NOTES

Innovation, Industrial Structure and the Long Wave: The British Economy c.1873-1914

Roger Lloyd-Jones
Sheffield City Polytechnic

This article is an attempt to critically appraise the relationship between innovatory clusters, industrial structure and the long-wave in late XIXth and early XXth century Britain. Since the crisis of the early 1970s the ideas of Kondratieff and Schumpeter are once more topical[1] and long-wave analysis is again established as a legitimate mode of inquiry.[2] In a recent study two American theorists Hartman and Wheeler,[3] acknowledging their debt to Schumpeter, have utilized a long-wave approach in their assessment of the XIXth century British and American economies. The intention here is to critically assess their work; more specifically focusing analysis on the British economy for the years between 1870 and 1914. This period incorporated the so called Great Depression[4] and the British Climacteric.[5] An epoch too when Britain faced fierce international competition both economically[6] and politically.[7] The relevant Kondratieffs are the downswing 1873 to 1896 and the

[1] For example, a recent isse of *Futures* was entirely devoted to long-wave analysis in which the contributions of Kondratieff and Schumpeter were explored in some detail. See *Futures* Vol. 13, No. 4, 1981.

[2] Jos Delbeke, "Recent Long-Wave theories: a critical survey", *Futures*, Vol. 13, No. 4, 1981.

[3] R.S. Hartman and D.R. Wheeler, "Schumpeterian Waves of Innovation and Infrastructure, Development in Great Britain and the United States: The Kondratieff Cycle Revisited", *Research in Economic History*, Vol. 4, 1979 (hereafter Hartman and Wheeler).

[4] For a critical assessment of the Great Depression epoch in Britain, see S.B. Saul, The Myth of the Great Depression 1873-1896 (London, Macmillan, 1969).

[5] W. Arthur Lewis, *Growth and Fluctuations 1870-1913* (London, George Allen and Unwin, 1978) esp. Ch 5.

[6] D.H. Aldcroft (ed), *The Development of British Industry and Foreign Competition 1875-1914* (London 1968) also R.J.S. Hoffman, *Great Britain and the German Trade Rivalry, 1875-1914.* (Philadelphia, University of Philadelphia Press, 1933).

[7] For a recent discussion of the political implications of growing foreign competition

subsequent upswing from the late 1890s.[8] A final section will outline a new approach to the study of the long-wave in particular stressing the need to examine the dynamics of industrial structure during the downswing phase of the cycle.

Hartman and Wheeler: The Kondratieff Cycle Revisited

Hartman and Wheeler taking the historical growth experiences of the British and US economies in the XIXth and XXth centuries offer an interpretative framework based upon the long-wave approach. Developing the tradition particularly of Schumpeter their aim is "... to see whether fluctuations in the time paths of important macro-economic variables have been influenced by the size and timing of innovations and infrastructural development."[9] Their general framework is based upon the following propositions:

1) A Schumpeterian view of economic development emphasizing a clustering of innovatory activity and infrastructural change. For Schumpeter: "The fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumer goods, the new methods of production or transportation, the new markets, the new forms of industrial organization that capitalist enterprise creates."[10] In Schumpeter's framework the stress is upon disequilibrium, it is the dynamic competition between entrepreneurs which forms the basis of economic development. His emphasis upon discontinuity is based on the belief that the business cycle is the direct consequence of the appearance of clusters of innovations. Innovations are not randomly distributed over the entire conomic system in any given time span "... but they tend to concentrate in certain sectors..."[11] they tend to cluster, to come in bunches, simply because first some and then most firms follow in the wake of successful innovations. For Schumpeter economic development appears in the form of innovations, it occurs in cycles and the driving force is entrepreneurial activity. The length or frequency of fluctuations is a function of the lag between the time when an innovation is adopted and the time when it begins to bear fruit in the form of an increasing volume of production. He distinguishes three cycles; the Kitchen, Jugler and the Kondratieff, the latter representing the lag mechanism associated with major innovatory clusters.

see P.J. Cain "Political Economy in Edwardian England: The Tariff Reform Controversy", in Allan O'Day (ed.), *The Edwardian Age. Conflict and Stability 1900-1914* (London, Macmillan, 1979).

[8] These phases represent the downswing of the second Kondratieff and the upswing of the third.

[9] Hartman and Wheeler, p. 39.

[10] Quoted in G. Mensch, *Stalemate in Technology. Innovations Overcome the Depression* (Cambridge, Massachusetts, Ballinger Publicity Co, 1979) p. 7.

[11] G. Mensch, C. Coutinks, K. Kaasch, "Changing Capital Values and the Propensity to Innovate", *Futures*, Vol. XIII No. 4 (1981), p. 282.

2) Secondly they attempt to relate the micro and macro levels of the economy via the utilization of an evolutionary theory of the firm. This theory (developed by Nelson and Winter)[12] is a neo-Schumpeterian approach which focuses upon the evolutionary growth paths generated by the aggregate actions of individual firms searching for new and profitable production techniques. Nelson defines the approach as follows:

"For Schumpeter the most important firms are those that serve as vehicles for action of the real drivers of the system — the innovating entrepreneurs. Firms (and entrepreneurs) may seek profits, and may innovate or imitate to achieve higher profits. The competitive environment within which firms operate is one of struggle and motion. It is a dynamic environment, not an equilibrium one. The essential forces of growth are innovation and selection, with augmentation of capital stocks, more or less tied to the process."[13] According to Nelson and Winter, firms establish more or less stable production rules which structure the mode of decision-making. These rules change only when competitive environmental shifts require a change in regimes. Movements in the economy are generated by shifts in favour of firms whose decision rules are Schumpeterian in the sense that they "... are favourably attuned to the economic environment."[14] Whilst welcoming this approach as an important step forward Hartman and Wheeler call for the need to focus more sharply upon the macro-economic impact "... of the clustering of innovation on patterns of firms growth and survival," and they hypothesise "that waves of innovation and infrastructural development reflect at a macro-economic level the concentration in space and time of the evolutionary technical changes simulated by Nelson and Winter."[15] A more detailed exploration of the Nelson and Winters approach will be made in a later section of the paper.

