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# The Course of the Great Depression

## A Consistent Business Cycle Dating Approach

Hans Christian Heinemeyer

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# The Course of the Great Depression. A Consistent Business Cycle Dating Approach

Hans Christian Heinemeyer*
Freie Universität Berlin†

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**Abstract**

This study dates business cycles in 10 European countries, the United States, and Japan between 1925 and 1936. The aim is to establish a consistent dating of the world economic crisis, which is a precondition for understanding the sharp economic decline in many countries during the interwar period.

Three approaches were applied that are common in business cycle dating. First, a deskriptive analysis infers on recessions based on the two-consecutive quarters approach often associated with the US National Bureau of Economic Research. Second, the time series is decomposed into trend and cycle using the Hodrick-Prescott (1980) filter. The third approach is to use Markov-regime switching models, which was proposed by Hamilton (1989) for such purposes.

The results of confirm that the Great Depression was a global phenomenon, not limited to the US or Germany. Business cycle comovement in the interwar period is at a level comparable to the post-WWII period. This finding points at the contribution of international business cycle integration to the course of the decline in single countries.

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†Department of Economics, Boltzmannstrasse 20, 14195 Berlin, Germany, e–mail: hans–christian.heinemeyer@wiwiss.fu–berlin.de.

# 1 The relevance of comparative dating of the world economic crisis

The world economic crisis[1] has been subject to comprehensive investigation in the field of economic history. Business cycle research is another field, for which the Great Depression is a focal point. At the intersection of the two literatures a comparative, cross-country business cycle dating is missing, despite its implications for explanatory approaches. The rationale of many hypothesis of the Great Depression relies in one way or another on the course of the business cycle at the national and international level.

Of course, there does exist a number of studies on the Great Depression, in which the time series evidence for certain countries is being investigated.[2] However, the dating of interwar cycles provided by these studies is of limited value for cross-country analysis, since it concerns individual countries. The dating reflects national experiences during this period or it is guided by interest in the economic history of one specific country. Analyzing the Depression in an international perspective makes it necessary then to incorporate datings, which result from different approaches. Datings have been based on different data frequencies, too, namely on quarterly or even annual data. Both factors certainly provide pitfalls.

This study proposes a comparative business cycle dating by consistently analyzing macroeconomic fluctuations in the US, Europe, and Japan between 1925 and 1936. It investigates the respective Depression(s) applying techniques typical of business cycle research. Another goal is to produce several stylized facts that a general theory on the Depression should be able to explain, mainly the chronology of turning points in different countries and differences across countries in the degree of severity of the downturn. The data used in the analysis is available at monthly frequency for the interwar period.

In economic history most hypotheses on causes and origins of the crisis have been derived from analysis of the depression in the United States (US), e.g. Friedman and Schwartz (1967) held responsible only the Federal Reserve's restrictive monetary policy in 1928 and 1929. But the early literature was not able to convincingly explain the downturn. For some time now, the focus of research is thus shifting towards international developments during the interwar period. Eichengreen (1992) and Bernanke (1995) stressed the importance of the gold standard, i.e. the international monetary framework

[1] I am using the terms *Great Depression* and *world economic crisis* as synonyms.

[2] Cf. Temin (1998) and Eichengreen (2004) for an overview.

between 1925 and 1931, as a transmission mechanism of adverse monetary shocks. Others have doubted that the depression originated in the US and locate the cause of the decline in the economic periphery instead, e.g. Ritschl (2002) and, quite early, Kindleberger (1973/86).

Similarly, the focus of business cycle research has been almost exclusively on the Great Depression in the US (beginning with Fisher 1933).[3] Recently the strand of the literature concerned with international co-movement of cycles has begun to take into account the development of the crisis in other countries, too (e.g. Bergman, Bordo, and Jonung 1998, Bordo and Helbling 2003). However, since the interest of business cycle research is to explain business cycles in general, some authors have raised the question, whether "the Great Depression should be treated as a singular, anomalous event or a litmus test for any general theory of business cycles." (Basu and Taylor 1999, p.5) After all, business cycle research views the Depression as just one downturn among many others.

The limited interest of the business cycle literature on the other hand implies that economic history can contribute to the issue by dealing appropriately with the special nature of the Great Depression. Despite the broadening of the country focus, neither of the two literatures has proposed a consistent dating of the world economic crisis.

A straightforward business cycle dating of the global economic crisis is a prerequisite for discussing the global causes, conditions, and impact of the Great Depression. Hypotheses that build on the effect of international dependencies require thus a comparative description and dating of the recession. It is a building block, at which point in time which country experienced the peak and trough in industrial production. The dating of turning points can help to verify or falsify hypotheses on the crisis within single countries and at the global level. In order to propose a comparative dating, this study applies three approaches, which are widely-used business cycle analysis: (i) the dating procedure associated with the NBER, (ii) conventional trend-cycle decomposition using the Hodrick–Prescott (HP) filter, and (iii) Markov-regime switching models as proposed by Hamilton (1989).

The study adds to the economic history literature by regarding the Great Depression mainly as a business cycle event at an international scale. Its focus is comparably narrow: Less than answering open questions, it proposes a dating in order to provoke further research in this direction. In addition to dating and describing macroeconomic cycles during the interwar period, I

[3]Temin (1998) provides an overview of the US centric literature.

shall check very roughly which of the findings support and contradict certain hypothesis, particularly Eichengreen (1992).

The paper proceeds as follows. In the next section contains a review of the role of business cycle fluctuations in hypothesis on the world economic crisis. Section 3 provides results country-by-country from three approaches that are common in business cycle research. The individual results are used in section 4 for making inferences on the course of the global crisis. Section 5 concludes.

## 2 The Great Depression as a business cycle episode

Modern business cycle research has established the conception of non-deterministic cycles that are caused by a continuous flow of stochastic shocks. The economic system turns these shocks into fluctuations, i.e. it functions as impulspropagation mechanism. Features of the resulting quasi-cycles are variable frequencies and amplitudes.

Central to business cycle theory is the interest in what kind of shocks prevails in producing fluctuations and how fluctuations are diffused through the economy. Within the aggregate supply - aggregate demand (AS–AD) framework cycles result from domestic shocks in demand or supply. These can be either real shocks or monetary shocks. In their *Monetary History of the United States* Friedman and Schwartz (1963) explain the Great Depression in the US by an exogenous monetary shock that affected the real economy.

