The Industrial Revolution and Industrial Economics

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I. Introduction

The concept of industrial revolution has proved to be a very valuable source of problems and thereby also of theoretical progress. However, it sometimes seems that questions beginning with 'when', 'where', and 'how' have pushed the question beginning with 'what' to the background.

This article attempts to start again with 'what'. The primary purpose of this article is to defend the position that the industrial revolution was equivalent to the emergence of real industries in the sense of modern industrial economics, and especially of the model of the industry life-cycle. I hope to justify the assertion that this answer will also shed some light on some of the other questions.

This statement includes proposing that the process of intensive growth, unprecedented technological progress and radical changes in industrial organization, which is commonly alluded to as the industrial revolution, should be understood as occurring at the level of industries, not of nations.

The position advocated here should not be confused with the position that competition is the source of benefits to society which is at least as old as de Mandeville, or with the more specific position that enterprises and the people who lead them are the 'visible hand' of economic progress, as Chandler proposed.[1] There is some overlap with theories which consider the process of technological change to be the major explanatory factor of economic progress and especially those theories which emphasize discontinuities in that process. Mokyr's recent study is an example.[2]

The position defended in this article should nevertheless be clearly distinguished from the argument that technological change *per se*, and not techno-

[1] A.D. CHANDLER JR., *The Visible Hand: the Managerial Revolution in American Business* Cambridge Mass, 1977.

[2] J. MOKYR, *The Lever of Riches: Technological Creativity and Economic Progress* (New York, 1990).

logical change as part of the *competitive process in industries*, is the (single) explanation of the industrial revolution.[3]

It will also be attempted to link the core proposal of this article with two famous, if hardly uncontested, general models of industrialization: those of Rostow and of Gerschenkron.

Rostow[4] proposed that economic growth proceeds through an orderly sequence of stages of which the most crucial is the stage of take-off into sustained growth. One factor bringing about this take-off is an increase in the aggregate level of (productive) investment, another the emergence of a political-institutional environment conducive to rapid growth,[5], a third and most important factor is the emergence of 'leading sectors'. Those leading sectors would, according to Rostow, lead the whole economy into modernity characterized by sustained growth.

Gerschenkron[6] agreed with Rostow in so far as the existence of a sudden change in the tempo of growth is concerned and in considering the British case the ideal type of industrialization, but he does not agree that a take-off will always happen in the same way and that a fixed set of (pre-)conditions must be fulfilled. Gerschenkron proposed that the 'degree of backwardness' (compared to Britain) of a country determines which factors are crucial to industrial take-off. Specifically, he proposes that in a more backward country (Germany) the banks and in an even more backward country (Russia) the government must at least partly fulfill the role which private entrepreneurs played in Britain. I will not attempt to revive any of these theories wholesale nor survey the many studies that have been dedicated to prove or more often disprove parts or the whole of both theories, but I do think that they both contain insights whose usefulness will become more readily apparent when considering the industrial revolution from the point of view of industrial economics.

II Industrial economics

The essential point about industrial economics is that it is the discipline in which 'industry' is taken seriously as an unit of analysis. If industry is more

[3] For instance, see J. GASKI, "The Cause of the Industrial Revolution: A Brief Single-Factor Argument", *Journal of European Economic History*, Vol. II, No. 1 (1982).

[4] W.W. ROSTOW, *The Stages of Economic Growth*, (New York, 1960).

[5] Rostow makes insufficiently clear the difference between these factors and "preconditions", especially with respect to this factor, as Cairncross writes in his extremely critical review of Rostow's theory. A.K. CAIRNCROSS, "The Stages of Economic Growth", *The Economic History Review*, April 1961, pp. 455-458.

[6] A. GERSCHENKRON, *Economic Backwardness in Historical Perspective*, (Cambridge Mass., 1962).

than just a classifying device its definition becomes highly important. Earlier theorists such as Joan Robinson proposed to use the cross-elasticity of demand to delineate industries. This is an essentially static concept which neglects other forms of competition besides price competition. The majority of later writers chose to define an industry as the group of those enterprises which take the acts and (presumed) strategies of others into account when designing their own competitive strategies.

