The U.S. Business Cycle, 1865-1939: Dynamic Factor Analysis vs. Reconstructed National Accounts

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Abstract

This paper presents insights on the American business cycle during the pre- and interwar periods derived from disaggregate diffusion indices. We employ a Bayesian approach to dynamic factor analysis, and obtain factors representing economic activity in the U.S. economy across the divides of World War I and the Great Depression. We find a remarkable increase in volatility across World War I, which is even stronger than suggested by Romer (1987, 1989) from a re-examination of Historical National Accounts. Extending our results across World War II, we find that the post-war moderation in aggregate volatility occurred only relative to the interwar period but not with regard to the rather mild fluctuations we find before World War I. Our estimates also broadly confirm the NBER business cycle chronology for the prewar and interwar period.

Keywords: U.S. business cycle, volatility, dynamic factor analysis

JEL codes: N11, N12, C43, E32

1. Introduction

Measuring the American business cycle during the pre- and interwar period has been the subject mater of controversial debate. While there is broad agreement on the business cycle turning points, the issue of volatility is still not fully resolved, as different available estimates yield contradictory results. Did business cycle volatility increase markedly after World War I? Is there a moderation after World War II, not just with respect to the interwar period but also compared to the prewar years? How severe were the key recessions other than the Great Depression of the 1930s, that is, the recessions of the mid 1880s, of 1907, and of 1920/21?

Research on these issues has largely focused on the quality of Historical National Accounts (HNA) and the scope for their improvement. For the half-century before 1929 when the official National Income and Product Accounts (NIPA) set in, mainly two GNP series have been in use, an official series generated by the Commerce Department and the alternative Kendrick (1961) estimates (see Romer, 1988 for a detailed discussion and an explanation of their connection to earlier work by Kuznets (1941), Kuznets (1946)). Both series are essentially indices that employ different weighing and deflating schemes (one being weighed using 1982 prices, the other using 1929 prices). Balke and Gordon (1986), Balke and Gordon (1989) produced a revision and a widely used quarterly interpolation of the Commerce series. Romer (1988), Romer (1989) presented a revised Kendrick series, which combined income and product estimates of GNP to obtain an estimate that she argued was unlikely to exhibit systematic bias in volatility vis-a-vis the true unknown data. For both the pre- and interwar period, the series she obtained is markedly less volatile than the Commerce series and the Balke/Gordon estimate derived from it. However, no strategy has been devised as yet to make her calculations, as well as the underlying plausibility considerations she presented, empirically testable. Doing this is one objective of the present paper.

Intertemporal comparisons of volatility by HNA also hinge on comparable data coming from a consistent source. Using comparable historical series across the World Wars, Romer (1986) argued that no major reduction in volatility from the pre-WWI to the postwar period could be found. The empirical basis for such comparisons necessarily remains narrow, dictated by the availability of series that cover sufficiently long spans on a consistent methodological basis. Again, the issues is whether a testing strategy can be derived that makes the most efficient possible use of the sparse information available.

The present paper takes up these debates and offers an alternative but complementary approach. We draw on the growing literature on diffusion indices (using a term of Stock and Watson (2002)) of economic activity, which are distilled from a large panel of disaggregate time series using dynamic factor analysis. Stock and Watson (1991) note that for a set of over a 100 disaggregate series representing the U.S. postwar economy, these indices reliably replicate the NBER's business cycle turning points, as well as the stylized facts about business cycle intensity. In the present paper, we adopt a Bayesian version of this methodology[1] and apply it to a wealth of disaggregate historical time series, taken mostly from the NBER's Macrohistory Database (which itself dates back to the business cycle project of Burns and Mitchell (1947)). We look at the evolution of volatility over time on the basis of different subsets of our data, and alternating between constant and time-varying coefficients.

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[1] See e.g. Stock and Watson (2005) for a review.

The basic idea of this approach is to replace the aggregation techniques used in the construction of HNA with a statistical algorithm, where the aggregation exploits the information in the contemporaneous variance/covariance matrix of a large array of disaggregate indicator series. To our knowledge, this approach was first applied in the context of presenting an alternative to HNA estimates by Gerlach and Gerlach-Kristen (2003) for Switzerland between the 1880s and the Great Depression. Sarferaz and Uebele (2006) employ a Bayesian version of this approach to obtain an index of economic activity for 19th century Germany that helps to decide between different rivaling HNA-based chronologies. The present paper extends this methodology to the historical application of macroeconomic diffusion indices with time-varying factor loadings.

Our findings on changes in historical business cycle volatility are even more dramatic than Romer's. We picture the pre-World War I economy as probably even less volatile than her estimates would suggest, and reaffirm the results that the postwar business cycle was no less volatile than the fluctuations of the late 19th century. At the same time, we reopen the case for a sharp real recession around 1920 that seemed settled through Romer's (1988) work. Introducing identifying restrictions to distinguish between real and nominal factors, we find minimal volatility of monetary and financial conditions in the 19th century but a massive increase after 1914, supporting the popular claim that the establishment of the Federal Reserve System in 1914 had negative, if any, effects on the stability of the U.S. monetary and financial system.

The remainder of the paper is structured as follows. The next section briefly sketches the main ingredients of the factor model we employ. Section III, divided up in several subsections, presents the evidence. Section IV concludes.

II. Theory

Dynamic factor models in the vein of Sargent and Sims (1999), Geweke (1977) and Stock and Watson (1989) comprise that a given dataset can be divided into a latent common part, which captures the comovements of the cross section and a variable specific idiosyncratic part. These models imply that the economic activity is driven by some few latent driving forces, which can be revealed by the estimation of the dynamic factors. A Bayesian approach to DFMs is provided by Otrok and Whiteman (1998), Kim and Nelson (1999) and Kose, Otrok and Whiteman (2003). Del Negro and Ortok (2004) provide the estimation procedure for dynamic factor models with time-varying parameters. For the estimation of the time-invariant parameters, we use the methods described in Kim and Nelson (1999), because we condition on the first p initial observations.