It is also possible that fluctuations stem from the transmission of foreign shocks, i.e. they are due to innovations in other countries. The fact that many economies turned down during the 1920s and 1930s has raised the question, which countries experienced a depression caused primarily by domestic factors and which countries were affected primarily through the downturn of other economies. In those case, in which the recession was due to domestic innovations, the kind of innovations is of central interest.[4] Following the hypothesis of Friedman and Schwartz the rest of the world was affected by the downturn in the US, which was induced by the Federal Reserve's restrictive monetary policy in 1927 and 1928.

After all, identification is the central issue, i.e. which shocks are crucial and how they are propagated. In order to disentangle cause and effect, the dating of business cycle turning points has always played an important role, particularly in order to criticize the consistency of an explanation. The monetarist hypothesis of Friedman and Schwartz was weakened among other things, because it proved difficult to identify a monetary shock in the US large enough to explain the harsh downturn abroad. Particularly so, since IP in some countries declined several month before the US economy began to turn down (Eichengreen 2004).

Figure 1 depicts the course of industrial production and mining (IPM) in the US, Japan, and Germany as well as two composite series of IPM in West-

[4]See Temin (1998) for an account of the different shocks to the US economy during the 20th century.

ern and Eastern European countries.[5] For manipulations of the series as to achieve comparability cf. section 6.1. The extraordinary development of the series illustrates the magnitude of the Great Depression. It is important to note that figure 1 displays monthly observations of an index of physical IPM and not, as it may seem, business cycle components in the sense of deviations from some growth trend.[6] The graph shows that apparently the whole industrialized world was affected by the crisis with the largest decline in IPM to be found in Germany, the US, and Central Eastern Europe. IPM in Western Europe began to decline at about the same time as in the former countries, but at a lower pace, whereas Japan somehow managed to escape the crisis in mid-1931, although "the slide into the abyss (Kindleberger 1973/86) of its economy had begun in 1930 as well.

Eichengreen (1992) replaced the theory of Friedman and Schwartz by the hypothesis that the Great Depression was merely indirectly triggered by the monetary policy of the Federal Reserve in 1928 and 1929. According to him the background against which the Great Depression took place is crucial. His argument rests on two pillars: first, the fact that the policy of central banks around the world was tied to that of the Federal Reserve by the interwar gold standard. The rules of the gold standard forced several countries, e.g. Germany, to pursue a monetary policy in response to the shocks that was inappropriate for the economic situation as these countries were already on the edge of recession (Eichengreen 2004). Second, the economic decline abroad - already since 1929 - prevented the US economy from exporting more abroad in order to make up for the decline in domestic demand.

In his seminal *Golden Fetters*, Eichengreen concentrates on the first of these arguments, i.e. that the institutional set-up of the gold standard worked as a mechanism to propagate fluctuations resulting from monetary policy shocks to the international economy and aggrevating them. Therefore, Eichengreen (1992) stresses the importance of untying the Golden Fetters, i.e. to dissolve the gold standard, in order to resolve the crisis. Against this background it is interesting to note that figure 1 indicates that the decline in Germany and the US came to a halt already in early 1931 for about half a year, i.e. several month before the dissolution of the gold standard.

[5]Eastern Europe: Austria, Czechoslovakia, Hungary, and Poland; Western (and Northern) Europe: Belgium, Britain, France, Sweden, and Finland. Unweighted averages.

[6]The data were seasonally adjusted using X11–ARIMA from the *pastecs* package in *R*. In order to check robustness of the adjustment, I applied seasonal dummy variables as well, but without notable change. Still, I consider X–11 to be more appropriate than the dummy variable approach, since I find it difficult to assume that seasonal effects remained constant over the course of the crisis.

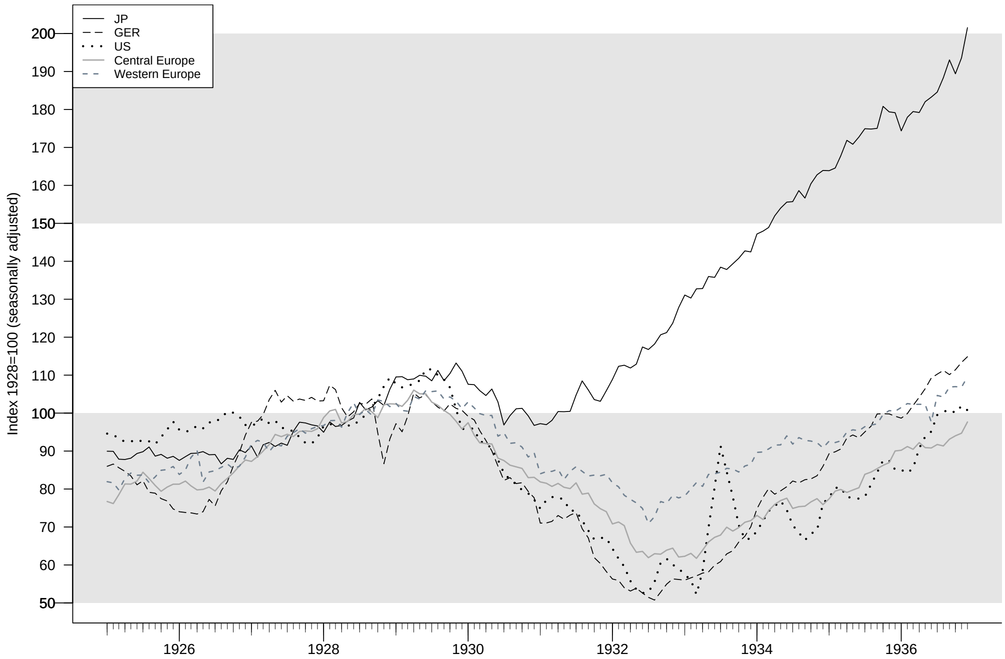


Figure 1: Industrial production in Europe, the US, and Japan, 1925–1936

Eichengreen (1992, 2004) has underlined the importance of comparative accounts of the interwar period. His explanation explicitly stresses the importance of international economic relations arguing that conditions within and between many countries were fragile in this period. Implicitly, it also relies on timing of macroeconomic cycles in the rest of the world (ROW), most notably in Europe. Yet, figure 1 provides neither visual evidence of a significant positive response of IPM to monetary policy shocks in the US in 1928 nor of an immediate effect in most countries of the dissolution of the gold standard in 1931.