Modern 'dynamic' theories of industrial economics include the use of competitive instruments besides price competition such as advertising and innovation.

The 'industries' as defined by the National Bureau of the Census are not necessarily 'industries' in the strict sense of modern theory. Testing of theories in industrial economics with SIC data cannot always be allowed.[7] Of great relevance to the subject of this article is the fact that the 'industries' or 'sectors' which figure in historical analyses even more seldom conform to the 'industries' an industrial economist would like to see analyzed. Most often they are much too broadly defined which makes it difficult to observe the industry-specific developments which theories of industrial economics predict.

The first widely influential model in industrial economics was the Structure - Conduct - Performance (SCP) model of Mason and Bain.[8] In this model the structural characteristics of an industry determine the conduct of the enterprises and 'conduct', in turn, the 'performance' in the sense of productive and allocative efficiency or other indicators of general welfare. The model gave a theoretical basis for identifying, especially with the help of regression analysis, simple relations such as between concentration and profit margins.

Bain also introduced the concept of 'barriers to entry'[9] and although there have been profound differences of opinion as to what exactly constitutes a barrier to entry the concept has become an important building block of almost all modern theories in industrial economics. A valuable distinction is between 'natural' barriers to entry which arise from the characteristics of the production process (e.g. scale advantages) and 'unnatural' barriers to entry which are raised by the behaviour of incumbent enterprises.[10]

[7] See N.M. WIJNBERG, "'Industry' and 'innovation'," *De Economist*, Vol. 137, No. 4, p. 499-505, 1989.

[8] First manifestation of the model in E.S. Mason, "Price and production policies of large-scale enterprises" *American Economic Review Supplement*, Vol. 29 (1939), pp. 61-74.

[9] The 'classic' text is: J.S. BAIN, *Barriers to New Competition*, (Cambridge (Mass.), 1956).

[10] Some writers use the term 'innocent' instead of 'natural'. Some writers, especially of the Chicago school, call 'unnatural' barriers 'true' barriers, implying that only these are to be considered real barriers to entry for the purposes of antitrust law. See R.H. BORK, *The Antitrust Paradox*, (New York, 1978) and R. POSNER, *Antitrust Law: an Economic Perspective*, (Chicago, 1976).

The most important criticism of the SCP model has been its (implicit) reliance on neoclassical static analysis. Although some adherents of the Chicago-school advocate a return to neoclassicism the majority of theorists adhere to a dynamic approach in which the unreality of neoclassical presumptions is acknowledged.

As already mentioned above, innovative competition becomes in the dynamic approach as important as price competition. Technological progress becomes in this way endogenous to the competitive process. No permanent equilibria are ever reached such as is predicted, at least in theory, by the neoclassical analysis.

It is not the purpose of this article to give a review of all current movements in industrial economics such as the Austrian approach, the contestable-market approach, or the evolutionary approach. However, the industry life-cycle model can be considered to incorporate some of the most basic insights of the mainstream theorists, even if some of them do not explicitly use it. The industry life-cycle model describes the development of the industry through two or more phases which are characterized by different types of (dynamic) competition and therefore also by different rates of technological progress.

Apart from demand-related factors and the already mentioned barriers to entry, two concepts have often been proposed to explain industrial dynamics and the rate of technological progress: opportunity and appropriability. The first is a measure of the richness of the entrepreneurial environment, determined by the progress of basic science, the relations between the scientific and the business community, and the supply of still unused inventions. The second is a measure of the possibility of extracting profits from a succesful innovation. This is determined by the protection offered by the legal system and the costs of imitation as compared with costs of innovation.

The use of the concepts of opportunity and appropriability does not have to be restricted to the context of technological competition. They can also be usefully employed to describe the opportunities for competing with other means than technological innovation and the appropriability of profits.

