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Were British 'Business Cycles' Cyclical?
Evidence from Historical Statistics, 1700–1913

I. Introduction

'Business cycles' are the sequences of 'recurrent but not periodic' expansions and contractions, proposed by Arthur Burns and Wesley Mitchell (1946), 'occurring at about the same time in many economic activities' and varying in duration from one to 12 years.[1] This description, which is accepted by most economists, assumes *a priori* that sequences of peaks and troughs in individual time series — the 'specific cycles' — occur simultaneously. If so, then these 'comovements' of the 'many activities' (as Zarnowitz, Lucas and others have characterized them) can be marked by a single set of 'general' turning points: the 'reference cycle'.

It is not clear the extent to which this assumption about business cycles derives from empirical evidence. The problem is compounded by the persistence of growth in industrial economies since the eighteenth century, which has made it difficult to observe cyclical behaviour independently of 'trend' in largely nonstationary time series. Burns and Mitchell never entirely trusted their own time-series evidence, which actually revealed that in important aspects each episode was 'unique'. As a consequence there has always been a degree of uncertainty in the statistical treatment of comovements and hence quantitative investigations have often yielded ambiguous results.

In the case of the British economy in the nineteenth century, most historians have expressed doubts about the diffusion of fluctuations across the 'many activities' and have concluded that they were to a degree heterogeneous and divergent. Reference measures — which are essentially univariate — may not therefore be appropriate as representations of a phenomenon whose dynamics are multivariate. The usual practice

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[1]*Measuring Business Cycles* p. 3.

of decomposing time–series data into 'trend' and 'cycle' has also been questioned in postwar research, by Kendall and later by Solomou, Aldcroft and Fearon. Either approach can be justified only by making *a priori* identifying assumptions about the nature of business cycles. These in turn are only justified if the time–series evidence supports comovements. There is moreover the question whether short–run fluctuations are asymmetric in their responses to expansions and contractions, and whether cyclical components in linear time–series models actually reflect this property. This paper proposes to investigate these issues: whether short–run fluctuations in nineteenth century UK time–series comove in the absence of the usual identifying assumptions and (as assumed by the historiography) evolved as a consequence of industrialization; and whether they are asymmetric.

II. The Research Background: Evidence and Methodology

Ashton (1959) argues that eighteenth century instabilities were the product of financial crises and natural apocalyptic forces dominated by dearths and plenties in harvest yields; but that by the nineteenth century these 'undulations were more regular'.[2] Aldcroft and Fearon (1972) claim, with reservations, that eighteenth century fluctuations 'were shorter and came to an end more abruptly than those of the nineteenth' and that those 'of the first half of the nineteenth century...tended to be shorter and more frequent than those in the latter half...'[3] In the same volume Rostow supports the evolutionary interpretation: whereas traditional fluctuations had been of the 'inventory cycle' type, it was the 'structural' shift from agriculture to industry that led to the diffusion of the 'trade cycle' throughout a broad range of activities between 1790 and 1914.

The majority of historians have nevertheless emphasized the heterogeneity of cyclical behaviour in the nineteenth century British economy. Matthews (1954a) questions the

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[2](1959) pp. 138, 173.

[3](1972) pp. 2–3.

idea of 'general trade conditions' in the war period 1790–1815. Matthews (1954b) finds conflicting evidence of 'cyclical' turning points from 1833 to 1842: the period was a 'long, confused and heterogeneous' contraction with a number of 'complicating factors' and 'a good deal of divergence [in] the timing' of the different industrial sectors.[4] Hughes (1960) describes mixed conditions for the years 1848–1857.[5] Dornbusch and Frenkel (1984) demonstrate that the 'crisis' of 1847 was atypical of the century, and was actually two distinct crises, of different origins, in May and October. Rostow (1972) doubts the homogeneity of nineteenth century 'cycles': not only were 'no two cycles...quite the same' but also the character of the episodes changed as the economy evolved, giving each episode 'unique historical circumstances'.[6] Ford (1981) finds it 'difficult to specify a typical British fluctuation or cycle'; each episode had 'unique institutional and geographical features...apart from varied behaviour patterns'.[7] Lewis (1978) goes further: after analysing industrial production data he concludes that because they cannot predict future from past behaviour, 'the movements of industrial production, though wave-like, are not cycles'.[8] Eichengreen (1983), in a multivariate (VAR) study, finds evidence of structural breaks in the late nineteenth century, which implies changes in the character of cycles over time.

These doubts are also apparent in the output of the National Bureau of Economic Research itself. Burns and Mitchell concluded that each 'business cycle is an individual...differing in countless ways from every other'.[9] Gayer, Rostow and

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[4](1954b) pp. 217, 224.

[5](1960) p. 28.

[6](1972) p. 74.

[7](1981) p. 134.

[8](1978) p. 18.

[9](1946) p. 466.

Schwartz (1951), applying Mitchell's methodology, found that 'the precise timing of minor...expansions and contractions [in the nineteenth century UK economy] cannot be easily be generalized'; that output might even have increased during the 'contraction'; that recovery could have arisen from a variety of conditions, not all of which are present in each episode; and that the time-series data suggest that peaks were usually spread over several years.[10] Zarnowitz (1992), describes business cycles as 'varied, complex and evolving phenomena of both history and...dynamics' which are intractable to single-cause theories.[11]

There is also unease about methodology, despite continuing reliance on reference chronologies and trend-cycle decompositions. The former is accepted as a proxy for comovements in the 'many activities'. Beveridge (1944) proposed an index of industrial production as a proxy for a British 'trade cycle' from 1785, with an average peak-to-peak duration of eight years. Both Rostow (1948) and Gayer, Rostow and Schwartz measure peaks and troughs in 'general' conditions, though both distinguish 'major' from 'minor' episodes. Aldcroft and Fearon (1972) estimate reference peaks and troughs in the Deane (1968) UK GNP series. Ford (1981) attempts a similar analysis from income, investment and unemployment data. Later work which relies on reference-dating (or examines the idea critically) includes Huffman and Lothian (1984), who apply Burns and Mitchell's summary measures, Solomou (1987, 1994) and Dimsdale (1990).

Trend-cycle decompositions and the practice of smoothing data by moving average filters are common in postwar attempts to identify historical business cycles. Beveridge (1944) fitted a linear time-trend to his data (and then ignored half the peaks and troughs in the residual series, as pointed out by Kendall (1946)); Aldcroft and Fearon (1972) also detrended their data; and both Feinstein (1972) and Lewis (1978)

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[10]Volume 2, p. 614.