3) Thirdly an attempt is made to fit the time paths of the macro-economic variables to the temporal sequence of the Kondratieff cycle. The authors admit to employing the Kondratieff periods "... with some trepidation" and recount that "... the mention of Kondratieff cycles in the presence of most economists invites scepticisms." They also make it clear that the primary purpose of their research "... is not to prove or disprove the existence of the Kondratieff cycle."[16] Merely the temporal framework of the Kondratieff price cycle is utilized to discuss the macro-economic impact of innovatory clusters.

Acknowledging that a major criticism of the long-wave hypothesis of Kondratieff is its primary focus upon price fluctuations, Hartman and Wheeler set out to examine other measures of aggregate economic activity. Long-run data on

[12] R. Nelson and S. Winter, "Towards an Evolutionary Theory of Economic Capabilities", *American Economic Association, Papers and Proceedings*, Vol. 63, 1973.

[13] Hartman and Wheeler, p. 43.

[14] Hartman and Wheeler, p. 44.

[15] *Ibid.* p. 44.

[16] *ibid.* 39.

unemployment rates, aggregate production, aggregate supply and demand and components of GDP are presented. [17] The authors stress the tentative nature of this material but maintain that a survey of the data leads to the conclusion that distinct periods of pronounced innovational and infrastructural activity "... have existed in Great Britain and are identifiable by several measures. Furthermore these periods coincide with Kondratieff price troughs and are part of a general activity pattern which coincides rather neatly with Kondratieff long-waves."[18]

It is also claimed that the "... periodic patterns are particularly pronounced for Great Britain from 1760 to 1920."[19] The secular swings of the Kondratieff are associated with movements in the variables as outlined in Table 1, Table 2 provides estimates of the magnitudes of movement.

Table 1

MOVEMENTS IN MACRO-ECONOMIC VARIABLES OVER THE KONDRATIEFF CYCLE (HARTMAN AND WHEELER, pp. 66-67)

Kondratieff Downswing Period	Kondratieff Upswing Period
Associated Variable Movement	Associated Variable Movement
(i) High innovatory activity	(i) Relatively low innovatory activity
(ii) High levels of infrastructural activity	(ii) Relatively low levels of infrastructural activity
(iii) Falling prices	(iii) Relatively low unemployment
(iv) Aggregate supply shifting out rapidly and always faster than aggregate demand	(iv) Relatively low increases in real national product
(v) Relatively high unemployment	(v) Increases in indices of technical progress below trend
(vi) Relatively large increases in technical progress above trend	(vi) Actual national product and industrial product below potential national and industrial product
(vii) Actual national product and industrial product above potential national and industrial product	(vii) Real gross domestic fixed capital formation below trend, and real exports above trend
(viii) Real gross domestic fixed capital formation above trend and real consumption and real exports below trend	

Given this outline of the movements and time paths of the major variables let us now focus on the peirod 1870-1914 and especially the Kondratieff downswing 1873-96. The obvious starting point is to concentrate on the two basic 'motor forces' identified by Hartman and Wheeler: clusters of innovations

[17] *Ibid.* pp. 48-49, 49-52, 56-57.
[18] *Ibid.* p. 66.
[19] *Ibid.* p. 66.

Table 2
SUMMARY OF CYCLICAL CHARACTERISTICS: GREAT BRITAIN 1790-1920 (HARTMAN AND WHEELER, 58)

Period	Aggregate Price Movements i	Aggregate Production ii	Market Conditions iii	Unemployment iv	Patterns in National Product Component v	Relationship of Actual Potential Output vi
1790-1813	Up 3.25%	Up 2.87%	D>S	Low	—	—
1813-49	Down 2.09%	Up 2.74%	S>D	High	—	—
1849-73	Up 1.01%	Up 2.55%	D>S	Relatively low 3.66%	—	—
1873-96	Down 1.19%	Up 1.99%	S>D	Relatively high (5.03%)	Investment above trend. Consumption below trend imports below trend	Actual output greater then potential output
1896-1920	Up 4.97%	Stable Up 0.62	D>S	Low 3.38%	Investment below trend Exports above trend. Consumption above trend imports above trend.	Actual output less than potential output.

and infrastructural development. An estimate of the former is given by a time series of annually sealed patents and the latter is accounted by means of the number of canal miles and railway kilometres opened. The authors provide the following data.

