Identifying International Business Cycles in Disaggregate Data: Germany, France and Great Britain

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Abstract

This article analyzes international business cycles in Europe 1862-1913 using disaggregated data and Dynamic Factor Analysis. In comparison with estimates of real national product there is more evidence for international business cycles in disaggregated data of Germany, France and Great Britain before World War I. This is because data used to construct historical national accounts are often not sufficient to date business cycles. Especially, general price fluctuations that are used to deflate national accounts in current prices are badly documented. Thus, national products in current prices seem to give a more accurate picture of real business cycle fluctuations than their deflated counterparts.

Keywords: International Business Cycles, Historical National Accounting, Disaggregate Data, Dynamic Factor Models

JEL-Codes: E31, E32, F15, N13, N73

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1 Introduction

The analysis of international business cycle comovement has lately received little impetus from economic history research. In the light of the recent world economic crisis, however, the demand for answers from this research discipline has increased.[1] In order to correctly understand the causes of crises one of the key features one has to know if downturns are of national or international nature, and which institutions are likely to foster or prevent common business cycles. Given a normative consensus about the favored degree of cyclical comovement political effort could lead to a better design of economic institutions.

History could be a good test for which institutions lead to closer economic fluctuations. Especially the data from the time of classical gold standard (1880-1914) could provide some valuable insights, because this period seems to be good example of institutions leading to conformity between nation's ups and downs.[2] In times of the classical gold standard, economies were characterized by stable prices, flexible labor markets, innovative corporations and little government spending. Furthermore, stable exchange rates, high factor mobility and well-developed commodity market integration were features of that period. However, while this should be paired with high international output correlation, at least between the industrialized core of Europe, empirical evidence shows mostly the opposite (Backus and Kehoe 1992, A'Hearn and Woitek 2001, Haroon, Simonelli, and Surico 2009). So what is wrong, theory or evidence?[3]

The evidence on international business cycles for the 19$^{\text{th}}$ century stems usually from historical national accounting. When it comes to national accounting errors before World War I, the simple lack of trustworthy data is one of the main culprits. Indeed, national product estimations may include more noise than signal.[4] They are therefore ill-suited to reconcile the contradicting thoughts and observations on 19th century international business cycles. This paper uses a dynamic factor model to analyze historical international business cycles. It demonstrates that most of cyclical fluctuations before World War I had an international character and therefore confirms the theoretical considerations favoring strong international business cycle comovement during the classical gold standard.

Using estimations about national accounts to determine cyclical comovement is a questionable approach due to both lack of data and adequate aggregation methods. Uebele and Ritschl assume that a financial market index for Germany for the period 1870-1913 provides a better indicator for cyclical movement than any of the four estimations of National Net Product (NNP), which differ among each other

[1] An important sign is the great interest in Barry Eichengreen's and Kevin O'Rourke's blog, which compares macroeconomic indicators between the 1930s and today. See http://www.voxeu.org/index.php?q=node/3421

[2] Flandreau and Maurel (2005) show the relation between monetary unions and business-cycles.

[3] Baldwin and Martin (1999) warn against exaggerating the similarity between the first and second globalization. However, the differences they point to do not solve the contradiction found here.

[4] Ñote that in the interest of readability, the different types of national accounting are grouped under the umbrella term "national product," even if national income is actually meant. I further discuss definitions and calculation methods in the chapter 3.

significantly (Hoffmann 1965, Hoffmann and Müller 1959, Uebele and Ritschl 2009), and use the stock index as a benchmark to discriminate between them. This shows that the choice beween different estimations for the same national aggregate itself must have a great influence on the level of correlation between international business cycles. Doubtless, this problem is not limited to German data but also affects other countries in a similar way.[5]

Furthermore, Uebele and Ritschl (2009, p. 46) point to the fact that the cyclical characteristics of price data contribute massively to the problem above as they illustrate by a comparison of nominal and real NNP estimations. Since Hoffmann's and Hoffmann/Müller's original datasets in nominal prices were deflated ex-post Burhop and Wolff (2005), the huge discrepancies between turning points of those series in real prices almost disappear if the series are compared in nominal prices (Uebele and Ritschl 2009, p. 47).[6] One possible solution to handle such problems is the construction of better deflators. Unfortunately, this requires a collection of new data and the probability of success is not necessarily high. In contrast, using single series directly for dating business cycles aggregated by a statistical procedure appears to have a higher rate of return. For some countries, this method has been successfully applied already(Gerlach and Gerlach-Kristen 2005, Grabas 1992, Sarferaz and Uebele 2009, Spree 1977).

With contemporary US data, better performance of dynamic factor models based on disaggregated time series compared to national accounting could be shown, especially for nowcasting the current state of the economy, which is rendered difficult by regular data revisions (Stock and Watson 1998, Otrok and Whiteman 1998). A further application of the technique to modern data is Brümmerhoff and Grömling (2010), where the author shows that the 1998 version of nominal West Germany's GDP between 1970 and 1990 differs substantially from its 2006 revision. Additionally, Ciccone and Jarocinski (2009) indicate that diffent versions of income estimations in the Penn World Tables heavily influence the determinats of economic growth of 67 countries.

There are some works analyzing international business cycle comovement using dynamic factor models; however on the basis of national accounting data (Kose, Otrok, and Whiteman 2003, Haroon, Simonelli, and Surico 2009). For periods without national accounting, the value of such analyses is limited: even the best method cannot produce reliable results using bad data. So far, there is only one international analyses using the disaggregate approach for Latin America countries (Aiolfi, Catao, and Timmermann 2006) but none that addresses the puzzle of gold standard members and their alleged business cycle correlation. By using data for France, Germany and Great Britain, this paper carries out that approach. It explains the method, discusses the results and relates them to previous research.

[5] France: Lévy-Leboyer and Bourguignon (1990), Toutain (1997); Great Britain: Feinstein's estimations based on the income and expenditure accounts Feinstein (1972); USA: Balke and Gordon (1989a), Romer (1989).

[6] Note that use the term "turning point" not in its strict mathematic sense; i. e. where the second derivative equals zero. Instead, I use it in the more common sense of peaks and troughs, or, in the language of differential calculus, where the first derivative equals zero.

2 The Model

The method is a so-called dynamic factor model (DFM). The basic motivation to use it is similar to that of using diffusion indices (Burns and Mitchell 1946), but it differs in the statistical rigor.[7] Both methods use time series from various sectors of the economy as indicators for aggregate economic performance. Due to progress in time series econometrics, however, a proper formalization was introducted to quantitative macroeconomics in the late 1980s (Stock and Watson (1989), Stock and Watson (1991) and Stock and Watson (1998), but see also Sargent and Sims (1977)).

Trying to construct national accounting aggregates with historical time series leads often to unsatisfactory results for business cycle analysis, because these series do not match the strict criteria for national accounts. In contrast, DFMs are able to accomodate series such as the number of letters posted per year (Gerlach and Gerlach-Kristen 2005). Economic reasoning suggests that such series contain valuable information about the state of the economy, but formal restrictions dictate that not all of them can be used in classical national statistics. In rare data environments, DFMs are therefore often more efficient in exploiting scarce data resources.

