THE ROLE OF THE ENGINEERING IN PLANNING

By

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I shall begin by stating the obvious. In modernising countries the engineer has a supremely important role to play in the general society and even more so in economic planning and economic decision-making. I am acutely aware of this supremely important role. Therefore, if I appear on occasions to be somewhat critical, this should not be taken to mean that I do not have a great deal of respect for engineers. I chide out of affection and disappointment, rather than from dislike or pique.

I shall divide my remarks into four parts - the training of engineers; the role of the engineer in business decision-making; the role of the engineer in national economic decision-making; and, finally, the role of the engineer in technological research.

THE TRAINING OF ENGINEERS

I speak here with some diffidence as a person who has been insufficiently exposed to applied science and technology. Yet, from the little I know, it seems to me that the training of an engineer - with its stress on the applied aspects of the natural sciences, the use of mathematics as a tool, and the solution of problems in an environment subject to a number of constraints on the range of possible solutions - is a wholly admirable one, judged from a purely intellectual point of view. The qualities which this training imparts are also useful providing a good basis for both national and private decision-making in economic matters. It is no doubt for these reasons that the engineering profession commands - and quite rightly so - a great deal of respect in the Latin American countries; and in both Mexico and Argentina, for example, the title "Ingenerio" is just as honorific as "Doctor".

Yet, from my experience in the field of economic planning in Trinidad and Tobago, I have come to the conclusion that the engineer ought to be exposed to more contact with the discipline of economics in the course of his

training. Let me state the case for this proposition. Economics is essentially the science of choice. As such, economic analysis serves to elucidate the choice between present and future consumption, between different ways of producing the same commodity, between conflicting objectives of contemporary economic policy, between the relative emphasis to be placed on the development of different sectors of the economy, between production for the home market and production for export, between different ways of spending Government revenue, etc.

Now, as I have suggested before, the engineer in his work as an engineer deals with several of these problems of choice even though in a somewhat different form and subject to several constraints which are not sufficiently taken into account in many theoretical economic systems. In view of this, a more systematic introduction to the logic of choice is bound to make the student a better professional engineer, even if he restricts himself in the course of his work to purely engineering problems. It would not take, in my view, the engineering student much time nor should he find it particularly difficult, to master the essential tools of economics, since he already has to spend time in the study of mathematics and of the operations of mechanisms.

In fact, my experience in economic planning has suggested that the ideal national planner would be someone who combined the two disciplines of engineering and economics. In the U.S.S.R., U.S.A., France, and an increasing number of Latin American countries, this new species of engineer-economist has emerged and is making a valuable contribution to economic decision-making in industry, in planning bodies and in development corporations. Many of the best economic planners of today are people trained in both subjects - Chenery in the U.S.A., Pierre Massé and others in France.

It is out of my conviction that this is a desirable development that I welcome the effort being made in the Social Science Division in the University at St. Augustine to develop a special School of Business Management which can provide engineering students with the tools of economic decision-making for use in both the public and private sectors. In this marriage between economics and engineering the development of the new techniques of "linear programming" and "operations research" has served to play the role of match-maker.

THE ENGINEER IN PRIVATE ECONOMIC DECISION-MAKING

It is a well-known fact that many top business executive positions in the U.S.A. are going increasingly to graduates in Engineering. The reason for this is not surprising. Many large corporations are in the position of the character in Molière's play who never realised that all along he had been talking prose. Whether they realise it or not, these large corporations are actively engaged in economic planning, and by this I mean that they are engaged in rational

decision-making. They have to estimate the growth of demand for the product in the light of the rate of growth of output and employment which they expect in the economy as a whole; they have to plan their investments carefully to meet expected increases of demand; they have to make decisions about the time when economic obsolesence will overtake the plant; they have to choose the most appropriate technology and combination of factors of production; they have to estimate the rate of return on the investment over a fairly long period; in making plans for investment they have to decide on the best and most economical method of raising the money.

