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THE CONTRIBUTION OF THE ECONOMIST TO PROGRAMMES OF TECHNICAL DEVELOPMENT

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TITLES, I am afraid, are a disease. The late Professor Wheeler, the Biologist, once read a paper under the title 'Academic Dry Rot' and spent one-third of the paper wondering where librarians would file it. In the Widner library at Harvard it was filed under *fungi*. I tried to persuade Professor Thomas to change this title, but I did not succeed. However, I have the last word, because I wrote the paper. He was aware of this when he said that Mark Twain always offered eight or nine titles but the same lecture was always given. In accepting this title, I have done something which it seems to me the Conference as a whole may have been doing.

It seems to me that the contribution of economists in a taxonomic or classification sense might mean doing four different things. One would be to try to explain the economics of the creation and development of new techniques. We have had no discussion on this. Another would be to explain the economics of why producers adopt new techniques. A good deal has been said about this. Thirdly, we must try to understand how the economy as a whole adapts, adjusts, and achieves a balance as it absorbs new techniques in agriculture or anywhere else. Some of the finest discussion has been on this problem. Fourthly, we must try to measure the additional income resulting from technical change and its distribution from a welfare point of view beyond its distribution to the different factors of production. There has been only limited concern with this problem at this Conference. Indirectly it is asking who gets the payments and how does it affect earnings, rents, and capital returns. What happens to land rents as a result of technology? If a new technique is land saving it must reduce rent and the claim of rent.

We have come to believe that knowledge associated with the productive arts is not only changing but has become increasingly important in developments affecting production. This belief holds that improvement in this knowledge has become a major source of economic growth and that the vast differences among countries in the levels and rates of increase in production are to no small degree

the result of differences in the stocks of accumulated useful (technical) knowledge. Nor are these beliefs about the role of knowledge altogether new. Marshall opens Book IV with a few words about each of the three classical agents of production and then observes, 'Knowledge is the most powerful engine of production; it enables us to subdue Nature and force her to satisfy our wants.'[1] Difficult as it is to demonstrate precisely how much of the growth in national income has come from new knowledge and the resulting improvements in technology, developments since Marshall wrote strongly support his far-reaching insights. The rise in income *per caput* has not come mainly from more land and capital or from more work by labour, but from more output per unit of input in which better technology has played a big part, as is now clear in the case of the United States.

Whether one thinks of this 'engine of production' as a stock of accumulated useful knowledge, or as the particular knowledge that has become embedded in the productive arts, or simply as the existing technology, and although changes in it are deemed to be important in economic growth and development, we know surprisingly little about the economic characteristics of this engine, how it functions in the economy, and what it may take to have more of this kind of knowledge and to get it distributed better among countries.

However, we have not been too clear on what we mean by technical change. Sometimes it is a good thing to try to evolve into the thing from many angles, but I think that by now we should have notions that are somewhat more manageable of what is technical change in a rigorous economic context. Furthermore, we have been claiming too much for new technique. An important part of additional production has come from other sources than just new techniques. A number of you have argued that it has been education —the deepening of the understanding of people who really farm. Others have identified this growth in the specialization and division of labour. There are those who have touched on the effect of policies and institutions on total product. And then there is a factor that moves in the other direction. None has stressed the role of diminishing returns of any specific factor. While I have pointed out the declining role of land in agriculture, nevertheless underneath we have the diminishing returns of all inputs against land. It may be that this is more than offset by these other positive developments including pure techniques.

Economists have not come to grips with this set of problems for

[1] Alfred Marshall, *Principles of Economics*, bk. iv, ch. i, London, Macmillan and Co., 8th edition, 1920 (1st edition 1890).

several and quite different reasons. For one, received theory has impounded technology in *ceteris paribus* and thus economists have abstracted from advances in technology in analysing production. Moreover, beliefs of most economists that the secular diminishing returns against agricultural land will come regardless of changes in technology also has its roots in this approach. On the power of this belief one may cite both Marshall and our distinguished colleague Colin Clark. It is now sixty-five years since Marshall wrote, 'Whatever may be the future developments of the arts of agriculture, a continued increase in the application of capital and labour to land must ultimately result in a diminution of the extra produce which can be attained by a given extra amount of capital and labour.'[1] Colin Clark despite his notable achievements in gauging quantitatively the conditions of economic progress wrote, as late as 1941 in his book *The Economics of 1960*, '. . . it is seen that the world supply and demand of primary products will balance at a value of about 1·9. In other words, the terms of trade for primary products will improve by as much as 90 per cent. from the average level of 1925–34.'[2] There are as yet five years to go before we reach 1960 but I venture that all of the King's men (horses would be helpful!) and a Commodity Credit Corporation of 10 or even 20 billion dollars of stock cannot bring about a 90, or a 50, or even a 20 per cent. increase in the relative (parity) price of U.S. farm products. We must take steps to get technology out of the *ceteris paribus* pound and free our minds from the ultimateness of diminishing returns against agricultural land in our economic horizons (and by this I mean the next twenty to twenty-five years).

Another reason why economists are not making much headway in analysing the production and income implications of changes in technology arises from the fact that where changes in output per unit of input are being considered they are putting too much into the box they have labelled 'technology'. Those who have added this additional box to the boxes already provided by received theory have not left it empty but unfortunately have allowed it to become a receptacle for all manner of things. By using the input-output approach to determine the contributions made by improvements in technology it is all too easy to ascribe all of the notable rise in output per unit of input to new technology. This approach, however, entails two serious difficulties: one, the resulting increase in the ratio of out-

[1] Marshall, ibid., bk. iv, ch. iii, sec. 2. See my exploration of this issue some two decades ago in 'Diminishing Returns in View of Progress in Agricultural Production', *Journal of Farm Economics*, vol. xiv, Oct. 1932.

[2] Colin Clark, *The Economics of 1960*, London, Macmillan and Co., 1943, p. 52.

put to input is a residual in the analysis; and, two, there are at least two important factors, in addition to advance in technology, that can and do increase output per unit of input. Technology has not been isolated and too much has been credited to change in technology in accounting for the rise in production and income.