Table 3
PATTERNS OF INNOVATIONS AND INFRASTRUCTURAL DEVELOPMENT UK 1760-1920 (HARTMAN AND WHEELER, 62)

Period	Increase in Sealed Patents (i)	Increase in Railway Kilometres (ii)	Increase in Canal Miles (iii)
1760-90	438%	—	Very large
1790-1813	56%	—	Continual but diminishing expansion
1813-49	472%	20,640%	Very little
1849-73	51%	152%	—
1873-96	341%	29%	—
1896-1920	20%	12%	—

There is a clear contrast between columns i and ii. The former appears to offer at least a secular trend which is consistent with Hartman and Wheeler's predictions, but column ii offers no such support. There is a rapidly declining trend of infrastructural activity from 1849; thus while the Kondratieff downswing 1813-49 demonstrates high infrastructural activity, the subsequent downswing does not. Further from their own data infrastructural activity is less in 1873-96 than it is in the upswing 1849-73 which clearly contradicts statement ii in Table 1. Hartman and Wheeler do not confront this problem: they merely comment on the downswing 1873-96: "For British railroads this was a period of slower growth, however, use of steam and steel ships expanded considerably."[20] No additional data on infrastructural activity is added to the initial figures on railway kilometres; they simply cite as footnotes the works of Mitchell and Dean, Court and Saul. Yet in a summary of their results they state clearly:

"All of these downswing periods have also been marked by disproportionate levels of infrastructural expansion."[21]

This simply does not fit the evidence for Britain during the Kondratieff downswing 1873-96. Indeed for the whole period 1870 to 1913 Arthur Lewis[22] has argued that the ratio of domestic investment was low in Britain and in a very recent work Floud has acknowledged "the fact that investment in the domestic economy was lower, as a proportion of gross domestic product, in Britain, than in several other countries."[23] Feinstein's figures show the stock of real capital increasing only by an average rate of 1.4% between 1873 and 1914. The biggest investment boom of the period occurred at the end of the century and peaked in 1903.[24] This would appear to contradict in broad terms Hartman and Wheeler's comments on the behaviour of real domestic fixed capital formation during the Kondratieff downswing and upswing phases. Lewis maintains that the domestic investment ratio was low because new investment was not sufficiently profitable. He goes on to claim:

"The ultimate cause was the exhaustion of the innovations which had propelled the industrial economy in the century up to 1880. By this time the British railway system was largely completed... Railways were such a large user of capital goods that the system had to find some substitute propellant if it was to maintain its growth momentum. The old techniques in the basic industries... were also reaching exhaustion and although the United States was developing highly capital intensive methods, yielding twice as much output per head, the British were slow to move in this direction. They were also slow in developing

[20] HARTMAN and WHEELER, p. 65.

[21] *Ibid.* 66.

[22] W. ARTHUR LEWIS, *op. cit.*, p. 113.

[23] R.C. FLOUD, "Britain 1860-1914: a survey", in R.C. FLOUD and D.N. MCCLOSKEY (eds.), *The Economic History of Britain since 1700.* Vol. 2: *1860 to the 1970s* (Cambridge. CUP 1981) p. 15.

[24] W. ARTHUR LEWIS, *op. cit.*, p. 115.

the new science based commodities, leadership of which passed to Germany and the United States."[25]

Lewis is suggesting that not only was the level of infrastructural development at a low ebb in late XIXth century Britain but that there was also a problem with the pace of innovatory activity. There is in other words a contradiction between Lewis's claims and the estimates of Hartman and Wheeler concerning the rate of increase of innovatory patents 1873-96. For the Kondratieff downswing 1873-96 the authors show sealed patents climbing by 341%, compared with 51% in the preceding upswing 1849-73, and 20% in the proceeding upswing 1896-1920. They claim that during the late XIXth century downswing "... Britain... moved into a period of substantially increased innovative activity" while during "... the next upswing period '1896-1920 ... innovative activity appears to drop sharply...".[26]

This prompts the question: are sealed patents an adequate proxy for innovative activity? Two basic objections spring to mind. First we may ask at what stage of the couple invention: innovation do sealed patents capture, and what are the implications of the couple for the process of economic change? As we have seen, Schumpeter emphasized the discontinuous nature of innovative activity. He draws a sharp distinction between invention and innovation, they are "... economically and sociologically two entirely different things."[27] Rosenberg claims that for Schumpeter inventive activity stands as an exogenous factor outside of his basic framework. "Inventions come into the Schumpeterian stage already fully grown, and not as objects or processes the development of which is a matter of explicit interest — the characteristics of the inventive process, and the stage through which inventions proceed on the way to full commercial application and exploitation, never emerge."[28] Schumpeter never subjected to systematic examination the processes which determine the length of time which separate the making of an invention and its innovation. But what stage in the development sequence does the patent represent the initial idea, or perhaps the earliest conception of a product in its substantially commercial form, or the extent to which technical and engineering feasibility has been achieved?

This is not mere nit-picking for, as Rosenberg observes, while "... for some inventions no serious technical obstacles to their implementation may exist once the basic idea has been established, for other inventions such obstacles are formidable and can be overcome only after much further time consuming search and experimentation."[29] These 'obstacles' then generate different time lags between invention and innovation reflecting in part the varying complexity of

[25] W. Arthur Lewis, *op. cit.*, p. 117.

[27] Quoted in N. Rosenberg, *Perspectives on Technology* (Cambridge CUP 1976) p. 67.

[28] *Ibid.* p. 68.

