DEBATES

Technology as the Cause of the Industrial Revolution: Some Comments

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I. *Problems with the argument*

John Gaski's recent attempt to offer a " single factor " argument in explanation of the origins of the industrial revolution in Great Britain appears of sufficient interest and novelty to provoke a reply. The gist of the argument is that, with the important exception of " technology ", no one of the supposed " causes " of British industrialization was indeed both necessary and sufficient, i.e. in terms of Carl Hempel's formulations, no such " factor " may be given the status of *explanan* in relation to the *explanandum* of the industrial revolution (3, 7). Technology is the exception because, as a discrete " factor ", it did alone have the power to " induce " the other necessary (but insufficient) factors — population growth, agricultural transformation, capital formation, market demand, resource utilization and an appropriate " economic climate ". Accordingly, developments in technology and their complex impact on other factors represent the essential cluster of *explanans* which propelled Britain into industrialization. For reasons of both brevity and approximate agreement, we will accept here that the industrial revolution was a real phenomenon, a significant discontinuity and substantially authochronous. Very brief comments will be made only upon the former of Professor Gaski's argument, the notions of cause and discontinuity associated with it, and some of the implications of an emphasis upon the factor of " technology ".

At no point is it clearly shown that any one of the factors other than technology could not have acted as the key means of inducement of the essential conjunction of factors. It is only suggested that they were not " sufficient " in isolation. The latter is true of technology also. More significantly, even if no one of the several factors was a sufficient cause of the industrial revolution,

this does not deny the possibility that their historical conjunction was itself such a sufficient cause. Nor is the outside world admitted as a dynamic element. This affects the form of the argument profoundly. For instance, if we allow that an appropriate level of population growth may generate increased consumer demand and capital accumulation, why may it not also result in imports of necessary raw materials together with transfers of agricultural, industrial and infrastructural techniques from outside? Surely, we may permit the entry of forces exogenous to Great Britain without at the same time arguing that her industrialization was derived?

The treatment of agricultural change seemingly illustrates a need to differentiate underlying factors from those triggering or timing mechanisms which may have been sufficient to explain the timing of the industrial revolution. Whether or not Kerridge's agricultural revolution (circa 1560-1780) has fully ousted the more traditional 1760-1830 turning point is not here a matter under review (9). Of prime importance is the claim that a historical, causal relationship could not have existed between two phenomena whose occurrence was some one hundred years apart. This is not at all clear. First, even Kerridge's agricultural revolution flows to its close sometime around the supposed beginnings of the industrial revolution. Secondly, the nature of the chain or chains of causal regress involved is nowhere made explicit. One part of such a chain may have involved triggering mechanisms or links such as enclosures, a fall in food prices, the fortunes of war, alterations in navigation and transport constraints or developments in empire trade and economic relations which, as secondary phenomena then determined the timing and perhaps something of the nature of the industrial revolution. In this sort of argument, what is meant by a clause such as " necessary and sufficient? " In this case, any of the second group of epiphenomena might be regarded as both " necessary and sufficient ", but only in terms of a pre-existing scenario which included the underlying factor of an increase in agricultural productivity.

The argument about whether a factor had " existed before " is applied to capital formation, and is spurious. If considerable fixed capital formation, existed long prior to the later eighteenth century, and if this fact serves to " eliminate " the factor as a sufficient cause of the industrial revolution, then such a dismissal must operate too for technology, resource endowments and, perhaps, the " economic climate ". Moreover, if we accept notionally that a factor becomes sufficient when it and only it *induces* a necessary and sufficient confluence of necessary but not sufficient factors, then there is nothing here which forbids this role for capital, whose formation (in many economic and historical models) has been regarded as crucial to the growth of population, consumers and producers markets, exploitation of raw materials, capturing of economies of scale and increases of industrial and other productivities through embodied or other technological change. Even if capital formation did not increase significantly during the first half of the industrial revolution period, this does not logically

exclude the possibility that a minimum level of capital formation was a necessary and sufficient condition for the sufficient " congruence " of other necessary factors.