Still another reason why so little is known about the economic characteristics of technological change has been the confusion caused by the substitution of capital for labour. The rise in output per worker has frequently been taken as an indication of an improvement in technology. While it is exceedingly difficult to untangle the substitution effects of changes in the relative prices of inputs—wages rising relative to other inputs—from the increases in output per unit of input caused by new techniques of production, only confusion can come from lumping the two in the belief that what one has is mainly or entirely the technological variable.

Thus, if we are to improve our understanding of the economic implications of changes in the stock of useful technical knowledge, we at the very least need (1) to take technology out of the *ceteris paribus* pound, (2) to examine more closely than we have what is in the box now labelled 'rise in output per unit of input', and (3) to distinguish between substitution among inputs caused by changes in input prices and the production effects of new and better techniques of production.

Let me now turn to some of the contributions that economists may make to programmes of technical development. As I see the priorities, we must first improve our understanding of the role of technology as an engine of production.

I. *Working with Large Aggregates*

Input and output data, especially in the United States, have made it possible to undertake studies which indicate that production has risen markedly relative to the quantity of factors employed in production. I shall first direct attention to a study of the production and income of the United States taken as a whole and then to two studies concentrating on U.S. agriculture.

1. *An interpretation of U.S. production and income data.* As a rough approximation about nine-tenths of the truly remarkable increase in real income *per caput* that has been achieved in the United States during the past eight decades has been a consequence of more output per unit of input and only about one-tenth of this increase has come from additional capital and labour according to a recent report of the

National Bureau of Economic Research. Fabricant,[1] concentrating on the changes that occurred from 1869–73 to 1949–53, found that the United States had enjoyed an average rate of increase in real income *per caput* of slightly under 2 per cent. per annum.[2] (1·9 per cent. if one dare be that precise!) This means, as Fabricant points out, that the '*per caput* volume of goods consumed or added to the tangible capital stock of the nation has multiplied over fourfold' during the eight decades.[3]

Fabricant then asks, 'How did this remarkable growth in income per person come about?' *Of the 1·9 per cent. rise per annum, he found that 1·7 per cent. represented simply more output per unit of input*, leaving only the small remainder, 0·2 of 1 per cent. per year, contributed by additional capital and labour. The stock of tangible capital increased not only as fast as did our population but even a little more than did income for it rose close to 2 per cent. *per caput* over this period. Labour, veiwed as input per head of population, rose somewhat during the first four decades and then receded about that much and thus 'changed surprisingly little' when one compared the first and the last decades of this period.[4]

It follows, therefore, if the total input of capital and labour combined rose no more than 0·2 of 1 per cent. that about nine-tenths, that is, 1·7 of the 1·9 per cent. increase a year, of the observed over-fourfold increase in real income *per caput*, achieved during the eight decades, was a consequence of a vastly higher ratio of output to input. Fabricant ascribes this to an 'improvement in national efficiency'. He goes on to show that this efficiency not only has 'tended to rise persistently; but it has also tended to rise in all corners of our economy'.[5]

[1] Solomon Fabricant, *Economic Progress and Economic Change*, 34th Annual Report National Bureau of Economic Research, New York, May 1954.

[2] Many difficulties arise, of course, in measuring income. One of these arises when one attempts to adjust money income for changes in the level of prices. There are not only changes in the general level of prices over time, but there are also differences by location. In as much as an increasing proportion of the population has come to live in cities; many of these cities have become very large; and prices are higher in such cities than they are in small cities, towns, and on the farms; there undoubtedly is some upward bias in the observed increases in *per caput* income.

[3] Suppose a similar rate of growth in income were achieved during the next eighty years. It implies that whereas the average family in the United States had an income of somewhat over $5,000 in 1953, eight decades from now the average family will have an income of about $25,000 of 1953 purchasing power, a level now enjoyed only by the top 1 per cent. or so of the nation's families. (See p. 5 of Fabricant's report.)

[4] When the services of capital and of labour are combined and treated as an aggregate input, 'There appears to have been a net rise of no more than a fifth or sixth' in this input on a *per caput* basis (see Fabricant, p. 5).

[5] Ibid., p. 10. One needs to be on guard here and ask whether Fabricant has

Where did this remarkable improvement in national efficiency come from? Surely not from more land and natural resources.

2. *An interpretation of U.S. agricultural production, 1910–50.* In my *Economic Organization of Agriculture*, using the agricultural production and input data developed by a number of colleagues in the old Bureau of Agricultural Economics, we have:

	1910	*1950*	*Increase in %*
U.S. agricultural production	100	175	75
Changes in inputs:			
1. Upper limit:			
Using 1910–14 input prices	87	116	33
Average annual increase in production per unit of input	..	..	0·8
2. Lower limit:			
Using 1946–8 input prices	95	108	14
Average annual increase in production per unit of input	..	..	1·35

At that time I was inclined to ascribe most of this very substantial rise in output per unit of input to new and better production techniques,[1] and Mr. Englund quoted me accurately this morning as saying that I had allowed for external economics, division of labour, and had then said that most of the rise came from new techniques. But I want to reopen the question. Where did this growth in U.S. agricultural production relative to the amount of land, labour, and capital employed come from?

3. *A projection: the contribution of technological progress to farm output, 1950–75.* Table 1 is from an important recent study by Varnon Ruttan of Purdue University[2] which I suspect will be one of the first sets of data widely used by general economists in trying to understand the recent history of the United States on the basis of concepts which they ought to—and I think do—understand. You have to study the table very carefully to catch the subtleties in it. In his study, the projection 'slow technical progress' is based on 0·8 per cent. per year advance in output per unit of input, and the 'rapid technical

underestimated the increases in capital or labour or the two of them combined? His category of 'tangible capital' does not include consumer equipment and military assets which have increased more rapidly than other reproducible tangible capital; nor does it include land and subsoil assets which, however, have increased less rapidly; if these omitted items were added to figures which he used, this rate of increase per caput per annum over the eight decades instead of being close to 2 per cent. would be 'down to perhaps 1·5 per cent.'. See footnotes 4 and 6 on pages 6 and 7 of the Fabricant report cited.

[1] See ch. 7 of my book for a fuller treatment.

[2] The paper will appear in *Review of Economics and Statistics*, vol. 38, Feb. 1956. Table reproduced here with the permission of Dr. Ruttan.

progress' on 1·35 per cent. per year. (See my figures for lower and upper limits above.)