[11](1992) p. 9.

employed moving-average filters to emphasize 'cyclical' characteristics. Such practices have from time to time been questioned. Aldcroft and Fearon (1972) argue that the 'study of cycles throws up severe problems of definition and measurement', that the 'most important of these is the relationship between the cycle and the trend' and that it may indeed be that 'because the two are so inextricably linked together [it is] impracticable to make any distinction at all.'[12] Solomou (1994) comments that the trend-cycle decomposition 'procedure makes strong economic and econometric assumptions which may be misleading' if incorrect.[13] The time-series literature since the 1970s has shown that trend-cycle decompositions and moving-average filters can induce spurious effects.[14]

The trend component is normally modelled as linear, but this cannot be assumed *a priori*. Post-World War II macroeconomic time series tend to have optimal representations which are stationary in first differences rather than about a deterministic time trend, implying that 'trend' and 'cycle' are governed by the same data generating process. However the evidence for this in nineteenth century UK data is less extensive and at best mixed. Crafts, Leybourne and Mills (1989) have found that for three industrial production series, 1700–1913, 'there is no strong evidence against analysing [them] as though they are DS [difference-stationary] processes...'[15] On the other hand Crafts and Mills (1995) find 'strong evidence' of a cyclical component after 1874, but only in the (Crafts-Harley) aggregate; the component series are not considered.[16]

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[12](1972) pp. 4–5. See also Goodwin (1953).

[13](1994) p. 248.

[14]The literature on this point is substantial. See *inter alia* Chan, Haya and Ord (1977), Nelson and Kang (1981) and Harvey (1989).

[15](1989) p. 49.

[16](1995) p. 19.

Such research is designed primarily designed to investigate growth–rate behaviour of aggregates. The models are linear and univariate; none explicitly represents comovements or assesses nonlinearities in cyclical components for an entire data set, in particular the possible asymmetries between the durations of expansions and contractions. In the latter case it has been argued, e.g. by Sichel (1993), that linear models with symmetric disturbances are inappropriate.[17]

The term 'business cycles' has become an imprecise vernacular denoting a consensual view of short–run fluctuations as recurrent comovements of the majority of economic activities; yet one which appears to have been challenged by much of the historical time–series evidence. The scepticism shown by historians of the nineteenth century British economy has been of a strength insufficient to offer a serious challenge to the consensus. Nor has an objective assessment of the statistical evidence, without the standard identifying assumptions, yet been attempted.

With the possible exception of Solomou, who concentrates on growth–rate swings, economists still rely on the 'results' of Burns and Mitchell as a valid empirical foundation for business–cycle models. A dependence on reference chronologies which assumes that sectoral comovements are present in the data has obscured rather than clarified the issue. Evidence supporting the comovement hypothesis does not appear incontrovertible. The usual appeal to Burns and Mitchell for empirical verification is not sufficient; for *Measuring Business Cycles* was actually an interim report, its discussion limited to hypotheses for further investigation and to problems of methodology. Despite examining hundreds of time series, the best the authors could do was to establish diffused 'turning zones' rather than sharply defined clusters of peaks and troughs.[18] Furthermore, like Beveridge they 'weeded out' significant

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[17](1993) p. 235. See also the survey of nonlinear time–series models in Mullineux and Peng (1993).

[18](1946) pp. 70–1.

numbers of turning points to enforce the conformity of 'specific cycles' to their own *a priori* computations of the reference cycle, a practice which renders their results unreliable for purposes of empirical verification.[19]

Unsatisfactory documentation of comovements thus compromises the historiographical foundations of nineteenth century UK business cycles. There exists a possibility, even a presumption, that the standard methodology, with its trend–cycle decompositions and the 'weeding out' of 'nonconforming' turning points, obscures the dynamics of empirical behaviour with 'stylized facts'.[20] Indeed divergences appear to be the only feature directly observable in time–series data, a point which is at least implicit in most of the literature published since *Measuring Business Cycles* appeared in 1946. Stronger evidence of empirical regularities is required if reference dates and trend–cycle decompositions are to be permissible as modelling strategies.

III. Investigation of the Time–Series Evidence: an Assumption–Free Strategy

The weakness of the existing evidence requires that comovements be treated as hypothetical rather than conclusive. Whether business cycles are actually apparent in pre–1914 British historical data without the standard filters and transformations, and if so whether they evolved as a consequence of industrialization, cannot be resolved by an appeal to the results of previous quantitative research. In the interests of objectivity and consistency the identification of turning points must employ rigorous mathematical criteria unadulterated either by 'weeding' or by the filtering and decompositions implicit in time–series models. Moreover the multivariate nature of the hypothesis implies that turning points in vectors of variables, rather than in individual

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[19]These methods are described in *Ibid.*, Chapter 4, Section 4.

[20]Burns and Mitchell's statistical technique is increasingly criticized. For example, King and Posser (1994), p. 437, question whether the business cycles identified by this method are not merely statistical artifacts.

time-series aggregates, are the appropriate basic units of analysis. The relevant questions are:

1. whether the directly-observable fluctuations in nineteenth century British economic data are sufficiently homogeneous and conforming to be represented by a single set of reference dates or by turning points in an aggregate output measure;
2. whether short-run fluctuations developed into a general cycle during the nineteenth century; and
3. the extent to which expansions and contractions were asymmetric in duration.

Direct observation of the short-run fluctuations known to have existed in the pre-1914 period should help to establish whether they can actually be characterized as 'business cycles'.

The Identification of Turning Points. In accordance with the revised strategy turning points are defined as observable local time-series extrema: formally, an observation X_t in a time series $\{X_t\}$ is defined as a local maximum *iff* $(X_{tt} > \max\{X_{t-k}, \ldots, X_{t-1}\}$ *and* $(X_t > \max\{X_{t+1}, \ldots, X_{t+k}\})$. A local minimum is the mirror image of the above, i.e., with $> \max\{\ldots\}$ replaced by $< \min\{\ldots\}$. In practice each observation is examined for evidence of maximality or minimality within the 'window' length $[X_{t-k}, \ldots, X_{t+k}]$, from observation k to observation T-k (where T is the final observation in the series). Setting k=1 gives a minimum specific-cycle duration of two years, which follows the Burns and Mitchell criterion as closely as the annual sampling frequency permits. The window is hence the set of triplets of data points X_{t-1}, X_t, X_{t+1}, where t=1,...,T-1. No maximum duration is specified, since turning points according to this definition occur at sufficiently frequent intervals in most economic time series to permit specific cycles of the required length to be identified. (Such lengths are not, however, guaranteed; see below.)

The advantage of a mathematical metric is that it avoids the problem implicit in weeding: having to make subjective distinctions between conforming and non-conforming turning points. Enforcement of quantitative criteria permits algorithmic implementation via computer programs.