# 3 Time series analysis

The data set comprises monthly indices of industrial production and mining (IPM) from 10 European countries, the US, and Japan. The data was chosen as a proxy of aggregate economic activity, because it is recorded at a high frequency, internationally comparable[7], and there does not exist any other broad indicator of economic activity, such as GDP, for the interwar period. The first dating exercise is a business cycle analysis, which uses the definition often associated with the classical dating procedure of the US National Bureau of Economic Research (NBER). It is subsequently denoted as pseudo NBER dating. The main part in section 3.3 relies on the Markov-regime switching model suggested by Hamilton (1989) for similar purpose. These approaches are complemented by trend-cycle decomposition in section 3.2, an approach that is widely applied in business cycle research, too. The latter serves mainly to cross check results.

The question is, whether there are systematic similarities and differences in the development of IPM between countries. A sensible hypothesis should then both be able to explain the general development across countries during the interwar period and say something on systematic differences between countries in the course of the crisis. Linking such similarities and differences to patterns of institutional or policy similarities and differences would certainly strengthen a hypothesis.

## 3.1 Deskriptive business cycle analysis

The starting point of the analysis, the above figure 1, shows several aspects worth noting. First, it appears difficult to restrict the Great Depression to the period 1929-1933. IPM in Germany stagnated already in 1928, whereas the recovery after the crisis was sluggish both in Western and Eastern Europe. This observation raises the question how to sensibly date the Great Depression at all. Second, there appears to be a certain degree of co-movement in the development of IPM across the selected regions though less for Japan. The eyeballing suggests potential business cycle integration. Third, a positive reaction of IPM in those countries going off gold is not immediately apparent from the plot.[8] Fourth, the exceptional scope of the crisis is visible from the time series. Usual recessions put a dent in IP, but do not cause a severe downward shift in the long-run.

[7] Cf. Mattesini and Quintieri (1997), FN 5.

[8] Among the countries leaving the gold standard in 1931 are Austria, Britain, Czechoslovakia, Finland, Germany, and Sweden (cf. Wolf and Yousef 2005).

Table 1: Drop in IP between business cycle peak and trough

| **Country** | **Peak date** | **Peak level** | **Trough date** | **Trough level** | **IP drop** |
|---|---|---|---|---|---|
| Poland | Apr 29 | 107.9 | Mar 33 | 47.9 | -56% |
| United States | Jun 29 | 111.5 | Mar 33 | 52.2 | -53% |
| Germany | Apr 29 | 105.3 | Aug 32 | 50.7 | -52% |
| Belgium | Jun 29 | 104.0 | Jul 32 | 50.2 | -52% |
| Austria | Jun 29 | 109.3 | Dec 32 | 58.5 | -46% |
| Czechoslovakia | May 29 | 107.7 | Mar 33 | 61.3 | -43% |
| Hungary | May 29 | 106.9 | May 32 | 66.5 | -38% |
| France | Feb 30 | 113.3 | Jul 32 | 72.7 | -36% |
| Sweden | Jan 30 | 107.6 | Jul 32 | 70.2 | -35% |
| Britain | Aug 29 | 112.6 | May 31 | 78.7 | -30% |
| Finland | Aug 29 | 102.4 | Mar 32 | 74.6 | -27% |
| Japan | Nov 29 | 113.2 | Dec 30 | 96.8 | -15% |

*Notes:* The figures are calculated on the basis of the seasonally adjusted data.
The base year of each index is 1928=100.

From the graph it is impossible to perform straightforward dating of turning points and of recessions. The popular strategy in deskriptive business cycle analysis is, therefore, to follow a rule associated with the NBER. The rule defines a recession as two consecutive quarters of decline in the absolute level of industrial production.[9] Following this rule, I identified recessions for each country in my sample using quarterly averages over the monthly data. The resulting recession episodes are depicted in appendix A (figures 12–23). An even simpler approach in descriptive analysis is to compute turning points as I have done from the monthly data in table 1.

Taken together, table 1 as well as figures 1 and 12–23 provide a simple benchmark for more sophisticated approaches. The calculations given in table 1 are consistent with the common claim that the US and Germany experienced the largest drop in industrial production between 1929 and 1933. But also in Poland and Belgium the drop in IPM from its pre-Depression peak to the trough amounts to over 50%. If one enlarges this group by Austria and Czechoslovakia, where IP still declined by more than 40%, and by Hungary, the country next in the order, five out of the seven countries most severely affected are situated in Central (Eastern) Europe. These countries reach their peak production between April and June 1929. All of the remaining five countries reach their respective peak production level later than June 1929, namely between August 1929 and February 1930. The opposite is the

[9]The actual NBER dating procedure is more flexible and relies on several aggregate series.

case for the lower turning points: The latter group experiences the trough in IPM between December 1930 and July 1932. Except for Hungary (May 1932), all countries of the former group reach the lower turning point between July 1932 and March 1933. It seems as if the extent of decline in a country's IPM coincided with its duration and the point in time it began.

From table 1 one learns yet little about how the Depression fitted into the general business cycle pattern. I used the pseudo-NBER procedure to date recessions in the interwar period. The first result of which is that every country in the sample experienced a recession in the mid 1920s. For the US and Germany the approach even implies two recessions during this period, the first one in 1925 and another one in late 1927.[10] Regarding the Great Depression, a more or less severe recession is identified for each country at the turn of the decade as well. The analysis indicates that almost all countries in the sample experienced a very long and double-dip recession. Only Sweden, Finland, and Japan experience comparably short recessions not showing the double-dip pattern. Although, the initial downturn took place relatively contemporaneously, the following turning points varied a lot over time by country. The approach yields that the Depression in the US ended already in mid-1932 (cf. figure 12). This timing is in advance of the through indicated by table 1 as well as the official NBER dating, both of which give the trough in March 1933.[11]

Figures 12–23 exhibit large differences in the development of IP between countries.[12] These differences are evident already during the pre-depression boom. In the United Kingdom (UK) the recovery from a short, but huge, slump following the miner's strike in 1926 immediately turned into a boom in late 1926.[13] The German economy, in recession since spring 1925, picked up at about the same time and experienced an intense, but short-lived boom. The sharp increase in its IPM was probably fueled by the inflow of American capital at that time (cf. Ritschl 2002, p.XXX). One reason, which could have positively affected Germany's IPM is that Britain dropped out as an exporter from the world market for coal during the miner's strike. The US

[10]Except for the contraction in 1925, the results are broadly consistent with the recessions acknowledged by the NBER's Business Cycle Dating Committee on NBER's website.

