DEBATES

The Cause of the Industrial Revolution and 'Single-Factor' Arguments; an Assessment

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In a recent issue of this Journal J.F. Gaski presented an argument reducing the causes of the industrial revolution to one prime mover – technological change.[1] The framework of analysis is the traditional empiricist one which sees events linked to their causal antecedents according to the general law: if (A) then (B). The methodology employed to confirm this general law in this case is interesting. A number of 'factors' are identified which are characterised as necessary conditions for industrialisation. Each factor is considered on its own and found to be necessary but not sufficient to cause industrialisation. Finally one factor alone is identified as the sufficient condition for industrialisation 'because it alone could have induced the others.'

In setting out his necessary and sufficient conditions for industrialisation Gaski is implicitly appealing to a general law which states, 'if there is a sufficient population (P), agricultural development (A), capital accumulation (K), technological innovation (T), adequate demand and markets (D), a sufficiency of natural resources (R) and favourable economic climate (C) then industrialisation will occur (I) or, more generally, if (P, A, K, T, D, R, C) then (I). It is suggested that these conditions existed in England at the end of the XVIIIth Century therefore industrialisation occurred. This formulation has the merit of being falsifiable. All that is required are operational definitions of (P) (D) etc. and (I) then, given a sufficient number of cases, the validity of the general law could be tested.

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[1] J.F. GASKI, "The Cause of the Industrial Revolution: A Brief Single-Factor Argument" Journal of European Economic History Vol. 11 No. 1 Spring 1982.

This essay takes issue with the discussion on three grounds. Firstly on the grounds that there is a confusion in the use of the terms necessary and sufficient conditions. Secondly in that there are theoretical inconsistencies in the treatment of each of the ' factors ' which make up the necessary condition for industrialisation. Thirdly a failure to specify in any quantifiable way the magnitudes and rates of change of the ' factors ' which make up the necessary condition for the transition from pre-industrial to industrial economy means that they are non-operational and hence his general law can be neither confirmed nor rejected.

We begin by discussing the concepts of necessary and sufficient conditions. A causal statement implies a sequence of events. McClelland cites the example of explaining the lighting of a match.[2] Every time oxygen is present (C_1), the match head is dry (C_2) and the match is struck (C_3) then it will light (E) or if (C_1, C_2, C_3) then (E). These three factors (using Gaski's terminology) make up the sufficient condition for the event (E). Any one of the factors considered individually is necessary but not sufficient. The cause of the occurrence of the event (E) is the set of necessary conditions which make up the sufficient condition. Each factor is necessary because without it the event cannot occur. The whole cause of the event (E) is the set of conditions sufficient to produce it.

Consider now our earlier formulation of the factors considered necessary conditions, by Gaski, for industrialisation:

if (P, A, K, T, D, R, C) then (I).

Clearly technology, in this formulation, could not be regarded as a sufficient condition since it is only one of the necessary conditions. The sufficient condition is the complete set of necessary conditions. By other criteria for sufficient conditions we could allot technological progress a special role if it were specified to be the one necessary condition common to all possible sets of sufficient conditions. Since only one sufficient condition is offered this is not possible.

However we find that although technology is included as a necessary condition it is characterised as a sufficient condition because ' it tends to elicit the other necessary conditions.' That is to say that there is a causal relationship between technological progress and the other necessary conditions. Unlike the deterministic relationship, however, which is specified between the set of necessary conditions and industrialisation the relationship between technological change and the set of necessary conditions sufficient for industrialisation is specified as probabalistic i.e.

probably if (T) then (P, A, K, T, D, R, C)

and

if (P, A, K, T, D, R, C) then (I)

Technological change then is made the sufficient cause for industrialisation by

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[2] P.D. McClelland, Causal Explanation and Model Building in History, Economics and the New Economic History (London 1971) p. 33.

moving one step back in the chain of causal regress and identifying it as sufficient to produce the sufficient condition for industrialisation. We have here a stage theory of the industrialisation process. Stage one sees technological progress. Stage 2 sees the emergence of the set of necessary conditions sufficient for industrialisation. Stage 3 sees industrialisation. The problem now is to see to what extent the components of the stages have any theoretical or empirical content.