Historical Data: Coverage and Reliability. Price and output data are available from 1700 and 1760 respectively. The data sets are:

Prices: Sauerbeck's (1886), the *Statist* (1846–1870) and Rousseau's (1938) indices, 1815–1860; UK Board of Trade official statistics, 1871–1913; and O'Brien's (1985) industrial price indices, 1700–1815;

Output: Hoffman's (1955) industrial production, Feinstein's (1972) GDP, industrial production and GNP (expenditure) estimates, Lewis's (1978) GDP series, Feinstein and Pollard's (1988) investment and Crafts and Harley's (1992) revised industrial production index.[21]

Analysis is by sub-periods 1700–1760, 1760–1790, 1790–1815, 1820–1860 and 1855–1913. The Board of Trade and Sauerbeck/*Statist* indices were complied contemporaneously; Crafts and Harley's industrial production index is based on Hoffman's series with modified weightings.

Output data are subject to considerable error, as acknowledged throughout the literature. Some of the inaccuracies are self-inflicted, as in the Beveridge, Lewis and Aldcroft and Fearon estimates, which were 'adjusted' to conform to business-cycle priors by the imposition of moving averages and trend-cycle decompositions. Feinstein's (1972) 'best guess' at margins of error in his own estimates exceeds ±25 percent for some output series.[22] He also takes note of business-cycle priors: turning

[21]Some of these are obtained from Mitchell (1988): *viz.*, Sauerbeck, Rousseau and Board of Trade prices; and Feinstein and Pollard output data.

[22](1972) pp. 19–21 and Table 1.9. The reliability problem does not disappear in post-1945 national income accounts, even though these are estimated contemporaneously. The UK Office of National Statistics, for example, admits to error

points are compared to the original reference chronology, proposed by Mitchell and Willard Thorp in *Business Annals* (1926), and then 'adjusted' to conform to those dates. In practice this involves increasing or decreasing levels where the data clash with descriptions of trade conditions in the *Annals*, by ± 8 percent on average, while leaving mean levels unchanged.

The dangers in these several 'adjustment' techniques are various, but all risk the induction of 'spurious' peaks and troughs. These data sets are nevertheless included despite their shortcomings because they are in widespread use and because they form the quantitative basis for the prevailing historiography.

The Identification of Comovements. Burns and Mitchell insisted that specific cycles must comove, 'for if there were no bunching of cyclical turns there would be no business cycles answering to our definition'.[23] Operationally this must imply that component series turn at the same time as the aggregate in each data set, with comparatively few leads or lags. The necessary condition for 'bunching' or clustering is therefore that component variables have the same numbers of peaks and troughs as their aggregate, without 'weeding': in effect that aggregates behave as reference series for their components. The approach followed here is to determine for each data set whether turning-point numbers are equal for all variables and whether they are clustered. Possible evolution of behaviour is assessed by the analysis of sub-periods.

IV. Results

The turning-point data give an impression of fluctuations that were largely 'confused and heterogeneous'. Numbers vary substantially in all data sets, and 'leads' and 'lags' are in fact undefined unless turning points are weeded to enforce conformity with the

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margins of $\pm 2\frac{1}{2}$ percent for GDP, and up to $\pm 7\frac{1}{2}$ percent for some other series. See *United Kingdom National Accounts, Sources and Methods*, HMSO, third edition.

[23](1946) p. 6.

aggregates. Expansions turn out to be both more diffused and more persistent than contractions during the eighteenth and nineteenth centuries.

Variations in Specific–Cycle Lengths. Comovements require, at the least, that peaks and troughs in the principal aggregates largely coincide with those in GDP in any sample period. Table 1 lists peaks and troughs in Feinstein's indices of GDP, aggregate industrial production and investment, and in the Board of Trade wholesale price index, for the period 1855–1913. Also shown are the proportions of turning points common to GDP and each of the other three series: first, as a proportion of total GDP turning points; and second, as a proportion of the totals for the other series. The average specific–cycle length for GDP is approximately 7¼ years, with maximum and minimum lengths ten years and two years respectively, all within the parameters set by Burns and Mitchell and accepted by most business–cycle analysts.

Differences between the two measures are an indication of variations in turning–point numbers. The degree of comovement, as measured by turning points common to GDP and each of the other series, is variable and in some cases the turning points in one series do not even have equivalents in the other. As an example, the second measure for industrial production is 0.86 — i.e., all but two of its turning points (marked with an asterisk in the table) occur at the same time as those of GDP. Although on the face of it this indicates close conformity, the figure is misleading; it represents average behaviour for the period and hence reflects the ex post perspective. The first measure shows only two–thirds of GDP turning points (marked with a double asterisk) actually coinciding with those in industrial production. There is moreover a behavioural anomaly in the middle of the period: the four 'extra', i.e. non–equivalent, turning points in GDP — 1867, 1868, 1877 and 1878 — would have presented difficulties for any ex ante forecast relying on industrial production as a coincident indicator. The unweeded coincidence rate for industrial production in the sub–period 1855–1886 was only 50 percent of GDP turning points — a result which is effectively random. The ex post proportion of 0.67 was only achieved during the last three specific cycles, from 1886 to 1908, a pattern which could not have been reliably forecast from the experience of the 30 years to 1885.

The conformity of the investment aggregate is much weaker by both measures. Numbers of common turning points are only 11 percent of GDP totals and only 13 percent of own turns. No turning points at all are identified in the 16 years from 1886 to 1902; and so the peak-to-peak duration of 19 years (1883–1902) exceeds Burns and Mitchell's stipulated maximum specific-cycle length of 15 years.[24] This is an example of behaviour with which the standard approach to cycle identification is unable to deal: although 'extra' turning points can be weeded out, the 'missing' ones cannot be fabricated.

Turning points in the Board of Trade wholesale price index show little evidence of the pro-cyclicality usually assumed by business-cycle analysts. The coincidence proportions are low, and prices have a higher frequency of turns than output: 20 of these after 1871 against 12 for GDP, equivalent to mean specific-cycle lengths of 4½ years and 6½ years respectively. Divergences between price and output dynamics are also apparent in the earlier period, 1760–1860. The coincidence measures for the Crafts-Harley aggregate and two price indices, O'Brien's and Rousseau's, shown in Table 2, are in the range 0.08 to 0.25.