[29] *Ibid.* p. 71.

the technical difficulties which need to be solved before an invention becomes operationally feasible. For example, in Bessemer's basic patent of 1856 the oxygen method of steel making was outlined, but the method could not be exploited until it was possible to produce pure oxygen on a large scale, a possibility Rosenberg claims was not realised until some three-quarters of a century later. Certainly the data on sealed patents provided by Hartman and Wheeler are insufficiently sensitive to distinguish between different time paths in the sequence of the couple invention: innovation. Yet they maintain "... that the length of time from invention to patent to commercialization and diffusion is relatively short."[30]

In turn this assumption underpins their claim that waves of innovative clusters and infrastructural activity leads to aggregate supply moving out faster than aggregate demand in the Kondratieff downswing i.e. invention patents are relatively quickly transmitted into innovations which stimulate a rapid growth of industrial production and national product. But does "aggregate supply shift out rapidly" during the downswing 1873 to 96? Coppock working on data for growth rates of industrial production per capita shows a real collapse in growth rates between the early 1870s and the late 1880s, and finally negative growth on the eve of war. (See Table 4).

Table 4
AVERAGE ANNUAL REAL GROWTH RATES OF BRITISH INDUSTRIAL PRODUCTION (EXCLUDING BUILDING) PER HEAD[31]

Year	Growth Rate Per Head
1861-65 - 1866-74	2.4
1866-74 - 1875-83	0.9
1875-83 - 1884-89	0.2
1884-89 - 1890-99	0.4
1890-99 - 1900-07	0.2
1900-07 - 1908-13	−0.2

For Gross National Product Crouzet has pointed to "a long phase of deceleration and distinctly slower growth than before from the early 1870s, with some recovery in the 1890s but renewed slowing-down at the beginning of the 20th century."[32] Indeed column 11 of Table 2 of Hartman and Wheeler shows a

[30] HARTMAN and WHEELER.

[31] Table from S.B. SAUL, *The Myth of the Great Depression 1873-96* (London, Macmillan 1969).

[32] F. CROUZET *The Victorian Economy* (London, Methuen, 1982), p. 53 see also W. ARTHUR LEWIS *op. cit.*, Chapter 5. The views expressed here are, of course, at variance

falling secular trend of aggregate production which is only a gentle slope between 1790-1873 then accelerates markedly from 1873 to 1914. Hartman and Wheeler's predictions concerning the behaviour of aggregate supply during the Knodratieff downswing 1873-96 are suspect and certainly sealed patent data tell us little about the sequential process invention: innovation which it is necessary to unravel if we are to explore more systematically the behaviour of aggregate supply.

Secondly let us focus attention on the second part of the couple: innovation. After all it is high levels of "innovational activity" which are associated apparently with the Kondratieff downswing. It will be argued that Hartman and Wheeler's patent data are insufficiently sensitive to distinguish between different categories of innovation and that such distinctions are vital to recent explanations of the long-wave mechanism. Writing in the same neo-Schumpeterian tradition as Hartman and Wheeler, Gerhard Mensch has stressed the importance of categorising different types of innovation. He argues that "... it is important to separate the choice among and opening of alternative lines of development from steps forward in lines of development that have already been established..."[33] This constitutes Mensch's key distinction between basic innovations and improvement innovations. Basic innovations have the following properties: (a) they occur in clusters; (b) basic innovatory spurts produce several new industrial branches; (c) these innovations venture into new industrial territory, giving labour and capital new lucrative tasks in areas where there is no direct competition with existing employment; and (d) basic innovations tend to follow the path of least resistance and some terms of higher need.[34]

On the other hand, improvement innovations allow for further development in established areas of activity i.e. areas established by basic innovations. An example of an improvement innovation in the industrial sphere "... could be the introduction of a new product that is superior to its ancestor in its quality, reliability, ease of use... raw material use, labour cost etc. It could also be the application of new and better production techniques that would allow old and

with those of McCloskey for the late Victorian economy. Thus McCloskey argued that British total factor productivity growth was approximately of the same order of magnitude as that of the United States before 1900. D.N. McCloskey "Did Victorian Britain Fail?" *Economic History Review* XXIII 1970 pp. 446-59. Apart from the fact that the residual index 'estimating' total factor productivity has been called a 'measure of our ignorance' the assumptions on which the analysis is based is hostile to the whole neo-Schumpeterian approach. Thus the neo-classical framework on which McCloskey's work is embodied includes such non-Schumpeterian requirements as the absence of risk and uncertainty. As Nicholas has recently argued "... the heritage of neo-classical production theory... at least in its pure form, takes history out of economics." S. Nicholas, "Total Factor Productivity Growth and the Revision of Post- 1870 British Economic History", *Economic History Review*, Vol. XXXV, No. 1, 1982 p. 95.

[33] G. Mensch, *op. cit.*, p. 48.

[34] G. Mensch, *op. cit.*, pp. 9-18, 48.

new products to be made more reliably, of better quality or simply in larger quantities, or at a lower price."[35] Thus improvement innovations incorporate both product and process innovations.

Mensch also defines a third tier of innovations: the so-called pseudo-innovations. These are related to minor adaptations which merely alter the style, appearance or packaging of a given product and act in the main to lengthen the product life cycle. They are also associated with minor changes which are associated with product differentiation. Design obsolescence in automobiles is an obvious example. In the late XIXth century, a case in point, is the British penchant for product differentiation.