A synthetic version of the life-cycle model can be presented.[11] In the early phase(s) of the (ideal type) industry barriers to entry are low, competition

[11] This version is mainly based on the model of de Jong which is an explicit 4-phase model. See H.W. DE JONG, *Dynamische marktttheorie,* (Leiden, 1989), and the chapters by de Jong in H.W. de Jong (ed.) *The Structure of European Industry* (Dordrecht, 1988) and H.W. DE JONG & W.G. SHEPHERD (eds.) *Mainstreams in Industrial Organisation,* (Dordrecht, 1986). See also E. HEUSS *Algemeine Marktttheorie* (Tuebingen, 1965), D.C. MUELLER "The corporate life cycle" in S. THOMPSON & M. WRIGHT (eds.) *Internal Organisation, Efficiency and Profit* (Oxford, 1988). More specifically with regard to innovation: C. FREEMAN, J. CLARK & L. SOETE *Unemployment and Technical Innovation,* (London, 1982), or W.J. ABERNATHY *The Productivity Dilemma* (Baltimore/London, 1978).

and especially innovative competition is strong and often proceeds in a leapfrogging fashion in which competitors are not content simply to match each other's initiatives but strive to continually overmatch them.

Technological opportunity is plentiful, appropriability is low. Legal protection (patents etc.) often becomes relatively valueless because of the nature of the competitive process in this phase. Sometimes, enterprises actually benefit by allowing their competitors to make the same technological choices as they did. Customers may require that there is at least one independent competitor producing approximately the same thing.[12]

The low barriers to entry diminish the possibilities of reaping monopoly/oligopoly profits during a longer period. However, the fast growth of demand can cause some short-term profits to be exceptionally high.

In the more mature phase(s) product-innovation is replaced by process-innovation and/or product differentiation; innovative competition is replaced by price competition or "image" competition. Opportunity declines and appropriability increases. Barriers to entry have grown in height (increasing concentration and usually decreasing the strength of competition) which also increases appropriability. Demand stagnates, increasing the effective height of barriers to entry even further. Finally, the industry becomes static and may pass away or new radical innovations may restart the cycle.

This is of course a highly summary treatment of such a model. Most important is that it shows how (1) an industry can be considered to develop from a phase in which risk-taking and innovative behaviour is the dominant strategy to a phase in which risk-avoidance dominates, and (2) that the essential character of each of these two phases can be described in terms of barriers to entry, opportunity and appropriability.

To round off this review of industrial economics, I want to mention one further theoretical concept: the natural trajectory. This concept has been introduced by Nelson and Winter.[13] The natural trajectory is a shorthand description of the dominant general mode of solving technological problems in a certain period.

Whether scientific progress will be translated into enduring opportunity for an industry is dependent on the question whether the specific piece of scientific progress accords well with the dominant natural trajectory of the period.

While in dynamic theories in general and in life-cycle theories in particular technological progress is incorporated in the competition process within

[12] This is called "second sourcing" and was a widespread practice in the semiconductor and microchip industries when still young. See G. Dosi, *Technical change and industrial transformation*, (London, 1984).

[13] R.R. Nelson & S.G. Winter, *An Evolutionary Theory of Economic Change*, (Cambridge, Mass., 1982).

industries, the natural trajectory should be considered exogenous to that process. However, the character of a natural trajectory may be partly determined by the results of (technological) competition in other or previous industries. The results of processes in other or previous industries may also affect barriers to entry, opportunity, and appropriability of nascent industries. These two types of inter-industry effects make it possible to given a new meaning to Rostow's concept of leading sectors.

III Industrial economics and the industrial revolution

Before "dynamic" industries could emerge two sets of conditions had to be fulfilled. Barriers to entry, opportunity and appropriability had to be at levels which allowed industries to enter the first phase of the life-cycle and to develop under their own steam. However, first the arena in which competitors had to perform their bloody but beneficial rites had to be cleared. The "market" had to win its independence from the "state". The two sets of conditions are not completely independent and it would not serve the argument to call the first "conditions" and the second "precondition". Nevertheless, for the clarity of the exposition I will make an attempt to treat them separately.

1. The market and the state

Markets existed long before the industrial revolution. The market is an instrument of exchange and distribution. It can have many other socio-political functions. It is not automatically an instrument of growth. It is not the only possible instrument of growth. However, before the endogenous dynamism of industrial competition can lead to intensive growth it is necessary that the state resigns its pretensions to be the *arbitrator* of the market process.