Variations in turning-point numbers appear to be a property of all data sets. Table 3 shows this examples for the period 1852–1913. The program identifies 195 turning points for 11 of 13 Feinstein industrial production variables. The expected total if all series fluctuated with the aggregate would be a multiple of the number of turning points (14) in the aggregate, i.e. $14 \times 11 = 154$. Departures from the expected value can be divided into 'extra' and 'missing' turning points, which are shown at the bottom of the table. The former are 'extraneous' turns in series with numbers greater than the

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[24](1946) p. 58.

aggregate, e.g. manufacturing, with 22–14=8 extra; the latter are those in series with smaller numbers, e.g. transport and communication, with 14–11=3 missing. ('Total' turns are in effect a net balance of extra and missing numbers.) The ratio of total to expected turning points shows an excess of 27 percent for industrial production and investment and 17 percent for GDP. Prices have a shortfall of 9 percent.

Such behaviour in not confined to the late nineteenth century. As shown in Table 4 for industrial production, variability increased during the Napoleonic wars. It is close to unity from 1820 to 1860, but because the figure is on a net basis the ratio does not tell the whole story. An inspection of column 3 reveals considerable variability — 38 'extra' and 20 'missing' turning points. The analysis indicates that an evolution to conforming cyclical behaviour during the period of industrialization is not supported. For industrial prices (Table 5) the ratio is high during the war period because there are only two turning points in the aggregate; in the other sub-periods it is less than unity, behaviourally similar to later nineteenth century prices.

Proportions of coincident turning points in component series are low in the period up to 1860. Calculations for the first conformity measure are shown in Table 6 for the O'Brien and Hoffman/Crafts-Harley variables. The latter increased in the mean proportion of coincidences from about one quarter, 1760–1815, to one third, 1820–60. Only tobacco shows a natural coincident relation with the aggregate, the two series having identical turning points. Prices have mean coincidences of less than 20 percent in both sub-periods; the highest, for brewing, is under 50 percent.

Mean specific-cycle lengths in Feinstein's industrial production and investment aggregates are 9 and 8¼ years respectively (from the data in Table 1). Those in the Crafts-Harley aggregate are shorter: 4½ years in the period 1760–1815, and 4⅞ years from 1820 to 1860 (based on Table 4). This may appear to lend some support to Ashton's view that fluctuations were more frequent in the earlier period; but unfortunately averages tend to obscure variations in behaviour. Moreover the evidence of Tables 1 to 6 clearly does not imply any evolution to a general business cycle.

The effects of turning-point variation can be summarized as frequency distributions. Table 7 shows a sub-period analysis for the Hoffman/Crafts-Harley data to 1860; Table 8 gives results for the later nineteenth century. Column 1 in both tables gives the range of possible turning-point numbers occurring in a single year, from zero to the maximum number of variables. The other columns show the number of years in the sample period in which each frequency occurred. If component series had actually comoved with their aggregates, their turning points would be found in the same years in which the aggregates reached peaks and troughs. Some years would hence show no turning points, while the rest would contain the maximum number, the relative frequencies depending upon the behaviour of the aggregate. As shown in Figure 1, the histogram for such perfectly clustered behaviour would be U-shaped. Of course as has been demonstrated empirical specific-cycle lengths diverge substantially. A simulated example of such dynamics is shown in Figure 2 for a hypothetical set of six variables whose specific cycles are all different, ranging from three to ten years. The effect of this is to give the frequency distribution a central peak, i.e., one neither at zero nor at the maximum number of turning points. All empirical distributions save Hoffman/Crafts-Harley, 1820-1860, have such peaks; and the latter has a flat rather than U-shaped distribution. There is thus little evidence of clustering either before or after 1820.

The Problem of Leads and Lags. Although Burns and Mitchell insisted on clustering as a necessary condition they conceded that the case for business cycles would not be compromised by the presence of some systematic leads and lags.[25] This presents analytical difficulties. Stable timing relations require that each turning point in the 'reference' series have a direct equivalent in the indicator series, and as has been

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[25]See the NBER bulletin 'Statistical Indicators of Cyclical Revivals' (1938).

established this is not the case. For example, although industrial production turning points in 1866 and 1869 have direct equivalents in the GDP series, those in the latter in 1867 and 1868 have no equivalent in the former. In such instances, which occur frequently in these data sets, the timing relation is strictly speaking undefined. Only proportions of coincidences can be measured, and as has been demonstrated these are weak owing to divergences in specific-cycle dynamics.

Table 9 gives examples for Feinstein's aggregates. Even when weeded the largely coincident relation between GDP and industrial production breaks down and becomes a lag relation during the 1880s. The difficulty with the weeding process is that it yields a highly stylized result which exaggerates coincidences. As has been shown the actual coincidence rate with GDP turning points up to 1886 is little more than 50 percent, whereas after weeding it jumps to 75 percent (12 out of 16 residual turning points). Moreover the 1885 peak in industrial production is a trough in GDP, and such out-of-phase behaviour is fairly common in nineteenth century time-series data. Conformity of investment to GDP is weak even after weeding, changing from leading to lagging to coincident relations several times during the sample period. Of the nine turning points which occur in the same years as those of GDP, five — in 1857, 1868, 1902, 1907 and 1908 — are actually out of phase (see Table 1).

Table 10 shows the effects of weeding on timing relations for 11 of the 13 Feinstein industrial production variables. Manufacturing, for example, jumps from 0.45 to 0.93. Most variables do not show consistent timing relations even when weeded. The only natural coincident indicator is a service-sector series, transport and communication, nearly three-quarters of whose unweeded turning points coincide with those of the aggregate. From columns 3 to 5 it can be seen that even when 'extraneous' turning points are ignored, a single timing relation is dominant in only three cases: the two manufacturing series, with over 90 percent coincidences; and transport and communication, with 80 percent. The other series are each spread between at least two timing relations, e.g., building, with 57 percent coincidences and 35 percent leads.

These are in any case obtained only after substantial adjustments: the three 'coincident' series require first, the weeding out of eight turning points in manufacturing to obtain a fit with the aggregate; and second, the removal of two and three turning points, respectively, in the aggregate to obtain agreement with the other manufacturing and transport and communication series (see Table 3, column 2).

Natural timing relations do not occur in these data, and so the Table 10 results are only of interest as an illustration of the pitfalls of the weeding strategy. Because different turning points in the aggregate are eliminated in each comparison, no common basis of comparability exists across the data set, and the aggregate cannot be used as an overall reference series. There is not, for example, a single turning point common to all 13 Feinstein industrial production series. The most turning points occurring in any one year is ten, in 1907; the average over the period 1855–1913 is only four per annum. Gas production has no turning points at all.

Asymmetries and Diffusion. It is acknowledged that the principal dynamic feature of the industrial revolution was economic growth.[26] In fact, growth has dominated short-run fluctuations in the past 200 or so years to the extent that modern quantitative business-cycle analysis has come to regard the two phenomena as being governed by a single data generating process.[27] The time-series literature has shown that secular growth may produce asymmetries between the durations of expansions and contractions.[28] Nearly all the output series in the present study tend to increase in levels over time. Table 11, showing year-on-year changes for industrial production series from 1760 to 1913, illustrates this tendency. Percentages of years in which

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[26]See, for example, Blanchard and Fischer (1989) Chapter 1.