Payne, for example, notes that: "by increasing specialization designed to exploit marginal differences in quality, and by creating the impression that the differences were greater than they were in reality, many British firms were able to secure a degree of oligopoly power..."[36]

There is a definite sequential pattern in Mensch's innovative system. In periods of prolonged depression (referred to by Mensch as the 'technological stalemate') the economy becomes structurally ready for basic innovations and swarms of such innovations allegedly occur. Following this clustering process a diffusion of improvement innovations drives the economy into a growth cycle. Over time a substitution of process for product innovation will take place and as the series of improvement innovations are truncated by more pseudo-innovations the growth cycle levels off.[37] Mensch has not been without his critics. Delbeke, while acknowledging that the difference between basic and improvement innovation is crucial, maintains that a major weakness in Mensch's research is a lack of a good criterion for identifying between the two types of innovation. He concludes "... the interpretation of a concrete innovation is difficult and risky."[38]

Nevertheless, accepting the difficulties of defining basic and improvement innovations, it is clear that Schumpeterian clusters are closely associated with major innovatory change and Hartman and Wheeler might well have offered a survey of such critical changes rather than relying on their crude patent data. It would have been consistent with their neo-Schumpeterian approach and provided a useful complement to Mensch's location of basic innovatory clusters during the downswing of the long-wave.

Unfortunately, the construction of lists of major innovations is a hazardous enterprise. As van Duijn admits: "Every author in the field agrees that it is extremely difficult to measure the contribution of a particular innovation, and

[35] *Ibid*, p. 47.

[36] P. Payne, "The emergence of the large scale company in Great Britain, 1810-1914", *Economic History Review*, Vol. 20, 1967, pp. 524-5.

[37] See G. Mensch, C. Coutinks, K. Kaasch, *op. cit.*, *Futures*, Vol. 13, No. 4, 1981 p. 284.

[38] J. Delbeke, *op. cit.*, *Futures*, Vol. XIII, No. 4, 1981, p. 250.

this makes every list subject to much criticism."[39] It is not without surprise, therefore, that the evidence of major innovatory clustering is contradictory. The most comprehensive survey for Britain during the XIXth and XXth centuries has been undertaken by R. Baker[40] but unfortunately he dealt with major inventions and his list is consequently subject to the first criticism. At the same time Clark, Freeman and Soeta have referred to this list as "... a rather coherent and comprehensive sample of the major inventions of the last two centuries;"[41] and it deserves at least a brief comment. Baker selected a list of 'significant' inventions from all the patents issued in the UK from 1734 onwards and the data do seem to support the view that clustering of basic inventions does take place. It is possible to identify clusters during the downswing of the long wave, (1874-89 and 1928-36) but clusters also appear during certain phases of the upswing as for example between 1897 and 1903. This latter peak surpasses that of the downswing 1874-89. Clark, Freeman and Soete conclude: "There does not, therefore, appear to be clear prima facie evidence that the observed clustering is unambiguously related to particular economic circumstances, whether favourable or adverse."[42]

Turning directly to innovations van Duijn has published two lists of 'major' innovatory changes, one in 1981 and the other in 1983. The first offered a list of some 80 major innovations in 13 different industrial sectors, the second a more wide survey of 160 'major' innovations — the latter ranging from the internal combustion engine to the safety match. Needless to say neither of these lists adequately capture Mensch's basic innovations though the first is a more reasonable approximation. By abstracting from van Duijn's two tabulations those 'major' innovations occurring between 1849 and 1920 we can detect whether any definite clustering occurred during the Kondratieff downswing 1873-96. The data are given in Tables 5 and 6.

While the data from both tables shows a clustering of major innovations in the downswing 1873-96 compared with the previous upswing 1849-77, table 5 also shows major innovations clustering during the upswing 1896-1920. In other words clustering is not an unambiguous property of the Kondratieff downswing 1873-96. Further the picture which emerges for Britain in Table 5b is rather depressing; of the 14 major innovations listed between 1873 and 1896 only 2 are attributed to British innovatory developments. Table 6b gives a more optimistic picture but it is the data from the former table which is more likely to approximate basic innovations. One inference that could be drawn from the data is that the British could invent (Baker data) but were reluctant to innovate (van Duijn

[39] J.J. VAN DUIJIN, *op. cit.*, *Futures*, Vol. XIII, No. 4, 1981, p. 271.

[40] R. BAKER, *New and Improved - Inventors and Inventions that have changed the modern world* (London, British Museum Publications Ltd 1976).

[41] J. CLARKE, C. FREEMAN and L. SOETE, "Long-Waves, Inventions and Innovations", *Futures*, Vol. XIV, No. 4, 1981, p. 310.

[42] *Ibid.* p. 311.

Table 5a
MAJOR INNOVATIONS IN 13 INDUSTRIAL SECTORS*

Kondratieff periods	1849-73	1873-96	1896-1920	Total
No major innovations	5	14	14	33

Table 5b
COUNTRY OF ORIGIN OF MAJOR INNOVATIONS 1873-96

USA	6
Germany	4
UK	1
France	2
Others	1

Source J.J. VAN DUIJN *op. cit*, *Futures* Vol. XIII, No. 4 1981 Table 4.
* The Industrial Sectors included synthetic fibres, resins, telecommunications, automobiles, steel etc.

Table 6a
MAJOR INNOVATIONS 1849-1920

Kondratieff periods	1849-73	1873-96	1896-1920	Total
No major innovations	20	30	23	73

Table 5b
COUNTRY OF ORIGIN OF MAJOR INNOVATIONS 1873-96

USA	6
Germany	4
UK	1
France	2
Others	1

Source J.J. VAN DUIJN, *op. cit*, *Futures* Vol. XIII, No. 4 1981 Table 4.
* The Industrial Sectors included synthetic fibres, resins, telecommunications, automobiles, steel etc.