Ruttan's projections are especially useful as a way of characterizing the changing roles of labour, land, capital, and of current inputs in agricultural production. Technical progress, however, is identified with the 'rise in output per unit of input' in agriculture. Is there not more than technical progress at the bottom of this?

Each of these three studies is based on large input and output aggregates. I want to direct attention to two major difficulties in working with such data in an attempt to gauge technical progress.

The first, to which I have already alluded, is the fact that the 'rise in output per unit of input' is not an independent estimate but emerges as a residual in the analysis. In such extraordinarily large and complex aggregates as are represented by production and income (the outputs) and by capital and labour (the inputs) in Fabricant's study for the entire U.S. economy, one must be exceedingly wary. What is income? What is labour and capital? There are omissions, doubling counting, and problems of prices and weights—the index number problem at every turn. The rise in output per unit of input, as a residual, may be substantially off the mark.

The ground on which one stands becomes firmer as the aggregate is reduced, as is the case when one concentrates on the agricultural sector. In principle, however, the same problems are at hand, although they do appear to become more manageable. In agriculture the changes in the relative prices of the various products entering into the aggregate called agricultural production have not changed drastically over time. On the input side, however (land, labour, and so on), there have been great changes in the structure of relative input prices, with wages rising markedly relative to most other inputs. Ruttan in an earlier study concentrating on the technological progress in the meat packing industry dealt critically with the theoretical problems in determining technical progress.[1] The device of ascertaining a *lower* and an *upper* limit which I used in my study was an attempt to take account of the marked changes in the relative input prices in agriculture that occurred from 1910 to 1950.[2] You can do this in a study of change in direction. And the direction has not reversed itself. I think that is obvious.

The second major difficulty in using these output and input aggregates arises in determining the developments which have caused the

[1] Ruttan, *Technological Progress in the Meat Packing Industry, 1919–47*, R.M.A. Marketing Research Report No. 59, U.S.D.A., Jan. 1954, pp. 15–28. This is one of the University of Chicago R.M.A. studies.

[2] Ibid., Ch. 7.

Table I

Projections of Alternative Farm Output and Factor Input Indexes for 1960 and 1975

(1950 = 100)

	*Zero technical progress**		*Slow technical progress†*		*Rapid technical progress‡*		*Very rapid technical progress§*	
	Low land inputs (I)	*High land inputs (II)*	*Low land inputs (III)*	*High land inputs (IV)*	*Low land inputs (V)*	*High land inputs (VI)*	*Low land inputs (VII)*	*High land inputs (VIII)*
1960 Projections								
Inputs:								
Labour	88	88	88	88	78	78	78	78
Land	96	104	96	104	96	104	96	104
Capital‖ (A)	178	172	140	136	149	143	124	121
(B)	183	177	145	140	153	147	127	124
Current‖ (A)	214	207	169	163	178	172	148	145
(B)	204	198	161	155	171	164	141	138
Contribution to output from:								
Inputs	122	122	112	112	110	110	100	100
Technological change	0	0	10	10	12	12	22	22
Total output	122	122	122	122	122	122	122	122
1975 Projections								
Inputs:								
Labour	81	81	81	81	67	67	67	67
Land	90	110	90	110	90	110	90	110
Capital‖ (A)	346	318	199	169	218	201	132	122
(B)	378	348	218	185	238	219	144	133
Current‖ (A)	547	505	317	240	346	318	210	193
(B)	491	441	285	234	311	277	189	173
Contributions to output from:								
Inputs	160	160	135	135	129	129	100	100
Technological change	0	0	25	25	31	31	60	60
Total output	160	160	160	160	160	160	160	160

* Increased inputs are assumed to account for the entire increase in output.

† Technological change is assumed to occur at a sufficiently rapid rate to permit an increase in output per unit of input of 1·0 per cent. per year between 1950 and 1975. This is the 1910–50 rate calculated on the basis of 1945–8 prices and techniques.

‡ Technological change is assumed to occur at a sufficiently rapid rate to permit an increase in output per unit of input of 1·23 per cent. per year between 1950 and 1975. This is the 1910–50 rate calculated on the basis of 1910–14 prices and techniques.

§ It is assumed that technological change occurs at a sufficiently rapid rate to account for the entire increase in output. This requires an increase in output per unit of input of 2·2 per cent. per year between 1950 and 1960 and 2·4 per cent. per year between 1950 and 1975.

‖ Estimate (A) for capital and current inputs is based on the assumption that the ratio of capital to current inputs (C_1/C_2) will continue to decline at the same percentage rate as during the period 1910–14 to 1945–8. Estimate (B) is based on the assumption that the 1925–7 to 1949–50 rate will continue. See text for further discussion of estimates A and B.

output to rise per unit of input. That is what I have been harping on in a number of my comments as I have gone along. There is more in this box labelled 'rise in output per unit of input' than technical progress, and that is the rub. We will not have an empty box. We have a Pandora's box, and we are afraid to open it because everything will pop out at us.

There are, as I see our contemporary economic history, three major developments in process, each of which is increasing this output-input ratio and there is one which works in the opposite direction. I have left out the factor which Fernandez y Fernandez touched on, because I treat the whole question whether an economy is allowed to reach its optimum or not as a different concept. So I have a methodological reason for not introducing it here. Altogether, then, there are four developments—three with positive and one with a negative sign—which make up an unanalysed conglomerate which we call 'the rise in output per unit of input'. The three that add are:

1. The increase in the amount of capital that is being invested in the human agent. No attempt has been made to my knowledge to gauge the *per caput* rise in this form of capital or to determine its marginal and average productivity. I think it can be done, and we are going to try to do it in some of our research at home—to see how important this has been. It will be an attempt to answer the questions put to those who stress education and related matters that improve the skills and ability of human agents.

2. The increasing returns associated with economic progress as envisioned by Allyn A. Young.[1] One does well to start with Adam Smith's famous theorem that the division of labour depends on the extent of the market. And I want to bring in Dean E. C. Young here, because he precisely documented this paragraph in his paper the other morning better than I could have done it. You see, it is the division of labour that depends on the extent of the market, with these two related aspects—the growth of indirect or roundabout methods of production and the division of labour among industries. How large a role this particular development has played in the rise in output per unit of input, no one has tried to ascertain. There are economists who are of the belief that it has been more important than all technology. How valid is this belief? It is time we found out, and some of us have thought out a method by which we can get at least some approximation. There are some countries which have the choice of joining in a world economy and having the advantages of a great

[1] A. A. Young, 'Increasing Returns and Economic Progress', *The Economic Journal*, vol. 38, Dec. 1928.

division of labour, or of not doing so. I think the Latin American scene provides some cases.