[27]See the preface to Niemira and Klein (1994).

[28]There are, of course, other types of asymmetry proposed in the literature: 'steepness', 'deepness', etc. These are discussed *inter alia* in Sichel and in Mullineux and Peng, *op. cit*.

variables increased are generally higher than those in which they decreased, implying that expansions are more diffused and also of longer duration than contractions, both in individual variables and in overall terms. The exceptions are in the pre-Waterloo period: output of paper and malt rose in under half the years. The sub-period arithmetic means rose from 55 to 75 percent of years during the nineteenth century (bottom of the second, fourth and sixth columns); so that although the actual *rates* may have fluctuated, growth became more diffused through the economy as the century progressed. In fact, aggregate production increased in more than two-thirds of all years after 1820 by these calculations.

Asymmetries between numbers of series expanding and those contracting in a given year would thus be expected. Diffusion indices for the Hoffman/Crafts-Harley and Feinstein industrial production data sets, showing the percentages of series rising in a given year (Figures 3, 4 and 5), demonstrate this tendency clearly. Years above an index level of 50 are those in which a majority of series increased. Visual inspection reveals that all graphs are above this level in more years than they are below it.[29] The frequencies are shown in Table 12: the first column on each page gives the number of series which could have increased or decreased in a given year; the other columns show the percent of years in the sample period for each of these possible numbers. The first three columns for the Hoffman Crafts-Harley series, for example, show that in every year between 1760 and 1815 at least one series increased; and that in 7.3 percent of years none of these series decreased (i.e., the cells in the second and third corresponding to the value 0 in the first column). In 5.5 percent of years all eight series increased; but in no year did all decrease. The cumulations of the 'increases'columns for both sub-periods give a majority of Hoffman series (i.e., five or more) increasing in 47.3 of the years between 1760 and 1815 and in 80 percent of years between 1820 and 1860 (nine or more). On the other hand, a majority decreased

[29]The 50 percent level is sometimes used in diffusion research to distinguish years of 'recession' from those of expansion. See, for example, Simkins (1994), p. 387.

in about one quarter of the years from 1760 to 1815, and in 15 percent of years from 1820 to 1860. There were thus only half as many years in the period to 1820 in which the majority decreased as those in which the majority increased. A majority of Feinstein series (seven or more) increased in nearly 80 percent of years from 1855, but a majority decreased in only 19 percent of years. These 'diffusion asymmetries' suggest that 'recessions' — years of contraction in the majority — are fewer and hence much more difficult to identify and to track than expansions. Such evidence accords well with the postwar historiography of the nineteenth century British economy, which has found that conditions associated with years of contraction were often 'heterogeneous and confused'.

V. Conclusion

The results presented in this paper clearly show the limitations of the standard reference-cycle approach, which is unjustified by the actual dynamics of short-run fluctuations and which thus obscures their true nature. When applied to nineteenth century British historical data it yields, as Matthews and other have found, a picture of behaviour in which the conformity of specific cycles is tenuous and unpredictable. An analysis of historical data free of summary measures and data transformations has shown the following:

1. Reference measures do not capture the divergences in the British economic behaviour in the pre-1914 period. In all data sets variations in turning-point numbers are greater than those expected if the comovement hypothesis were supported. This is so even after data have been adjusted to conform to an *a priori* reference chronology. Conformity of variables within and across data sets is weak: the example of Feinstein's industrial production variables shows the average number of turning points per annum to be only four of a possible 13. Such divergences imply that no single variable, aggregate or component, is likely to serve as an adequate reference series for a whole data set.

2. Although specific cycles lengthened after 1860 there is no evidence of convergence to comovement. 'Business cycles' thus do not appear to have evolved with industrialization.

3. In the presence of such variation leads and lags cannot be properly defined. Attempts to do so require weeding which exaggerates the degree of coincidence; yet few series, even when weeded, have a dominant timing relation.

4. Expansions were both more persistent and more diffused than contractions. The latter were patchy and so would have been less predictable and less easily identifiable as general economic 'recessions'. If, as has been argued, asymmetric behaviour implies nonlinearity, then models with symmetric disturbances would be unlikely to capture the short-run time-series properties of these data. If, on the other hand, business cycles are not governed by a data generating process separable from that governing long-run behaviour, then linear difference-stationary models may be optimal.

These points merely reinforce the doubts and questions about the nature of short-run fluctuations raised by postwar economic historians. The time-series literature still hypothesizes, in a phrase of Niemira and Klein borrowed from Burns and Mitchell, a general 'rhythm of business activity', but no evidence of any such phenomenon emerges from the time series analysed here. On the contrary, when the various filters are removed the behavioural divergences — also described by Burns and Mitchell — are highlighted. Variation in turning-point numbers and the weak conformity of series seem to be a feature of all collections of historical variables. The business cycle in the UK economy before 1914 therefore appears illusory, and economic historians are well-justified in their reservations. These should perhaps have been made operational at an earlier stage.

TABLE 1

UK Macroeconomic Aggregates: Peaks and Troughs 1855–1913

Feinstein's GDP		Feinstein's Industrial Production	
Peaks	Troughs	Peaks	Troughs
1857**	1858**	1857*	1858*
1866**	1867	1866*	
1868	1869**		1869*
1876**	1877	1876*	
1878	1879**		1879*
1883	1885	1885	1886
1891**	1893**	1891*	1893*
1902**	1903**	1902*	1903*
1907**	1908**	1907*	1908*
Coincidences with GDP turning points:		0.67	
Coincidences with own turning points:		0.86	

TABLE 1 (continued)

	Feinstein and Pollard Investment		Board of Trade Prices	
	Peaks	Troughs	Peaks	Troughs
		1857	—	—
	1865	1868	—	—
	1872	1873	1873	1876
	1877	1880	1877	1879
	1881	1882	1880	1881
	1883	1886	1882	1887
			1889	1890
			1891	1896
			1898	1899
	1902		1900	1902
		1907	1904	1905
	1908	1909	1907	1908
Coincidences with GDP turns:	0.11		0.22 (after 1871)	
Coincidences with own turns:			0.20	