[11]Information taken from the NBER's website: nber.org/cycles.html. The deviation is likely caused by two short and very strong positive shocks, which bias the averaging over quarters.

[12]However, a comparison of boxplots of all series remained too inconclusive to systematically depict differences.

[13]This is somewhat in contrast to stagnation mentioned by Kindleberger (1973/86) and also by Ritschl (2002), which might be due to the different frequencies, monthly vs. annual, and series, IP vs. GDP, considered.

economy enters short-lived upswing comparably late and only after a period of stagnation. In contrast, the French business cycle appears to lag the overall cycle by about a year. The country experiences a prolonged decline from summer 1933 until early 1935, thus at a time all other countries are growing strongly. Explanations focussing on the gold standard have ascribed the French decline to its membership in the Gold Bloc, i.e. a group of countries, which continued to adhere to the rules of the gold standard (e.g. Eichengreen 1992). Since Poland and Belgium, two other Gold Bloc members, did not fare as badly as France, the adverse performance might have also been connected to political unrest, e.g. to the February riots in 1934. IPM in the US develops exceptionally from the summer of 1932 to autumn 1933. At first, the index increases strongly, but thereafter shows another large drop. Since I did not find any reference to this event in the literature, it obviously did not attracted much attention by researchers, presumably because it is averaged out when analyzing lower frequency data.

In the midst of the Great Depression an economic upturn is apparent from the graphs in many countries. Viewed in detail, there is an obvious international co-movement in the this development although country-specific differences remain. According to this dating approach, this temporary upturn takes place in 1931 in all of the countries, except in France, Poland, and the US. It separates what Eichengreen (2004) calls the first and the second stage of the Depression. An exceptional case is Japan, where the end of the first recessionary period marks the early end of the decline at all. It appears difficult to link this upturn to the dissolution of the gold standard, since e.g. in Britain, IPM starts to increase several month in advance of the country's exit from the gold standard, which is the true for other countries as well. Still, in Britain the second recession is comparably short.

The pseudo-NBER approach reveals the global dimension of the depression and indicates a certain co-movement of business-cycles. In nine out of twelve countries, including the US, Germany, and Britain, IPM peaks before September 1929. Accordingly, the stock market crash at Wall Street in late October 1929, another usual suspect in the literature, appears rather the result than the cause of the mess. Large differences between countries are found in the severity of the downturn as well as in the development of IPM after 1931. The deskriptive analysis is not suited to evaluate the length of the downturn and its extent within a single approach. It is difficult to infer on the long-term development. As the pseudo-NBER approach is very sensitive to temporary jumps in IPM it potentially underestimates the duration of the recessions, too.

## 3.2 Trend-cycle decomposition using HP filtering

A standard approach in analyzing the development of industrial production and GDP is to separate the cyclical components in a series $y_t$ from its trend component.[14] The approach in this paper is to assume that $y_t$ is composed of a secular trend $x_t$, cyclical fluctuations around this trend $c_t$, additional seasonal fluctuations $s_t$, and random fluctuations $\epsilon_t$. Such a relationship can be formalized as

$$y_t = x_t + c_t + s_t + \epsilon_t \tag{1}$$

After the series has been seasonally adjusted, it is possible to isolate growth trend by applying the Hodrick-Prescott (HP) filter to the series. This filter relies on a smoothing parameter $\lambda$. Its objective function is given by

$$\min_{x_t} \sum_{t=1}^{T} (y_t - x_t)^2 + \lambda \sum_{t=2}^{T} [(x_{t+1} - x_t) - (x_t - x_{t-1})]^2 \tag{2}$$

Equation (2) yields an estimate of the growth component $\hat{x}_t$. It appears to be based on measurement without theory. Yet, the approach requires assumptions, which are part of various business cycle theories. A strong assumption is that of separability of the components. The functional form of the trend, namely its smoothness, must be assumed as well.[15] Against the background of the Great Depression, it is an advantage that the HP filter allows for non-linearity of the growth trend. It appears inappropriate to assume a linear growth component during this period, which is often done in studies on post-WWII growth.

Figure 2 depicts the resulting growth components for all countries. The curve progression is highly unusual for HP filtered growth components. Only the estimated trend of Japanese IPM displays the features that we know from the post WWII period. If interprets these results by the underlying idea of decomposition, the Great Depressionis not merely a peculiar business cycle phenomenon in most countries in the sample. Instead, it is the consequence of an exceptional shift in their growth path. As for any other filter, one can doubt if the HP filter is producing the 'true' pattern, e.g. if it captures the level shift during the crisis years correctly. Yet, even regarding

[14] Both $y_t = log(Y_t)$, $x_t$, $c_t$, $s_t$, and $\epsilon_t$ refer to log transformations of the orininal variables.

[15] The filter was proposed by HP (1980). $\lambda$ is specified according to Ravn and Uhlig (2002).

it only as a means to take the high frequency fluctuations is helpful, since the smoothed series provide an intuitive summary of fundamental similarities and differences across countries.