Our panel of data y_{it}, spanning a cross section of $i = 1, \ldots, N$ series and an observation period of length T, can be described by the following equation:

$$y_{i,t} = c_i + \lambda_{i,t} f_t + u_{i,t}$$

where f_t represents the latent factor, c_i is the constant term, $\lambda_{i,t}$ is the coefficient linking the common factor to the i-th variable at time t, and $u_{i,t}$ is the variable-specific idiosyncratic component. For the factor we assume an AR(q) process:

$$f_t = \varphi_1 f_{t\text{-}1} + \ldots + \varphi_q f_{t\text{-}q} + \upsilon_t$$

The law of motion for the idiosyncratic shock $u_{i,t}$ is expressed as:

$$u_{i,t} = \theta_1 u_{i,t\text{-}1} + \ldots + \theta_p u_{i,t\text{-}p} + \chi_{i,t}$$

and the factor loadings are assumed to be either constant or (in the time-varying model) follow a driftless random walk:

$$\lambda_{i,t} = \lambda_{i,t\text{-}1} + \varepsilon_{i,t}$$

The disturbances $\chi_{i,t}, \varepsilon_{i,t}$, v_t are i.i.d. normal.

The factors in this model are identifies up to a scaling constant and a sign restriction. The scale indeterminacy can be tackled by fixing the variance of the factor innovations υ_t to be equal to a constant (see e.g. Sargent and Sims, 1977). We deal with the sign indeterminacy of the factor loadings $\lambda_{i,t}$ and the factors f_t by restricting one of the factor loadings to be positive (see Geweke and Zhou, 1996). Neither of these two identification assumptions restricts the information content of the factor model.

We estimate the model in Bayesian fashion via the Gibbs sampling approach. This procedure enables the researcher to draw from nonstandard distributions by splitting them up into several blocks of standard conditional distributions. In our case, the estimation procedure is subdivided into three blocks: First, the parameters of the model $\{c, \varphi_s, \theta_r,\}$ for $s = 1, \ldots, q$ and $r = 1, \ldots, p$ are calculated. Second, conditional on the estimated values of the first block, the factor f_t is computed. Finally, conditional on the results of the previous blocks we estimate the (possibly time-varying) factor loadings. All blocks are calculated by applying the methods described in Kim and Nelson (1999). After the estimation of the third block, we start the next iteration step again at the first block by conditioning on the last iteration step.

If the number of iteration steps goes to infinity, then it can be shown that the conditional posterior distributions of the parameters and the factor will converge to their marginal posterior distributions at an exponential rate[2].

Similar to Del Negro and Otrok (2004) we use the cross section mean of the factor loadings $\bar{\lambda}_t = \frac{1}{N}\sum_{i=1}^{N} \lambda_{i,t}$ as an approximation for the change in volatility of the dataset.

The prior for the autoregressive parameters is similar to the conjugate prior applied by Kose, Otrok and Whiteman (2003), where the prior mean is equal to zero and the covariance matrix is the diagonal matrix $\Sigma = \mathrm{diag}(1, \frac{1}{2}, \ldots \frac{1}{p\ \ 1})$, which implies that we give more distant lagged values less weight. For the prior on the variances of the idiosyncratic components we follow Otrok and Whiteman (1998), which is Inverted Gamma(6,0.001). As in Del Negro and Otrok (2004), the prior on the variances of the disturbances in the factor loadings law of motion is chosen to be relatively tight.

III. Empirical Results

(a) 1869-1929, Constant Factor Loadings

We begin with the comparison of volatility between the prewar and interwar period. As discussed above, factors are identified only up to a scaling factor (and a sign convention, which is innocuous). Hence, comparisons of volatility can only be made conditional on prior calibration. We implement this throughout by calibrating our

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[2] See Geman and Geman (1984).

series to the standard deviation of the (annualized) Balke and Gordon (1986) series from their Hodrick/Prescott[6,25]-filtered trend. In a first step of our analysis, we obtain a factor of general economic activity imposing constant factor loadings, as is standard. The factor loads on 52 series, of which 32 can be categorized as real, while another 20 are nominal. Most data are from the NBER Macroeconomic History Database; some additional series we inserted from the newest edition of the Historical Statistics of the U.S.[3] Appendix A provides a list of variables.

(Figures 1a and 1b about here)

Results in Figure 1a show the factor, the simulated 67% upper and lower confidence bands, as well as the original Balke and Gordon (1986, 1987) version of the Commerce GNP series for 1869 to 1929. By construction, the factor and the Balke-Gordon series have the same volatility for the sample period as a whole. We note that both series, in spite of the vastly different methods of their calculation, tell broadly the same business cycle chronology. Figure 1b includes the factor and the 2/3 confidence bands, plotted against Romer's (1986, 1989) version of the Kuznets/Kendrick GNP estimate for the same observation period. Again, the factor paints broadly the same picture in terms of the business cycle chronology it implies.

Differences between the HNA estimates of GNP and the factor, however, appear to exist in volatility. Unsurprisingly, the factor is on the whole more volatile than Romer's series. This is so by construction, reflecting the higher overall volatility of the Balke/Gordon estimate. We are interested instead in comparing the ehavior of volatility across the divide of World War I.

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[3] See Carter, Gartner, Haines, Olmstead, Sutch and Wright (2006).

(Table 1 about here)

As Table 1 bears out, both the Balke/Gordon and Romer estimates of GNP show an increase in volatility across World War I. This effect is stronger in the Balke/Gordon estimate, largely because it exhibits a much sharper recession in 1920/21 than the Romer series. Comparing the factor estimnates to the datam, we obtain an even stronger increase in volatility across World War I than the Balke/Gordon estimate. This has two implications. First, even if we accept the higher overall volatility of the Balke/Gordon estimate for the observation period as a whole, the volatility of economic activity before World War I was lower than their series implies – which reinforces a claim made by Romer (1988, 1989) on the basis of new HNA re-estimates.

However, we also see that by all means, our factor shows very high volatility for the 1920s. Indeed, the factor appears to reinstate the 1920/21 recession, which looked severe in the traditional Commerce estimate of GNP (and hence in Balke/Gordon) but rather less severe in the Kendrick (1961) estimates and their adaptation by Romer (1986, 1989). We find this effect to be noticeable, as it seems to put a question mark between the assertion of Romer (1988) that the volatility of the Balke/Gordon series in the 1920s is an artifact caused largely by employing 1982 prices in their weighing scheme. Our factor is rich in contemporary price information and avoids any mechanistic aggregation that might generate spurious volatility. Hence, it is immune against this critique. In the following subsections, we will therefore subject both results – lower volatility pre-1914, increased volatility thereafter – to further scrutiny.

(b) 1869-1914 – Expanded Dataset

The first step is to look into the prewar period in greater detail, and to see if there are any major changes in volatility within this subperiod. The attempt to compare volatility across World War I required narrowing the available dataset to 52 series that are available for the whole period from 1869 to 1929. One salient feature of the pre-war business cycle as represented in Figure 1 above seems to be the time variation of volatility. As the factor was extracted from the common component of the underlying time series for both the pre-war and the interwar period, any dynamics pertinent to the latter but not to the former might be carried over and distort the business cycle measurement for the prewar years. We therefore repeated extracting the common component from the same 52 series for the pre-war period only (Figure 2a).