Withdrawal of public authorities from the market as arbitrators clearly does not mean withdrawal of public authorities from society or their withdrawal from the market as agents. Neither does it mean that no state policies interfere with the market process. It simply means that public authorities refrain from systematically supplanting and second-guessing the market process. In Adam Smith's original analysis, public authorities ideally will restrict themselves to the provision of (quasi-) public goods. If the results of the market process are not to the liking of the public authorities they can create new public goods such as social security. If they perceive important positive or negative external effects they can tax or subsidize.

Of course, not even the most liberal public authorities keep themselves to this brief. However, public authorities have come a long way since the Middle Ages in perceiving that the market process is not *per se* abominable and that there are at least some problems which the market can solve better than the most well-meaning public authorities.

Bridbury writes:

> Markets were profitable in the Middle Ages, not in the sense that anyone clever enough to attract trade to a particular centre could expect to make money out of those who came to spend and out of those who paid for stands and shops or for the services provided by inns and hostelries, but in the sense that trade and tradesmen were themselves fair game, legitimate victims of whatever depredations a franchise holder cared to visit on them'.[14]

The market had no right to be there. It was allowed to function only by the pleasure of public authorities. The competitive process had no right to be there. If there existed a 'justum precium' price competition was wrong and absurd. The laws against 'engrossing, forestalling and regrating'[15] explicitly forbade entrepreneurs to take advantage of the market process by competing purposefully on a large scale. Trade in goods by those not directly involved in their production was looked upon disapprovingly. The church protested against Sunday being a market-day but this endured even into the XVIth century because of a desire by the public authorities that markets would interfere as little as possible with the normal work-days of craftsmen who should be able to sell their own produce.[16]

Guild regulations further hampered the market process, fixing prices and processes. The relatively high stability of customs and the low tolerance of social change did the same.

The withdrawal of the state from the market took place at the same time that the state and the state apparatus expanded. Brewer,[17] for instance, paints a picture of rapid growth of the role of the state in society, especially in Britain. Taxes were increased to finance a growing army and an ever more active administration. This only seems contradictory. The modern state 'consumes' a much larger part of GNP than the pre-modern ever did. However, although taxes always cause businessmen to complain, non-arbitrary taxation and the public goods the state provides with the proceeds of the taxes do not interfere with the market process *per se*.

Jones writes that a crucial upturn in European growth occurred when the private market was supplemented by the governmental provision of public goods.[18] Public authorities began to perceive their role as purveyors of specifically public goods. They also largely gave up their powers to determine market behaviour, leaving entrepreneurs free to seek profits in whatever way they preferred, selling wholesale or retail, integrating or desintegrating.

[14] A.R. Bridbury, "Markets and Freedom in the Middle Ages", in B.L. Anderson & A.J.H. Latham (eds.) *The Market in history*, (Kent, 1986), p. 109.

[15] Engrossing is buying up to sell again wholesale, forestalling is attempting to force up prices by cornering a market, regrating is buying to sell again in the same market (or within 4 miles of it).

[16] J. Harvey, *Medieaval Craftsmen*, (London, 1975), p. 61.

[17] J. Brewer, *The Sinews of Power*, (Unwin Hyman, London, 1989).

[18] E.L. Jones, *The European Miracle*, (Cambridge, 1981).

Agents on the market were allowed to compete because public authorities perceived that they could remedy most ills caused by the market process more effectively outside of the market. This in turn made the growth of the state apparatus a necessity.

2. Opportunity, appropriability and barriers to entry

More was needed to promote dynamic competition than this dissociation of public authorities and the market. Competitors had to be given the means to compete and to be allowed to use them for their individual gain. Opportunity and appropriability had to rise above a certain minimum. Individual agents had to be able to 'discover' competitive advantages and at least some of these advantages had to be privately appropriable. Also, barriers to entry had to be lowered to allow the first real industries to enter their life cycles.

Opportunity in general increased together with the increase in physical mobility of goods and of labour, increasing the possibilities of profitable arbitration by private agents between different markets and the possibilities of employing new input factor mixes. The growth of population and the resultant growth of demand, even if the average standard of living did not noticeably increase, brought new possibilities to make profit on the basis of scale advantages. The release from sumptuary laws and the growing importance of fashions also created new opportunities to make profits and to compete with new instruments such as advertising on a grand scale.[19] The simple fact that it became so much cheaper to print and distribute also contributed to making advertising an important instrument of competition.