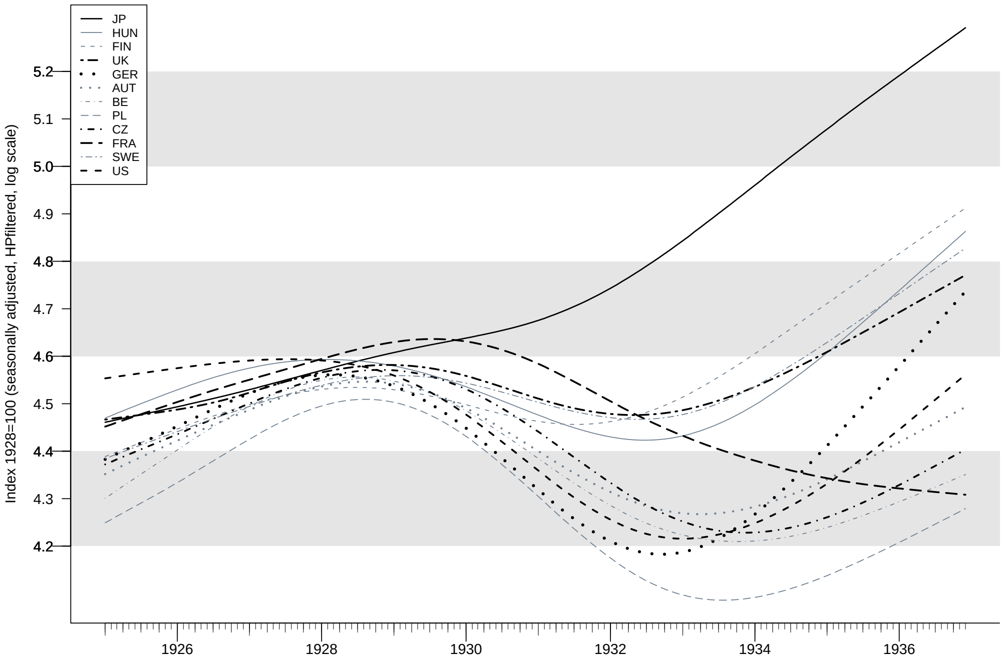


Figure 2: Trend components of IPM obtained from decomposition

It is striking how similarly the growth components develop until mid-1928. Deviating from this, the decomposition indicates that IPM in the US stagnated already since 1925. The common shift in the growth path is first observed in the US and Germany. The Depression deeply but narrow dented the growth trend of German IPM. In contrast, its impact on the US economy seems smoother. The graph shows the comparably small impact of the Depression on the growth path in Britain, Finland, Hungary, and Sweden.

I have categorized each country according to the progression of its HP growth component. One dimension of the grouping is the extent to which an economy was affected by the Depression. The other dimension is how quickly its economy recovered from the slump. Grouping the countries along these dimensions yields table 2. Next to Japan, France is not listed in this table. The country's growth trend is too different, first because its progression is

Table 2: Extent of slump vs. speed of recovery

| Extent of slump | Speed of recovery Quickly | Slowly |
|---|---|---|
| **Large** | Germany<br>United States | Czechoslovakia<br>Belgium<br>Austria<br>Poland |
| **Small** | Finland<br>Sweden<br>Hungary | Britain |

lagging that of all other countries. Second, if one holds the Great Depression responsible for the prolonged decline after 1933, the long run effect of the crisis on the French economy was apparently much larger than for any other country.

Persistence of the crisis seems to an important differencing criterion between countries. In fact, figure 2 makes it look improbable that the Depression was over in 1933. Table 2 adds the speed of recovery as a second dimension to the simple comparison of pre-Depression peak levels with the levels at the lower turning points . Certainly, the distinctive feature of the crisis was its different extent across countries, but there were important differences in the speed of the recovery as well. Only these differences explain why Germany overtook its pre-Depression level of IPM already in 1935. By contrast, Poland succeeded in doing so first in 1938 (acc. to Landau and Tomaszewski 1986). It is perhaps no coincidence that all four countries, which were affected heavily and recovered only slowly, are economically small and directly neighboring Germany.[16] At the same time, there is no country in any other group, which is a adjacent to Germany.

Having obtained $\hat{x}_t$, one can subtract $\hat{x}_t$ from $y_t$ in order to compute the residual component, which consists of $c_t + \epsilon_t + (x_t - \hat{x}_t)$.[17] Although the latter relation cannot further be decomposed, it can still serve as an approximation of the cyclical component $c_t$. This residual component is also often dubbed business cycle component.

The residual component suggests almost two complete cycles during the period 1925-1936. This gives a reasonable average duration of above 6 years

[16]Interestingly, these countries seem not to benefit in particular from the strong recovery in Germany since 1932.

[17]It actually even consists of $c_t + \epsilon_t + (x_t - \hat{x}_t) + (s_t - \hat{s}_t)$.

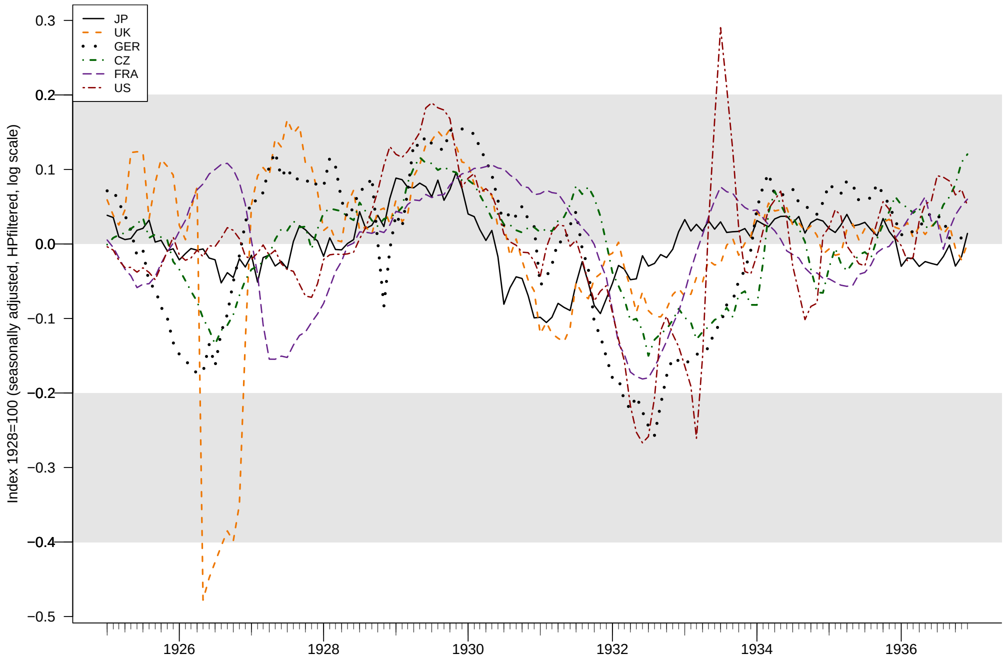


Figure 3: Cyclical component of IPM for important economies

for one entire business cycle. The graph displays large cross-country differences between 1925 and 1929. From late 1929 onward IPM in important economies appears to progress comparably synchronized. Although the variation in cyclical fluctuations in IPM remains high in this period, a hypothetical, unweighted mean would provide a good approximation to each country's cyclical component. [CORRELATION]

These findings also suggest the existence of an international business cycle at the time and its potential interrelation with the Depression. In contrast to the differences detected in the secular trend components, short-term fluctuations in the Central European countries do not appear to systematically deviate from those in the rest of Europe and the US. Again, the French cycle shows a characteristic lag, whereas the cyclical component for Japanese IPM indicates comparably low correlation with the other countries especially after 1930. At least for the period 1925 to 1929, figure 3 is not clearly supportive of Ritschl's (2002) claim that the varying reparation and transfer schemes during the 1920s induced specific German business cycles (*Sonderkonjunkturen*).