(Figure 2a about here)

As can be seen, results differ somewhat from the common factor for the longer period, bu the main patterns are preserved: there is a strong upswing in the early 1870s, followed by a recession in the second half of the decade, as well as a second recession in 1885 and an intermittent upswing. The recessions of 1894, 1904, and 1907 are also clearly visible. Eyeballing would again suggest that in terms of turning points, the fit with the Balke/Gordon series is somewhat better.

(Figure 2b about here)

As an alternative to this benchmark, in Figure 2b we look at a factor extracted from an expanded dataset of 103 series, which provide a much broader coverage of the U.S. economy. Calculation of this broader factor exhibits two main results: first, all recessions and upswings except for 1906/1907 now seem to be of more or less equal intensity; the evidence from Figures 1 and 2a of more intense fluctuations prior to 1890 disappears. Secondly, however, the factor is estimated only very imprecisely. A look at the error bands suggests the possibility of severe recessions in 1878, 1885 and – newly – 1891 as well as 1898, while the evidence for the 1894 recession becomes much weaker.

Hence, broadening the dataset seems to come at a cost, as the many additional series appear to introduce considerable additional noise, which the model finds hard to deal with. A tentative conclusion from the broader evidence seems warranted, however: prior to 1905, the evidence for major shifts in the volatility of the U.S. business cycle is at best mixed. The one recession that stands out from the pre-1914 evidence is the sharp contraction of 1907. It seems to initiate a pattern that became typical of the interwar business cycle.

(c) 1869-1929: Time-Varying Factor Loadings

An alternative to broadening the dataset that allows making volatility comparisons across World War I is to allow factor loadings to vary. As laid out before, time-varying factor loadings render it possible to capture structural changes that affect the interplay between sectoral and aggregate dynamics. The analogy is with an index number (which is what the factor actually is). Making the factor loadings variable is then analogous to allowing the index weights to change over time[4]. Proceeding this way with our 52 series across World War I, we obtain a striking confirmation of our previous results.

(Figures 3a and 3b about here)

Figure 3 shows a time-varying factor of economic activity for the period of 1869 to 1929, along with the Balke/Gordon and Romer estimates of GNP[5]. This factor is remarkably flatter than both the Balke/Gordon and Romer series for pre-1914. eyeballing suggests that during this period, its turning points are now closer to the Romer series, whereas the cyuclical movements of the constant factor shown in Figures 1a and 1b above seemed closer to the Balke/Gordon series. We find this result to be noticeable, as it reflects romer's criticism of indices with constant weights as exaggerating volatility: as soon as we allow index weights to vary, much of the volatility in the factor disappears, suggesting it was spurious in the first place. The principal innovation here is that we do not do this by introducing a priori information from e.g. census data, as would be common in conventional HNA construction, but rather by likelihood methods that invoke the information content in the changing cross-covariance of a large number of disaggregate series.

However, we again do not find a reduction in volatility after 1914. The time-varying factor now fluctuates wildly and is very close to the Balke/Gordon series,

[4] Note, however, that the factor loadings, whether time-varying or not, do not have the same economic interpretation as conventional index weights. While the latter typically represent employment, value added, or expenditure shares, the factor loadings are determined optimally from the iterating on the estimated joint distribution of factor loadings and data.

[5] The observations before 1880 get used up by a "training sample" required for initiating the prior. Graphing them would thus carry no information.

except for the 1920/21 recession where it is even more volatile. Thus, our analysis seems to conform with the traditional hypothesis of violent aggregate fluctuations after World War I, which is not reflected in the Kendrick (1961) and Romer (1988) estimates of GNP.

(Table 2 about here)

Table 2 summarizes the volatility results for the time-varying factor, again calibrated to the Balke/Gordon series. As it turns out, the standard deviation for pre-1914 is now down to almost half the level of the Romer series, while it is significantly higher than bothe GNP series for the interwar period.

We conclude from this exercise that the higher volatility of the so-called Commerce series and its adaptation by Balke and Gordon (1986, 1987) is not primarily a problem of too narrow data representation or aggregation by the wrong price vector. We were able to generate rather volatile indices of economic activity for the 19th century using constant factor loadings from a rather broad set of data (in Figure 1 above) that suffers from neither of the criticisms raised against this series. Instead, we find that changing sectoral weights seem to be the major problem plaguing the data before World War I. As soon as we allowed the factor loadings to vary, we were able to generate an outcome that is markedly less volatile than even the Kendrick/Romer estimate of GNP for the pre-war period. This finding would not be easy to obtain with HNA methods, as the necessary census information on changing sectoral index weights is only seldom available at sufficiently high levels of quality and observation frequency, and certainly not for the U.S. prior to World War I.

(d) Structural Factors: Real vs. Nominal

In this subsection, we refine the analysis to account for real and nominal influences separately. The literature on factor analysis of economic activity is divided on how to do this best: a non-structural approach is to extract more than one factor from the full dataset, forcing the second factor to be orthogonal to the first one. This procedure is generally seen as yielding good characterizations of real activity by the first factor, and of nominal conditions by the second factor. A more structural alternative to be followed here is to restrict factor loadings a priori by exclusion restrictions. We do this in Figure 4 for 1880 to 1929.

(Figure 4 about here)

Results for the real factor (Figure 4a) seem reassuring. The Great Depression of the 1880s appears back on stage, as do the 1904 and 1906 recessions. We also see the wartime boom and post-World War I recession in the data very clearly. The late 1920s also show a sharp economic expansion, an effect that was not visibile in any of the existing GNP estimates, but that does show up in the index of industrial production by Miron and Romer (1990). An exciting message is delivered by the nominal factor shown in Figure 4b: while the 19^{th} century is essentially flat in nominal shocks to the U.S. economy, very marked shocks appear during World War I. The postwar deflation is clearly visible (if a bit belated), as is the nominal expansion of the late 1920s. hence, both real and nominal volatility increased greatly across World War I, the latter even more strongly so than the former.

Several tentative conclusions suggest themselves. First, it seems safe to rule out major monetary causes of the pre-war recessions. Neither are the nominal impulses very strong nor does the timing (in the sense of Granger causation) seem to be right. Second, monetary shocks gain greatly in size but not in significance after World War I. Again, timing seems to be a problem. Third, the evidence sheds an unfavorable light on the performance of the Federal Reserve System after its establishment in 1914: while the classical gold standard apparently did not too badly in smoothing out nominal shocks, its more managed version does not look impressive at all.

