that the tendency in recent years has been in the opposite direction, and instead of the international division of labour which results from specialization at the national level, we find nowadays each country proceeding to diversify its resources. This process has usually taken the form of more industrialization in what were the primary producing countries—Argentina, Australia, and Denmark are examples—and an increase in home agriculture in the most industrialized nation in the world—Britain. Self-sufficiency is becoming a feature of the international situation.

Since the economy of a country is the sum of its individual industries, it might be expected that the national interest would be similar to the individual interests. That it does not in fact seem to

the General Economy in the Industrial Countries of Europe, Berlin, 1927 (based on data prepared by F. Baade); and, Fritz Baade, 'Development Possibilities in European Agricultural Economy', in *Schriftenreihne des deutschen Volkswirts*, iii, Berlin, 1928.

run in the same direction suggests that while economic considerations may operate at the farm level, they are over-ridden at the national level. Thus, western European countries produce beet sugar by the sweat of their brows at times when cane sugar is rotting in the West Indies for want of a market, and some countries in Asia, unless they take Mr. Davies's advice, may produce dairy produce that could more cheaply be imported from the Antipodes.

Whenever diversification reduces efficiency it means that full advantage of technical innovations will be denied until each nation is willing to restore its allegiance to the law of comparative advantage by fostering the industries for which it is best suited.

D. T. HEALEY, *Institute for Research in Agricultural Economics, University of Oxford, England*

An earlier speaker said that we probably all have a bias towards agriculture. I hope that we as economists do not have such a bias, either towards agriculture or to any other sector of the economy. I believe that it is still true today—as it always will be true—that the economic problem is the allocation of scarce means among competing ends. This is true whether we are concerned with the optimum distribution of resources between enterprises within agriculture or between the agricultural sector as a whole and the industrial. Therefore, it is our duty to draw attention to the maldistribution of resources which all too often occurs when governments attempt to impede the operation of free market forces.

Rural over-population has often been stressed at this Conference. It has been assumed that the surplus labour can easily be absorbed in secondary industry either in producing the machines needed for agriculture or in producing other commodities. But in most countries this will inevitably require the importation of capital either for machines or machine tools, followed by the importation of raw materials. For example, the plan recently prepared by the International Bank for the development of southern Italy included estimates of the extra imports which would be required. How can a country service the debt and pay for necessary imports? In the last analysis, only by additional exports. Any actions by governments in the way of maintaining or increasing trade barriers are therefore reprehensible and serve only to impede the raising of the world's real income.

It is here that organizations like G.A.T.T. (now the Organization for Trade Co-operation) and the O.E.E.C. are so important. Both organizations have done valuable work since the war in reducing

tariffs and quotas, but according to the latest report of the O.E.E.C. only about 80 per cent. of the trade in food and feeding-stuffs between member countries had been freed by the end of 1954. It is the more regrettable, therefore, that at the last meeting of G.A.T.T. the United States asked for and was granted a waiver on the Agreement so as to restrict the import of certain dried fruit and dairy produce.

It is not only the restriction of trade in agricultural products which is detrimental to the expansion of agricultural production and prosperity; for instance, any attempt to support the British textile industry against competition from India or Japan will result in those countries being unable to attract surplus agricultural labour into the industry and will prevent their being able to pay for imports. At the same time, the British economy will be adversely affected as a result of its failure to transfer resources to activities in which the value of net output per employee is higher.

Finally, I would make a plea that government action designed to assist technical development in agriculture should be restricted mainly to the provision of a *framework* within which individual enterprise and initiative will flourish. Only in this way, I believe, will the maximum rate of progress together with the maintenance of personal freedom be achieved.

EDITH H. WHETHAM, *University of Cambridge, England*

Dr. Englund's paper has stimulated me to a tentative classification of countries by the way in which technical progress in agriculture may affect their international trade.

The first group consists of those countries whose export trade in agricultural products dominates their economic situation and largely determines their standard of life. In this group, I would classify Denmark, New Zealand, Australia, Burma, and a few other primary producing countries. For these countries, technical progress in agriculture is an essential part of meeting competition in world markets over whose price their governments have little influence. A small technical change affecting costs, the failure or inability to follow technical changes elsewhere, may here have a large effect on the total volume of exports of agricultural produce, or on the distribution of the existing volume of trade among competitors.

My second group consists of countries essentially importers of agricultural produce, of which the United Kingdom is the most conspicuous. Here technical progress in agriculture probably leads to a declining volume of imports; the extent of the change depends,

of course, on the comparative costs, at the margin, for supplies from this group of countries and those in my first class.

And thirdly, there are the countries which are importers or exporters of marginal quantities of various agricultural products, according to the internal balance between domestic consumption and domestic supplies and between domestic costs and international prices. The uneven rate of technical progress between such countries may shift their trade quite sharply from an export to an import balance, but in total such changes may not be of great importance in the volume of world trade as a whole.

J. FF. RICHARDSON, *Office of the High Commissioner for Australia, London*

I should like to hear the views of members on the question of the effect, as they foresee or might predict it, of technical changes in agriculture upon the terms of trade. I mean the terms of trade as between a country which exports mainly the products of agriculture and a country which imports an important part of its requirements of agricultural products. Miss Whetham's classification might be a useful one in this connexion.