From the perspective of trend-cycle decomposition the Great Depression was not only a business cycle phenomenon. A major reason for its severeness was a contemporaneous shift in most countries' growth trend. The decomposition provides a measure of this fundamental development, but it is somewhat artificial. It only allows an arbitrary dating, because it is not possible to jointly evaluate the trend and the cycle.

## 3.3 Results from Markov regime switching analysis

Empirical evidence suggests that many macroeconomic variables behave differently during upswings and downturns, i.e. the underlying data generating process (DGP) is subject to non-linearities (Hamilton 1989). One potential reason is that utilization of factors of production in an economy changes with different states of growth of that economy, e.g. during booms and recessions. The state is only one of many factors affecting output dynamics. Translated to business cycles, this implies that even during a boom, one might temporarily observe declining output.[18]

Hamilton (1989) proposed the following autoregressive (AR) process of order one or $n$, subsequently denoted as AR($n$), for the analysis of such fluctuations in a series $y_t$, which in our case is the IPM index at time $t$.

$$y_t = c_{s_t} + \phi y_{t-1} + \epsilon_t \tag{3}$$

, where $c$ is a constant, which takes different values depending on the state of the economy $s_t$ at $t$ and $\epsilon_t \sim N(0, \sigma^2)$. $c$ changes when the economy is shifting from one state $s = 1$ into another state $s = 2$. During one state $c_s$ remains time-invariant. The states themselves are not observable.

Markov regime switching (MS) models are based on such AR processes with variable dynamics. The approach was very successfully used in analyzing IPM in the post-WWII period (cf. Krolzig 1997, Hamilton 2005). It appears particularly well suited for the interwar period, too. One can certainly expect a major shift in factor utilization during an event as disruptive as the Great Depression. The MS approach allows for time series analysis, where AR parameters are time-varying and can thus account for non-linearities in the DGP. Furthermore, it produces stylized facts that are straightforward to compare and has therefore become increasingly popular for characterizing fluctuations in aggregate economic activity (see e.g. AKT 2004).

[18] As an illustration cf. the differenced series in appendix A.

As a simple specification, we assume the existence of two states of the economy. Let the economy be driven by two regimes. Thus, the DGP is driven by two regimes, regime 1 and 2, which lead to recessions and booms, repectively. Let regime 1 prevail from time $t = 1$ up until $t = t_0$, i.e. in period $t_0$ occurs a regime shift in the stochastic DGP. The process under regime 1 with $s_t = 1$ yields

$$y_t = c_1 + \phi y_{t-1} + \epsilon_t \tag{4}$$

for $t = 2, ..., t_0$. As the model is applied to the first difference of the IPM index, the coefficients $c_1$ and $c_2$ represent the mean growth rate during state 1 and state 2, i.e. during recessions and booms, respectively. The complementary model with $s_t = 2$ for $t = t_0 + 1, t_0 + 2, ..., t_0 + T$ gives

$$y_t = c_2 + \phi y_{t-1} + \epsilon_t \tag{5}$$

Note that $s_t$ itself is a random variable. When estimating the model, one infers on the probability that one regime, which leads to the respective state, prevails conditional on the available set of information about the likely state in the previous period. The simplest such specification is that $s_t$ is the realization of a two-state Markov chain with

$$\begin{aligned} Pr(s_t = j \mid s_{t-1} = i, s_{t-2} = k, ..., y_{t-1}, y_{t-2}, ...) \\ = Pr(s_t = j \mid s_{t-1} = i) = p_{ij} \end{aligned} \tag{6}$$

As stressed by Krolzig (1997) model selection within the MS framework is not always very straightforward. Since the estimation relies on numerical and iterative procedures, there is the risk of obtaining local maxima. Krolzig (1997, chapter 7) recommends as a solution that the researcher should have some prior view on potential regime shifts. I obtain such prior information by applying a general-to-specific modelling strategy similar to Krolzig (1997). On the one hand, the results from the MS approach should not entirely contradict the pseudo-NBER dating. On the other hand, regime probabilities obtained from the simple two-state model applied to each country provide prior knowledge about potential DGPs. This model is an MSM(2)-AR(7), i.e. a MS-AR with switches in the mean (M) and an AR process of order seven. It is a slight modification of the original Hamilton MS-AR.[19] The fit

[19]Hamilton applied a MSM(2)-AR(4) to quarterly US GDP. However, models with higher AR-order than 7, like the analogous MSM(2)-AR(12), were too computationally demanding to be performed here. Estimation of MS models in this section was performed via the *MSVAR* package v1.31k in *Ox* v3.40.

of this model as well as the resulting AR-coefficients serve as a starting point for more complex models.

The estimation was performed using monthly percent differences instead of log differences. Against the background of the Great Depression the latter cannot be regarded as a good approximation of the former.[20]

The two-state model yields meaningful regime switches only for the course of IPM in Finland, Germany, Austria, Czechoslovakia, Sweden, and Japan. In similar studies of the postwar period, parsimonious two-state models performed mostly very well (cf. Hamilton 1989, Krolzig 1997). The results for these countries plus the US are presented in table 3.[21] The regimes identified for the aforementioned countries are largely consistent with the pseudo-NBER dating. Take the case of Germany, for which the model provides evidence of a recession in mid 1925 as well as of a double-dip recession between spring 1929 and fall 1932. Considering the switching means $\mu_1$ and $\mu_2$, the analysis of German IPM yields coefficients of $\mu_1 = -2.29$ and $\mu_2 = 1.41$. The recessionary regime 1 is comparably persistent according to the high probability of remaining in regime 1 conditional on being in regime 1, given by $p_{11} = 0.895$. From this figure one can directly compute the expected duration of recessions in interwar Germany as $(1 - p_{11})^{-1}$ yielding nearly 10 months.

