Must Science Ruin Economic Progress?*

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ECONOMIC progress is the orderly assimilation of innovation into the general standard of life. It usually connotes a widespread sharing of new benefits, but is by no means inconsistent with some degree of uneven distribution of wealth or income, for in a non-socialistic community some disparity generally raises the standard of life of the mass to a point higher than it would be under a forced equality of distribution of wealth, the envies caused by disparity notwithstanding. The purely material standard in Great Britain was raised fourfold during the nineteenth century, and probably rather more in the United States. If we take into account also length of life and proportion of leisure, the increase is much greater. The improvement arises only to a very small extent in changes in the average innate capacity of man, not co-operant with, or parasitic upon, his environment. It is almost all due to innovation in social activity (including social education and the reactions of economic betterment upon physical and mental ability). The greater part of the innovation is scientific innovation—in physics, engineering and public health—but a not inconsiderable part falls outside these categories, and belongs to the non-physical section—better ideas about money, more social confidence in banking and credit, improved political and social security and legal frameworks for the better production and diffusion of wealth. The elaboration of these factors depends partly on intellectual prevision and invention, but mainly upon average moral standards, and calibre of character, since many political schemes, including international co-operation, are impracticable only because of failings in the present standards of human nature.

It is being commonly stated that scientific changes are coming so thick and fast, or are so radical in their nature and implications, that the other factors of social life, the intangibles of credit, the improvements in political and international organisations and ideas, are unequal to the task of absorbing and accommodating them, or else they present new problems which have no counterpart. If changes in social forms and human nature or behaviour cannot possibly be made rapidly enough for the task, then in that sense science may 'ruin' economic progress, and the world might be better served in the end if scientific innovation were retarded to the maximum rate of social and economic change.

Civilisation went through a long period when the limiting factor to progress was the scientific, but is now passing through a stage when the limiting factors are non-scientific. The lack of identity in the *tempo* of change creates new problems, tending to offset scientific advantages, of three types. First, for example, the utilisation for essential or competitive purposes of rare minerals, the need for which becomes general, but the distribution of which is particular and accidental, sets up great political strains, and we have invented no means of adjusting the international effects of accidental monopoly of essential elements. Second, the problem of scope, where the scale of production upon which, for example, a chemical innovation can be made to give its real economic advantages, is a scale inconsistent with the size of markets freely open in a nationalistic world. Here strains are set up in the international machine and the balance of trade, which may gravely jeopardise economic progress, and dry up the juices of commerce. Third, for example, where the innovation is absorbed most easily for offensive purposes in a military or naval sense, it may create rivalries and changes of balance of power inimical to economic security, and compel new economic sacrifices outweighing the direct economic advantages of peaceful uses. It is open to question whether the innovation of aircraft has yet become, on net balance, economic progress.

Inasmuch as all economic production creates real vested interest in a location or a skill devoted to it, and every scientific innovation alters the centre of gravity of collective demand, every such scientific change disturbs an economic equation. That equation for human life may often be richer ultimately, but the pain or waste of disturbance has to be debited to the gain, before the net balance is progress. For the time being, the balance may be net loss, the price paid for to-morrow. If to-morrow is continually postponed, because it, in its turn, is redisturbed, and the economic to-morrow never comes, it is 'jam yesterday, jam to-morrow, but never jam to-day'. Wastes of absorption will be at a minimum in certain conditions, which are related to the wearing life of existing assets and places, and to the rate of flow of new skill into new directions.

The orderly absorption of innovation into economic progress, apart from improvements in the non-economic factors of such progress, depends upon two kinds of balance. The first is the balance between two classes of scientific discovery, that which accelerates or makes easier the production of existing economic goods, and that which creates new kinds of economic satisfactions—the derivative and the direct. Let us suppose that in a static society a million people are employed making boots, and the gramophone has not been invented. Then let a labour-saving device be invented, such that the same quantity of boots can be made by half the workers, and boots are half the price. Assuming that the demand for boots is quite inelastic, and no more are wanted, there is potential unemployment for half a million people, and the whole population has now reserve unspent purchasing power, saved on cheaper boots. The

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gramophone is introduced, employing the potentially unemployed, and absorbing the reserve or released purchasing power.