Table 5b). If this was the case we would expect the sluggish development of new industrial sectors in Britain and indeed a number of authorities suggest that this might well have been the case from the 1870s down to the First World War. In the latest major survey of the Victorian economy Francois Crouzet has claimed:

"English industry did not succeed in adapting to the new conditions of the international economy... in making the necessary and large scale effort of innovations. On the one hand, traditional industries failed to sustain a high level of technology that would keep them competitive. On the other hand, the new industries, e.g. organic chemistry, electrical equipment and motor cars, only developed at a modest rate, too modest to replace the old industries."[43]

Crouzet acknowledges that one can easily paint a too gloomy picture of British industry at the end of the XIXth century "... a picture that is probably biased."[44] There did appear for example to be a relatively rapid adaption to modern techniques in a number of sectors on the eve of the First World War i.e. during the upswing phase of the Kondratieff. Accepting these reservations Crouzet nevertheless lends support to the position of S.B. Saul, who, while also guarding against excessive pessimism, stresses that by the last quarter of the XIXth century "... Great Britain had ceased to engender new products and new processes."[45]

Reviewing the literature on technological change in Britain 1870-1914, Crouzet concludes "... on the technological plane, the British economy showed up serious deficiencies and there was too little innovation."[46] In short the evidence for the clustering of innovatory activity and infrastructural development specific to the Kondratieff downswing 1873-96 is weak for Britain and as Hartman and Wheeler's argument rests largely on such a clustering pattern their overall treatment of British economic development in the late XIXth and early XXth centuries is seriously weakened.

Industrial Structure and the Long Wave

But if the empirical support is suspect there is still much in the theoretical construction which is important and can offer a new departure in the study of the long wave. Their work can be extended to establish the basis for a linkage between industrial structure, innovatory clustering and the long wave. They begin their approach with an attempt to link the micro- and macro- levels of the theory by a critical use of Nelson and Winter's evolutionary theory of the firm.

They stress the need to relate the impact of innovatory clusters at the aggregate level of the economy to the behaviour of the basic business decision-making unit, the firm, and they hypothesize '... that waves of innovation and

[43] F. CROUZET, *op. cit.*, p. 382.
[44] *Ibid.* pp. 288-290.
[45] *Ibid.* pp. 385-386.
[46] *Ibid.* p. 390.

infrastructure reflect at the macro-level the concentration in space and time of evolutionary technical change simulated by Nelson and Winter"[47] However, Hartman and Wheeler do not specify the type of firm behaviour pattern which is consistent with their hypothesis. Such a pattern can now be outlined and its resulting consequence for the dynamics of industrial structure explored. During the innovatory cluster there would be a rise in the number of new innovatory business units and a growing survival problem for more conservative enterprises; less dynamic firms would be subject to intense competitive pressure. That is, the competitive environmental shifts postulated by Nelson and Winter which would require a change of firm's regimes.

There is a high probability that entry rates and exit rates would rise[48] and firm population movements would consequently be volatile. Industrial structure will therefore be subject to marked shifts as its constituent element firms struggle for dominance and survival. Thus firm behaviour and innovatory clustering may be linked to the Kondratieff downswing phase via a volatile firm population structure. Consequently movements in industrial structure can constitute a test for the downswing phase of the long-wave; industrial structure in other words should display what we may term a neo-Schumpeterian pattern.

A detailed survey of British industrial structure has yet to be undertaken but my own research[49] has provided the reconstruction of the industrial structure of the Manchester cotton industry and the Sheffield iron and steel industry.[50] I have argued that techniques of industrial reconstruction allow[51] the economic historian to "... trace the industrial dynamics of a given population of firms" and to examine its volatility "...in relation to a number of variables associated with entry and exit rates and the degree of firm mobility between size categories."[52] The behaviour of Manchester cotton firms c. 1815-1833 and Sheffield iron and steel firms 1880-1901 will be used to test the neo-Schumpeterian hypothesis. The basic ground for adopting this material is three fold:

[47] HARTMAN and WHEELER, p. 47.

[48] For an analysis of the conditions of entry and exit see E. MANSFIELD "Entry, Exit and the Growth of Firms" in B.S. YAMEY (ed.), *Economics of Industrial Structure* (Harmondsworth, Penguin 1973).

[49] The research has been conducted in cooperation with MR A.A. LE ROUX, for the cotton industry, and MR M.J. LEWIS, for the iron and steel industry. I am indebted to both these colleagues for our work in industrial reconstruction.

[50] R. LLOYD-JONES and A.A. LE ROUX, "Marshall and the Birth and Death of Firms: The Growth and Size Distribution of Firms in the Early 19th Century Cotton Industry", *Business History*, Vol. XXIV, No. 2, 1982 (hereafter *BH* 1982) and R. LLOYD-JONES and M.J. LEWIS, "Industrial Structure and Firm Growth: The Sheffield Iron and Steel Industry 1880-1901", *Business History*, Vol. XXV, No. 3, 1983, 1983 (hereafter *BH* 1983).

[51] See R. LLOYD-JONES and M.J. LEWIS, "Ratebooks and Industrial Structure: A Technique for Reconstructing the Local Economy", *Local Historian*, vol. XVII, No. 5, 1987.

[52] *BH* 1983, p. 260.

a) During the respective time periods the two industries were studied they represented important sectors of the economy. Cotton was the leading sector of the early XIXth century British economy and the steel industry was one of the key industries of the late XIXth century.[53]

b) The industries were examined during two different Kondratieff downswings and each in their own time phase were subject to significant technological innovations and competitive pressures.[54]

c) The two industries represent contrasting sectors of the economy, one a consumer good, the other a capital good.