TABLE 2

Conformity of Price Fluctuations, 1760–1860

Crafts–Harley Industrial Production Aggregate 1760–1815		O'Brien Industrial Price Index 1760–1815	
Peaks	Troughs	Peaks	Troughs
			1761
1761	1763	1762	1764
1764	1765		
1767	1768		
1769	1770	1768	1770
1772	1774	1772	1773
1778	1779	1777	1781
1785	1786	1783	1785
1792	1794	1786	1789
1796	1797		
1799	1801		
1807	1808		
1811	1812	1810	1811
Coincidences with industrial production turning points:		0.08	
Coincidences with own turning points:		0.13	

TABLE 2 (continued)

Crafts–Harley Industrial Production Aggregate 1820–1860		Rousseau Price Index 1820–1860	
Peaks	Troughs	Peaks	Troughs
			1822
1825	1826	1825	
1829	1830		1830
		1831	1833
1836	1837	1836	1837
1839	1840	1839	
1841	1842		1843
1846	1847	1845	1846
		1847	1851
1854	1855	1856	1857
1857	1858	1858	1859
Coincidences with industrial production turning points:			0.25
Coincidences with own turning points			0.24

TABLE 3

Examples of Variations in Turning-point Numbers

Feinstein's Industrial Production 1855–1913		Feinstein and Pollard Investment 1855–1913	
Series	Number of Turning Points	Series	Number of Turning Points
Aggregate	14	Aggregate	15
Manufacturing	22	Manufacturing	16
Chemicals	18	Railway	17
Metals	28	Agricultural	18
Engineering	22	Residential	20
Textiles	25	Mining and quarrying	19
Food	22	Distributive	8
Other manufacturing	12	Transport and communication	25
Building	21	Gas	27
Transport and communication	11	Public sector	24
Gas	0		
Total	195		189
Expected	154		126
'Extra'	60		33
'Missing'	19		12
Total/expected	1.27		1.26

TABLE 3 (continued)			
Lewis GDP Series 1852–1913		Board of Trade Price Series 1871–1913	
Series	Number of Turning Points	Series	Number of Turning Points
GDP	18	Aggregate	20
Agriculture	27	Textiles	20
Construction	28	Coal	16
Distribution	18	Food and Drink	21
Manufacturing and mining	26	Animal Products	18
Transport of Goods	24	Sugar	17
Shipping	6	Wine	19
		Misc. materials	15
		Corn	17
Total	147		163
Expected	126		180
'Extra'	33		1
'Missing'	12		18
Total/expected	1.17		0.91

TABLE 4

Variations in Turning-point Numbers, 1760–1860: Hoffman/Crafts-Harley Industrial Production Series

Series	Number of Turning Points 1760–1790	1790–1815	1820–1860
Copper ore	18	8	16
Cotton yarn	18	13	—
Woolen and worsted cloth	16	14	20
Sugar	16	15	24
Malt	18	17	20
Paper	18	11	14
Ocean shipping	14	13	11
Pig iron and steel	—	—	10
Copper	—	—	15
Shipbuilding	—	—	17
Cotton goods	—	—	19
Silk goods	—	—	24
Bread	—	—	19
Tobacco	—	—	15
Leather	—	—	23
Building	—	—	2
C–H aggregate	14	9	16
Total	132	100	265
Expected	112	72	256
'Extra'	20	29	38
'Missing'	0	1	29
Total/Expected	1.17	1.39	1.04

TABLE 5

Variations in Turning-point Numbers, 1700–1815: O'Brien Industrial Price Series

Series	Number of Turning Points 1700–1760	1760–1790	1790–1815
Metals	15	10	12
Textiles	12	10	1
Brewing	7	7	4
Salt	20	9	3
Coal	21	8	8
Leather	6	6	5
Candles	16	10	9
Construction	27	10	8
Price index	19	13	2
Total	143	83	52
Expected	171	107	18
'Extra'	11	0	35
'Missing'	39	34	1
Total/Expected	0.84	0.71	2.89

TABLE 6

Proportion of Turning Points in Component Series Coinciding with Aggregate Turning Points: Analysis by Sub-periods

	O'Brien Industrial Prices Proportion			Hoffman/Crafts-Harley Industrial Production Proportion	
Series	1700–60	1760–1815	Series	1760–1815	1820–60
Metals	0.33	0.14	Copper ore	0.27	0.38
Textiles	0.25	0.20	Cotton yarn	0.23	—
Brewing	0.43	0.36	Woollen	0.39	0.7
Salt	0.20	0.08	Sugar	0.23	0.27
Coal	0.05	0.00	Malt	0.35	0.12
Leather	0.33	0.09	Paper	0.21	0.32
Candles	0.38	0.17	Ocean shipping	0.36	0.5
Construction	0.11	0.28	Pig iron and steel	—	0.33
			Copper	0.26	0.11
			Ship building	—	0.25
			Cotton goods	—	0.3
			Silk goods	—	0.33
			Bread, etc.	—	0.35
			Tobacco	—	1.00
			Leather goods	—	0.55
			Building	—	0.35
Mean	0.18	0.14	Mean	0.26	0.33

TABLE 7

Turning-point Frequency Distributions: Hoffman/Crafts-Harley Series 1760-1860

Number of Turning Points per Anum	Sub-period Frequencies			
	1760-90	1790-1815	1760-1815	1820-60
0	1	1	2	2
1	2	2	4	0
2	1	2	3	0
3	4	3	7	4
4	6	8	13	4
5	12	6	18	4
6	3	2	5	7
7	2	2	4	4
8	0	0	0	7
9				4
10				2
11				1
12				2
13				0
14				0
15				0
16				0

TABLE 8
Turning-point Frequency Distributions 1852–1913

Number of Turning Points per Annum	Feinstein Industrial Production	Feinstein and Pollard Investment	Lewis GDP	Board of Trade Prices	Feinstein GNP Expenditure
0	5	4	12	2	4
1	4	9	13	3	11
2	7	8	10	9	30
3	7	10	6	4	19
4	9	9	6	5	8
5	10	7	6	7	8
6	5	7	7	5	2
7	6	3	0	4	
8	1	0		2	
9	2	0		0	
10	1	0			
11	0				
12	0				
13	0				

TABLE 9

Variations in Timing Relations after Weeding: Feinstein's GDP and Industrial Production Aggregates, 1855–1913

Turning Points			Turning Points		
(1) GDP	(2) Industrial Production	(3) Timing Relation	(4) GDP	(5) Investment	(6) Timing Relation
1857	1857	C	1858	1857	Lead
1858	1858	C	1866	1865	Lead
1866	1866	C	1869	1868	Lead
1869	1869	C	1876	1877	Lag
1876	1876	C	1879	1880	Lag
1879	1879	C	1883	1883	C
1883	1885	Lag	1885	1886	Lag
1885	1886	Lag	1902	1902	C
1891	1891	C	1908	1907	Lead
1893	1893	C			
1902	1902	C			
1907	1907	C			
1908	1908	C			