The progress of the past hundred years has been essentially of this order, and innovation has enabled purchasing power to be released for new spending, first upon far *more* of the same article at the reduced price ; second upon more of other existing goods and, third, upon entirely new kinds of satisfaction, such as bicycles or radio sets. In this connexion it must be remembered that an old article may be so transformed in degree as to be equivalent to a change in kind—the silk stocking and feminine footwear are cases in point. Now even if these two classes of innovation, direct and derivative, are in balance, the process of absorbing them will give rise to economic 'growing pains' and temporary dislocations of capital and employment, but the gains will rapidly outweigh the disadvantages. But when they are not in balance, the process is more painful, and the debit to be set against progress very much greater.

The introduction of machinery has been for three hundred years accompanied by the same hostile arguments, for the immediate effects in unemployment are much more obvious and human than the countervailing employment given by the released purchasing power, which may occur in some other place or country. Illustrations may be found all the way from Queen Elizabeth's sentiments on stocking-knitting machinery, to the Luddite riots, and the eight looms per weaver, of to-day. But in the literature of the whole series, nothing can outdo, for detailed economic jeremiad and precise calculation of woe, a contemporary examination of the effect of the introduction of the stage coach in the middle of the seventeenth century upon the post horse industry and all that depended upon it ("In Grand Concern of England", 1673).

The argument so far, no doubt, begs the question of the meaning of progress, and assumes that silk stockings and fine shoes represent a 'higher' standard of life than black, homespun woollens and rough boots—a doctrine that is not acceptable to Mr. De Valera for example—but as we are not entering the field of morals or ethical aims, we are obliged to assume that those objects which are actually the subject of average human desire must be given their economic significance accordingly, and not attempt to solve the larger problem simultaneously. In this sense such a mechanical invention as the totalisator must take its place in 'progress' at this stage.

The problem of balance, in the direct and the derivative, is not, however, so simple in practice, for the sum total of the effect of derivative innovations (creating technological unemployment) ought to be balanced by the sum total of direct innovations or increased demand for other products (new and expanded employment). But many direct innovations are not additive ; they are substitutional, and destroy the need for old commodities. If combs are made from celluloid, and dishes from papier mâché or pyrex, they will certainly not create a wholly additional demand or employment —there will be a displacement of the old types in metal or bone combs or china dishes. This substitution goes into rival classes of utility also, and a radio set may be a real substitute for a billiard table, and oil may be the enemy of hops, if cheap bus-riding supplants long sittings in public houses. These substitutions may be gradual enough to be absorbed as a normal feature of progress, but if they are very rapid and coincide with certain other economic disturbances they may be very distressing. By 'normal' I mean such as can be coped with by the direction of new labour entering industry or new capital spent on renewals, leaving the contractions to take place by natural age attrition without unemployment, or by premature obsolescence—for the moment this is the optimum point of change.

The lack of balance between derivative and direct innovation may be due, of course, to a terrific drive and rapidity in scientific recovery of the industrial type, but it is only fair to say that the excess of one may be due to causes on the economic side. If for purely monetary reasons, the gold standard, etc., the purchasing power of money is continually increasing through falling prices, and, with the current inability to change the money totals of wages and other costs, real wages are rising, it becomes increasingly possible to substitute innovations of machinery for hand labour, or complex for simple. A change that was not worth making on a balance of old wage costs against new capital costs in 1923, became well worth making by 1932, and indeed imperative, if any profits were to be preserved. Hence the almost artificial pressure which a rigid monetary system may bring to bear towards the over-rapid application of new methods and creation of unemployment.

The second kind of balance which is vital to economic progress and may be ruined by over-rapid innovation is that between obsolescence and depreciation. Nearly all scientific advance for economic progress has to be embodied in capital forms, to be effective, more and more elaborate, large and costly. The productivity of such apparatus and plant per man involved becomes greater, and even allowing for the men employed in making the machinery or process, the total satisfaction is continually produced with less and less human effort. Now it used to be said of British machinery that it was made good enough to last for ever and long after it became old-fashioned, whereas American machines were made to be worn out much earlier, and were thus cheaper, but could be immediately replaced by capital assets containing the latest devices. If the period of physical life and fashionable life can be made to correspond, there is greatest economy and security of capital. But if the expensive embodiment of the latest science can be outmoded and superseded long before it is worn out, there is waste of capital, loss of interest, and resultant insecurity of business and investment.