We again extend the analysis to 1939, keeping in mind, however, that the estimates are not recursive, such that the estimated factor loadings for any point in time t are potentially affected by extending the observation period from T to $T+S$. Results are shown in Figure 5.

(Figure 5 about here)

As Figure 5 bears out, taking the Great Depression of the 1930s on board tends to dampen the previous swings somewhat, and also to affect their timing. Notably, the real expansion during World War I now looks weaker, and the postwar recession is shifted backwards by one year. The nominal swings, in contrast, come out sharper and much more significantly as far as the post-1914 years are concerned. As to the Great Depression, the nominal turning point is now in 1929 (influenced also by the stock market index that is enters the nominal factor), while the real turning point is – somewhat implausibly – in 1931. Again, this shows how strongly the results are affected by the non-recursive nature of the estimates: a contemporary observer somehow informed by the Great Depression would have inferred since World War I that monetary shocks were pervasive and significant. For an agent updating the information set recursively in real time, this was probably not at all clear, as the low significance levels of the factors obtained till 1929 show. This shows how important it is to avoid statements on policy effectiveness from non-recursive estimates if the underlying structures are not time-invariant[6].

(e) Long-Term Volatility of U.S. Economic Activity

Our analysis of historical business cycle volatility can also be extended to the long run of over a century, albeit on a narrow database. In this subsection we present evidence based on a consistent set of 14 time series that wer recorded since 1890 on an unchanged basis, and that are readily available. Evidently, the problem of inadequate data representation becomes a big one over such a long period, and is unlikely to be mitigated by the choice between constant and time-varying factor loadings.

(Figures 6 a and b about here)

As can be seen from Figure 6, some clear patterns emerge despite the unavoidable data limitations. Most importantly, the increase in volatility during the interwar period is clearly reflected in the data, as is the Great Moderation of U.S. aggregate fluctuations after World War II. We do find it notable, though, that the levels of 19th century volatility are not reached again until the 1960s. We also observe recurrent volatility since the mid-1970s, an effect that is not borne out by modern GNP series for the U.S. We have no doubt that this evidence is generated by the heavy dependence of our factors on raw material production and financial indicators, whose

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[6] Amir Ahmadi and Ritschl (2006) have a factor model of monetary policy transmission on the interwar U.S. economy, and find only very minor effects.

high volatility in the last decades of the 20th century is undisputed. Clearly, however, the postwar business cycle as reflected in our factor was no less volatile than the pre-World War I cycle, which confirms a result of Romer (1986).

IV. Conclusions

Factor analysis of aggregate economic activity presents an appealing alternative to Historical National Accounts whenever the data are incomplete or plagued by structural breaks in reporting. In this paper, we re-examined the volatility of historical business cycles in the U.S. since 1869. While focusing mostly on the comparison between the pre-war and the interwar period, we also presented a long-term perspective from the late 19th century to the late 1990s.

Our main findings are that the business cycle prior to World War I was even less volatile than has previously been thought, and was quite plausibly no more volatile than the postwar business cycle of the 1950s. We also find pervasive evidence that the interwar years, in particular the period immediately following World War I, were more volatile than has been maintained in the more recent literature. This would make the Great Depression of the 1930s less of a historical singularity.

Many of our findings derive from the analysis of time variation in factor loadings, or the weights assigned to the various individual series in constructing the index of aggregate economic activity. To this end, we employed a Bayesian approach to factor analysis, iterating over the likelihood function by Gibbs sampling. We found time varying factor loadings to be an effective way of dealing with the structural changes in the U.S. economy, a problem that is hard to deal with in HNA approaches. As a result, we suspect that spurious volatility in national accounts of the U.S. business cycle is not so much a problem of missing or too narrow data but rather of the inflexible weighing schemes underlying most work in national accounting with historical data.

We also took a more structural approach, restricting our data to load into one real and one nominal factor separately. While the real factor replicates the well-known business cycle turning points without problems, the nominal factor shows only very minor movements in the 19th century. Viewed in this perspective, the creation of the Federal Reserve System in 1914 had apparently no stabilizing influence on the monetary and financial system of the U.S. economy. Whether it also affected economic activity in the U.S. in the long run is an issue for further research[7]

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Appendix: Data series and sources