When Burns and Mitchell (1946) performed their analysis, most time series were analyzed by experts. The use of computers to perform that task has doubtlessly increased the speed and reliability of the research, but the necessary formal procedures also led to a more abstract approach and therefore increased the approach's transparency. The computer scans the time series for their common component and then decomposes each series in a common and variable-specific part. While the common component or the "factor" describes the common movements of all series, the specific component one characterizes the varying component . Thus the metalworking industry could be positively affected by a booming economy (common factor), but could deviate from overall trend through bad management (specific component).

The decomposition is

$$y_{it} = \lambda_i f_t + u_{it} \tag{1}$$

where y_{it} reflects the value of the series i at point of time t, and f_t reflects the common component.[8] In consequence, u_{it} is the residual that equals the specific component for series i. λ_i is a series-specific weight that designates the level of correlation between the factor and every series y_{it}.

The model assumes an autoregressive process for the dynamics of the common component, so that the current value of a series is determined by its past values:

$$f_t = \phi_1 f_{t-1} + \phi_2 f_{t-2} + ... + \phi_q f_{t-q} + \epsilon_t \tag{2}$$

f_t is the actual index value of economic activity and f_{t-1}, f_{t-2}, ... f_{t-n} are its past values. $\phi_1, \phi_2, ..., \phi_q$ are unknown parameters, describing the dynamic structure. ϵ_t

[7] Diffusion indices for Germany have been constructed by several authors (Spiethoff 1955, Spree 1977, Spree 1978, Grabas 1992).

[8] Hereafter, I will also use the term "diffusion index" to describe the "factor," since these are conceptually (but not econometrically) similar and economic historians are familiar with the former expression.

is an error term. I assume that its mean is 0, that its variance is constant, and that there is no correlation with the specific component u_{it} in equation 1.

The number q explicates how much correlation goes back in time. Coefficients larger than q are assumed to be zero. (If there are values f_x that in fact influence the value of f_t, but their coefficient ϕ_x is zero (since $x>q$), q was chosen too low.) At the same time, q should not be defined too large, since the calculation of the parameters requires more data, which is the limiting factor in historical quantitative research. Referring to Burns and Mitchell (1946, p. 3), who postulate an average period of eight years for business cycles, I choose q=8. For a business cycle model, this is of course a relevant parameter choice. For the trend-cycle decomposition, I have chosen the most common method: logarithmizing the data and using the Hodrick-Prescott filter.[9]

Similar to the common component, I allow for autocorrelation of the specific component:

$$u_{it} = \theta_1 u_{it-1} + \theta_2 u_{it-2} + ... + \theta_p u_{it-p} + \omega_{it} \quad (3)$$

The error terms ω_{it} are not correlated in the cross section, since the common component, by definition, reflects the common part of all fluctuations. Furthermore, I assume that p, the number of lagged terms, is one.

There are some difficulties with the estimation of such a model. First, there are no observations for independent variables in equation 1. Thus I have to identify the common factor *and* the parameters λ_i, the AR-coefficients and the error term's variances. This is done applying a Bayesian method which allows for decomposing the joint distribution of these unknowns in conditional distributions.[10] Since Bayesian statistics always relies on making random draws from distributions of random parameters, an iterative procedure starts by assuming arbitrary values and making random draws from the conditional distributions. One of the recurring steps applies the Kalman filter to estimate the factor conditional on the parameters λ_i, and the distribution parameter of the error terms.[11] As a side benefit, results do not just include point estimations but also quantify their particular uncertainty, e.g. in terms of standard deviation. Moreover, error bands illustrate point estimations and their uncertainty graphically.

I will also identify the explanatory power of the common component by calculating the coefficient of determination for each series, and table it in descending order. This will allow for discriminating between the important and irrelevant sectors in the data set, and show which countries are represented better.

Experiences with historical data suggest that in the second half of the 19$^{\text{th}}$ century, industrial series are explained better by the common component while agricultural series are less well explained (Sarferaz and Uebele 2009, p. 384). Thus I am

[9] The respective discussion paper regarding the Hodrick-Prescott filter was published in 1980 at Carnegie Mellon University. It was published in the Journal of Money, Credit & Banking as late as 1997 (Hodrick and Prescott 1997). See also Ravn and Uhlig (2002) for the choice of the smoothing parameter.

[10] Classical statistics using the the maximum likelehood method are applicable, too. However, they do not use data efficiently (Kose, Otrok, and Whiteman 2003, p. 1220f).

[11] See Hamilton (1994, Chapter 13) for the Kalman filter and state space models.

Table 1: Composition of country data sets

	Britain	France	Germany
Coal/Metal	3	4	5
Textiles	3	-	3
Food	3	5	3
Transport	1	5	-
Finance	-	1	2
Other	5	-	2
Real	15	14	8
Nominal	0	1	7

able to reduce the complexity of the data by identifying the series with high explanatory power. These should be those that are closely correlated with many of the other series in the sample. The economic interpretation may be that manufacturing is a vertically highly integrated sector, where the production processes include usually more stages than in mining or agriculture. A higher average explanatory degree of the diffusion index is therefore related to an increase of the industrial output share.

There are several other methods to estimate comovement, such as the well-known principal components analysis (PCA) (Hartung and Elpelt 2007, p. 527-533). In contrast to dynamic factor analysis, PCA does not require any assumptions about the structure of the data, since it is non-parametric, but this has also a downside: the time dimension is not taken in account. PCA treats cross-sectional datasets and time series equally. In this sense, it is a deeply ahistorical.

3 Data

The dataset contains 15 series for France, Germany and Great Britain in the period 1862-1913 (Table 1). I have used only readily available data, including time series for France from the NBER Macrohistory Database,[12], data for Germany from Spree (1978), and the industrial production index for Great Britain by Hoffmann (1955).[13]

Spree's dataset consists of 18 time series and is the foundation of his analyses of German business cycles from 1820-1913 (Spree 1978).[14] Table 1 provides an overview about the elements of his dataset in comparison to the other two.

Hoffmann's data from the British industrial sector starts in parts dated already in 1700 and contains real production data of the various manufacturing sectors. The five "other" series in Table 1 include tobacco, paper, and leather production.

The French data set is based on several statistical publications such as the *Annuaires Statistiques de la France* and one from the Department of Transport.[15] The

[12] http://www.nber.org/databases/macrohistory/contents

[13] Spree's and Hoffmann's series can be downloaded from http://www.histat.gesis.org.

[14] Sarferaz and Uebele (2009) apply the dynamic factor model to this data set.

[15] For further sources, see remarks at the Macrohistory Database.

data set contains mostly information about the transport and food sector. Apart from one, all data is given in real values.

The question may be asked whether diffusion indices from two countries are comparable, although they are not composed of series from the same sectors and of the same kind.[16] If comparability was not given, it would reduce the power of the method considerably. In this case all series that are not available for both countries would have to be deleted.

Initially, two aggregates from different data sounds indeed dubious. But these concerns can be dispelled. First of all, the argument for identical data sources assumes that each single series has a certain impact on the results. But with the examination of the correlation between the series, the method aims to identify those series which have a big influence and those which have not. A series which is hardly correlated with the others is weighted less, and may even have no influence on the aggregate whatsoever.[17]

Furthermore, national accounting aggregates from different countries use different datasets as well – but their comparability across countries has not been questioned in the literature so far. While one of the principles of national accounting is comparability, historical national accounting repeatedly replaces missing data by interpolation, which has considerable effects on the cyclical characteristics, and the data missing are of course not the same in different countries.[18] A consequent application of the principle "same data for all countries" would have to result in a revision of all historical national accounting products.