Of course, laws or regulations prohibiting innovations have an adverse effect on technological opportunity but even though an explicit prohibition was still promulgated in Britain as late as 1638[20] this can be considered the last gasp of the guild-powered anti-innovation lobby.

For technological opportunity to exist, it is not absolutely necessary for science and technology to advance exogenously at a high rate. It should be sufficient that no scientific/technological equilibrium trap exists, making small steps forward useless, and that there is at least some liaison between entrepreneurs and the scientific community. There is extensive evidence in late pre-industrial Europe, and especially in England, that this was the case while the most famous counter-example, China, might have found itself in such a equilibrium trap.[21]

Nevertheless, the justifiable self-confidence of European science in the early post-Newtonian period can only have been an advantage, even when

[19] See N. McKendrick, J. Brewer & J.H. Plumb, *The Birth of a Consumer Society*, (Bloomington, 1982).

[20] A.E. Musson, *The Growth of British Industry*, (London, 1978), p. 56.

[21] See M. Elvin, *The Patterns of the Chinese Past*, (London, 1973).

there are few direct links between the greatest scientific feats (among which, of course, the theory of gravitation) and the principal technological developments of the industrial revolution.

Appropriability also can be interpreted broadly, including security against confiscation of profits and property. As already mentioned above, the withdrawal of public authorities from the market has had the effect of strengthening appropriability in that sense. Property rights in general have been made stronger and easier to transfer, not only between persons but also between corporations. More important for industrial dynamics, property rights were *perceived* to have become stronger, especially in Britain.[22] North and Thomas have suggested that the increase in strength of property rights in general may have provided the crucial ingredient for the economic growth of the Western World.[23] Rosenberg and Birdzell emphasized the importance of the rights of corporations.[24]

> "Four of those rights set the stage for economic growth based on innovation. First, individuals were authorized to form enterprises, with less and less political restrictions. Second, enterprises were authorized to acquire goods and hold them for resale at a profit or loss, again with little or no restriction. Third, enterprises were authorized to add activities and to switch from one line of activities to another that seemed more promising .... Finally, while the assets of the enterprises and such profits as it accumulated might be taxed at predetermined rates, its property came to be regarded as immune from arbitrary seizure ....

These rights have the effect of increasing opportunity (especially the third) and appropriability in general. Of course, in Britain after the South Sea Bubble, explicit incorporation was severely restricted. However, partnership contracts were made to fulfill essentially the same function.[25] Other "new" property rights, rights of industrial and intellectual property, have been developed, making innovative competition more rewarding. The patent has grown from a grant of monopoly in the Middle Ages to an instrument to protect innovative competition in modern times.[26] Trademarks and designs have recei-

[22] J. Mokyr, "The Industrial Revolution and the New Economic History, in J. Mokyr (ed.) '*The Economics of the Industrial Revolution*, (Totowa, New Jersey, 1985), p. 16:' Most importantly, the right to own and to manage property was truly sacrosant, contrasting sharply with the confiscations and conscriptions of the French Revolution and the Napoleonic era. ... Nowhere in the world was property perceived to be more secure than in Britain".

[23] D.C. North & R.P. Thomas, *The Rise of the Western World*, (Cambridge, 1973).

[24] N. Rosenberg & L.E. Birdzell, *How the West Grew Rich; the Economic Transformation of the Western world*, (London, 1986), p. 22.

[25] P. Lane, *The Industrial Revolution*, (Weidenfeld & Nicholson, London, 1978), p. 88.