(a) 103 series, 1867-1914

1	Wholesale Price Cotton, raw
2	Oats production
3	INDEX OF CROP PRODUCTON, TWELVE IMPORTANT CROPS
4	INDEX OF TOTAL CROP PRODUCTION
5	WHEAT CROP
6	WHEAT CROP
7	POTATO CROP
8	OAT CROP
9	CORN CROP
10	COTTON CROP
11	WHEAT CROP ACREAGE
12	WHEAT CROP ACREAGE
13	POTATO CROP ACREAGE
14	OAT CROP ACREAGE
15	CORN CROP, YIELD PER ACRE
16	CORN CROP ACREAGE
17	COTTON CROP ACREAGE
18	COTTON CROP, YIELD PER ACRE
19	CATTLE SLAUGHTERED UNDER FEDERAL INSPECTION
20	TOBACCO CROP
21	TOBACCO CROP ACREAGE
22	SHEEP AND LAMBS SLAUGHTERED UNDER FEDERAL INSPECTION
23	m01038U.S. Live Hog Receipts 01/1859-12/1940
24	m04001aU.Price of Wheat, S. Wholesale , Chicago, Six Markets 07/1841-07/1944
25	m04005U.S. Wholesale Price of Corn Chicago 01/1860-12/1951
26	m04007U.S. Wholesale Price of Cattle Chicago 01/1858-12/1940
27	m04008U.S. Wholesale Price of Hogs Chicago 01/1858-12/1940
28	Wool Prices, HSUS (2006), pp3-208
29	"Population, Hist. Stat. Of the US, 2006, Vol. 3
30	Raw Steel production
31	Copper Prices,HSUS (2006), pp3-217
32	BITUMINOUS COAL PRODUCTION
33	LOCOMOTIVE PRODUCTION, BALDWIN LOCOMOTIVE WORKS
34	PIG IRON PRODUCTION
35	a02084U.S. Rail Consumption, American Iron and Steel Institute 1849-1961
36	a02244U.S. Merchant Vessels Built and Documented, Tonnage, Bureau of the Census-Customs Bureau, Annual Data 1797-1940
37	a02102U.S. U.S., Gross Tonnage of Yachts Built, Dept. Of Commerce-Bureau Of Marine Inspection and Navigation 1847-1937
38	a02135U.S. Total Merchant Marine, Annual Data Only 1843 - 1940
39	INDEX OF MANUFACTURING PRODUCTION
40	TOTAL COAL PRODUCTION
41	Brick Prices, HSUS (2006), pp3-217
42	U.S. Prices of No. 1 Anthracite Foundry Pig Iron M and N spliced
43	U.S. Wholesale Price of Copper P and Q spliced
44	Coal Prices (anthr.)
45	Coal Fuel Mineral Production
46	a02047U.S. Building Permits, Value of Total , Chicago 1854-1870, 1872-1943
47	Cargo moved on NY State canals
48	m07023U.S. Total Exports 07/1866-10/1969
49	U.S. Raw Silk Imports AA, AB and AC spliced
50	m07038U.S. Coffee Imports 01/1867-06/1941
51	m07040U.S. Tea Imports 01/1867-09/1941
52	m07042U.S. Tin Imports 01/1867-06/1893 08/1893-06/194 LONG TONS
53	m07028U.S. Total Imports 07/1866-10/1969
54	m07043aU.S. Raw Cotton Exports 01/1867-12/1941
55	Vessels entered US ports
56	Stock Prices, NBER Cowles and HSuS3-757
57	U.S. Net Savings of Life Insurance Policy Holders spliced together, NBER
58	U.S. Index of Wholesale Prices, T, U and V spliced
59	m04051U.S. Index of the General Price Level 01/1860-11/1939
60	m13001U.S. Call Money Rates Mixed Collateral 01/1857-11/1970
61	m13019U.S. American Railroad Bond Yields High Grade AT and AU spliced
62	m14124aU.S. National Bank Notes Outstanding Total End of Month 01/1864-12/1879
63	a13049U.S. Earnings Yield of All Common Stocks On the New York Stock Exchange 1871-1938
64	m13002U.S. Commercial Paper Rates New York City 01/1857-12/1971
65	US Notes
66	Business Failures
67	m12003U.S. Index of American Business Activity 01/1855-12/1970
68	m12015U.S. Bank Clearings Daily Average 10/1853-09/1943
69	Patents granted
70	a10030U.S. Number of Concerns in Business 1866-1938
71	a02004U.S. Index of Value Of Total Building, Original Data, Long 1868-1939
72	a02009U.S. Value of Building Permits Per Capita, Riggleman (Current Dollars) 1830-1933
73	a02010U.S. Value of Building Permits Per Capita, As Per Cent Of Trend, Riggleman (Constant Dollars) 1830-1933
74	a02037U.S. Adjusted Index of Building Permits, New England Cities, Riggleman 1875-1933
75	a02038U.S. Adjusted Index of Building Permits, Middle Atlantic Cities, Riggleman 1875-1933
76	a02040U.S. Adjusted Index of Building Permits, East North Central Cities, Riggleman 1875-1933
77	a02041U.S. Adjusted Index of Building Permits, West North Central Cities, Riggleman 1875-1933
78	a02042U.S. Adjusted Index of Building Permits, South Central Cities, Riggleman 1875-1933
79	a02043U.S. Adjusted Index of Building Permits, Western Cities, Riggleman 1875-1933
80	a02046U.S. Brooklyn ,Value of Permits For New Buildings 1874-1935

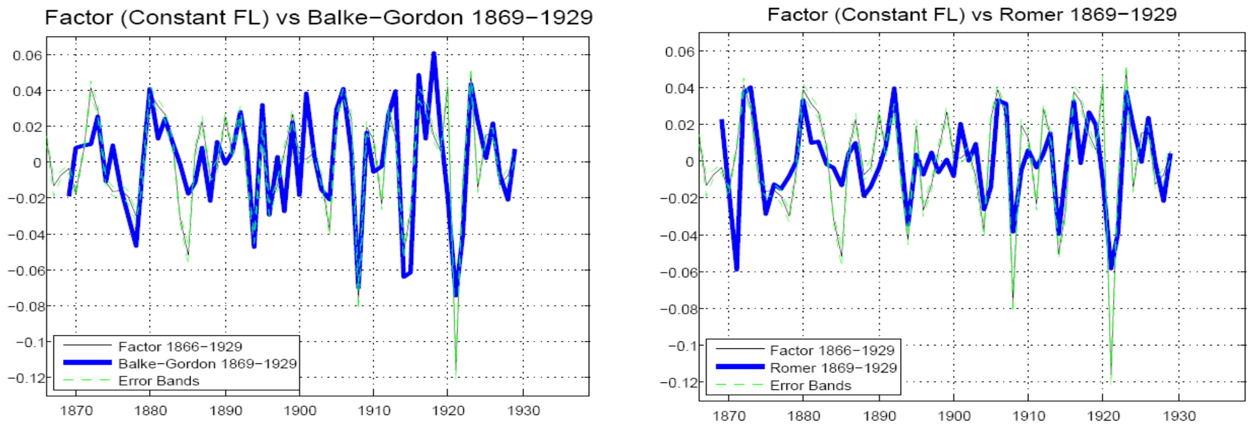
81 a02047U.S. Value of Total Building Permits, Chicago 1854-1870, 1872-1943
82 a02050U.S. Value of Total Building Permits, St. Louis 1875-1933
83 a02068U.S. Increase in Number of Lots, Detroit Area 1830-1926
84 a02069U.S. Net Increase in Building Lots, Pittsburgh Area 1830-1934
85 a02094bU.S. Length of Pavements Laid, Chicago 1855-1936
86 a02097U.S. Increases in Wire Mileage of Western Union Telegraph Company 1867-1962 (SEE NOTE)
87 a02223U.S. Federal Construction Expenditures For Public Works, Federal Works Agency-Department of Treasury 1791-1919, FISCAL YEARS
88 a02224U.S. Federal Construction Expenditures For Public Buildings, Federal Works Agency- Dept. of the Treasury 1791-1919, FISCAL YEARS
89 a02226U.S. Federal Construction Expenditures For Rivers and Harbors, Department of Treasury- Federal Works Agency 1822-1919
90 a02238U.S. Estimated Production of Nonfarm Residential Housekeeping Units, Gottlieb 1840-1939
91 a02239U.S. Nonfarm Residential Building Activity, Manuel Gottlieb 1850-1939
92 a02240U.S. Nonfarm Nonresidential Building Activity, Gottlieb 1850-1939
93 a02241U.S. Total Nonfarm Building Activity, Gottlieb 1850-1939
94 a02250U.S. Index of Number Of Total New Buildings, Long 1856-1935
95 a02251U.S. Index of Number Of Total Residential Buildings, 1 To 29 Cities, Long 1856-1936
96 a02252U.S. Index of Number Of Total Nonresidential Buildings, Long 1856-1936
97 a02254U.S. Index of Value Of Building Permits, Riggleman Adjusted By Isard 1830-1933
98 a02281U.S. Federal Construction Expenditures, Nonmilitary, Fwa-Treasury Department 1791-1919
99 a02283U.S. Number of Residential Units Erected, Ohio, Gottlieb 1857-1915
100 a02284U.S. Total Value of New Buildings Erected, Ohio, Gottlieb 1837-1914
101 a02287U.S. Value of New Residential Buildings Erected, Ohio, Gottlieb 1861-1914
102 a02288U.S. Value of New Nonfarm Residential Buildings Erected, Ohio, Gottlieb 1861-1914
103 a02082aU.S. Miles of Railroad Built, Bureau Of the Census-Railway Age 1830-1952