It appears therefore a pragmatic approach to cautiously use all available data to begin with, and an analysis of the composition of the factor and its economic implications should follow. In the following, I describe the how exactly the model is applied, and then present the results and discuss them with regard to the history of international business cycles.

4 Research Design

The series to investigate consist of net national product (NNP) in current and constant prices, as well as three single series data sets, likewise nominal and real ones.[19] All series, including NNP series, are logarithmized and Hodrick-Prescott filtered in

[16] Broadberry and O'Rourke (2010, Ch. 4) discuss that topic.

[17] For this reason, the data is not weighted *ex ante*, either. For instance, steel production and sugar consumption are treated equally although it can be expected that steel is much more important than sugar.

[18] For a summarizing critique of Hoffmann's national accounting series for Germany, see Burhop and Wolff (2005). A sophisticated comparison of the French counterparts can be found in Baubeau and Cazelles (2009).

[19] For the German NNP, I use Hoffmann's income-based estimations by Burhop and Wolff (2005, p. 651f). Uebele and Ritschl (2009) provides a detailed reasoning for this selection. For the british real aggregate, I use the compromise estimate by Feinstein (1972, Table 6, p. T18, column 13). For the nominal aggregate, see Feinstein (1972, Table 1, p. T4, column 13). For the french nominal national product, I use the NNP at factor costs by Lévy-Leboyer and Bourguignon (1990, Table A-1, p. 312ff, column 10). The french real aggregate can be found in Maddison (2001, p. 424-426). For the period 1862-1870, Maddison uses his own but revised estimates from Maddison (1995), see Maddison (2001, p. 405) for an explicit explanation.

order to exclude long-term trends.[20] The smoothing parameter is set to 6.25 (Ravn and Uhlig 2002).

The degree of linear correlation is given by a plain correlation coefficient, which is very widespread. One may also use other methods such as frequency specific coherency as in Uebele and Ritschl (2009), but this has the downside of making the paper even more technical. Since the main message does not depend on this, I do without more sophisticated correlation statistics.

I will put the emphasis on two problems related to the aggregation of historical time series which may artificially reduce cross country cyclical comovement. The first deals with the role of deflating nominal NNPs. It is commonplace that nominal NNPs tend to have a greater match than real NNPs. This is even true for data of the same country from different sources, which should be exactly identical in theory. (For example, in the more recent historiogaphical literature on Germany, disregarding this problem has led to rather implausible results for the 1870s (Burhop and Wolff 2005).)

The second issue is that aggregating historical series along the lines of modern accounting rules yields potentially unsatisfying results. Therefore, I use a statistical aggregator which summarizes the common fluctuations of a given country.

In a final step, I develop an *international* diffusion index. This index is based on all 45 series and does not discriminate by country or sector, but weights the series corresponding to their degree of mutual synchronization. By definition, this index reflects the "natural" maximum of international business cycle symmetry in the given data set. It is for example possible that there are international similarities at the sectoral level, which disappear if the data are first aggregated at the national level but remain informative in an international diffusion index. All national aggregates, be they from accounting or a statistical procedure, can thus be compared against this upper limit.

The diffusion index based on international data shifts the focus to another important question: Which sectors are reflected by those series, which indicate a higher international correlation than others? Hence, I calculate the coefficient of determination of the international diffusion index for each series and illustrate my results in descending order in Table 4.

5 Results

5.1 Real and Nominal Business Cycles

Researchers distinguish between nominal and inflation adjusted data to separate real changes in standard of living and price effects. If national product is used as an indicator for the standard of living, using inflation adjusted aggregates is essential.

[20] There is an intense discussion about trend filtering in the literature. Amongst others, the Hodrick-Prescott filter applied to difference-stationary data may generate artificial business cycles on a particular frequency, depending on how the smoothing parameter is set A'Hearn and Woitek (2001). In this case, results are sensitive to the chosen filter. Please contact me for the respective results.

Most historical accounting series are constructed in current prices, and then divided by a price index, which equals a real national product.[21]

The real national product is the obvious choice when investigating international business cycles as Backus and Kehoe's famous paper demonstrates . Table 2 shows correlation coefficients between real NNPs of Germany, Great Britain and France. While correlation between real output is positive, it is nevertheless small.[22] Backus and Kehoe (1992) indicate even less correlation between British and German Business Cycles (0.03) for example. The differences to Backus and Kehoe's results are most likely due to slightly different observation periods and HNA-series, and underline the measurement problems when it comes HND-data. Figure 1 shows the detrended real national products: there are little similarities between the three nations until 1880 but a common peak in France and Germany around 1900.

A higher correlation can be found for the nominal national products in the second part of Table 2. German and French nominal business cycles correlate well (0.65) and also their correlation with Great Britain is significantly higher than in real terms. Indeed, Figure 2 demonstrates that international business cycle comovement in the 19th century can be identified by national accounting; note for example the upswings in the 1870s and late 1890s. The finding of these high correlations is not trivial when considering the discussion about the problems national product estimates. It may be a sign that a large part of the data problem may indeed be connected to the process of deflating output aggregates in current prices.

Another reason may be that prices correlate internationally far better than output data in general.[23] If so, I should find an even higher degree of international comovement in price indices, and the correlation of output in current prices should lie somewhere between the cross border correlations of real output and prices, respectively. This, however, is not the case for our data as part three of Table 2 indicates: For no country pair inflation is correlated higher than the production in current prices. As a consequence, the degree of international output correlation can not be attributed to a simple linear combination of price and volume correlation. Instead it seems to be due to the particular (and non-linear) combination of output and prices indices. Looking at nominal cross country correlation may therefore be only half-satisfying but still convey much more about international business cycle similarity than real output evidence.

This problem gains even more relevance in the discussion about business cycles of Germany and its neighbors in Section 4. In the case of Germany, the division of different nominal NNP estimations by the same price index lead to surprising results: They may lead to reversed cycles. Once more, this demonstrates that even the correct application of a method can lead to deceptive results due to lack of sufficient data.

In sum, since the quality of historical price indices is highly questionable it is a promising field of research. The next section deals with the question which role

[21] Exceptions are of course the estimates from the output side, which are calculated in real numbers per se. Therefore this paper focuses on income and expenditure approaches.

[22] Artis and Okubo (2009), Haroon, Simonelli, and Surico (2009) and Bergman, Bordo, and Jonung (1998) present similar findings.

[23] I obtained the deflators implicitly from the respective real and nominal national product series.