Cotton Industry

The reconstruction of the Manchester cotton industry c. 1815-33 falls within the downswing of the first Kondratieff c. 1810-17 - 1844-51. The industry clearly indicates high entry and exit rates resulting in a volatile industrial structure. The original 90 firms that consitituted the 1815 population had been decimated by 1833; approximately three-quarters had left the industry by the latter date.[55] The basic data led to the conclusion that: "... the population of 1833 was dominated by firms who had entered the industry since 1815. This category accounts for 69 percent of all firms in 1833. Firm population was volatile, with high exit rates compensated by high entry rates."[56] Cotton, the leading sector of the early XIXth century British economy, displayed a firm behaviour pattern which appears to be consistent with the neo-Schumpeterian interpretation of the long-wave. Does such a pattern hold for the late XIXth century Sheffield iron and steel industry? The industry was reconstructed for the period 1880 to 1901 giving an approximate time path to the downswing of the second Kondratieff. The original 1880 population totalled 301 firms providing a survey of some three times the number of firms covered in the analysis of the cotton industry.

Sheffield's industry was sub-divided into three industrial types composed of

[53] For the cotton industry see S.D. CHAPMAN, *The Cotton Industry in the Industrial Revolution* (London, Macmillan, 1972); for iron and steel see F. CROUZET, *op. cit.*, Ch 8. MANCHESTER and SHEFFIELD, of course, constitute major centres of their respective industries.

[54] The cotton industry 1815-33 was subject to the rapid diffusion of steam mule spinning and the introduction of the power-loom, the latter underlying the rise of new integrated spinning and weaving firms. Major developments in the steel industry involved the rapid diffusion of the Siemens-Martin steel and the introduction of the Thomas process.

[55] In a more recent study we have shown that 63 firms left the Manchester industry between 1825 and 1833. R. LLOYD-JONES and A.A. LE ROUX, "Factory Utilization and the Firm: The Cotton Industry c. 1825-1840", *Textile History*, Vol. XV, No. 1, 1984.

[56] *BH* 1982, p. 147.

four size categories — the latter being designated, small, medium, large and giant.[57] Firms were grouped as follows:

i (B) Basic producers of iron and steel;
ii (C) Cutlery producers, including pure fabricators and integrated concerns producing both cutlery and the basic product;
iii (TE) Tool and engineering goods producers, including pure fabricators and integrated concerns producing both tools, engineering goods and the basic product.

The following profile of Sheffield industrial structure between 1880 and 1901 is outlined in Tables 7 and 8.

Table 7
SHIFTS IN SHEFFIELD INDUSTRIAL STRUCTURE BY INDUSTRY TYPE 1880-1901

Industry type	B				C				TE			
Size category	1880		1901		1880		1901		1880		1901	
	No	%	No	%	No	%	No	%	No	%	No	%
Small	28	47	30	49	70	74	69	68	77	52	79	48
Medium	20	34	19	31	21	22	25	24	42	29	53	32
Large	8	14	9	15	3	3	8	8	16	11	17	10
Giant	3	5	3	5	1	1	0	0	12	8	16	10
Total	59	100	61	100	95	100	102	100	147	100	165	100

Source *BM*, 1983 Table 2.

Table 8
SHIFTS IN INDUSTRIAL STRUCTURE 1880-1901: ALL INDUSTRIES COMBINED

Size category	1880		1901	
	No	%	No	%
Small	175	58	178	54
Medium	83	28	97	30
Large	27	9	34	10
Giant	16	5	19	6
Total	301	100	328	100

Source *BH*, 1983 Table 3.

All in all 57 percent of the 1880 population of firms survived to 1901 with 43 percent leaving the industry. This compares with only 24 percent of cotton firms surviving from the 1815 population to 1833, with 76 percent leaving the

[57] *BH* 1983, Table 1.

industry. The small iron and steel firm showed, for example, a marked resilience compared with the small cotton firm. While 85 percent of all small cotton firms left the industry between 1815 and 1833 the rate of exit of small iron and steel firms was less than half that level between 1880 and 1901, 40.6 percent of the 1880 population exiting. The contrast between the two industrial structures is also marked in the case of entry firms, these firms making a significantly greater contribution to changing industrial structure in Manchester compared with that of Sheffield.[58] The survey of Sheffield's industrial structure allows a positive conclusion: "... industrial structure is stable, there is no discernible tendency towards a given size category either in a given industry type or for the combined industrial structure. Certainly, the industry does not display the volatility shown by Lloyd-Jones and Le Roux for the early XIXth century cotton industry".[59] The evidence is clear, Sheffield iron and steel firms do not behave in a way consistent with a neo-Schumpeterian pattern during the late XIXth century Kondratieff downswing. It must be stressed that this is only a preliminary survey but evidence from two other sources tends to confirm the Sheffield pattern.