3. The progress in technology as new and better techniques are employed in production.

The development that subtracts is the toll taken by specific factors—land as seen by the classical economists—as production is ever increased as one looks back, for instance, over our contemporary economic development. Diminishing returns against land could hide a lot of technical progress. There is some fragmentary evidence that something like this may have been occurring in the great western interior of the United States.[1] In that area it looks as if in the years between 1930 and 1950 we have been using more inputs to get outputs. Recent figures from our colleagues in Washington, Sherman Johnson and his group, suggest that it takes more than 10 per cent. more inputs now to produce their 110, when it used to take 100 to produce the same complex of inputs. That looks like diminishing returns against something in process where you have had an explosion in production so characteristic of most of the American scene. It may well be, too, in large parts of Russia which have their counterpart in our Plains States, that they may be up against diminishing returns in the Plains States context. This may be a more real fact than is realized by us or by them.

II. *Working with the Development of a Particular Production Technique*

The difficulties inherent in the large input and output aggregates are so formidable that other and less ambitious approaches are warranted. One such would be to study the development and acceptance by producers of a particular new technique of production and to determine its production and income effects and what it has done to the relevant factor supplies and their relative prices.

It would appear that corn hybrids might permit one to do a study along this line. What has hybrid corn done to the value of farm land? Rent? Has it saved human inputs, or has it not? Capital? I think it can be done. Mr. Griliches, a very brilliant man who has come to us from California, has worked out an essentially intricate econometric model and is finding the data quite appropriate. If he has good luck, we may have something to say on this, but for the moment it is still, of course, a bird or two in the bushes.

In the belief that more attention should be given to reporting

[1] T. W. Schultz, 'The Economic Development of Our Western Interior', *Journal of Farm Economics*, Proceeding No., vol. 35, Dec. 1953.

studies that do not pan out, I made an attempt recently to study the production effects of new techniques in the very isolated Tingo Marie Valley in Peru where for over a decade a large new experiment station has been operating, serving especially the producers in the valley. But all was for naught, because of the large toll which banana diseases are now taking.

III. *The Role of Programmes of Technical Development*

It is convenient to think of the economists as having two useful tasks: one, to characterize how the economy functions. What I have said already is part and parcel of this particular task. We would like to know how the economy functions as it generates more products. Capital, human agents, extent of the markets, new technology, diminishing returns, are all concepts which we bring into play, and which characterize it and which we have got to know. The other task pertains to policy. I shall merely mention the more important issues which belong in this area.

1. The development of new agricultural techniques is a substitute for capital and other inputs in agricultural production.

A country may invest more resources in research and extension and fewer resources on land reclamation and improvements and come out ahead if the marginal returns of the first exceed those of the second. Taking a long view, our unfolding experiences point strongly in this direction. We should be well advised to put much more money into something that would bring our technology forward, and invest more in the human agent, than to put it into some of the other things which we are committing ourselves to in a policy sense.

2. The development of new techniques in general should be viewed as one form of (new) capital and as such it is in competition with all other forms of capital as you make decisions on the economy as a whole. One would suspect that it would be on the score of investing more in new techniques that some of the decision-taking in the Russian economy may turn out to be at an advantage.

If it is true that the expected returns on additional capital committed to the development and extension of new techniques are high relative to those from other forms of capital, the direction of the transfer in allocating our (accumulated and new) capital is clear. Such insights as we have indicate that a substantial reallocation along these lines is warranted and both private decisions and public policy seem vaguely aware of the need of doing so, but with a great lag, I should argue.

3. The development of new techniques in agricultural production may introduce some additional much needed price elasticity on the supply side. This goes back to the thesis of part of Mr. Bellerby's paper in which he was introducing the issue of income elasticity, and observed how inelastic is the supply in a short-run context. Now, a policy issue is involved if we get, as I think we are getting, additional supply elasticity as a result of new techniques. This is very precious to us in agriculture, given the kind of adjustments that we have to live with.

The supply of farm products is exceedingly inelastic over a period covering one or two production periods. Taking farm products as a whole there are some economists—Cochrane, for example—who believe that this supply schedule is virtually vertical. Here again, such evidence as we have suggests that our technological progress has and can introduce some additional supply elasticity.[1]

4. The distribution of accumulated technical knowledge (represented by technology) among countries can be greatly improved.

This technical knowledge is at present distributed very unequally among countries. Reducing this particular inequality does not entail a levelling process; that is, it is not a case of taking away and thus lowering the level of technology where it is now high in order to bring it up where it is now low. What is involved is raising the level in countries where it is low. This is one of the rare cases where you can move towards an equality without reducing those that are now high. It is an important social consideration. What is involved, of course, is raising the level in countries where it is low. Moreover, in the process as a whole, the economic complementarity among countries is such that it is highly probable that all would become better off. That is to say, improving the technology in Latin America will not only result in greater income there, but all the rest of the world, through trade, will gain and share somewhat in those benefits.

The programmes associated with Point IV represent an effort to improve the existing distribution of technology among countries. There are, however, other important channels for achieving this goal, not that they are substitutes for technical co-operation, whether bilateral or multilateral, as for example, in the case of the United Nations and the Organization of American States. But in our efforts to undertake public programmes of technical co-operation we are in danger of overlooking and neglecting the important contributions

[1] T. W. Schultz, 'The Instability of Farm Prices Reconsidered', *Journal of Farm Economics*, vol. 36, Dec. 1954.

of business firms as carriers of new techniques of production, and of foundations and universities in disseminating science and technical knowledge, and of the useful role which religious groups play in the agricultural, education, and health programmes.[1]

I close by simply saying afresh that in the box that catches our real gain we have several things. I think they are investments in the human agent, the extension of the market for the greater division of labour, the pure techniques which we are talking about, and finally the one that is running negative—diminishing returns. There are profound policy implications here if it is true that we are living in an age where we can, by making resources available to sciences, to research and to extension, continue to have this great burst of technique which generally makes other resources go farther.