(b) 52 series, 1865 to 1939

1	Wholesale Price Cotton, raw
2	Oats production
3	m01038U.S. Live Hog Receipts 01/1859-12/1940
4	m04001aU.Price of Wheat, S. Wholesale , Chicago, Six Markets 07/1841-07/1944
5	m04005U.S. Wholesale Price of Corn Chicago 01/1860-12/1951
6	m04007U.S. Wholesale Price of Cattle Chicago 01/1858-12/1940
7	m04008U.S. Wholesale Price of Hogs Chicago 01/1858-12/1940
8	Wool Prices, HSUS (2006), pp3-208
9	Cotton production, HSUS (2006), pp4-111
10	"Population, Hist. Stat. of the U.S., 2006, Vol. 3
11	Raw Steel production
12	Copper Prices, HSUS (2006), pp3-217
13	Brick Prices, HSUS (2006), pp3-217
14	U.S. Prices of No. 1 Anthracite Foundry Pig Iron M and N spliced
15	U.S. Wholesale Price of Copper P and Q spliced
16	a02084U.S. Rail Consumption, American Iron and Steel Institute 1849-1961
17	Coal Prices (anthr.)
18	Coal Fuel Mineral Production
19	a02244U.S. Merchant Vessels Built and Documented, Tonnage, Bureau of the Census-Customs Bureau, Annual Data 1797-1940
20	a02047U.S. Building Permits, Value of Total , Chicago 1854-1870, 1872-1943
21	a02135U.S. Merchant Marine, Total , Annual Data Only 1843 - 1940
22	a02223U.S. Federal Construction Expenditures For Public Works, Federal Works Agency-Department of Treasury 1791-1919,
23	a02102U.S. Yachts Built, Gross Tonnage of , U.S., , Dept. Of Commerce-Bureau Of Marine Inspection and Navigation 1847-1937
24	a02238U.S. Nonfarm Residential Housekeeping Units, Estimated Production of , Gottlieb 1840-1939
25	a02239U.S. Nonfarm Residential Building Activity, Manuel Gottlieb 1850-1939
26	a02240U.S. Nonfarm Nonresidential Building Activity, Gottlieb 1850-1939
27	a02241U.S. Total Nonfarm Building Activity, Gottlieb 1850-1939
28	Cargo moved on NY State canals
29	m07023U.S. Total Exports 07/1866-10/1969
30	U.S. Raw Silk Imports AA, AB and AC spliced
31	m07038U.S. Coffee Imports 01/1867-06/1941
32	m07040U.S. Tea Imports 01/1867-09/1941
33	m07042U.S. Tin Imports 01/1867-06/1893 08/1893-06/194 LONG TONS
34	m07028U.S. Total Imports 07/1866-10/1969
35	m07043aU.S. Raw Cotton Exports 01/1867-12/1941
36	a02082aU.S. Miles of Railroad Built, Bureau Of the Census-Railway Age 1830-1952
37	Vessels entered US ports
38	Stock Prices, NBER Cowles and HSuS3-757
39	U.S. Net Savings of Life Insurance Policy Holders spliced together, NBER
40	a13049U.S. Earnings Yield of All Common Stocks On the NYSE 1871-1938, Boston Industrail 1866-1870, HSUS, 3-768
41	U.S. Index of Wholesale Prices, T, U and V spliced
42	m04051U.S. Index of the General Price Level 01/1860-11/1939
43	m13001U.S. Call Money Rates Mixed Collateral 01/1857-11/1970
44	m13019U.S. American Railroad Bond Yields High Grade AT and AU spliced
45	m14124aU.S. National Bank Notes Outstanding Total End of Month 01/1864-12/1879
46	m13002U.S. Commercial Paper Rates New York City 01/1857-12/1971
47	US Notes
48	Business Failures
49	a10030U.S. Number of Concerns in Business 1866-1938
50	m12003U.S. Index of American Business Activity 01/1855-12/1970
51	m12015U.S. Bank Clearings Daily Average 10/1853-09/1943
52	Patents granted

(c) 14 series, 1890-1995

1 Cotton raw
2 Oats production
3 Cotton production
4 Raw steel production
5 Cargo moved on NY state canals
6 Stock prices
7 Telephones
8 US notes
9 Coal fuel mineral production
10 Wheat prices
11 Wool prices
12 Coal prices (anthr.)
13 Copper prices
14 Brick prices



(a) vs. Balke/Gordon series (b) vs. Romer series

Fig. 1: Factor of economic activity from 52 series with 67% error bands, constant factor loadings, 1867-1914

Table 1: Volatility Increase Across World War I, Constant Factor Loadings

Std.dev. from HP (6.25) trend	1869-1913	1914-1929	1869-1929	Difference Interwar-Prewar	Relative Interwar/Prewar
Romer GNP	0.0213	0.0267	0.0225	0.0054	1.2535
Balke/Gordon GNP	0.0263	0.0390	0.0296	0.0127	1.4829
Constant Factor 52	0.0256	0.0398	0.0296	0.0142	1.5565