The factor of physical safety alone means that each embodiment must be really durable, even if roughly finished, and, therefore, it is impossible wholly to reduce physical life to probable 'obsolescent' life. In this way an over-rapid series of innovations may mean the scrapping or unprofitability of much excellent capital for very small marginal gains. A responsible socialist community would see each time that the gain was worth while, but competitive individuals have no collective responsibility. Suppose the giant Cunarder attracts a profitable contingent for two years only, when a lucky invention in a new and rival vessel attracts all her passengers at a slightly lower fare. Here is progress in one typical sense, but the small net advantage to be secured by individuals as free-lance *consumers* may be dearly purchased by large dislocations or loss of capital reacting even upon those same individuals as *producers*. Now, if the innovation were very striking, and were reflected in working costs, the margin of difference between the old working costs and new working costs may be large enough to pay interest on the new capital employed and also to amortise the cost of the unrealised life of the asset displaced. A locomotive may have many years of useful life left, but a new type *may* provide a margin by lower working costs not only sufficient to make one adopt it on normal renewal, but also to pay for the premature scrapping of the old type.

The majority of modern innovation is, however, of the type which does *not* pay the costs of obsolescence and proceed by orderly and natural physical renewal or substitution. A similar type of argument applies to the capital expenditure generally on a district, which can be amortised over the economic activity of that area, such as a colliery area, but which is wasted if a dislocation occurs by the adoption of some innovation stimulating rival activity in another place. Similar but more poignant considerations apply to obsolescence in human skill and training, more rapid than the ordinary attrition through age retirement can accommodate. Physical capital forms, human vocational training, and centring in geographical areas, are all essential features in the absorption of scientific innovation into economic progress. Each has its *natural* time span, and a narrower span of scientific change is bound to set up large economic debits to be set against the economic credits of the change. A man running a race might be stopped to be given a new magic cordial, which *after* allowing for the two minutes stoppage, would enable him to finish a minute earlier. But if he is stopped at frequent intervals for other magic cordials, each advantageous by itself, the total period of stoppages would at some point exceed the possible gains of speed during the short undisturbed running periods, and he would finish later at the post, instead of earlier. This is a parallel to the current effects of too rapid disturbance on progress.

Under an individualistic form of society, it is difficult to alter the social technique of change, and to make its credits really pay for the debits, and make all the people who gain by the profits on new capital pay also for the losses on prematurely displaced capital, or the gainers by cheapness and variety pay the human costs of unemployment and the skill no longer wanted. The *basic* economic reason for social unemployment relief is not the humanitarian argument of social obligation against distress, *or* the argument against revolution, but the plain argument that the gainers by innovation should bear the losses of innovation.

At the same time, much can be done to shorten the hitherto natural time span and make society ready to absorb the quickened tempo of science. No prices ought to be charged except on the basis of costs fully loaded with short-period obsolescence —this would prevent over-rapid substitution, economic only to a narrow range of people. We have no adequate technique of change; we treat life as mainly static, with occasional and exceptional periods of change, whereas we must learn to look upon it as continuously changing, with occasional and abnormal periods of rest, and we have to secure all the changes of social outlook implied by that reversal of view.

The next field in which scientific advance alters the economic problem faster than we can solve it, is in the duration of human life. We have to provide a social dividend adequate to maintain a much larger proportion beyond the age to contribute to it. Combined with the altered birth-rate, a profound change is taking place in age densities, and the turnover from an increasing to a stationary and then a declining population, in sight in Great Britain, Belgium, Germany and even the United States, is bound to affect the *tempo* of economic life. A larger and more immediate problem of adjustment is, of course, the absorption of the results of science not in increased masses of new kinds of commodities made by the released labour of labour-saving devices on old kinds, but in generalised leisure. The transition from a state of affairs in which we have an uneconomically high commodity wage paid to a part of the population, and the rest with a mere pittance and enforced idleness, to a state where a part of the reward is taken *all round* in larger leisure, and where economic satisfaction from leisure is deliberately equated to that from commodities in the standard of life, may need a surgical operation, or a catalyst, such as the United States experiment can show.

In the past, the absorption of innovation has been achieved, according to contemporary explanation, by four agencies: (1) great elasticity of demand for the old commodities at reduced prices, food and staple household necessities, (2) rapid introduction of new things, (3) the rise in population *created* by the increase in produce, (4) overseas outlets in more backward industrial countries. In the first the elasticity completely alters as the standard rises, and generally there is not now the scope for lower price in food or clothing increasing the demand *pro tanto*: for the third, a rising standard no longer stimulates population but tends the opposite way; for the fourth, the external outlets are now largely self-producers. As regards the rapid introduction of new things—these mostly now demand increased leisure for their proper absorption and use, so that the two are co-related and mutually dependent.