Let me take one concrete example - the problem of the optimum location of a new branch plant of an existing corporation. The choice of the optimum location depends on a number of factors - nearness to markets, nearness to source of materials, availability of power, availability of labour, etc. In all of this the transport equation is of supreme importance. It is question of "optimising" subject to a number of constraints - very much an economic problem but one where an intimate knowledge of technology is essential. The engineer has to estimate the amount of power required, the cost of transporting power as against producing it on site, the relative cost of transporting materials to the plant as against the cost of transporting the finished product to the market. Moreover, he is best suited to advise on the method of transport of the material.

THE ENGINEER IN NATIONAL ECONOMIC DECISION-MAKING

There are several problems on the national decision-making level to which the engineer has quite a definite contribution to make. I shall discuss three areas of work for the engineer in this field.

First of all, there is the type of work done in industrial development corporations. Such work involves for the most part, the undertaking of feasibility studies of industrial investment projects - either individual industries or industrial complexes. Here the combination of economic and engineering skills comes very much into its own. It is in this area that we in Trinidad and Tobago have much to expect from our future economist-engineer especially those trained in chemical and mechanical engineering.

There is this difficulty, however. Many of these areas are highly specialised and are becoming increasingly so. There are now economist - engineers who specialise in textiles, in petrochemicals, in aluminium, in materials, in food processing, in steel - and so on. The high degree of specialisation required raises problems for a small country such as ours. A recognition of this fact suggests that for a long time our own economist - engineers will have to work in broad fields and that we shall have to remain dependent on outside consultants (whose advice can be very expensive) where a detailed knowledge of certain industrial processes is required.

Second, there is the whole field of planning for specific projects in the public sector - electricity, transport, buildings, etc. This is where the civil or electrical engineer is needed. He has to carry out appropriate feasibility studies, taking into account economic as well as technological factors. He has to undertake preliminary and final designs etc. He has to weigh costs against benefits.

This is obvious enough; but merely to mention the weighing of costs and benefits leads me to the third and most important problem with which I wish to deal under this heading.

This problem constitutes one of the most important problems of choice in economics - the best technique of producing a commodity from the point of view of the society. This is a case of the celebrated distinction between private and social costs with which economists have grappled for many decades. In the case of a labour-surplus economy such as Trinidad and Tobago, it emerges in the form of the very difficult problem of factor-proportions. Should one use much labour and little capital to produce a commodity in a situation where labour is plentiful and capital scarce? The problem is not as simple as it sounds. To the layman the answer to the question may seem obvious. Let us use as much l a b o u r as possible; that i s t o say adopt labour-intensive techniques. This is obvious if we are thinking of increasing employment, but to the economist the answer has a deeper meaning since it can be shown that to use much labour relatively to capital maximises not only employment but the national product. This is one of the best known theorems of neo-classical economics. I shall not attempt to prove it. Suffice it to say that, where one maximises the product of the scarce factor - in this case. capital - one maximises output and incidentally, consumers satisfaction. The point I wish to make is that the assumptions which need to hold true to make this theorem valid from the point of view of maximising the national product constitute a very tall order. The assumptions include the existence of perfect competition in both the product and factor markets and this reasoning also depends on the validity of what is called the marginal productivity theory of the shares of the different factors in the national product.

The practical problem from the point of view of economic policy is this : in a pure neo-classical world economies with surplus labour would find that the price of labour is very low, this reflecting a relative abundance of labour as compared with capital. In fact, in a very fundamental sense, the price of labour is zero because if unemployed labour were to be put to work on a job, the cost to the society of so doing would be nil. By putting the unemployed person to work society loses nothing because no production is lost by putting him to work. This can be expressed in technical language by saying that the opportunity cost of labour is zero. However, in practice the wage-rate secured by labour is always higher than zero. In this situation the cost to the businessman of employing a worker exceeds the cost to society. This state of affairs has led economists to formulate the theory of accounting prices which reflects the true social cost of factors of production such as labour and capital - such true social cost reflecting their relative scarcity. This approach leads to the argument that the price of labour in industry should be subsidised and that capital ought to be taxed so that the businessman in his calculations about choosing technology and combining factors of production would be forced to face up to the true social cost.