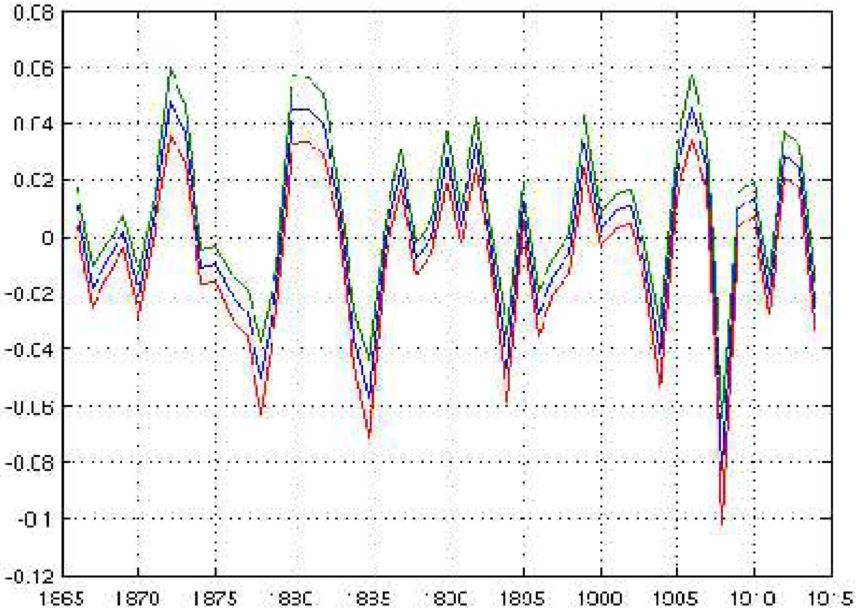


Fig. 2a: Factor of economic activity from 52 series with 67% error bands, constant factor loadings, 1867-1914

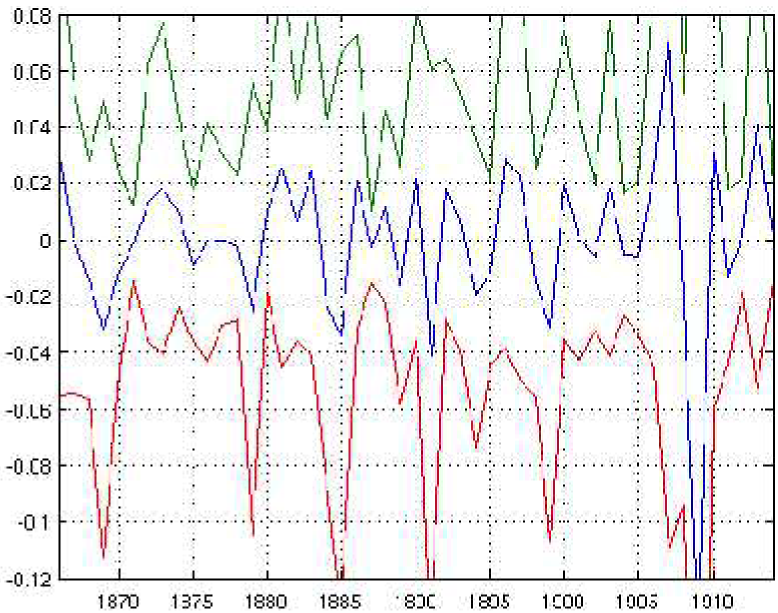
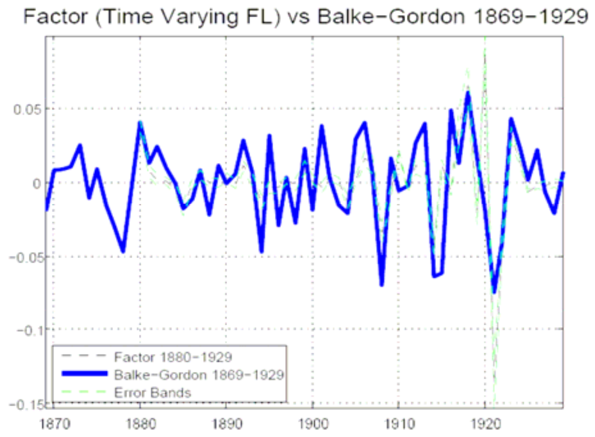
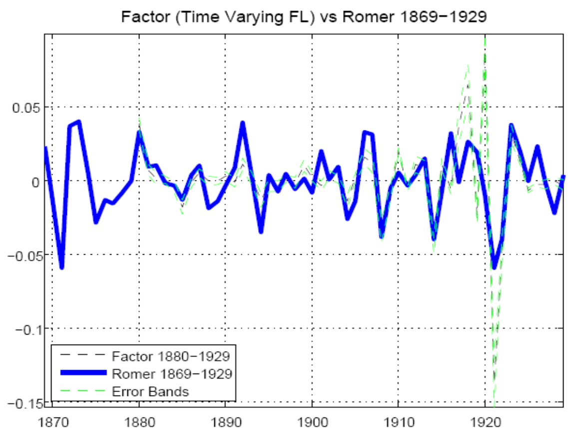


Fig. 2b: Factor of economic activity from 103 series with 67% error bands, constant factor loadings, 1867-1914



(a) vs. Balke/Gordon series

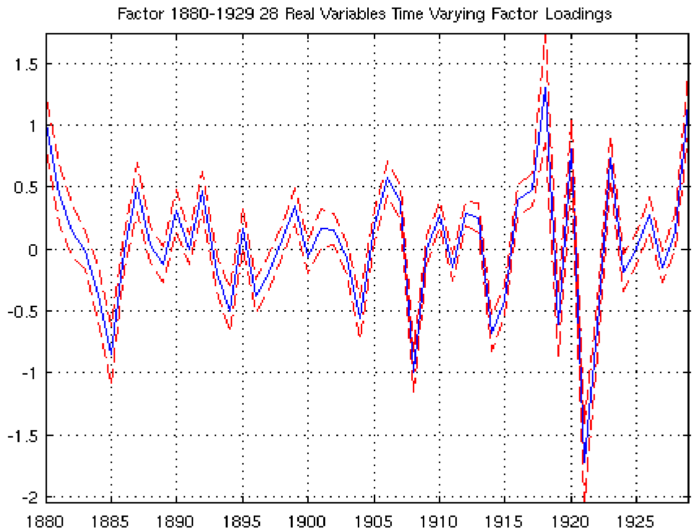


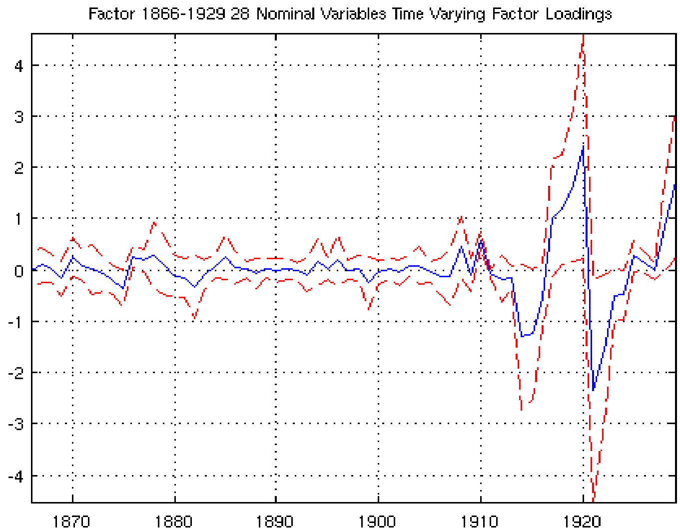
(b) vs. Romer series

Fig. 3: Factor of economic activity from 52 series with 67% error bands, time-varying factor loadings, 1867-1914