On the matter of the theory of comparative advantage in international trade, I thought that Dr. Englund's treatment was perhaps too simple a one. It is not just a question of comparing the economic feasibility of producing a certain product in one country—country *A*—as against producing it in country *B*, on the basis of a certain level of agricultural technology. In theory—that is if the economic theory in question were allowed to operate without being impeded by the political and social factors that *do* affect international trade—country *A* would produce that commodity in respect of which it had the greatest comparative advantage over country *B*; while country *B*—to take an extreme case—would produce the commodity in respect of which it had the smallest margin of comparative disadvantage. If only economic factors operated then technical progress in agriculture would be consistent with expansion of international trade.

From listening to the Conference discussions I get the impression, however, that in some instances technical developments affecting agriculture may increase or buttress agricultural protectionism. I am referring to cases where a certain country may find it feasible, as a result of technological development, to produce something it could not produce before. Even so it may still not be able to produce it economically.

Finally, I should like to refer to a matter which Dr. Cardon mentioned last evening. He referred to F.A.O.'s interest in the disposal of surpluses—an interest directed towards their disposal in a way that would avoid, if possible, damage to normal commercial trade. The surpluses that exist may be said to be the result of a combination of three things—beneficent agricultural policies, bountiful seasons, and technological advance. If such surpluses are freely disposed of they can do serious, and in some cases lasting, damage to normal commercial trade. There is need, therefore, to have flexibility in national agricultural policies in order that technical changes in agriculture can be reflected in prices and in the desired level of output to meet demand.

J. Arteaga y Ortega, *Ministry of Commerce, Cuba*

We should be aware of certain factors in the application of technology which limit the benefits that otherwise might be expected from technical progress. So far as production for subsistence and for the local market is concerned the benefits are very considerable, but the same results cannot be expected when production is for export. The principal effect of technical progress, that of increased productivity, may be reduced to nothing by the barriers of international trade. At the present time these are among the biggest obstructions to the application of technology; they thwart the objectives of both national and international organizations dedicated to the improvement of agriculture.

At our last Conference, at East Lansing, I pointed to the effects of these barriers on the development of agriculture in primary producing countries. At this Conference, which has as its theme 'The Implications of Technical Change in Agriculture', it becomes even more necessary to recognize the relationship between technology as it affects agricultural production and the barriers to international trade as they affect the marketing of agricultural products.

For under-developed countries there is another limiting factor to the benefits of technological progress (in this case those due to the use of machinery), namely, the large proportion of the population depending on agriculture for employment. It is necessary to determine with utmost precision the extent to which the benefits of mechanization will be offset by the results of the unemployment which it causes. In Latin America, principally in Central America, a full application of technology does not produce benefits of the same order as it does in highly developed countries. An industrial establish-

ment based on an investment of five or six thousand dollars per worker is more valuable to the general economy of an under-developed country than an investment of fifty thousand dollars in the U.S.A. There is a great need to harmonize the objective of increasing productivity by the application of technology with the structure of international trade.

S. R. SEN, *Ministry of Food and Agriculture, New Delhi, India*

During this discussion we have heard a pessimistic as well as an optimistic note. In fact, and although over the last two hundred years we have been hearing both these notes almost simultaneously, the optimists have perhaps proved to be the more correct in the long run. Technical changes have no doubt created short-term difficulties of transition but in the long run each important technical change, while inducing some change in the pattern of trade, has led ultimately to greater production, greater purchasing power, and greater volume of trade. While welcoming the long-term beneficial effect, however, we cannot completely ignore the difficulties of the transition period. This is where the statesman comes in. While he must not impede technical progress, it is also his duty to minimize the more immediate difficulties. Progress versus security has been the eternal problem of mankind, and perhaps wisdom lies in avoiding the extremes. For instance, technical progress has made travel much faster during the last fifty years. On the other hand, for reasons of health, security, &c., governments have been obliged to introduce passports, health certificates, and so on which have impeded free travel. Some of these measures are irksome but in spite of them we must agree that we can travel today much more quickly and easily than we could in the past. Similarly, technical progress may be accompanied by protective measures, and the pattern of trade may change. But the total volume of trade will go on increasing and the total volume of wealth will go on rising as emphasized by Professor Baade. As regards the problem of surpluses I would commend to you the F.A.O. study on the use of agricultural surpluses for financing economic development that was mentioned by Dr. Cardon. It shows, as the Belgian delegate to the last F.A.O. Council meeting pointed out, that we could use not only agricultural surpluses but also surplus manufactured goods, especially capital goods, to reduce much of the instability of international trade and to expand the market for all our products to the benefit of all countries—agricultural or industrial, under-developed or developed.

A. P. JACOBSEN, *Copenhagen-Lyngby, Denmark*

There can be no doubt that technical advances have an enormous influence upon production, processing, and transport, and as the increase in production will not be paralleled by increased consumption in the country itself, it provides a basis for the expansion of international trade.

Such an expansion has not taken place. On the contrary, international trade in agricultural products is diminishing. Technical advances are often used to expand the production of certain commodities to an uneconomic extent in order to increase self-sufficiency. In this way technical advance is hampering international trade, as Dr. Englund and other speakers have admitted.

The real reason for international trade should not be forgotten. Mr. Bellerby stated in his paper that certain farming communities are already so efficient that they command much of the international market. But why is this so? It is not because of their efficiency but because of their economic structure. In particular, it is the density of population and the degree of industrialization which give rise to the international exchange of goods. I think this was shown in my address to the Conference at East Lansing. It is very regrettable that valuable technical achievements often have uneconomic effects, nationally as well as internationally. It is not enough to exchange scientific and technical knowledge and experience. All such progress should be utilized through greater exchange of goods according to the economic structure of different countries.