J. R. Raeburn, *London School of Economics, England*

Before I deal with Professor Schultz's major points I would make two minor suggestions. First, in defence of Marshall, supposing we add the 60 years since his first edition to the 20–25 years which Professor Schultz has in mind, we get an 80–85 year span. And if we then look at Marshall's first edition, I think we may well find that he safeguarded himself sufficiently against accusations that he was too pessimistic about secular changes.

Secondly I would emphasize Professor Schultz's warning that we 'must be exceedingly wary of the use of aggregates. What is income? What is Labour? There are omissions, double-counting and problems of prices and weights.' And I would wonder whether in statistical assessments of input over the long period 1870–1950 in the United States, we do not encounter very serious difficulties indeed not only in aggregation but also in valuation, particularly of land and land improvements.

Now what I want to do in the short time available is to discuss the three changes which Professor Schultz lists as causing output to rise relative to input. These are basic to nearly all our discussions this week. Can we be still clearer about them? Can we see behind them any connexions between them? Can we see our way to a still more basic principle of somewhat easier and more general application, in China as in Canada, in India as in Iowa? We can, I think,

[1] The observations on Point IV and on related private and public effort are based on a three-year study of technical assistance in Latin America of the National Planning Association. The research of this study has been centred at the University of Chicago and has been under my general direction. A number of monographs are now nearing completion, growing out of this research.

though we must approach the problem more as psychologists than as statisticians.

What I suggest is that we are dealing with human behaviour in the face of risks and uncertainties—technical, price, social, and institutional. All the statistics of increased production per unit of input can be usefully considered as the outcome of two things: (i) reductions in uncertainties and risks, and (ii) increases in willingness to bear uncertainties and risks. Professor Schultz's three 'positive' points (investment in human beings, greater division of labour, progress in technology) are in fact aspects of these two.

I should like to set out these two in yet another way, perhaps more helpful in considering our own responsibilities and contributions.

Production of technical knowledge—knowledge of input-output relations. We as agricultural economists must recognize that much technical knowledge is not 'finished' knowledge fully ready to be marketed. The great mass of the technical knowledge we so often assume to be ready for market is in fact raw—is only at some stage along the line between (*a*) original conception and experiment, and (*b*) complete proof in relation to one particular soil type, climate, breed or strain of livestock, and so on. We must, I suggest, proclaim frequently that our technical knowledge is unfinished.

Not long ago I was talking with a man of many years' experience of agricultural administration in western Europe and elsewhere, and he said: 'We hear a lot about this gap between the scientific agriculturist and the native peasant farmer in the tropics and sub-tropics. But I don't think there is a gap. You see neither of them knows how to improve agriculture!' That was a deliberate exaggeration but I am quite sure from his years of experience and from observations I have made myself that a very substantial element of truth lies in it. Just consider not basic principles but what you do in any one particular locality—input-output relations there. What do we know for instance about the responses to nitrogen of particular varieties of rice, on particular soils, in particular localities of India? I suggest, virtually nothing. What do we really know about the effect of the organic matter as compared with the minerals in the dung of cattle on particular savannah soils in Africa? What do we know about the probable results of attempts to integrate livestock and crop production to get more modern farming systems, not only in savannah Africa but in very many other areas? Similarly in the temperate areas, consider this question of deep ploughing about which we hear so much. What is really proven about it in relation to different rotations, in relation to sub-soiling possibilities, and so on? We can go to

localities within a hundred miles of Rothamsted and find that expectations of crop responses to fertilizers are very varied indeed, not only amongst farmers but amongst their advisers. And still more are we in doubt about the *joint* effects of alternative fertilizer policies, rotations, the new weed killers, and the new pesticides. A great deal of trouble is caused for us and for the natural scientists themselves because, individually and in subject groups, they assume that their pet ideas and results are more fully finished and marketable than in fact they are. They therefore proclaim that much of their knowledge lies unused. One of our main jobs is to secure an understanding and an honesty about this situation, and to play a part in determining the finances and the priorities for further processing of all this unfinished knowledge. I am supporting Professor Schultz very firmly on this point.

On the other hand I have doubts about how far we should have anything to do as economists with the finance of work leading to new basic conceptions. Professor Schultz has implicitly put one point of view. I have time only to indicate another—one which was expressed by Lord Rutherford the great physicist when he said: 'We haven't any money; so we've got to think.'

Production of knowledge of the working of the market mechanism. This includes knowledge of government programming and pricing. In practical terms this is 'outlook' work, fully and well conceived—outlook work to help the decision-makers increase their knowledge and reduce their uncertainties, particularly those about future prices of factors and products. Here there is a wide range of work for the economist and I am not going to list all the elements in it. I would, however, like to make a few points in passing.

Obviously again, what we have to offer as knowledge is only half-finished—because it is not as comprehensive nor as internally consistent as it should be, and because it is not readily understandable. Secondly, we rarely disclose our own uncertainties fully enough, or give farmers estimates or guesses as ranges rather than as single estimates. Thirdly, to make progress we need to put in a great deal of unspectacular work to improve our statistics and to keep their definitions clear and well understood. Fourthly, much of the trouble in the poorer countries in marketing, and the production of knowledge about markets, arises from the narrowness of the markets, and we as economists should try to show the consequences of that narrowness more clearly than we have in the past, and show the benefits arising from investments in transport, storage, credit and information services. Fifthly, I feel we should keep the long-run as well as

the short- and medium-run considerations in mind more than we have in the past, particularly when there are actual or proposed arrangements for subsidies or artificial protectionist or social measures to keep labour in agriculture or to ensure benefits for agriculture as against other industries. It may for instance seem a good idea at first to try to secure that farm families have an assured share of the benefits of what we have been calling 'technical change' but we should, I suggest, think such ideas through—recognize their long-run effects on inter-industry, inter-regional, and international relations, and on the whole tone of political life.