The last technique used to dismiss the separately treated factors is introduced with market demand. At this point John Gaski inserts the central element of his conclusion into an argument designed to lead towards that conclusion. As a result, market demand fails as a sufficient cause " because of its inability to generate technological innovation autonomously ". Apart from the general inadequacy of this procedure, it is specifically unacceptable once more because it involves one at least or two untenable positions. Either we are again faced with a closed economy to which technology may not be transferred at any price, or we have embarked upon a tautological argument wherein British technology is more advanced than that of any other nation from which she might have obtained imported techniques. Until adequate proof to the contrary is forthcoming, it seems quite permissible to reverse this argument entirely. Britain was differentiated from other European economies not so much by demonstrated high levels of " technological feasibility ", but by the juxtaposition of such technical skills with other factors. These factors would certainly include those of the " conjunction " above, but would not fail to embrace also factors relating to location, internal space, topography, urbanism and the social flux. France and perhaps other European nations demonstrated a very similar ability in the areas of applied " science " and technology, and in fields such as practical inorganic chemistry the comparison was in Britain's disfavour. (1, 12) Of more importance still, Britain's strength lay in those forces which converted existing best techniques into average techniques, rather than in any which might have gained her a head start in the former. Technological progress, even when so narrowly defined, is more a story of systematically induced diffusion than of inspired creation (14)

It is also worth noting *en passant* that, if covertly, one of our two untenable propositions must also be present in Professor Gaski's consideration of the " economic climate ". How else may it be argued that government and other active agents cannot induce " technological innovation " when it is obvious that in the transfer process governments, agents and entrepreneurs may import from abroad, whilst in the internal diffusion-adaptation process, entrepreneurs innovate (act as entrepreneurs) under specific market, knowledge, and spatial constraints? We might recall that Alexander Gerschenkron's schema of European industrialisation is premised on dynamic interaction between states at different stages of economic development, an interaction directed by governments and mediated by processes of technological transfer and absorption. (4)

II. *Causal regress and discontinuity*

We might go much further and argue that the whole subject of historical causation is of far greater complexity than allowed for by John Gaski, and that

the key to the origins of the industrial revolution lies in the emergence of a sufficient coalescence of necessary factors rather than in the isolation of any one variable which induced the others. The dynamism of the industrial revolution did not belong entirely to technology but was inherent in a specific flux of " factors " which simply functioned as a more or less self-contained *system* of progressive economic and social forces. This is not to define the British industrial revolution as a random event, for its timing and to some extent its characteristics were determined by a series of necessary factors where *individual* emergences and characteristics *are historically* explicable and whose congress was sufficient cause.

We may begin with the rarely acknowledged dictum that " constancy in the direction of change does not stipulate constancy in the rate at which change proceeds. It is compatible with wild fluctuations in that rate ".(5) With this in mind, it is obvious that to quote a series of characteristics of " pre-requisites " to the industrial revolution which are observable prior to the 1780s is not to deny the validity of the term. Until shown otherwise, we may maintain that the industrial revolution witnessed a significant instability in the rate of industrial growth and was a non-periodic phenomenon. This is to say that the industrial revolution was a historical discontinuity, which might be explicable in terms of a fairly lengthy and complex " causal chain ". The historical forces behind the development of each " link " in that chain may in turn be identifiable as representative of a certain temporal continuity. But the phenomenon to be explained represents a discontinuity in terms of both the unique confluence of forces and the resulting significant alteration in the *rate* of change of a principal, defining element, i.e. in this case, industrial production.

III. *Science and technology*

It is no surprise to find that the crux of Professor Gaski's treatment of technology is found in the statement that " The technological developments of the XVIIIth century would have caused the industrial revolution in Britain therefore, even if all the other necessary conditions were absent ". (p. 232) Thus, the answer to the question "Why was Britain first? ", often invoked with reference to the tardiness of industrialization in France, lies not in the initial, wider context of British technology, but in its unique nature at that time.