TABLE 10

Proportions of Component Turning Points Coinciding, Leading and Lagging Feinstein's Industrial Production Aggregate 1855–1913

Series	(a): Proportion of 'Unweeded' Turning Points Coinciding	(b): Proportion of 'Weeded' Turning Points		
		Coinciding	Leading	Lagging
Building	0.38	0.57	0.35	0.08
Chemicals	0.22	0.33	0.58	0.09
Distribution	0.11	0.25	0.25	0.5
Engineering	0.36	0.57	0.36	0.07
Food	0.32	0.57	0.14	0.29
Metal	0.11	0.35	0.5	0.15
Manufacturing	0.45	0.93	0.07	0.00
Mining	0.35	0.50	0.36	0.14
Other manufacturing	0.58	0.9	0.1	0.0
Transport and Communication	0.73	0.8	0.2	0.0
Textiles	0.24	0.43	0.29	0.28

TABLE 11

Percentages of Years with Increases in Levels, Industrial Production Data

Hoffman Crafts/Harley 1760–1815		Hoffman Crafts/Harley 1820–1860	
Series	Percent of Years Increasing	Series	Percent of Years Increasing
Copper ore	61.8	Copper ore	67.5
Cotton yarn	56.4	Pig iron	75.0
Woollen Cloth	58.2	Copper	57.5
Sugar	40.0	Ship building	55.0
Malt	57.2	Cotton goods	80.0
Paper	43.6	Woollen Cloth	65.0
Ocean shipping	58.2	Silk goods	55.0
Aggregate	70.9	Bread	65.0
		Sugar	57.5
		Malt	60.0
		Tobacco products	72.5
		Leather	57.5
		Building	95.0
		Ocean shipping	75.0
		Paper	72.5
		Aggregate	67.5
Mean	55.8		67.3

TABLE 11 (continued)

Feinstein Industrial Production 1855–1913

Series	Percent of Years Increasing
Building	58.6
Chemicals	70.7
Distribution	94.8
Engineering	60.3
Food	72.4
Gas	100.0
Metal	62.1
Mining	74.1
Transport and communication	79.3
Textiles	60.3
Other manufacturing	81.0
Total manufacturing	70.7
Total industrial production	74.1
Mean	73.7

TABLE 12

Diffusion of Expansions and Contractions in Industrial Production Data

1760–1913

Hoffman/Crafts-Harley 1760–1815

	Percent of Years with:	
Number of Series	Increases	Decreases
0	0	7.3
1	7.3	3.6
2	5.5	18.2
3	12.7	21.8
4	27.2	23.6
5	21.8	16.4
6	16.4	3.6
7	3.6	5.5
8	5.5	0.0

TABLE 12 (continued)		
Hoffman/Crafts-Harley 1820–1860		
	Percent of Years with:	
Number of Series	Increases	Decreases
0	0	5.0
1	0	2.5
2	0	7.5
3	0	2.3
4	2.5	1.5
5	7.5	7.5
6	2.5	17.5
7	5.0	2.5
8	2.5	5.0
9	7.5	7.5
10	15.0	5.0
11	12.5	0.0
12	7.5	2.5
13	22.5	0.0
14	7.5	0.0
15	2.5	0.0
16	5.0	0.0

TABLE 12 (continued)

Feinstein Industrial Production 1855–1913

	Percent of Years with:	
(7)	(8)	(9)
Number of Series	Increases	Decreases
0	0	15.5
1	1.7	22.4
2	0	12.1
3	3.4	17.2
4	3.4	10.3
5	5.3	1.7
6	6.8	1.7
7	0	6.9
8	5.2	5.2
9	12.1	1.7
10	12.1	3.4
11	17.2	0.0
12	20.7	1.7
13	12.1	0.0