Production of managerial abilities. Here we are concerned particularly with abilities to use technical and market knowledge rationally in deciding on (*a*) what, how much, and when to produce, (*b*) combinations of factors of production, (*c*) scales of operation, and (*d*) financial arrangements. Apart from our contribution to general education, our practical contribution is in farm management research and extension. And here we could talk till the cows come home—and quite usefully, provided we keep the real decision-makers themselves in mind. But I would suggest that although we have now had decades of farm management work in many countries we have had very few close studies of the actual decision-making processes themselves. We are therefore still unable to explain satisfactorily why, for instance, additional benefits have to be one and a half times, and even up to twelve times, additional costs to induce commercial farmers to change their pest-control practices. And why many other simple, small, short-term investments are not made although they would be highly profitable on all rational assumptions. I once listed the possible explanations which theory could offer and I found as many as eleven. There may well be more. We may, of course, say that the psychologists should tackle the job. We certainly need their help, but we cannot push our own responsibilities on to them.

Some other general points are also worth stressing here.

Firstly, willingness to bear risks and uncertainties appears to vary directly with, among other things, (i) income of the decision-maker, (ii) his capital, and (iii) his education. Each of these is low in the very countries where we assume that what we are calling technical change is most desirable. Each of these is relatively high for decision-makers in many central governments. Does this mean that the senior civil servants and politicians are prepared *together* in the projects they formulate to make poor countries assume too heavy a burden of economic risk and uncertainty? Or does it not?

Secondly, the witch doctor! He works on a different basis in

reducing uncertainties. Should we not be more aware of the longer-run consequences of using him?

Thirdly, the *servicios* of Latin America, the community development projects of India, and the voluntary co-operative movement can all do a great deal to produce as well as to use managerial abilities. And they can be particularly effective in wrapping up in one reasonable marketable bundle technical knowledge, market knowledge, managerial abilities, and credit. Such a bundle reduces uncertainties in many ways. I am therefore sorry that we have not had a fuller discussion, particularly of *servicios* and of the voluntary co-operative movement.

Fourthly, if a government official fostering co-operative development or providing business management advice is in fact really producing managerial abilities, can we as economists measure his productivity? If not, how do we decide how many men, or women, of this type to buy? Is government budgeting in this connexion determined more by inertia or political momentum than by marginal principles?

Fifthly, it seems to me we have a responsibility to clarify our ideas about the ability of governments in free societies to *compel* good management rather than produce managerial abilities. John Maxton's discerning study, *The Control of Husbandry*, published soon after the war is well worth re-reading in this connexion.

Production of willingness to specialize—in other words to depend on the other fellows for supplies of goods and services needed and for markets. We often think of these matters in the narrow context of comparative advantage but in many of the poorer countries many uncertainties, political and social, have to be reduced. To give but one example of great significance I would refer you to the complex and almost overpowering problems which affect East Africa.[1]

Reductions of uncertainties by the State. This too is a large subject and I can do no more now than assert that we have a most important part to play by subjecting State policies and proposals to our close and impartial study.

But may I suggest that we should not think ourselves responsible for everything, including the scales of value of all social and economic groups? We are not super-human. We may have to say—to return to Dr. Duncan's colourful example—how many eggs of what kind make what size of omelet, of what flavour; but other people should decide how many and which eggs to break, and when.

[1] See Report of the Royal Commission on East Africa 1953/55. H.M.S.O. Cmd. 9475, London, 195

In conclusion I would also suggest that we may have philosophic guidance from Francis Bacon—perhaps better guidance, Mr. President, than from Keynes and his dentists:

> It were good . . . that men in their innovations would follow the example of time itself, which indeed innovateth greatly, but quietly, and by degrees scarce to be perceived; for otherwise whatsoever is new is unlooked for . . . and he that is hurt . . . imputeth it to the author. It is also good not to try experiments in States except the necessity be urgent, or the utility evident.
>
> [But as *yang* to that *yin*] . . . he that will not apply new remedies must expect new evils: for time is the greatest innovator; and if time of course alters things to the worse, and wisdom and council shall not alter them to the better, what shall be the end?

RUDOLF TURK, *University of Ljubljana, Yugoslavia*

One of the important tasks of the agricultural economist is to organize agricultural programmes. Some of the mistakes that may be made in the course of doing so were dealt with at the last Conference, and it appeared from the discussion that there were two main causes of failure. First we must consider planning with imperfect knowledge —to use a phrase of Mr. Heady's. Under this heading I include effects of political instability, administration deficiencies, vested interests, cultural and technical backwardness. Secondly, there is unrealistic appraisal of the existing situation and of the possibilities of planning. This last cause can be more easily removed than the first because it is only a consequence of an inadequate approach to the composition of the programme.

It follows that one of the more important measures is good organization of the preliminary work leading up to the programme, from the collecting of data to the completion of the investigation. In this respect the less well developed countries are faced with objective difficulties. They give greater emphasis to work of immediate utility and less to fundamental research.

Every programme is directed to the solution of a certain structural problem. The first phase is actually preparing for the solution, and is followed by the real solution, or rather the carrying out and the final judging of the efficiency of the solved task. The steps leading up to the solution are: orientation, analysis, and planning.[1]

In the first step we must gather concrete quantitative data which could serve as the basis for a passage from existing to optimal conditions. The analysis of the existing conditions must not be based

[1] Dr. tech. Josef Jezek, *Organisaini nauko Orbis*, Praha, 1957.

solely upon a collection of figures. In the period of orientation we should comprehend all elements of the influencing environment including geographical, social, and economic factors which represent the passive sphere of the organization, together with elements which are consciously introduced, such as science and technology, which represent the active sphere of the organization. Then we must consider the motives of the producers and consumers and the results of their activities in order that we may finally judge the action and effect of social measures and of other changes. To gather the data systematically we must first separate the general from the specific. We must work not only horizontally, but vertically. In the horizontal orientation, we observe and analyse factors which are common to the whole programme. But beside these, there are many other important factors which vary regionally and which we can observe only by separating them vertically. This includes the influence of geographical and historical factors.

The next phase in drafting a programme is the analysis—the phase of looking for a passage from the existing conditions into new ones by the introduction of new means and rules into the present environment. In this part of the research we try to determine the disparities between the existing and the possible conditions and look for ways to diminish them. We must test the effectiveness of the new elements in so far as they have not been previously tested. From data gathered in the previous phase by induction, new possibilities can be found by deduction. The working of new elements must be observed, isolated, and mutually connected. The analysis must be made from the standpoint both of the producer and of the national economy.