Table 2: Correlation coefficients

1. Between HNA-Aggregates
in Prices of 1913

	Britain	France	Germany
Britain	1	-	-
France	0.15	1	-
Germany	0.32	0.33	1

2. Between HNA-Aggregates
in Current Prices

	Britain	France	Germany
Britain	1	-	-
France	0.45	1	-
Germany	0.52	0.65	1

3. Between Price Indices

	Britain	France	Germany
Britain	1	-	-
France	0.35	1	-
Germany	0.42	0.44	1

4. Between National Diffusion Indices

	Britain	France	Germany
Britain	1	-	-
France	0.54	1	-
Germany	0.59	0.69	1

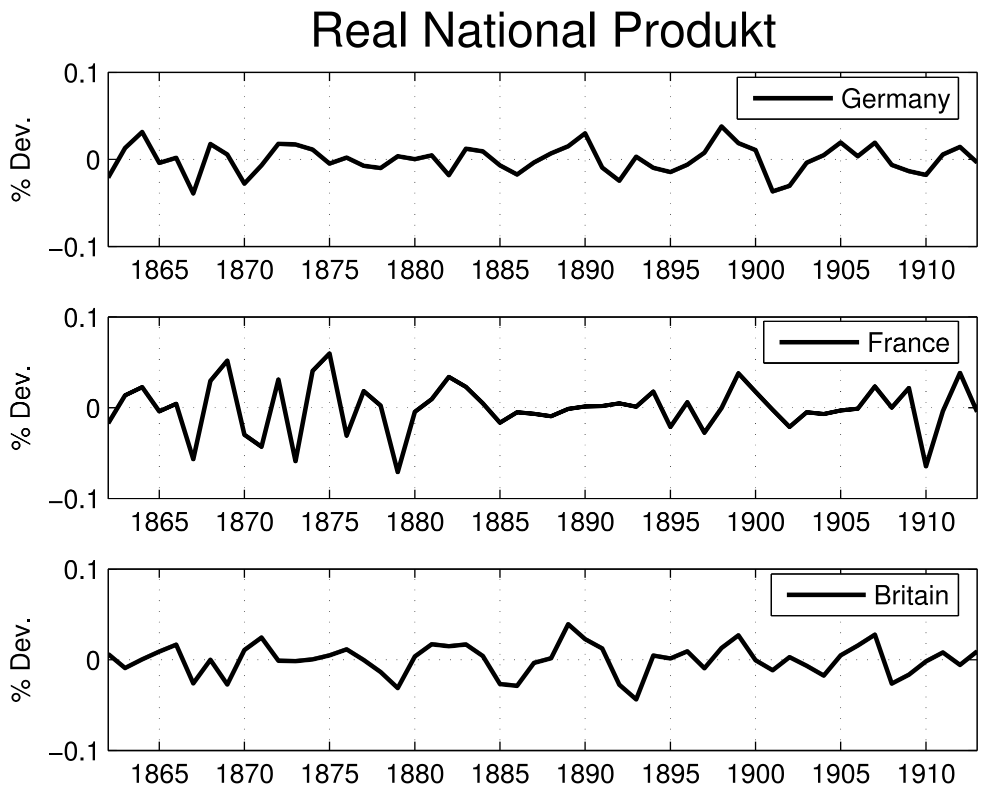

Figure 1: Real national product fluctuations, 1862-1913.

aggregation methods of historical time series play in business cycle research.

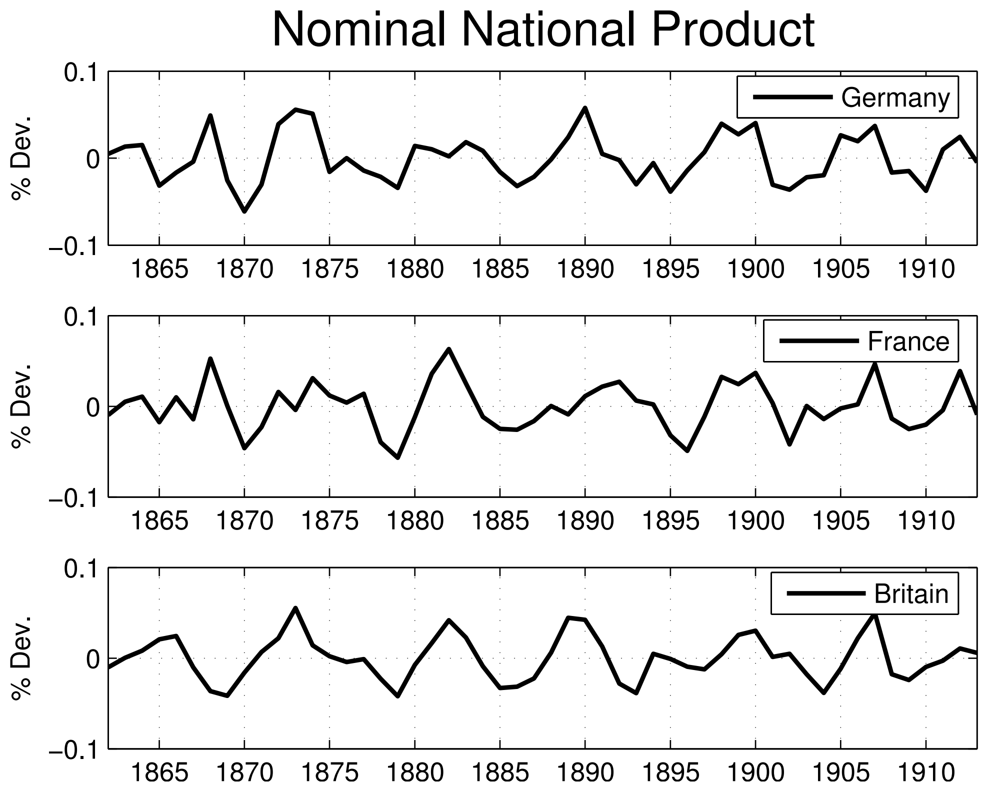

Figure 2: National product fluctuations in current prices, 1862-1913.

5.2 Results of the Dynamic Factor Model

First, I will discuss progress in business cycle research regarding the 19th century and their relation to my work concerning the methodology. Then, I will present the results in chronological order.

5.2.1 Relation to other methods

Backus and Kehoe (1992, p. 876) compared real national products using correlation coefficients. They state that the low correlation they find is mainly due measurement errors. Table 2 shows that there are improvement opportunities when using nominal instead of real series. A'Hearn and Woitek (2001) compare industrial output indices instead of net national products because they state that industrial output indices provide better indicators for cycles than national accouting. They find a coherency (the frequency domain counterpart to correlation) of 0.30-0.50 between France and Britain, 0.40-0.56 between Germany and Britain, and 0.15-0.20 between Germany and France.[24]

[24] These ranges occur because the order of bilateral comparisons plays an important role in this method, similar to R^2.

These are obviously quite high values for international comovement compared to Backus and Kehoe (1992). A'Hearn and Woitek (2001) even identify higher degrees of comovement by using certain frequency bands for their analysis. High frequencies reflect short cycles, while low frequencies represent long cycles. Three types of cycles are common in literature: the Kitchin cycle (3-5 years) (Kitchin 1923), the Juglar cycle (7-10 years) (Juglar 1889), and the Kuznets cycle (15-20 years) (Kuznets 1952). Due to filtering described above, Kuznet cycles are already deleted. Regarding the remaining fluctuations, A'Hearn and Woitek (2001) suggest that a higher degree of international comovement can be found in longer cycles than in the shorter ones. For the Juglar cycle, they measure coherency of 0.80-0.87 for Germany-Britain, 0.44-0.47 for Germany-France, and even 0.73-0.90 for France-Britain. Hereby they demonstrate that subsets of the national product, especially industrial production, have a higher degree of international comovement than the national product itself.