In Britain and nowhere else, technology was sufficient to " induce " the other necessary factors which propelled the nation into industrial revolution. Yet this is most certainly not the argument of many economic historians. (2,15, 16). Indeed, to the contrary, it is often argued that it was the perceptible *limiting context* of French technique which prohibited it from engendering widespread industrialization. For instance, although advanced industrial technique may have existed in certain centres, it failed to become average technique because of a lack of demand for industrial products, and therefore an unwillingness on

the part of perfectly "rational" French entrepreneurs to utilise the improvements. The calculated *potential* profit loss involved in not innovating was simply regarded as insufficient to justify costly industrial innovation. The French entrepreneur was not a fool. In contrast, because of quite other economic and social forces at work in Britain. the threat to profits faced by laggards (potential followers) was calculated by them as significant in the given market conditions and promoted emulation, adaptation and diffusion. However, John Gaski eschews contemporaneous experiences in favour of an irrelevant juxtaposition of his British model with experience in today's underdeveloped nations. Because the irrelevance of such a comparison relates to both the starkly altered *international* context of industrial development and to the quantum leaps exhibited by industrial technique between the early 1800s and the 1980s, it is not observable from Professor Gaski's point of view.

If we are prepared to admit that a happy confluence of explicable "necessary factors" was itself a sufficient cause of the industrial revolution in later eighteenth century Britain, then an estimate of technology as profoundly important may yet be attempted. Such a perspective also serves to uncover an essential link between industrial technique and natural science.

Sometime during the 1780s, at a time when much of British "technique" was no more advanced than that found in France, when mutual and valued interplay took place between the two nations, British culture became increasingly "scientific". In the metropolis, Edinburgh and the English provinces the study of natural and experimental philosophy (mathematics, physics, mechanics and chemistry) became a *predominant* cultural form for a very wide and increasingly influential nexus of intellectuals, professionals, artisans, inventors and businessmen. The individuals within this network were in relatively close spatial proximity, constant correspondence and in the process of erecting an informal system for the national scientific enterprise. The sense and the study of nature became the province of very many individuals, spawned numerous specific publications, institutions and forums, and was designed to satisfy a "utility" or a series of related utilities which were at once economic and social in nature (10, 17, 18). Creativity and study in the realm of the natural sciences was nowhere near as centralised or controlled as in France or other European nations (6, 11). It followed that much of the knowledge and awareness necessary for the creation *and* the improvement/diffusion of leading, advanced industrial techniques was highly available and, more significantly, almost costless. Thus a survey of British patent statistics for the decade of the 1790s does not indicate that new technologies were "locked into" one or two advanced regions such as Manchester, Birmingham or Newcastle. Indeed, the industrialising cities of Manchester, Sheffield, Birmingham, Liverpool and Newcastle between them represented only 11 per cent of total British patenting between 1790 and 1799. If Birmingham and Sheffield are excluded, the figure drops to a very low 3.5 per cent.

We emerge from this with the conclusion that Britain was unique, not in its possession of a highly feasible, progressive best technique, but in its early forging of a culture which, through innumerable minor innovations and increments to ancillary " pure " knowledge, induced the reduction of best techniques to the average technique of the competitive British industrialist. Greatly assisted by spatial and demographic forces, the economic function of British scientific culture was to reduce the cost of processes of learning, adaptation and diffusion. Any historian who wishes to explain the origins of this culture will in all probability find it in the sustained alteration in the structure of British society, which generated social groupings and sub-groupings whose members sought natural science for a multitude of social and economic purposes. (8, 10, 12, 13, 17, 18). In turn, the origin of the social flux will be found somewhere in that confluence of forces which link both John Gaski's thesis and our own commentary.

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