The coefficient $\mu_1$ implies an annualized growth rate of German IPM during recessions of –24.3%, which is computed as $((1+0.0229)^{12}-1)*100\%$. The corresponding annualized growth rate during booms is 18.3%. These growth rates relate to the following periods, where the probability of the German economy being in recession is above 50%: From September 1925 (1925:9) until January 1926 (1926:1), from 1928:9 until 1928:11, from 1929:7 until 1931:1, and from 1931:8 until 1932:7.[22]

Appendix B contains the corresponding plots of regime probabilities for every country in the sample (cf. figures 24-35 as well as table 5). Together with table 5, these figures reveal large country-specific differences. Austria's and Czechoslovakia's IPM are subject to frequent regime shifts even

[20]The results presented in this section stem from the estimation of the first differences of each series computed as percent change on the month earlier. Using the augmented Dickey-Fuller (ADF) test, the presence of a unit root could not be rejected at the 5% significance level for any series. Having taken first differences, the null of a unit root was rejected at the 5% significance level in each case indicating stationarity .

[21]Table 5 in appendix B gives the results for every country in the sample.

[22]This dating is similar to the one yielded by the pseudo-NBER approach, namely from the second quarter 1925 (1925–2) to the first quarter 1926 (1926–1) as well as from 1927–3 to 1927–4, 1928–2 to 1928–4, 1929–3 to 1931–1, and from 1931–3 to 1932–3.

Table 3: Regime coefficients obtained from an MSM(2)-AR(7)

| **Coefficient** | **Germany** | **Austria** | **Japan** | **Finland** | **US** | **Sweden** | **CZ** |
|---|---|---|---|---|---|---|---|
| *Regime-dependent means* | | | | | | | |
| $\mu_1$ | -2.29 | -1.82 | -0.74 | -0.86 | -0.02 | -3.71 | -0.78 |
| $\mu_2$ | 1.41 | 1.99 | 1.19 | 0.82 | 1.15 | 0.73 | 2.21 |
| *AR coefficients* | | | | | | | |
| $\alpha_1$ | 0.233 | -0.694 | -0.464 | -0.414 | 0.660 | -0.501 | 0.431 |
| $\alpha_2$ | -0.015 | -0.427 | -0.390 | -0.147 | -0.183 | -0.284 | 0.197 |
| $\alpha_3$ | 0.039 | -0.456 | -0.183 | -0.163 | 0.033 | -0.061 | -0.213 |
| $\alpha_4$ | 0.110 | -0.493 | 0.077 | -0.192 | -0.139 | -0.006 | 0.364 |
| $\alpha_5$ | -0.138 | -0.261 | 0.230 | -0.097 | -0.029 | 0.152 | 0.211 |
| $\alpha_6$ | 0.106 | -0.265 | 0.433 | -0.146 | -0.103 | 0.134 | -0.158 |
| $\alpha_7$ | 0.097 | -0.072 | 0.268 | -0.062 | 0.207 | -0.007 | -0.148 |
| *Persistence of recessions: transition probabilities and expected durations in month* | | | | | | | |
| $p_{11}$ | 0.895 | 0.795 | 0.703 | 0.945 | 0.984 | 0.635 | 0.871 |
| duration | 10 | 5 | 3 | 18 | 62 | 3 | 8 |
| *Variances and actual number of months in recession between 1925 and 1936* | | | | | | | |
| $\sigma^2$ | 5.02 | 8.27 | 1.76 | 10.85 | 4.71 | 8.70 | 1.21 |
| # month rec. | 40 | 66 | 41 | 30 | 131 | 12 | 94 |
| # obs. | 136 | 136 | 136 | 136 | 136 | 136 | 136 |
| ln$L$ | 308.84 | 253.13 | 362.39 | 266.13 | 312.65 | 270.83 | 372.38 |
| LM rejected | yes | yes | yes | yes | yes | yes | yes |

*Notes:* "LM rejected" refers to the rejection of the $H_0$ of a linear model using the Davies test. "# month rec." gives the number of months for which the probability of recession is above 50%.

after 1933. Either of these two countries experienced strong growth during expansions. In Austria recessions were rather short and strong, whereas in Czechoslovakia they were modest but long lasting. For Czechoslovakia, which comprised the most industrialized part of the former Austro-Hungarian empire, I find a high probability of recession during almost 70% of the sample period. Finland and Sweden experienced the least number of months in recession. The Swedish economy had few very short and strong contractions, in Finland there were only one modest, but continued recession in Finland. Japan, by contrast to any other country, was subject to frequent regime shifts only until 1931. In comparison, its recessions were not only short but also moderate with an annualized rate of –8.5%. The MS approach presents differences between these economies during the crisis in comprehensive manner.

The graphs indicate clearly that the initial two-state model does not fit very well the development of IPM in several countries during the interwar period. In these cases it is not possible to unambigously distinct periods of growth from periods of decline. In some cases the model indicates that one regime prevails all the time. In other cases the probability of one regime is not clearly higher than for the other regime.[23] The partial failure of the model might indicate that the economic development during the interwar period requires less parsimonious MS models.

At the same time also Krolzig (1997) and AKT (2004) have shown that allowing for more than two states improves the performance of MS models in explaining the economic development of certain countries. The MS model's applicability depends on amplitudes and exceptional states of growth in the time series analyzed, e.g. very high growth rates in Japan during the 1970s. Such features are the likely reason for the above results as well. Take the graphs from the pseudo NBER approach (cf. appendix A). The IPM series of some countries, for which the model failed to produce sensible estimates, are indeed having exceptional amplitudes. Within a short period of time, the amplitude is larger than 30% in the US (1933) and Sweden (1925) and larger than 60% in Belgium (1935) and Britain (1926). If economic fluctuations are in general not persistent enough, the MSM struggles as well in identifying regimes. This is the case for French, Polish, and Hungarian IPM.

One way to extend the simple specification (3) is to allow for state-dependent heterogeneity as well as for state-dependency of AR coefficients. In addition, it is possible to relax the restriction on the number of states, i.e.

[23] The former is the case for the US, Poland, France, and Sweden, the latter is the case for the UK, Hungary, Czechoslovakia, and Belgium.

to allow for three or more regimes.

(7) $$y_t = c_{s_t} + \phi_{s_t} y_{t-1} + \epsilon_t$$

, where $\epsilon_t \sim N(0, \sigma^2_{s_t})$. It is possible to test, whether a model with fewer restrictions like equation (7) is superior to a more parsimonious one like equation (3). Model choice is difficult, but it can be crucial for results.