Furthermore, these high values of the Juglar cycle may indicate that measurement and aggregation errors in national product estimations and industrial production have bigger influence on short cycles than on long ones, because these errors by definition have an irregular character.

In the rest of the paper, I want to go a step further than A'Hearn and Woitek when it comes to disaggregating the data. Instead of splitting up national products in different sectors, I use the data as disaggregated as possible. The dynamic factor model then identifies international comovement in these data series whatever sector and processing stage the goods belong to.

To identify national fluctuations, I estimate national diffusion indices, which solely reflect national dynamics. Part four of Table 2 reflects the results of this method at a glance. All values are higher than those for national products, while the hierarchy remains the same: Germany and France have higher business cycle comovement than Germany and Britain, while the relation between the French and British cycle is the lowest.

5.2.2 Chronological Discussion

Figure 3 shows the three diffusion indices. The scale reflects percentage deviations from trend. The indices themselves have no natural measurement unit, because they are based on series such as interest rates or wages which are of different kind. Therefore, I multiply the diffusion index with 0.02, which is roughly the standard deviation of a national product. It is remarkable that diffusion indexes exhibit some ups and downs clearer than national accounting series, which may indicate that the latter artificially obscure certain cycles or even spuriously dampen volatility.[25]

In the 1860s, there is no comovement between Germany, France and Britain. We know from earlier research that the German business cycle arrived at its most recent lower point in this decade in 1859 (Sarferaz and Uebele 2009, p. 381, Table 2), and experienced a peak in 1864. It is difficult to date the British cycle in the 1860s because it is characterized by high frequencies. French economic activity steadily increased from 1862 but slowed down already before 1869. Over the

[25] The volatility of historical business cycles is subject to an intense debate of in the literature on the US(Balke and Gordon 1989b, Romer 1989).

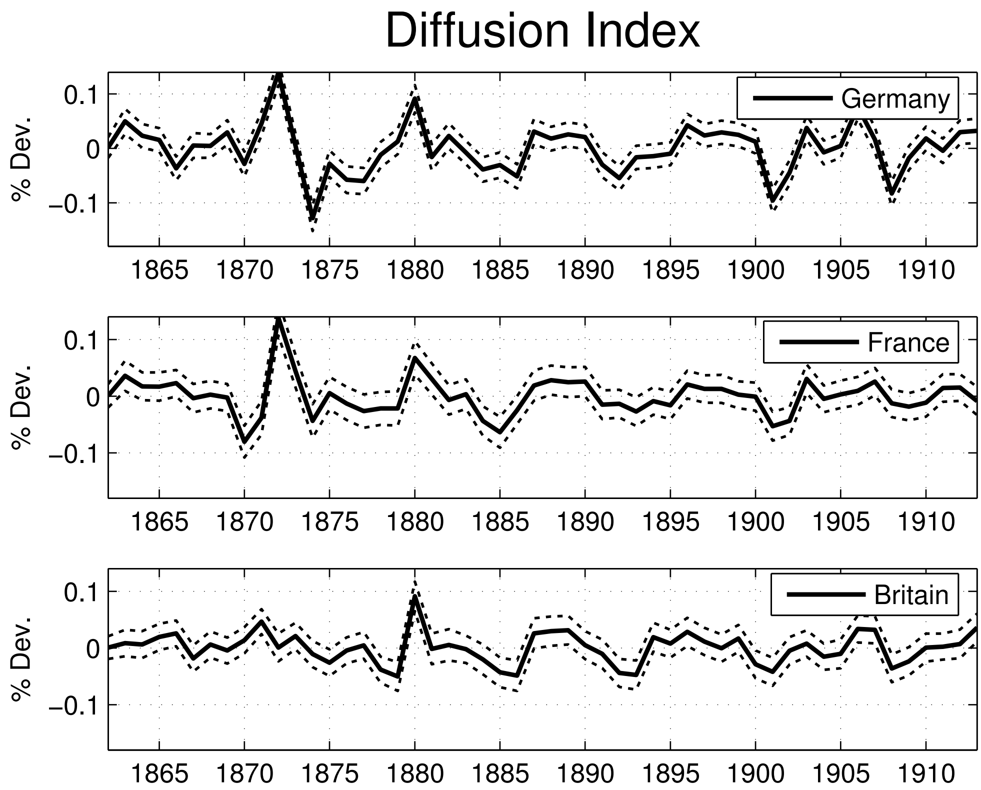

Figure 3: Diffusion index fluctuations, 1862-1913.

whole decade, France was apparently in a period of slow growth (Lévy-Leboyer and Bourguignon 1990, p. 6, Table 0.1) in contrast to Germany, which experienced rather rapid growth. However, this analysis of Germany's business cycle in the 1860s is no consensus in literature. While Spree (1977, p. 347) identifies positive growth rates for heavy industry in the first half of the decade, Borchardt (1976, p. 262) states that there was a crisis-laden first half of the decade followed by a boom at the latest in 1869.[26] According to Spree (1977, p. 351), this boom started in 1867. The curve of my diffusion index, in contrast, draws a different picture: the *Gründerzeit*-boom started not before 1870. Corroborating evidence comes from Burhop and Wolff (2005) who identify 1864 as a peak as well. However, they find the following downturn to be more rapid than the one indicated by my diffusion index. In consequence, the turning point in their analysis is reached in 1867, which rather supports Spree's findings (Burhop and Wolff 2005, p. 646).

Borchardt (1976) as well as Burhop and Wolff (2005) ground their research on the calculations of Hoffmann (1965). In comparison, this paper is based on Spree's data selection. In my opinion, historical national accounting aggregates are valuable in reflecting long run growth. For business cycle dating in the 19th century, they are not very helpful, which the inconsistencies of rivallin German national product estimates should be proof enough of.

The heavy slump at 1870 in the French diffusion index is worthwhile to mention (Figure 3). Taking in account the boom reflected in Germany's index for 1871, the results suggest a relation to the Franco-Prussian War 1870-71. The calculations by Lévy-Leboyer and Bourguignon (1990) draw a similar picture: French real national product decreases in the period 1869-1870 (Figure 1). They argue that this decrease is mainly caused by increased government spending for war (Lévy-Leboyer and Bourguignon 1990, p. 82f), which limited more useful public investments. The period was furthermore characterized by weak corporate profits, and below average transport activity (Lévy-Leboyer and Bourguignon 1990, p. 24, Figure 1.1; p. 86, Figure 3.2). However, focusing solely on the war as the reason for the economic downturn is very vague, since investments and profits already decreased between 1868 and 1869. Furthermore, Lévy-Leboyer and Bourguignon (1990, p. 78) argue that the railway boom ended in 1866. Are those results consistent with my diffusion index evidence?

If we take a further look at the composition of the French diffusion index, it also shows crisis symptoms prior to the war in some of the single series it is composed of. The series explained best by the index are goods carried by railway, inland navigation and pig iron production (Table 4, column F). Figure 4 indicates the stagnation of inland navigation from the early 1860s on. Moreover, the number of goods carried by railway (Figure 5) increased slightly in the period 1866-1868 and stopped expanding 1868 and 1869. In sum, the French economy has struggled prior to the war. The war has worsened the situation but was perhaps not the only reason for this struggle.