It is somewhat ironical to observe how engineers have reacted to th problem. At first the engineer was so blithely oblivious of the economic pro lem involved in the choice of techniques that he was concerned purely with mon costs of production and was almost invariably attracted to the most mode forms of technology which are more often than not highly capital-intensiv He often confused technological with economic efficiency. Anything that cou do the job more cheaply or more quickly was to be preferred.

More recently, however now that the factor-proportion problem h dawned upon his consciousness the engineer tends to go to the other extren and now uncritically advocates the adoption of account-prices. The wheel ha turned full circle.

It is most important that the economist should constantly remind the e gineer of the limitations of the accounting price approach. First, the approac assumes that perfect competition exists. This condition is rarely achieved i practice in the modern world and as such there is no reason to believe th simply adjusting the price of labour and capital to the economic levels woul bring about the economic optimum - although to be sure this would have th effect of increasing employment. Secondly, and more important in practic the extent of subsidisation and taxation implied by the accounting-price theo carries a tremendous fiscal problem for the Exchequer. The widespread use accounting prices would mean a tremendous re-distribution of income fro those who have jobs to those without jobs. It is partly a political and partly a economic problem. Thirdly, the accounting-price approach can often be som what naive in not recognising the problem of limited choice. In the real wor as we know it, there are often not a sufficiently wide range of combinations labour and capital which can be used to produce a given commodity. In fac in many cases there are only one or two combinations, most of them highl capital-intensive. Is there a labour-intensive method of refining petroleum Is there a labour-intensive method of producing steel? This is the problem know in technical language as "fixed technical coefficients". With all the subsidies an taxes in the world it would be impossible to use labour-intensive methods t produce economically, say nitrogenous fertilizers. The real point is to recognis that in a small economy dependent on exports, the use of capital intensive tech nology which often produces the commodity at the lowest money cost of pro duction may be the only alternative. The foreign purchaser is not interested i social cost or accounting prices; he is interested in money cost and the pric he has to pay in cash. Such considerations tend to form capital-intensive tech nologies. This is one very important constraint on the accounting-price ap proach in small countries and we in Trinidad and Tobago can ignore it only a our own peril.

Yet we must not overlook the fact that there is much value in the ac counting-price approach; and it is my view that the engineer would always b a better engineer if he keeps it constantly in mind. In fact, there are man cases where there is a real choice between methods of production and here th considerations which would argue in favour of labour intensive methods mus be pragmatic ones. There is no hard-and-fast rule. If building a road in rural area where labour-intensive methods will not result in too great a cost o in too large a difference in construction time as compared with very high

mechanised methods, the balance of advantage might be in labour-intensive methods. Accordingly, at the national planning level, the accounting price approach can be recognised by having two kinds of development projects—those where efficiency in money terms is important and those where it is not so important. This approach has been embodied in both the Venezuela and Trinidad and Tobago Five Year Plans where special programmes to provide employment while at the same time installing useful social and economic assets, have been admitted. It really boils down to taxing the employer and capitalist to provide work for the unemployed, while providing useful assets for the community.

This problem can, perhaps, be elucidated by introducing the notion of the dual economy—one of the central concepts in the theory of economic development. The dual economy is one where it is possible to distinguish two sectors —one modern, technologically progressive and capital-intensive; the other traditional, technologically backward and labour-intensive. In the former sector, output per man is usually much higher than in the latter and output per man also usually grows at a faster rate.

Now in a fundamental sense economic development means the gradual spreading out of the modern sector until it eventually eliminates the backward sector, thereby becoming co-terminous with the whole economy. The mechanism for achieving this is the accumulation of capital embodying advanced forms of technology. Considered in this perspective, the object of economic development is to eliminate the dual economy.