Firstly, Professor Payne has provided a detailed analysis of 2,625 Scottish limited companies formed between 1856 and 1895.[60] These firms covered the whole spectrum of economic activity ranging from manufacturing to public utilities, to shipping insurance and financial services. Payne's work is a gold mine of information on these early limited companies; unfortunately it does have limited applicability for the type of test I wish to apply. One major problem is that many of these limited companies were conversions of existing concerns[61] and therefore do not constitute genuine entry firms from the point of view of total firm population. Rather than entry data attention will be focused upon survival rates as an indicator of firm population volatility. Payne provides data for the number of Scottish companies in existence at the end of 1875 and 1894[62] and it is thus possible to trace the behaviour of the population of firms through the Kondratieff downswing of the late XIXth century and the subsequent upswing. Are the survival rates significantly different from that of Sheffield and do they vary over the two time periods (1875-1894 and 1894-1914) as

[58] For example, taking the medium and large category, entry firms contributed only 21.1 percent to the 1901 Sheffield population while a similar exercise for cotton shows entry firms contributing 59.1 percent to the 1833 population.

[59] *BH*, 1983, p. 261.

[60] P.L. Payne, "The Early Limited Companies, 1856-1895: An Historical and Analytical Survey". *California Institute of Technology*, Social Science Working Paper No. 222, June 1978 (hereafter *CIT* 1978).

[61] Payne points out, for example, that many of the limited companies in the iron industry formed in the early 1870s were conversions of existing firms *CIT* 1978 p. 30.

[62] *Ibid.* pp. 22-24.

the neo-Schumpeterian hypothesis would lead us to expect? These propositions are examined in table 9

Table 9
SCOTTISH LIMITED COMPANIES SURVIVAL PATTERNS 1875-1914[63]

N.o of Firms in Existence		Percentage Surviving	Sheffield Survival Firms %
1875	1894		1880 - 1901
444	205	46.2	57.0
1894	1914		
1606	743	46.3	

Scottish limited companies displayed a lower survival rate than Sheffield iron and steel firms during the Kondratieff downswing but volatility expressed in terms of the percentage of firms surviving shows remarkable symmetry for the two populations over their respective time periods. There is little here in support of a neo-Schumpeterian hypothesis.

Secondly, the findings for Sheffield tend to blend in with more general work on late XIXth century firm behaviour. The literature emphasises the slow pace of the merger movement in Britain, the reluctance of family firms to adopt public limited status and the consequent resilience of family control in the affairs of the firm.[64]

These tendencies held back the growth of large scale firms[65] and meant that British industrial structure compared with the United States or Germany was characterised by large numbers of small and medium sized firms.[66] It could be argued, of course, that small and medium firms are more effective carriers of Schumpeterian innovations than large-scale units but the overall impression during the late XIXth century is the 'conservatism' of British firms, typified by

[63] This table is adapted from Table 9 in *CIT* 1978, p. 24b.

[64] See, for example, A.D. CHANDLER, "The Growth of the Transnational Industrial Firm in the United States and the United Kingdom: A Comparative Study" *Economic History Review*, Vol. XXXIII No. 3, 1980. L. HANNAH, "Mergers in British Manufacturing Industry 1880-1918", *Oxford Economic Papers*, Vol. 26, 1974. P.L. PAYNE, Industrial Entrepreneurship and Management in Great Britain", in M.M. POSTAN and P. MATHIAS (eds) *The Cambridge Economic History of Europe*, Vol. VII Part. 1 (London CUP 1978), P.L. PAYNE, *op. cit., Economic History Review*, Vol. XX, 1967.

[65] A.D. CHANDLER, *op. cit., Economic History Review*, Vol. XXXIII, No. 3, 1980, pp. 398-400.

[66] L. HANNAH, *The Rise of the Corporate Economy* (London, Methuen, 1976), p. 13.

the trend towards private limited companies which gave the benefits of limited liability but restricted the number of share holders and was designed to keep effective control in family hands.[67] Chandler, for example, argues that a comparative analysis of the growth of large industrial firms in the United States and the United Kingdom 'emphasises how much more quickly managerial enterprise appeared' in the former compared with the latter. 'Normally' he claims '... it took a British firm three generations to reach the size and managerial strength that a comparable American enterprise achieved in one. 'British manufacturers moved slowly into the mass production of consumer goods and '... the failure of ... local heavy machinery firms to develop marketing organizations within Britain ... made it easier for the Americans to take over the British market for volume-produced standardized producer goods, such as harvesters, electrical equipment, elevators, shoe machinery, and printing presses.'[68]

This paper has attempted to examine the historical dynamics of the British economy in the late XIXth and early XXth centuries. Little support has been found for the neo-Schumpeterian notion of innovatory clusters acting as a key mechanism of economic change nor do such clusters appear to phase with the temporal sequence of the Kondratieff long-wave. An examination of movements in firm population structure reinforced this view. But to avoid finishing on a negative note these findings may yet again be an example of the peculiarities of British economic history.[69] A case can be made for the upswing of a 'technological' Kondratieff in the late 1890s associated in particular with rapid phases of growth in Germany and the United States. Thus Trebilcock in the latest text on Continental economic development has stated "...the German contribution to the high-technology Kondratieff at the century end could be approached only by the United States."[70] Part of the growing tension of this epoch was the British failure to exploit this technological Kondratieff.[71]

[67] A.D. CHANDLER, *op. cit.*, *Economic History Review*, Vol. XXXIII, No. 3, 1980, pp. 401-2.

[68] *Ibid.* p. 408.

[69] For a recent statement challenging the adoption of British industrial development as a standard to judge later developments see M. FORES, "Myth of the Industrial Revolution", *History*, Vol. VI, 1981.

[70] C. TREBILCOCK, *The Industrialization of the Continental Powers 1780-1914* (London, Longman, 1981), p. 49.

[71] For an interesting examination of Britain's relative economic decline and the political and strategic implications see P.J. CAIN, *op. cit.*, pp. 34-59.