Table 2: Volatility Increase Across World War I, Time-Varying Factor Loadings

Std.dev. from HP (6.25) trend	**1869-1913**	**1914-1929**	**1869-1929**	**Difference Interwar-Prewar**	**Relative Interwar/Prewar**
Romer GNP	**0.0213**	**0.0267**	**0.0225**	**0.0054**	**1.2535**
Balke/Gordon GNP	**0.0263**	**0.0390**	**0.0296**	**0.0127**	**1.4829**
TVAR Factor 52	**0.0120**	**0.0503**	**0.0296**	**0.0383**	**4.1917**

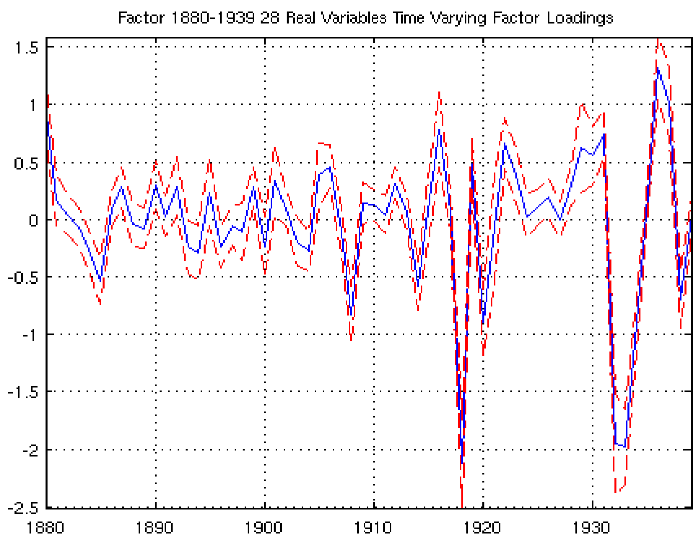


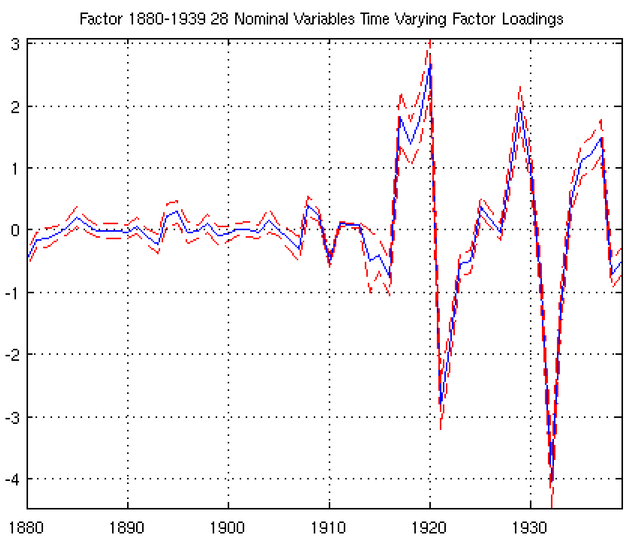


(a) Loading on 32 real series

(b) Loading on 20 nominal series

Fig. 4: Factors of economic activity from 52 series with 67% error bands, time-varying factor loadings, 1867-1929





(a) Loading on 32 real series

(b) Loading on 20 nominal series

Fig. 4: Factors of economic activity from 52 series with 67% error bands, time-varying factor loadings, 1867-1929

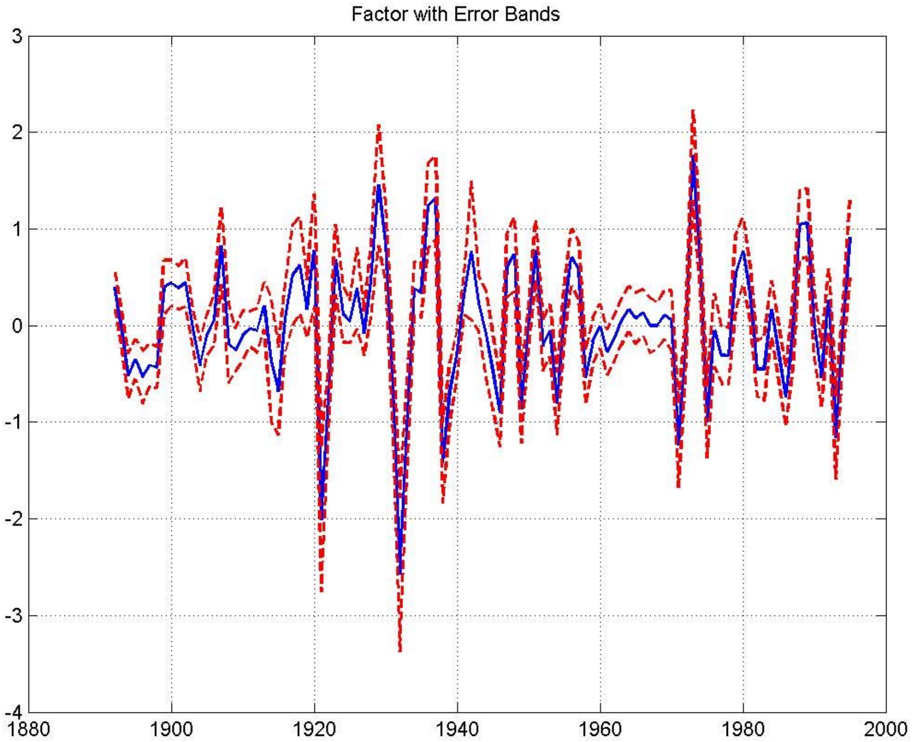


Fig. 5: Factors of economic activity from 14 series with 67% error bands, time-varying factor loadings, 1890-1995