[26] See C. MacLeod, *Inventing the Industrial Revolution*, (Cambridge, 1988).

ved protection with the object to promote competition. All these rights have been developed for the first time or to an extent never encountered before during the industrial revolution and its immediate aftermath. The case of the patent is especially instructive. Much explicit discussion has taken place concerning the contribution of the patent to technological progress. Dutton[27] has presented evidence that at least the inventors and innovators themselves considered the patent an essential means to convert ideas into profit. Not only the growing numbers of patents obtained (from 1,418 in 1770-1779 to 4,581 in 1840-1849) but especially the even more rapidly growing number of court cases about patent-infractions or to dispute patents are convincing signs of technology being used as an instrument of competition.[28] His final conclusion about patent protection is that precisely the imperfect nature of the patent in the early years of industrialization may have made it an ideal instrument to promote innovation.[29]

Many of the developments referred to above have had positive effects on the height of the barriers to entry. Guild regulations functioned of course as a most explicit device to restrict entry. The same was true with regard to the patent-as-monopoly, even if the 'new' industrial property rights can also have adverse effects on the height of the barriers to entry. Good informal contact between scientists and businessmen increases the chances that clever ideas result in new viable enterprises. (Quasi-)incorporation makes it easier to capitalize a new venture. Although it is commonly supposed that lack of capital was seldom a problem in industrializing Britain, one has to take account of the fact that entrepreneurs who did not succeed in rasing the necessary capital to start generally left little trace.

However, a large part of the height of barriers to entry is determined by factor mobility. If factor mobility is lower the barriers to entry are higher, *ceteris paribus*. 'Natural' barriers to entry such as scale advantages are more difficult to overcome if it is already problematic to bring the necessary inputs physically together. Some barriers to entry which are raised by the behaviour of incumbent enterprises (e.g. predatory pricing) might be theoretically unsound in the long run *if* the markets of factor inputs are near perfection but if factor mobility is low these types of behaviour can effectively close markets

[27] H.I. Dutton, *The Patent System and Inventive Activity during the Industrial Revolution*, (Manchester University Press, Manchester, 1984), p. 108 ff.

[28] Dutton *op. cit.*, p. 71. These data are, as he admits, not of the highest quality. The changes in the law in 1835 may have influenced the number of court cases although the effect may have been both ways. However, I would very much like to see comparable data about other countries and other periods. For my purposes, disaggregated data would be optimal but because of the low absolute numbers few results would be significant, I fear.

[29] Dutton, *op. cit.* p. 204.

to newcomers. One of the most salient facts about the 'modern' period is the constant increase of factor mobility.

The development of property rights and rights of corporations as mentioned above contributed greatly to the mobility of both production goods and, most importantly, capital.[30] The further development of letters of credit and the appearance of banknotes also contributed to make capital more mobile. This was made even more important by the fact that technological competition generally required ever larger quantities of capital investment.[31]

Advances in transport and advances in communication, partially caused by the advances in transport, gave labour a much greater mobility. The mobility of knowledge, considered to be a separate factor of production by a growing number of authors, also increased because of these reasons.

3. Some preliminary conclusions and some empirical results

Thus, conditions were created for the birth of industries and the process of technological progress by ('dynamic') industrial competition. Public authorities started to specialize in providing public goods and to withdraw from the market. New competitive instruments were made available to (potential) competitors as well as new means to appropriate the profits. Factors which had for centuries caused barriers to entry to be high disappeared or diminished in strength.

However, not all industries emerged at once in modern forms. The weight, in terms of contribution to GNP, of the traditional sector, the non-industries in the sense of industrial economics, remained preponderant for a long time. That not all parts of the economy developed at the same pace is uncontroversial. If would be useful to have dependable data at the level of particular industries. Regrettably, both dependability and desaggregation are scarce commodities in early cliometry. One has to work with approximations of approximations.[32]

[30] Even if, as Crouzet argued, 'ploughing back' was the most important source of capital for large-scale industrialization, there can be, of course, no question of ploughing back in the case of de novo entry. And, even if the entrant is already active in another industry and internally finances its entry, the existence of an effective capital market can be highly useful to ease the necessary transformations. F. CROUZET, *Capital Formation in the Industrial Revolution*, (London, 1972).

[31] For instance, see A.E. MUSSON, *The Growth of British Industry*, (London, 1978), p. 67, MOKYR (1985), *op. cit.*, p. 35, also DUTTON, *op. cit.* p. 156 ff. on the relatively large cost of innovation compared to fixed costs in general.