Figure 1. Turning–point Frequencies with Perfect Clustering

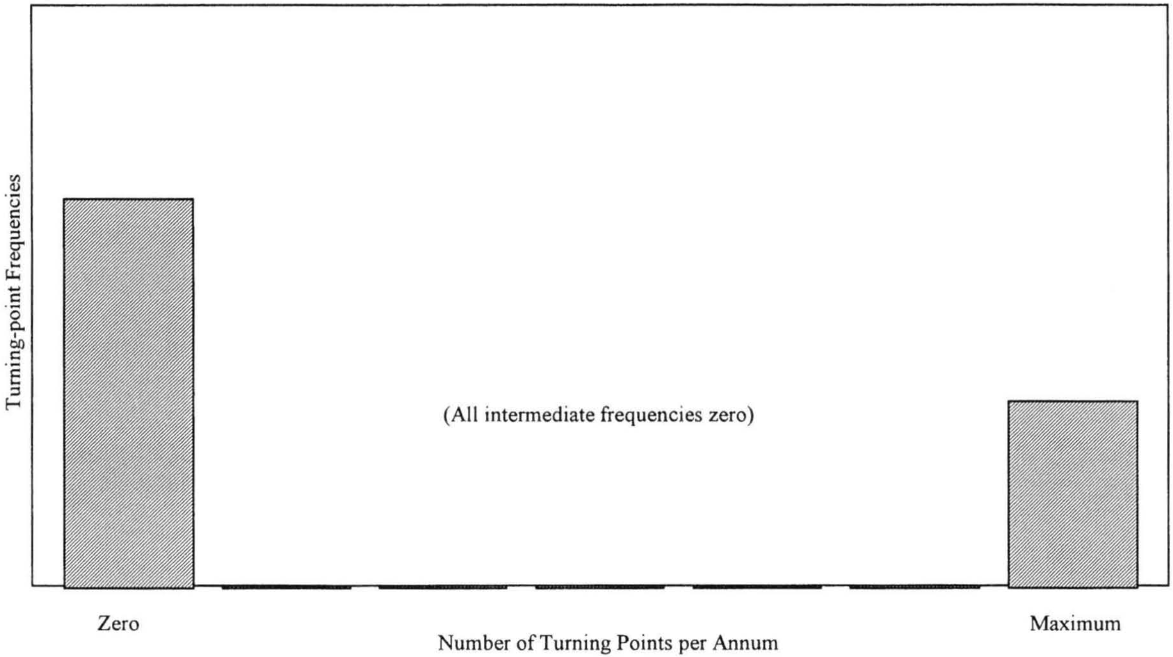


Figure 2. Turning–point Frequencies with Differing Specific–cycle Lengths

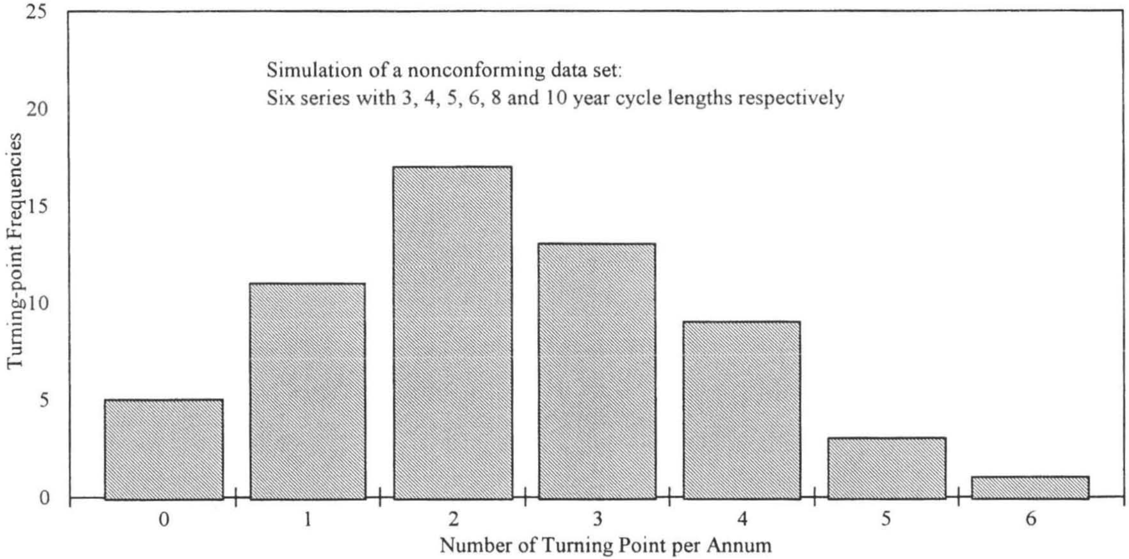


Figure 3. Diffusion Index: Hoffman/Crafts–Harley Data, 1760–1815

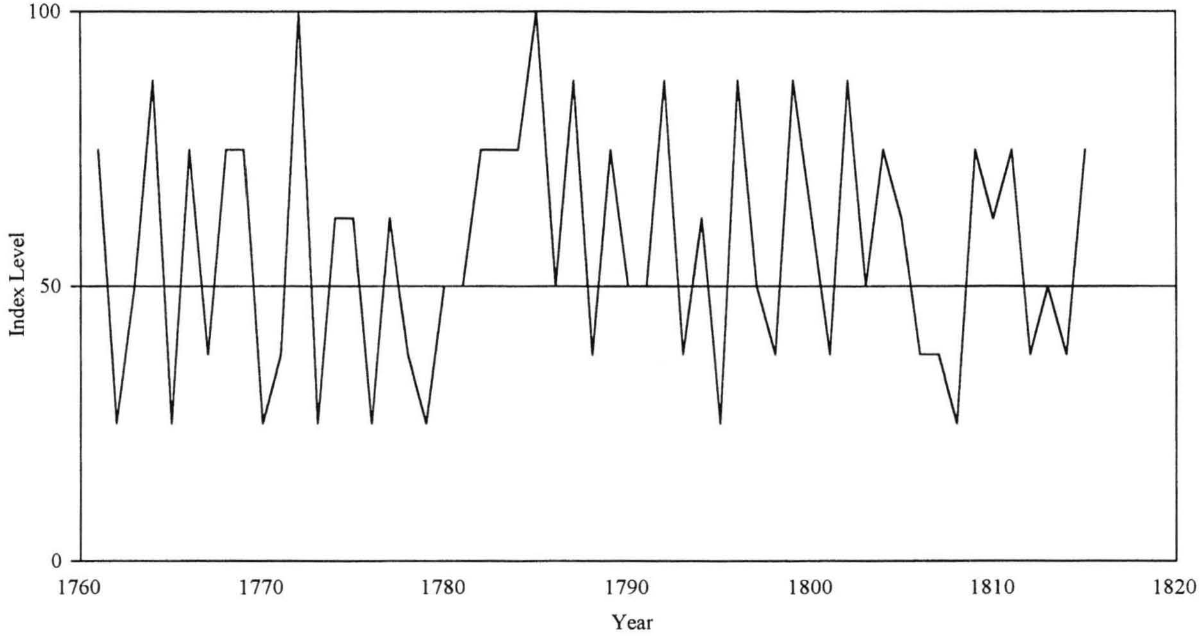
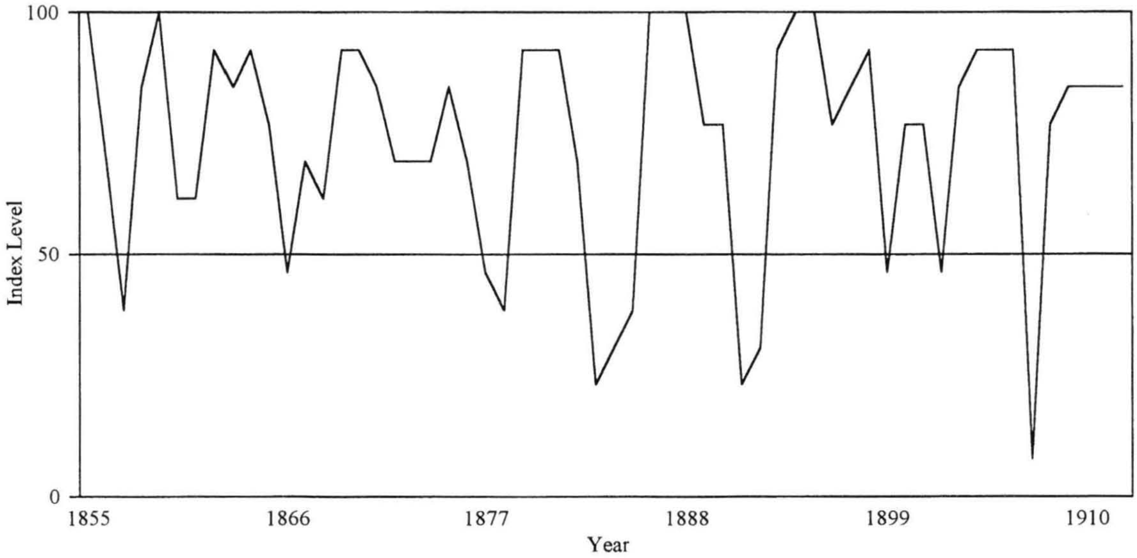


Figure 4. Diffusion Index: Hoffman/Crafts–Harley Data, 1820–1860

Figure 5. Diffusion Index: Feinstein's Industrial Production Data, 1855–1913



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