Similar to Germany's 1860s cyclical pattern, the 1870s cycle is a subject to discussion. The German and French diffusion indices have had their peaks in 1873, which is well accepted in literature. The following downturn is known as the *Gründerkrise*.

[26] The differences to the series shown here are caused by the different NNP series.

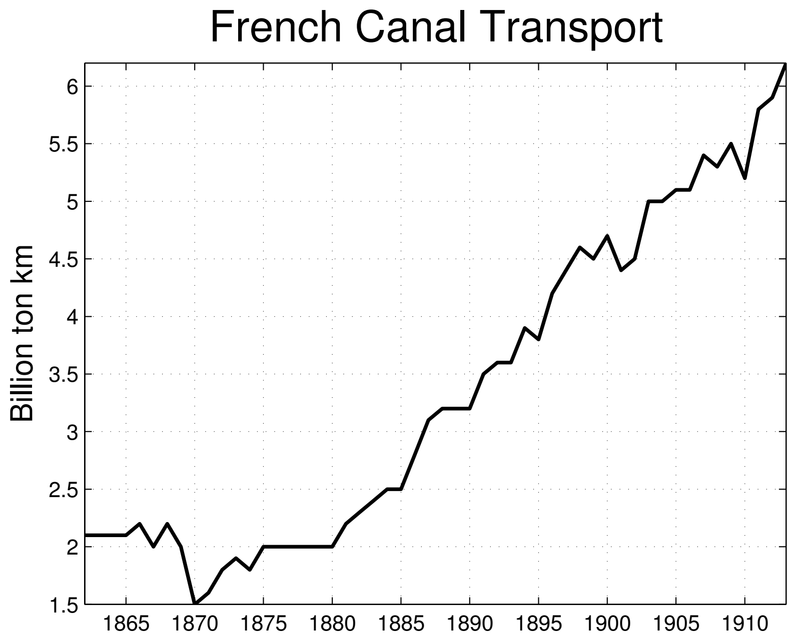

Figure 4: Inland navigation, 1862-1913.

Except for one, there is no disagreement in the more recent literature dealing with this boom and bust pattern. Based on Hoffmann's income estimations from the income side, Borchardt (1976, p. 205) finds above-average growth for the period 1870-1874 and stagnation until 1880. Pig iron consumption increased by 140 percent in the period 1863-1873 (Borchardt 1976, p. 262). Borchardt (1976, p. 265) stresses the exceptionality of this crisis regarding its duration and its consequences for the labor force, and Fischer (1985, p. 392) calls it a "severe recession."

Burhop and Wolff (2005) doubt this picture. Their criticism is based on a broad discussion and partial revisions of the four national product estimates by Hoffmann (1965) and Hoffmann and Müller (1959). Their compromise estimate contradicts the traditional view of boom and bust in the 1870s. However, Uebele and Ritschl (2009, p. 46) argue that this cyclical pattern is a result of the deflation of the originally nominal series.

Hoffmann's nominal series in Figure 6 show an anomaly. It is noticeable that the series by Hoffmann and Müller (1959) deviates less from its trend than the others, especially for the period before 1890. This series is based on Prussian income tax data and is widely seen as the most trustworthy for the level of national income. Its small standard deviation is closely related to tax policy in Prussia: Until 1890, personal income taxes were calculated as the average of the respective previous three years. Thus, these series are artificially smoothed. If they are divided by a price index to arrive at real national income, countercyclical fluctuations may result. Since the other estimates fluctuate more heavily in the 1870s, this effect does not occur; cycles may be smoothed but still procyclical. The compromise estimate by Burhop and Wolff (2005), however, weights the series derived from Prussian income tax more than the others because of its reliability. In consequence, the compromise

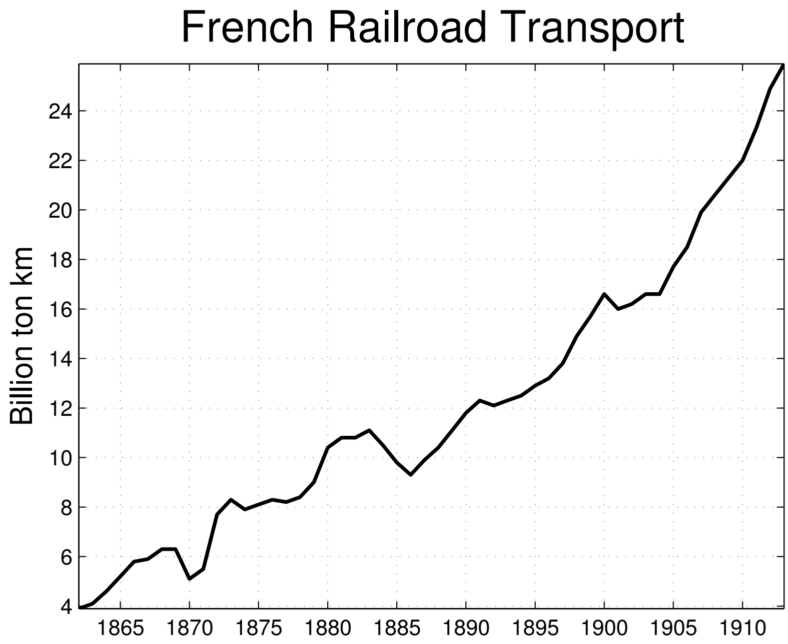

Figure 5: Number of goods carried by railway, 1862-1913.

estimate reflects the *Gründer*-boom as a downturn and the *Gründerkrise* as a boom.

Despite all criticism concerning Hoffmann's estimations, his German business cycle dating for the 1870s is widely accepted in literature, and its suggested dating is also reflected by my diffusion index. Furthermore, Table 3 indicates that the crisis in 1879 was an international one (Lévy-Leboyer and Bourguignon 1990, p. 25). Among others, it was accompanied by a severe harvest failure in the analyzed countries (Veblen 1893, p. 78).

The downturn until ca. 1886 and the following boom in the three countries is found by application of the index method.[27] Results for the nominal and real national products are consistent with this. Lévy-Leboyer and Bourguignon (1990) mention a bank run in 1882 in France, which however had neither nationally nor internationally a strong influence on the economy (Lévy-Leboyer and Bourguignon 1990, p. 25).

Using the index method we can identify the next crisis in the mid-1890s. Table 3 suggests crises in 1895 for Germany and France and in 1893 for Britain. Also, national accounting dates the British crisis in 1893 (Figure 1).[28] Obviously, the Baring bank collapse in 1890 predated this trough. While the national influence on the economy is beyond dispute, the international impact is questionable. In contrast to the index method, the national accounting literature for Germany suggests a turning point earlier than indicated here (Borchardt 1976, p. 267). Burhop and Wolff (2005, p. 646) argue that this crisis took place in the period 1890-1892, because compromise estimate decreased more rapidly in 1892 than in 1895.

[27] See also Burns and Mitchell (1946) for the NBER reference cycle.

[28] While Feinstein (1972) identifies 1893 as the beginning of the crisis, Burns and Mitchell (1946) postulate 1894.