[32] See J. HOPPIT, "Counting the Industrial Revolution", *Economic History Review*, 2nd ser., XLIII, 2(1990), pp. 173-193, who also laments the fact that especially industry-level data are lacking or highly inexact.

The hypothesis defended in this article is that 'industrial revolutions' happen at the level of particular industries. Particular industries emerge and the nature of competition in the early life-cycle phases of real industries causes high rates of technological progress. If this were true, one should expect to be able to see changes at the level of industries rather than at the macro-level (e.g. the rate of investment).

Sullivan[33] presented data from which he concludes that invention was widespread during the industrial revolution and not concentrated in a few progressive sectors. I appreciate his attempt to look at the rate of increase of the proportionate contribution of sectors rather than at absolute numbers. This could be a useful method if real industries were concerned. However, his sectoral definitions do not correspond well to meaningful industries in the sense of industrial economics. Moreover, as he himself concedes, invention, patenting, and innovation are three different things.

An increase in invention can be largely the effect of changes in sociocultural factors and scientific progress, an increase in innovation has to be connected to industrial dynamics because it is a measure of the nature of competitive behaviour. Patenting figures can present useful data to help evaluate innovative competition but the bare numbers of patents do not tell much about that.[34] Technological innovation leads to changes in factor-productivity and these changes seem to be much more concentrated, as McCloskey and Crafts[35] have shown.

Also, the disaggregation to the level of 'cotton' or 'woollens' these authors present brings us much closer to meaningful industries. If cotton textiles has an average annual growth of productivity of 2.6% as compared to 0.65% for all non-modern sectors minus agriculture, this is an indication that the nature of competition within the cotton industry was qualitively different. Before the industrial revolution in the accepted sense took place, there occurred something sometimes called the agricultural revolution. It is likely that productivity growth in agriculture in Britain in the XVIIIth century has been underestimated.[36] If the very broad sector of agriculture could be further desaggregated and if those parts of the sector which produced for the na-

[33] R.J. Sullivan, "The Revolution of Ideas: Widespread Patenting and Invention During the English Industrial Revolution", *The Journal of Economic History*, Vol. L, no. 2 (June 1990), pp. 348-363.

[34] I refer back for an example to Dutton, *op. cit.* and note 28.

[35] D.N. McCloskey "The Industrial Revolution: A Survey", in R.C. Floud & D.N. McCloskey (eds.) *The Economic History of Britain since 1700*, vol. I (Cambridge University Press, Cambridge, 1981), pp. 103-127. N.F.R. Crafts, *British Economic Growth during the Industrial Revolution*, (Clarendon Press, Oxford, 1985). Also N.F.R. Crafts, "British Economic Growth, 1700-1831: A Review of the Evidence", *The Economic History Review*, 2nd ser., Vol. 36, No. 2 (May, 1983).

[36] Crafts (1985), *op. cit.*, p. 84.

tional or international market were distinguished from those parts of which the production was largely destined for own (or village) consumption, it is to be expected that even more impressive records of innovation and productivity gains in particular agricultural industries might be discerned. If the industrial revolution were considered to be an industry-level process and as the emergence of industrial dynamics, not of industrialization in the sense of the introduction of the factory-system, might it not be the case that the agricultural revolution was simply the first manifestation of the industrial revolution, occurring at first in agricultural industries? New insights about the effects of crop-rotation techniques and especially the introduction of leguminous crops enormously increased opportunity while the enclosure system may, at least in Britain, have contributed to bringing appropriability to a beneficial level and lowering barriers to entry.[37]

III Concluding remarks: leading sectors and backward economies

The concept of the leading sector can be given two interpretations. The weak interpretation amounts to saying that in every period of the long wave movement of economic growth beginning with the industrial revolution technological progress and resulting productivity growth was initially concentrated in a few sectors.

The strong interpretation supposes not only this sectoral concentration but also a mechanism by which the developments in those few leading sectors would *cause* the whole economy to move forward, experience a new upswing of the long wave, or the original industrial revolution. The evidence presented in the last part of the last section indicates that at least a weak interpretation of a leading *industry* hypothesis finds some support.