We begin with a discussion of the characteristics of industrialisation. Gaski identifies two main characteristics. A change in factor proportions, more specifically a substitution of capital for labour and an 'acceleration of economic growth.' This later involves 'increased national investment and rising per capita income.' We immediately encounter problems because no real definition of industrialisation per se is offered. For our purposes we shall take it to be a rise in the share of industrial output as a proportion of GDP. The industrial sector is a group in some standard classification. For our purposes we may take it as S.I.C. II to XVII. We can say then that this rise in the share of industrial output in GDP is characterised by a more capital intensive production function and by an acceleration of economic growth. The latter involves rising per capita income and rising national investment. No definition of economic growth is offered. However since per capita income levels are rising we may take it to mean an increase in either GNP or NNP. An acceleration of these two indicators means that they are increasing at an increasing rate which will lead to rising per capita income provided population is increasing less rapidly. The rise in national investment is presumably a rise in investment as a share of GNP otherwise the economy could be encountering rising absolute levels of investment but investment falling as a proportion of GNP. Depending on the rate of growth of population it could presumably also find itself with falling levels of investment per capita which (assuming proportionality between population and labour force) is specifically ruled out by the more capital intensive production function. We can now make Gaski's definition of industrialisation clearer. Industrialisation is the process by which the share of industrial output as a proportion of GDP increases. This process is accompanied by a rate of growth of GNP which is faster than the rate of growth of population and a rate of growth of investment which is at least the same as that of GNP. The crucial indicators then for measurement of the process of industrialisation would be value added in the industrial sector, GDP, GNP, population and investment.

There are seven factors or necessary conditions which make up the sufficient condition for these indicators to behave in such a way that we may be said to be observing the process of industrialisation. Each of these is considered in turn.

The first is population. It is suggested that some threshold size of population is necessary before the transition from (stagnant) agricultural economy to (growing) industrial economy can take place. Beyond this threshold constraint

a 'sizeable' population provides a supply of cheap labour (presumably to the industrial sector) and a market for the industrial sector's output. On the other hand there is an upper limit to the population size necessary to permit the transition. This upper limit is the population size beyond which per capita output is restricted, saving is restricted and capital formation restricted. However even in the presence of optimal population a country may fail to develop due to lack of natural resources or the absence of technological change which last is the reason why we may not regard population as a sufficient condition for industrialisation.

This discussion of population fails on two counts. It is neither operational nor theoretically consistent. It is not operational because we are provided with no indicators of this upper and lower population size against which to check the movement of our indicators of industrialisation. The phrase 'optimal population' as Gaski uses it has no empirical content. On the theoretical level Gaski is also found wanting. The case of population in excess of the upper limit appears to be the classical case of the stationary state. Even with wages (per capita output) constant at or near the subsistence level no accummulation takes place (restriction on capital formation) and the stationary state has been reached. This view of economic development depends upon a fixed quantity of land, the law of diminishing returns and a relationship between accumulation, profit, rent, wages and total product which is not made at all clear. However it is not possible to have it both ways. The fixed quantity of land assumed in the over-population case implies for the under-population case that there are possibilities for increased marginal and average product of labour in the agricultural sector and, through the relationship implied in the overpopulation case the possibilities for profits and accumulation. This assumes, of course, that resort is not had to some kind of low-level equilibrium trap theory. It does not seem, then, that there is any theoretical or empirical justification for Gaski's statement that 'optimal population size represents a necessary condition for industrialisation.' It implies that in some majority of cases when countries entered the transition phase of their development from pre-industrial to industrial they had attained some necessary level of population. Gaski offers us no real theoretical or empirical justification of this view.

Consider now agriculture. Agriculture is viewed as a necessary condition for industrialisation insofar as increased agricultural productivity feeds the industrial sector and hence cuts down on foreign exchange requirements for imports. On the demand side the agricultural sector provides a market for industrial goods.

These activities have long been recognised as crucial aspects of agriculture's role in economic development. However Gaski's treatment of agriculture highlights the problem of attempting to work within a single factor framework. In considering increasing agricultural productivity as a necessary, but not sufficient, condition for industrialisation we must hold technical change and capital

formation constant since they are to be considered individually later on. In the absence of these two sources of increased productivity then gains can only be made through falls in the man/land ratio. This presumably occurs through reallocation of labour resources from agriculture to industry (though difficulties arise here in the context of a growing population i.e. even though the relative share of agricultural employment is falling absolute numbers may be increasing). What we are left with is the rather loose view that a necessary condition for industrialisation is the transfer of labour from the agricultural to the industrial sector.

Capital accumulation is characterised as indigenous to the process of industrialisation but not a sufficient condition for its occurrence. Once again the weaknesses of the single factor framework are shown up. It is stated with the force of a law that the increases in productivity which allow greater per capita output must come from ' more and better capital goods.' However in the context of Gaski's methodology we cannot allow ' better ' capital equipment since it would embody technological progress. Technological progress is a sufficient condition for industrialisation and capital formation has already been eliminated as a sufficient condition for industrialisation. We are thus left in the position that all investment whether new or replacement must not embody technical progress. It has long been a commonplace that much of the rise in output per head which occurred in the XIXth Century and XXth Century cannot be accounted for by increases in capital per head. We are left then to point out that the evidence does not point to increases in capital per head as the major source of rising productivity in the industrial revolution while reserving judgement on the reasoning which fails to separate capital from technical progress (disembodied progress notwithstanding).