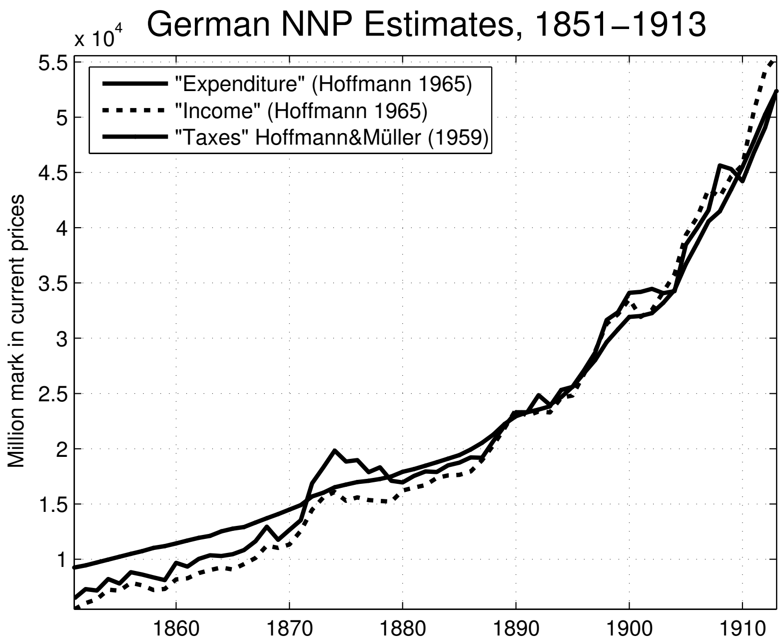

Figure 6: German nominal output estimates, 1862-1913.

Table 3: Peaks and troughs according to dynamic factor model

Peaks			Troughs		
Britain	France	Germany	Britain	France	Germany
1866	1869	1864	1869	1871	1870
1871	1873	1873	1879	1879	1879
1880	1881-3	1880	1886	1886	1886
1889	1890	1890	1893	1895	1895
1899	1900	1900	1901	1902	1902
1907	1907	1907	1910	1910	1911
1913	1912	1913			

Note: As trough I defined the last year with negative growth, as peak the last year with positive growth.

Analyzing 171 monthly-generated time series, Grabas (1992) delivered the most thorough analysis for Germany in the pre-World War I period. Unfortunately, her time series covers only the period from 1895 on. Based on contemporary reports, national accounting evidence, and the findings by Spree (1978, 107f) and Spiethoff (1955, p. 147), she dates the turning point in the end of 1893 or beginning 1894 (Grabas 1992, p. 104f). In contrast, my diffusion index indicates the lower point in 1895 and not earlier, although admittedly the decrease was slowing down since 1892 (Figure 3). The results of the French diffusion index draw a similar picture. This also contrasts the findings of national accounting, which dates the crisis to the years 1897 or 1896, respectively, depending on the use of real or nominal data (Lévy-Leboyer and Bourguignon 1990, p. 24, Figure 1.1).

In the first decade of the 20th century, the three business cycles resemble each other more than ever before. The diffusion indices indicate a boom at the turn of the century (1899 in Great Britain, 1900 in Germany and France). Although Spree and I used the same dataset, I cannot confirm his finding that there is no boom around 1900. I rather agree with Grabas (1992, p. 103), who identifies a peak in March 1900. Here it is once again shown that the the dynamic factor model is very efficient in data exploitation: Although the dataset is far from optimal, international comovement can still be identified. Since the findings coincide with country studies that draw on richer data, this demonstrate the superiority of the approach. The DFM does not just identify the same boom period like Grabas but also reflects the downturn with its low point around 1902. The lower point was reached in France also in 1902, whereas Britain went trough it in 1901.

In the period before the international boom around 1907, European economies had grown only moderately. Is there another interim-cycle between 1902 and 1907 as Burns and Mitchell (1946, p. 79) argue, or was there just a period of decreasing growth, as Grabas (1992, p. 103) suggests? Since my time series are of annual frequency, I cannot finally decide this question. However, Grabas's contribution seems more substantial to me, because she uses a broader dataset.

Historical national accounting indicates stronger differences in the dating of national business cycles for this period than the diffusion index method. While French national accounting identifies the same turning points as the index method does, estimations of real national product by Burhop and Wolff (2005, p. 646) and Borchardt (1976, p. 267) indicate crises around 1901 for Germany and 1904 for Great Britain (Figure 1 and 2).

In 1907, the business cycle of the three countries peaked as indicated by the diffusion index in Figure 3. Grabas (1992, p. 113) and Burns and Mitchell (1946, p. 78), who work with monthly-generated data, identify peaks in the beginning of 1907. At the same time, the US economy was in a downturn due to a bank run (Burns and Mitchell 1946). The lower point of this crisis was reached in 1908. It is likely that these developments had an influence on the German economy, e. g. through decreasing demand for German exports (Grabas 1992, p. 130). In Europe, the lower point was reached significantly later according to the diffusion index (1910 in France and Great Britain; 1911 in Germany). However, note that I define a trough as the last year before positive growth rates are again observed. If taking this into account, the cycles in Europe and America can be reconciled to a large extent. For instance, the German index strongly declines from 1908 on and remains at a very low level. This implies that there was a period of weak growth for a few years, which affected other countries as well. To some extent, this observation can also be made using national accounting. According to that, the trough was reached coincidentally in Britain and the US (Figures 1 and 2). For Germany, contradicting dates ranging between 1908 (Borchardt 1976) and 1909-1910 (Burhop and Wolff 2005) are found, and the French national product heavily decreased in 1910, while the diffusion index indicates a moderate upswing.

The years before World War 1 are characterized by a boom with its peak around 1913 in Germany and Great Britain, and 1912 in France. Since the war began in the summer of 1914, this year is not part of the dataset used for this paper. In contrast, Grabas (1992, p. 105) finds an upper turning point before the outbreak of the war. It may be worthwhile to discuss similarities and differences of the business cycle prior o World War I to the crisis prior to the Franco-Prussian War 1870-71.

Finally, visual analysis of the graphs indicates comovement for France, Germany and Great Britain, which is not limited to the diffusion index but can also be found to some extent in real and nominal national products. However, it seems that measurement errors cause the calculation of the correlation coefficients between national products to be lower than one would expect. In contrast, when eye-balling, the observer is able to ignore these errors, to emphasize similarities, and downplay differences. In principle, this is what the dynamic factor model is doing, only in a formally well-defined sense. It maximizes the comovement of data series and identifies possible international business cycles.

5.3 The International Diffusion Index

Finally, I calculate a diffusion index covering common economic activity by using all 45 time series. The international diffusion index shows common fluctuations independently from borders (Figure 7). Table 4 lists the series, which the international diffusion index is composed of. The sries are given in descending order according to how much of their respective variance is explained by either the international index or the country indices.

Obviously, the series related to the industrial sector are better explained by the international diffusion index than agricultural series. The best explained series is "wholesale prices for industrial raw material" with an explained variance of 65 percent, followed by the series "price of Scottish pig iron at Hamburg" with 61 percent and the French and German coal production with 55 and 52 percent respectively. Overall, nine out of ten of the best explained series are related to industry, transport or mining, while six out of the ten worst explained are related to agriculture or processing of agricultural goods.