However, the snag about this approach under contemporary conditions in many less developed countries is that the modern sector is very highly capital-intensive, while the labour-supply is also growing very rapidly. When the now developed countries were moving out from the stage of under-development, techniques of production were much less capital-intensive than they now are and their populations (and hence labour-forces) were growing much less rapidly than those of the now less developed countries. This explains why today many developing countries, even though they may show high rates of capital accumulation, are still plagued with large numbers of unemployed or underemployed. In many countries, such as the West Indies, the extent of structural unemployment and under-employment can be taken as an index of economic dualism. This also means that it would take such countries decades of very high rates indeed of capital accumulation to eliminate dualism and structural unemployment.

As I have suggested above, a small country which has to depend heavily on external markets to absorb much of its output has perforce to adopt highly-capitalised forms of modern technology in order that its money costs of production can be kept low and its competitive position safeguarded. This is so either because there is no other way of producing the commodity (the case of "fixed technical co-efficients") or because, where there is some degree of choice between different degrees of capital-intensity, high and rising wage-rates may induce the substitution of machines for men.

What is called for as an object of policy in these circumstances is not so much the complete elimination of the dual economy over a decade or so. A

more realistic goal would be "controlled" dualism seeking to convert as far as possible open unemployment into under-employment -in the economic sense of the provision of employment with a lower output per man than in the technologically dynamic export sector.

To some extent this will in any event take place automatically. For the service sector of the economy (whose output is usually supplied by domestic factors of production and which is relatively labour-intensive) can be expected to expand in response to the growth of output and income in the export sector and so help to absorb the unemployed and new entrants into the labour-force at levels of productivity lower than in the export sector. But this sector cannot be expected to do the entire job of absorbing the growing labour-force. Its ability to do this may be further impaired by the "overspill" of high wage-rates related to the high productivity of the modern export sector These high wage-rates can check the expansion of employment in services either by not making production worthwhile or by accelerating the rate of modernisation (super-markets, computers, etc).

For sufficient employment to be provided under these circumstances two other sectors will have to be relied upon - the public sector and the domestic agricultural sector (producing for the home market). As I have suggested above. there will have to be special labour-intensive programmes within the public sector quite apart from the "normal" "basic" programme. And in the domestic agricultural sector the emphasis of policy should be to raise output per acre rather than output per man. Overcrowded Japan gets higher yields per acre but lower yields per man in agriculture than the U.S.A.

TECHNOLOGICAL RESEARCH

The preceding reflections on the factor-proportions problem in small countries such as ours may be considered at worst pessimistic, at best fatalisitc On the other hand, the characteristic spirit of Science and Technology is optimism. The question may, therefore, legitimately be posed: can the engineer and the applied scientist do anything which would remove the grounds for such fatalism? I think that they can - but dramatic results should not be expected in the short run. The problem is that modern technology has developed in the advanced countries which more than a hundred years ago were able to eliminate the dual economy and achieve full employment and which since then have directed their research efforts towards developing more advanced and lower-cost technologies by seeking to economise on the scarce factor - labour. Most of the most economical technologies today, therefore, embody very little labour.

It would be idle to expect applied scientists from the less developed countries to be able to reverse this trend overnight. The U.N. Centre for Industrial Development is now beginning to sponsor research in adapting technology to

factor-propositions. I have no doubt that, while Governments and Universities all over the developing world should encourage and undertake such work, these efforts will take a long time to bear fruit.

At this stage, however, I would like to make a distinction between labour-using technical improvements and innovations rendering production on a relatively small scale more economic, or rather less uneconomic. I admit that this is a somewhat fine distinction, since one of the reasons for the economies of large-scale production may be a high degree of capital-intensity of the plant; but to some extent the two phenomena are independent of each other. In recent years there have been dramatic breakthroughs in steel technology making possible fairly economic production at fairly low levels of output through the use of electric furnaces. I am, therefore, less fatalistic about the short and medium-term results of research in this area. This in my humble opinion ought to be the area in which our best engineering and scientific brains in Trinidad and Tobago ought to concentrate.