It can be conceived that a socialistic organisation of society could obviate such of the maladjustments as depend upon gains and risks of absorption not being in the same hands, and a theoretical technique can be worked out for the most profitable rate of absorption of scientific invention, having regard to invested capital, and skill and local interests. It is sufficient to say that it needs a *tour de force* of assumptions to make it function without hopelessly impairing that central feature of economic progress, namely individual choice of the consumer in the direction of his demands, and an equally exalted view of the perfectibility of social organisation and political wisdom. But in the field of international relations and foreign trade, which alone can give full effect to scientific discovery, it demands qualities far beyond anything yet attainable.

Economic life must pay a heavy price, in this generation, for the ultimate gains of science, unless all classes become economically and socially minded, and there are large infusions of social direction and internationalism, carefully introduced. This does not mean government by scientific technique, technocracy, or any other *transferred* technique, appropriate as these may be to the physical task of production; for human wills in the aggregate are behind distribution and consumption, and they can never be regulated by the principles which are so potent in mathematics, chemistry, physics, or even biology. Scientific workers may contribute much by sharing the problems of social science along its own lines, by giving a greater proportion of brilliant minds to this field and by planning research.

Atomic Transmutation

TWENTY-SIX years have passed since the British Association last met at Leicester in 1907, and the apparently stable world of a quarter of a century ago has altered almost out of recognition. These changes in political, moral and spiritual values are reflected in the world of physical science, which differs almost *toto cœlo* from the structure raised by the labours of the nineteenth century and its predecessors. But even then rumblings were apparent, and it is a remarkable fact that the discussion on atomic transmutation, opened in Section A (Mathematics and Physics) by Lord Rutherford on September 11, had its antitype in a sectional discussion on the constitution of the atom opened by Prof. Ernest Rutherford, as he then was, at the 1907 meeting, to which contributions were made by Lord Kelvin, Sir Oliver Lodge and Sir William Ramsay.

Lord Rutherford, whose contribution to the present discussion was a masterly review of a quarter of a century's work on atomic transmutation, remarked that, at the discussion which he opened in 1907, he indicated the importance of the transformations of radioactive bodies, and emphasised the difficulty of explaining the part played by positive electricity—we had then no inkling of a knowledge of the positive electron. He reminded the audience that Sir Oliver Lodge, who nevertheless proclaimed his belief in the electrical structure of the atom, had remarked that the opener was an adept in the art of skating on thin ice. Kelvin, who in 1904 was prepared to accept the notion of the transmutation of the radium atom, in 1907 did not find the evidence for transmutation satisfactory. It was about this period that Lodge, in a letter to the *Times*, suggested that if Kelvin would read the evidence he would change his opinion; Kelvin's reply was that he *had* read Rutherford's "Radioactivity" and remained unconvinced!

The work of the eighteenth and nineteenth century chemists had given to the world some eighty-odd elements, and it was quite clear that the atoms of the elements were very stable structures. But though the old ideas of transmutation were exploded, the problem still existed, and indeed had been clearly formulated by Faraday. The discovery of radioactivity showed that elements such as uranium and thorium were undergoing spontaneous transformation, and a large number of new elements were brought to light. Moreover, the property was shown to exist in a very slight degree in elements such as potassium and rubidium, the remainder of the normal elements being stable under ordinary conditions over periods to be reckoned in millions of years.

It was in 1911 that the nuclear structure of the atom was clearly evidenced, and a little later that Bohr's masterly interpretation of the movements of electrons gave an explanation of spectral regularities. It soon became evident that outer electrons played no major part in transmutations, that the changes produced by stripping off electrons were only temporary in character, and that the structure of the nucleus must be changed if we wished to institute any permanent atomic transmutation. Moreover, evidence had accumulated to show that the nucleus was a very small entity.

If an α-particle were fired at a nucleus, the enormous forces developed in a head-on collision might be expected to disturb the structure of the nucleus, and it was in 1919 that decisive experiments were made. When α-particles were fired in oxygen, no effect was produced, but when they were fired in nitrogen, a new type of particle appeared—the *proton*.