The distribution listed by countries is disproportionately high dominated by German series, followed by France. Within the first ten series, there are six German series, while there is just one series within the last ten. There are many French series with less explained variance, which is mainly caused by the relatively high amount of French agricultural series. British series are the least internationally correlated in the whole dataset. However, I assume that including series from other

Table 4: Explained variance of diffusion index series

	Country	Description	R^2			
			Int'l	Single Countries		
				GB	F	G
1	Germany	Wholesale Prices Industrial Raw Materials	0.65			0.60
2	Germany	Import Prices Pig Iron	0.61			0.45
3	France	Coal Production (a01214)	0.55		0.53	
4	Germany	Coal Production	0.52			0.34
5	France	Railroad Freight (a03007b)	0.47		0.54	
6	Germany	Bills of Exchange	0.44			0.13
7	Germany	Pig Iron	0.40			0.54
8	Britain	Ocean Shipping	0.32	0.42		
9	Britain	Bankruptcies	0.30	0.16		
10	Germany	Marriages	0.29			0.04
11	Britain	Cotton Piece Goods	0.24	0.28		
12	France	Avg Daily Earnings (a08148)	0.23		0.11	
13	Germany	Bankruptcies	0.23			0.06
14	France	Pig Iron (a01212)	0.22		0.49	
15	France	Steam Total Power (a01172a)	0.21		0.16	
16	Britain	Patens Granted	0.21	0.09		
17	Germany	Wholesale Prices Food	0.18			0.07
18	Britain	Leather	0.12	0.09		
19	Germany	Yarn	0.11			0.00
20	Britain	Beer	0.11	0.23		
21	Germany	Interest Rates	0.10			0.29
22	Britain	Iron and Steel Products	0.10	0.20		
23	Britain	Tobacco Products	0.10	0.11		
24	France	Canal and River Traffic (a03007c)	0.09		0.30	
25	Britain	Coal Production	0.07	0.08		
26	France	Railroad Mileage Under Constr (a02085b)	0.06		0.00	
27	Germany	Textile Investment	0.06			0.09
28	Germany	Sugar Consumption	0.05			0.00
29	Britain	Silk Good	0.05	0.06		
30	Germany	Food Production	0.04			0.00
31	France	Potato Acreage (a01037)	0.03		0.03	
32	Britain	Paper	0.03	0.01		
33	Germany	Textile Profits	0.02			0.00
34	France	Railroad Mileage Growth (a02086)	0.01		0.03	
35	Britain	Linen Goods	0.01	0.05		
36	France	Wheat Production (a01012a)	0.00		0.01	
37	France	Wine Production (a01027	0.00		0.00	
38	France	Wheat Acreage (a01033b)	0.00		0.00	
39	France	Railroad Constr Exp (a02086e)	0.00		0.00	
40	Britain	Copper	0.00	0.01		
41	Britain	Wheaten Flour	0.00	0.01		
42	Britain	Sugar Production	0.00	0.00		
43	France	Potatoes (a01017a)	0.00		0.00	
44	France	Increases in Railroad Mileage (a02085a)	0.00		0.00	
45	Germany	Labor Productivity Dortmund	0.00			0.05

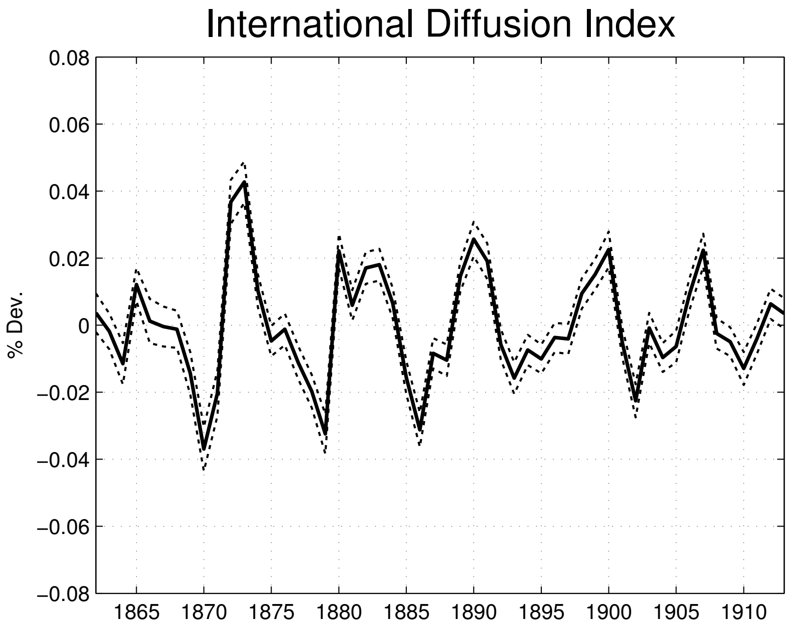

Figure 7: International diffusion index, 1862-1913.

Commonwealth members as well as Scandinavian and North-American data would result in a higher degree of international correlation of Britain.[29]

6 Conclusion

Up to now, national accounting was the main tool for the analysis of international business cycle comovement in the period of the classical gold standard. Due to methodological problems however, the presumably existing international comovement has empirically not been proven, because the datasets used for national accounting have neither an appropriate quality to show consistent cyclical coherence on a national level nor to show it on an international level. In essence, this paper outlines two major problems of historical national accounting. Firstly, the weighting, aggregating and in parts the interpolation of time series (as common in historical national accounting) result in a loss of cyclical information. Secondly, the knowledge about short-term fluctuations of the price level is very limited. Thus, deflated aggregates of national accounting are significantly more error-prone than nominal national products.

My findings for Germany, France and Great Britain clearly demonstrate international comovement, provided the adverse effect of deflation is recognized or disaggregated data sets are analyzed. To do so, I use a dynamic factor model, which weights the particular series based on their common fluctuations. The resulting turning points of business cycles are consistent for several reasons. Regarding Germany, my findings reflect *Gründer*-boom and -crisis. This dating can also be found in many

[29] Regarding these considerations, c. f. Backus and Kehoe (1992, p. 876) and A'Hearn and Woitek (2001, p. 337).

contemporary reports as well as in the qualitative and quantitative historiographical literature dealing with this period. Furthermore, the findings of the dynamic factor model are coherent with another sensitive indicator for business cycles such as the stock market index by Uebele and Ritschl (2009). Moreover, the French example reveals another advantage of index methods: while national accounting just reflects that the crisis was 1870-1871, investment series and disaggregated data indicate an even earlier crisis. In fact, this may result in new insights on the German-French business cycle history. In conclusion, while national accounting largely contradicts my theoretical considerations about the level of market international integration at the end of the 19th century, diffusion indices confirm these thoughts.

The German case shows that if national accounting is applied to insufficient datasets, analysis may end up in artificial business cycles. Sometimes it may even pervert the obvious. In consequence, such analyses make a proper analysis of the complex historical interdependencies more difficult. Following the argument that an historical perspective on crises should bring up recommendations for upcoming crisis, it is absolutely necessary to adapt methods to the particular circumstances, especially to the amount and quality of available data. If this is not taken care of, fallacies are likely to occur.

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