Markets are allowed a particularly powerful role in industrialisation. It appears that they are capable of generating all the other necessary conditions for industrialisation except for technical change. Demand (D) is recognised to offer a ' powerful incentive ' to technical change but ' it is only one of two conditions necessary for innovation. The other is technical feasibility ' (F). It appears, at this point, that we have a set of sufficient conditions for technical progress. Why these should not be regarded as the sufficient condition for industrialisation since they are sufficient for the sufficient condition for industrialisation is not made clear. At any rate we have now moved one step back in the chain of causal regress which now looks like this;

if (D, F) then (T)
probably if (T) then (P, A, K, T, D, R, C)
if (P, A, K, T, D, R, C) then (I)

Given the view also expressed that ' markets remain more a reflection of population then a cause, though,' we might move back one step further in the causal chain to,

probably if (P) then (D)

if (D, F) then (T)
probably if (T) then (P, A, K, T, D, R, C)
if (P, A, K, T, D, R, C) then (I)

Increasingly, far from a primary cause we have a number of interdependent variables with the only apparently exogenous one being F (technical feasibility) which reduces us to the commonplace observation that had the capacity to produce the innovations on which the industrial revolution depended not been present then the industrial revolution would not have take place.

Natural resources, defined as 'the raw materials which are converted into products by industry' are regarded as a necessary condition for industrialisation. That they are not sufficient is explained by the existence of many resource rich LDCs. This form of reasoning may also be used to indicate that they are not even a necessary condition for industrialisation. We may cite for example the success of the cotton industry in Lancashire or the performance of Belfast which, without an ounce of coal, iron or steel to its name raised its share of U.K. shipbuilding output from 0 to 10% in the forty years from 1860 to 1900.

The last of the necessary conditions is a favourable social and economic climate. Favourable social and economic conditions have been regarded as necessary conditions for economic growth of some form or other by policy makers and analysts since the days of the mercantilists and physiocrats. In the context of our discussion however without an operational definition of what constitutes a 'favourable' economic climate the variable has no empirical content.

We come now to technological change, the sufficient condition. Technological change is defined as 'the invention of the kind of machines or gadgets that are vital to industrial and economic progress.' In other words only those inventions which are necessary to industrialisation can qualify to be regarded as sufficient for industrialisation. Technological change it appears has linkages into the other necessary conditions which operate through demand. Technology improves output which creates its own demand via Say's Law and this demand filters through to the other necessary conditions bringing them into existence. This, of course, leaves us with the problem of the phenomenon of the existence of non-industrialised less developed countries in a technologically advanced world. They are explained away as due to a combination of the inability of local populations to either innovate themselves or import technology from outside and a failure of the economic climate in that governments have blocked the emergence of the other necessary conditions. This explains the probabalistic form of the relationship between technology and the set of necessary conditions but unfortunately it reduces the model to a rather uninteresting existential statement of the form there will exist occasions when technological change will lead to industrialisation.

What remains then of the single-factor argument on the cause of the industrial revolution. We have demonstrated that the single-factor explanation never

existed. It was, in fact, a number of interdependent variables combined with one exogenous influence — the progress of knowledge. Of these variables, all of which were characterised as necessary for industrialisation by Gaski, we have shown that they are either inconsistent at the theoretical level or empirically non-operational.

This essay has taken issue with Gaski on a number of points. His use of the hypothetico-deductive framework of explanation for the confirmation of his necessary conditions is wrong for various reasons but most importantly because a failure to sharply define the variables in question leads to a series of uninteresting statements of the form 'some population levels will induce industrialisation' or 'some technical changes will induce industrialisation.' More importantly the essay contends that the attempt to order a number of events into a causal sequence leads him to move further back in the causal regress so that what he finishes with is a stage theory in which one stage is arbitrarily selected as the prime cause.

This last point leads into a more general level of criticism. The use of facts in social science involves classification and generalisation. As part of this process we can ask the question why B occurs and face the problem of attempting to order the facts in a sequential manner with a view to eliciting a causal relationship. We can on the other hand simply ask the question how did B occur and then simply marshal our facts in order to describe the process by which B occurs. We conclude, then, with the suggestion that the search for causation in social science, represented by the former process, is a blind alley which leads us to arbitrarily order events which are in fact interdependent into a causal sequence. If we substitute for the question why, the question how, then our task becomes one of quantitative description of events. A task which is difficult and demanding enough without imposing the added burden of searching for causal relationships which can never be confirmed.