After finding possible transitions from the existing conditions to new conditions we start making plans for future activities. Planning is, in fact, the choosing from amongst possibilities each of which represents a theoretical solution of the existing problem. Every chosen path must have been tested in the earlier phases. It must represent, from the point of view of both micro- and macro-economic analysis, the best possible way of achieving optimal efficiency and welfare. It must be such that the means needed for its application are available; it must not disarrange the existing organizational co-ordination, unless the means exist for the re-establishment of this co-ordination.

After the ways have been chosen, we must decide on the location, the objective, the subject, and the technical equipment. Lastly, we decide on the working process, the organization, and the measures of control. A programme, therefore, is actually an adjustment of

the planned procedures, leading to new conditions on a higher qualitative level than the existing procedures reflecting the actual conditions.

The adaptation to agriculture of ideas which originate in non-agricultural activities is not a simple matter, as I well know. Furthermore, the agricultural expert and the producer are inclined to improvise with regard to organization. This is not hard to understand considering that their success greatly depends on factors which cannot be controlled. That is why they scorn any systematic work which is not connected with the technological side of agricultural production. But to them, as well as to others, let us apply the words of Bacon: the complacent scorn science, eccentrics bow to it, while the wise use it.

D. K. Britton, *F.A.O., Geneva*

In attempting to comment on Professor Schultz's paper I feel rather like David before Goliath; but I am going to fling only a very small stone, neither intending nor expecting to slay him.

I want to refer to his statement that division of technical knowledge between countries does not involve any levelling down of the better informed countries. I am not quite so sure about that point. It seems to me possible that knowledge once achieved can get locked up in a country, and it needs people to unlock it. It is not just a question of transferring knowledge—in the form, say, of an encyclopedia—from one country to another. Usually someone must be sent with the information who is skilled at 'unlocking' it. The country which is donor in this respect would suffer a real loss, I submit, if the drain were too heavy. That may explain why it is not always easy to get the best experts to leave one country to go to another. If the United States were willing to part with all its leading agricultural economists for five years, would that country be no worse off than if they had never left?

Mario Bandini, *University of Perugia, Italy*

What is *technical* knowledge? In my opinion it is that form of knowledge which is immediately followed by practical action. In that sense, it implies that the economic problems have been resolved—otherwise the technique is wrong. Scientific knowledge is a different concept because it does not include consideration of economic problems. Therefore scientific knowledge must be economically acceptable to become technical knowledge. I consider that the contribution of the economist to technical development is to ensure that

agricultural progress is not interpreted in the same way for every country and for every zone. It is to keep in mind, for example, that American techniques cannot be applied equally under all conditions. In my opinion, the function of the economist is to transform science into techniques.

H. C. M. Case, *University of Illinois, U.S.A.*

The comments I wish to make are not prompted so much by Dr. Schultz's stimulating presentation as by the programme and Conference up to the present time. I presume we came together to gain fellowship and inspiration from a group of fellow workers in our profession and to gather ideas which would enable us better to meet our responsibilities and problems. Dr. Cardon drew the outline of a large picture. It was left to each one of us, however, to fill in the details of that picture for our own countries. These national pictures are blueprints, we might say, which will and should differ widely according to our respective national conditions.

It has been said many times that agriculture has made more progress in the past century than in the preceding fifty centuries. In the countries represented here, however, we may find some communities where the conditions are as they were one hundred years ago, or even several hundred years ago; and on the other hand, we have communities that have gone as far as they can in using new techniques to raise their general standard of living. Any community can now draw on hundreds of possible techniques; the problem is to choose which projects are to be undertaken and emphasized—to put first things first so as to obtain balanced development.

It has been my privilege to visit most of the countries that are represented here. My visits have been almost too short to draw correct conclusions but there are some things which stand out in my mind. Some communities, literally, have had air transportation before they have had either good roads or good rail-roads. In some places you get the feeling that when capital was needed for the development of agriculture, a disproportionate amount accumulated in the cities. We need a sense of balance. I am not saying that all these responsibilities fall on agricultural economists. Dr. Raeburn very properly admonished us to be meek, and not to take ourselves too seriously. But as we view changes that are taking place in any country we can see quite a number of mistakes which have been made in emphasis on education or action programmes, as well as accomplishment, which should help us to develop an action blueprint. I would like to use two or three illustrations.

Deep in China, some of us visited a very good small experimental research station. Most of the research was well conceived, but I found one project entitled 'The reaction of the small intestine of the rabbit to various stimuli'. The man working on this project had received most of his advanced training in another country. Some professor had had to find a thesis subject for him and was thinking in terms of basic research, not recognizing the difficulty of an inexperienced student applying basic principles to practical problems. When the student returned home the thing he knew how to do was the study he had undertaken—and yet I doubt if there was a single rabbit in that immediate area. This illustrates the responsibility that falls upon us as teachers, to appreciate the conditions in which some of our students will find themselves. Perhaps we might well send some of our professors to foreign countries to gain knowledge of practical problems before we send the students. Again, consider practical instruction. A colleague of mine spent some time in a foreign country and was very successful in gaining the confidence and response of the people with whom he worked. As he was leaving, one of the officials said to him, 'You know, we had so-and-so here. He stood up on a rostrum and lectured us, but we did not follow his recommendations. Then so-and-so came and he commanded us, but we still got no results. I want to commend you because you went out among us and *showed* us how to get some of the jobs done.'

One further illustration: I have been chairman of the committee on our collaboration with some of the educational institutions in India, and I have a little picture at home which I treasure. One of our men took a few of his workers to clean the weeds out of a piece of corn or maize and to thin out the plants to a normal population before applying fertilizer. As they were working, an Indian woman ran into the middle of the plot and began slashing away with her little *macheti*, saying, 'the American is crazy; if he wants to destroy these plants, let's destroy all of them'. A local Indian restrained her, and they preceded to apply the fertilizer. Upon returning about ten days later to see the results, which were very evident, they were surprised to see this woman come running from the distance, and dropping down on her knees before them. My picture is of her looking up at the men and saying, 'I want you to forgive me. I didn't understand what you were doing. Truly the crop is beautiful to look upon.' That was a dramatic incident, but I suppose it did more in that village to focus attention upon the things needed to bring about results than any other approach could have done. All I am trying to say, then, is that

while we talk here about the application of fundamental principles, we do have the job of applying them to particular conditions, so that the local people will accept them. I feel there is still a big gap between much of the theory we discuss and our actual achievements in local communities. This applies not only to agricultural economics but to all agricultural techniques.