The strong interpretation has encountered even more resistance. Rostow proposed that cotton was the leading sector of the British industrial revolution but the sector remained relatively small during the revolution and how could developments there have led the whole economy to rapid growth? Macro-economic analysis makes this seem rather improbable. Habakkuk and Deane wrote: "Its raw material was imported and its capital-output ratio was low. The multiplier effect of investment in cotton cannot have been very great".[38]

[37] G.F.H. Chorley, "The Agricultural Revolution in Northern Europe, 1750-1880: Nitrogen, Legumes, and Crop Productivity", *The Economic History Review*, Vol. 34, no. 1 (1981), pp. 71-93. Lane, *op. cit.*, ch. 4., E.L. Jones, "Agriculture: 1700-80" in R.C. Floud & D.N. Mccloskey *The Economic History of Britain since 1700*, Vol. I, pp. 66-86 (Cambridge, 1981).

[38] H.J. Habakkuk & P.M. Deane, "The Take-off in Britain" in W.W. Rostow (ed.) *The Economics of Take-off into Sustained Growth*, (London, 1962), p. 72.

Industrial economics, as outlined in this article, offers two possibilities to save the strong interpretation. First, industrial development can be contagious in the sense that the results of the competition process in one industry may lead to changes in the levels of barriers to entry, opportunity and appropriability for another 'potential' industry or cause a mature industry to restart its cycle. Highly contagious industries may be termed leading industries. Secondly, what happens in particular 'leading' industries may disproportionally determine the course of the natural trajectory of the period or even the following period.

To call an industry a leading industry/sector one should start to look at whether the industry has indeed made outstanding gains in productivity. Then, one could consider whether one or both of the proposed mechanisms of the strong interpretation can be seen to operate.

The agricultural industries, in the opinion of the majority of writers, did create (pre-)conditions for further industrial development by releasing labour and helping to accumulate investment capital. It is harder to see how agricultural development influenced the natural trajectory.

In the following generation of industries with high rates of productivity growth there are a few which could be considered 'leading' in all senses. Steam-power is an obvious example but iron and cotton too could be considered to have strongly influenced the natural trajectory in the direction of mass production and interchangeable parts. All these industries certainly contributed to raising the level of opportunity and lowering the barriers to entry elsewhere (e.g.) by increasing further labour mobility and 'factory-training' the workforce).

Examples could be multiplied but it is not the aim of this article to provide a complete overview of economic history since 1700.

The points I want to make are (1) contrary to Rostow, economies do not take-off, industries do, (2) the industrial revolution can best be described as the emergence of particular industries, possibly starting with agriculture, (3) if industries not only achieve supranormal productivity gains during a certain period but can also be considered to have a significant beneficial effect on the emergence or re-emergence of other industries, those industries can be usefully described as leading industries, (4) this becomes an even more acceptable description if those industries also have a significant effect on the character of the natural trajectory.

All this has implications for understanding economic history and for policy-making. Most importantly perhaps, it leads to the conclusion that there is no generally applicable prescription to achieve macroeconomic growth through industrialization. Every period has its dominant natural trajectory, in every country industries face different mixes of barriers to entry, opportunity and appropriability. This presents a possible, even if weak, link with Gerschenkron's theory.

The degree of backwardness of a country may be translated in terms of

barriers to entry, opportunity and appropriability of industries, particularly potential leading industries. In countries where opportunity is plentiful but barriers to entry are high, especially resulting from difficulties in finding sufficient capital, it might be expected that banks will play a larger role in the process of industrialization. If private enterprises seem unable to overcome the obstacles in the path towards industrial dynamics, the government might do well to enter the market as an agent. I am certainly not saying that this was indeed the case in Germany or Russia, just that 'backwardness' and the resulting differences in the paths to industrialization could and perhaps should be interpreted and explained in terms of industrial economics instead of macro-economics.

In contrast, the British failure to participate fully in the development of two of the leading industries of the late XIXth century, automobiles and electricity, could well be explained by misguided government policies[39] which had an adverse effect on barriers to entry, opportunity and perhaps even appropriability in those two industries.

[39] See R. MICHIE, "The Finance of Innovation in Late Victorian and Edwardian Britain: Possibilities and Constraints", *Journal of European Economic History*, 1988, no. 4, pp. 491-530.