P. M. Raup, *University of Minnesota, U.S.A.*

In considering the contribution that economists can make to technical development we need to keep one basic point constantly before us. That is the importance of the human factor—the individual. If we can arouse the imaginations of people, awaken their aspirations, enlist their emotions, then even bad plans can be made to succeed. Without this support, even good plans will fail.

Many of you will see in the next few days the new communities created by the Finnish colonization and settlement agencies to house the expelled Karelian refugees. A few of us had an opportunity to see some of these rural and village communities in connexion with the A.E.R. conference two weeks ago. On the basis of our very brief visits, and armed with the confidence of the casual visitor, I would like to attempt some generalization about this settlement programme. I am encouraged to do this by the knowledge that most of you will have opportunity, I hope, to check these observations against your own impressions in the very near future.

I am tempted to argue that a massive settlement programme carried out without pre-planning, and under crisis conditions, may have succeeded better than would have a more carefully planned programme, carried out at a slower *tempo*. This has nothing to do with the destruction of a *latifundia* or with the special conditions referred to by Dr. Fernandez y Fernandez in his comments on Wednesday. Rather, it concerns the problems of capital formation, consumer behaviour, and labour input on the part of a people whose emotions had been touched to great depths.

From an economic standpoint, I believe we can see here an application of some of the recent developments in the theory of consumer behaviour, particularly the 'demonstration effect' to which Mr. Dussenberry devoted his little book a few years ago. Here in Finland entire communities have been uprooted, and whether uprooted or not, an entire people had been made poorer by an exhausting war. There were not such sharp differences in wealth and consumption patterns as would exist in a more normal community. Hard work, low

levels of consumption, sacrifice and saving were the order of the day, and almost everyone was involved.

In the absence of affluent neighbours, whose higher levels of consumption would have provided a daily reminder of how good the good life might be, I am inclined to think that the Finnish people were actually aided in their settlement programme by its almost overwhelming proportions. The whole nation seems to have been aroused. Capital has been created in the past ten years at an enormous rate, which we economists would probably have regarded as impossible.

There is a parallel to be drawn here, I think, with the experience of frontier settlement in the United States, Canada, Australia, and parts of South Africa and South America. When everyone is poor in material goods, a low level of individual consumption is not so obvious. If at the same time the hopes and imaginations of a people can be aroused, the ideal climate is created for rapid advance. This is the lesson I am tempted to read from the Finnish experience. This is what is happening in Puerto Rico, the Philippines, and I suspect it is what is happening—or what the government is attempting to bring about—in Russia.

Concern with the technique of appeal to the human imagination is a part of the recent emphasis on education and extension. It is in this sense that I choose to interpret the comments of Dr. Morales. How we, as economists, can draw upon these emotions and aspirations in our plans for economic development is the challenge I should like to leave before you.

M. G. Smith, *Ohio State University, Columbus, Ohio, U.S.A.*

I wish to mention three points. One is that there is a genuine increase in interest all over the world in the use and exchange of technical knowledge. I think this is a striking development and I am very optimistic about the future. Possibly fifty or a hundred years from now, we may look back upon this as a period of significant change in which some nations became genuinely interested in helping to improve the real well-being of people in other nations.

Dr. Schultz made a point, near the end of his paper, on technical assistance and the spread of information to other parts of the world. I want to ask why it is that under-developed countries are so slow to accept or to include advisers in agricultural economics. These countries do not seem to value agricultural economics, particularly where United States agricultural colleges have contracts to work with and advise education and research institutions in foreign countries.

Perhaps agricultural economics is one of those empty boxes that Dr. Schultz mentioned; or perhaps their lack of appreciation is due to our low productivity as agricultural economists. Anyhow, we should determine the role of the agricultural economist in foreign technical assistance programmes and in the exchange of technical knowledge. This may be a topic for a whole conference.

The second point I would like to stress is in connexion with education. I believe that technical knowledge pyramids, and that one bit leads to another. It is unfinished, as Dr. Raeburn has so well said. It may have been forgotten in our discussion sometimes that we are dealing with thousands of technical changes that are taking place simultaneously. If we think of only a single technical change, we may take a very pessimistic attitude towards its benefits. But when we put many of them together we have a considerable net improvement in welfare. This takes us back to the term productivity which has been stressed so often here. I wish to stress it again because I believe people other than economists do not pay enough attention to the productivity of all resources that are put into an economic effort.

Finally, I doubt if we have given enough thought to non-mechanical and non-physical technical changes. We are inclined to forget the managerial and marketing techniques which I include as technical changes.

T. W. SCHULTZ (*in reply*)

My comments on the discussion will be brief. Mr. Britton had the top economists of the United States going away for five years, and it would hardly be appropriate for me to evaluate the effect of this upon the community. It would be like asking a man whether he would be better off without his wife. The divorce-rate is nevertheless very high in the United States. The point is an important one; of course, there is a transfer. Mr. Bandini made a point that is too technical for me to handle in these comments because I may not have caught it precisely. I would rather discuss it with him carefully, because it is a conceptional point and one, I am sure, of importance. We certainly return the greetings of our colleagues from Poland.[1] I was a little amazed to find that the filling of all my little boxes is known as planning in Poland. Professor Case's comment was self-contained. It was a recommendation to blueprint your own efforts into private five-year plans when you get home. Professor Raup

[1] See p. 533.

stressed the human side, the *demonstration* effect. This may be brought into play in analysing consumer behaviour. There is a growing interest in what Mr. Smith said, but there is also a need for the agricultural economist's contribution. I could give some evidence that this aspect is being emphasized in university contracts right now. The excellent set of comments on the planning process from Professor Turk must be read to be appreciated fully. Comments made after only one hearing would not be appropriate. Unfortunately for discussional liveliness, Mr. Raeburn and I are too close together in our views. He has to get closer to an understanding of the problem of risk and uncertainty, and of how risk can be borne better by different combinations of public and private interests. This should be on our agenda. It ran through a great deal of what he said.