Building on the MSM(2) results, the aim is to identify a suitable MS-model for each economy in the sample. Since I want to allow for more complex set-ups, I am using MS models with shifts in the intercept (MSI).[24] MSI are not as computationally demanding as MSM and better suited for the analysis of less restrictive and thus less parsimonious models. In order to mark the difference between the estimation outputs, I am using a different notation for the respective state parameters, namely $\nu$ in case of MSI. Krolzig (1997) has shown that for dating purposes, both approaches lead to comparable results for simple specifications with two regimes. Based on the initial MSM(2)-AR(7) model and the rejection of the linear model, I adopt a three step strategy.[25]

1. If the smoothed regime plots of MSM(2) and MSI(2) indicate that a two-state model is not appropriate for a certain country, relax restrictions on the number of regimes stepwise up to $n = 4$.

2. Once the estimation output indicates that the number of states suffices to capture the fundamental development of IPM, I use diagnostic statistics of the residuals to check, whether restrictions ought to be entended or relaxed on (a) the numner of AR terms, (b) state-dependency of heterogeneity or the variance, respectively, as well as on (c) state-dependency of the AR-terms.

3. Using the likelihood ratio (LR) test, I decide whether additional restrictions are necessary or dispensable.[26] Finally, the most parsimonious

[24] In general, MSI models allow for smooth regime shift, whereas MSM models assume regime shifts within one period. For a conceptional description and a detailed comparison of the MSM and MSI approach, cf. Krolzig (1997, section 11).

[25] The LR test on the number of states does not have a standard asymptotic distribution. Thus, it is in general not possible to test $H_0\colon \mu_1 = \mu_2$ vs. $H_1\colon \mu_1 \neq \mu_2$ or $H_0\colon \nu_1 = \nu_2$ vs. $H_1\colon \nu_1 \neq \nu_2$, respectively (Krolzig 1997, p.247). However, a general test on the linearity of the model can be performed using the Davies test, which belongs to the class of likelihood ratio tests as well. It compares a model with n = 1 regimes, i.e. a linear model, to more complex model. The null is given by $H_0\colon n = 1$ vs. $H_1\colon n \geq 2$ regimes. Cf. Davies (1987).

[26] The LR test can be based on the LR statistic $LR = 2(lnL(\tilde{\lambda}) - lnL(\tilde{\lambda}_0))$, where $(\tilde{\lambda}_0)$ denotes the restricted ML estimate of the parameter vector $\lambda$. Under the null, LR has an asymptotic $\chi^2$ distribution with $r$ degrees of freedom. $r$ gives the number of restrictions.

model possible is chosen.

The following results are based on the resulting MSI($n$)-AR($p$). Models investigated subsequently dispose of different numbers of states $n$ and different AR orders $p$. Furthermore, the error variances may be state-dependent $\sigma_{s_t}$. Concerning the estimation, it is unsatisfying that for some countries the results are sensitive to the model specification, e.g. state-dependency of AR coefficients. Therefore, I apply further test statistics, namely the Akaike as well as the Bayesian Information Criterion, (AIC) and (BIC), respectively. If necessary, results from alternative specifications are mentioned.

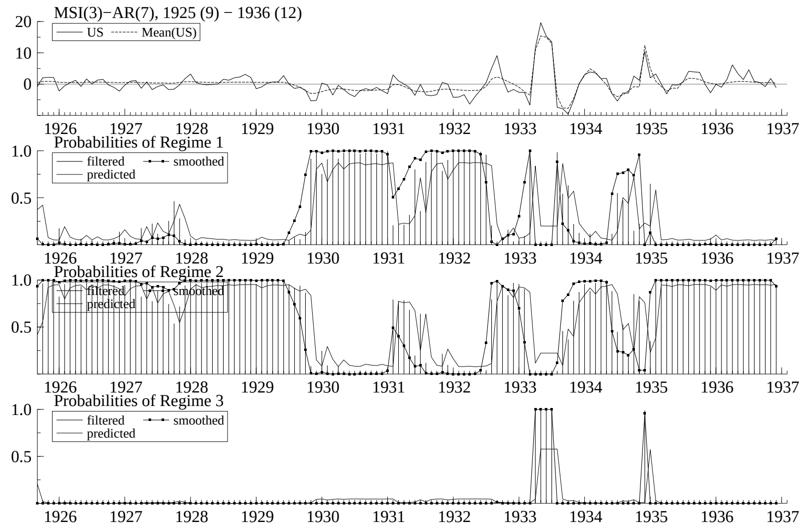


Figure 4: US IPM: MS model with 3 states, MSI(3)-AR(7)

Subsequently, the case of the United States, i.e. the economically most important country, exemplifies the empirical strategy. The outcome of the MSM(2) and similarly of the MSI(2) suggest that interwar IPM might be modelled more approriately allowing for more than two states. Figure 4 presents a MSI(3)-AR(7). The graph is a nice illustration of how the model works. In the upper row the fitted model, i.e. the estimated intercept, is plotted against month-to-month differences in IPM, given in percent (dotted vs. bold line). Shifts in the intercept are in fact recognizable. The plots in the second to fourth row indicate the corresponding conditional probabilities for each regime over time. I consider mainly the smoothed regime probabilities, from which I infer on the state of the economy. They determine the mean growth rates, which are one estimation output among others provided in the first column of table 4. Note that although most of the variation in the time series is explained by regime 1 and regime 2, the model fit is much improved when allowing for the third regime. The third regime leads to what Krolzig (1997, p. 240) denotes as an "outlier state". However, the model is still unable to account for the strong contractions during the first half of 1932, in 1933, and in the second half of 1934.

In order to account for two potential outlier states a MSI(4)-AR(7) is used, which can deal with periods of both extreme contraction and extreme expansion. The results are given in the second column of table 4. Indeed, the model identifies two regimes of moderate growth and decline, $\nu_3$ and $\nu_2$, as well as two regimes states that entail extreme positive and negative growth, $\nu_4$ and $\nu_1$, respectively. The residuals' plot points to the presence of both heterogeneity and autocorrelation. The LR test is used in order to evaluate, whether to prefer a MSIH(4), i.e. a MSI accounting for state-dependent heterogeneity, over a more parsimonious MSI(4). I computed the test statistic as $LR = 2(lnL(\tilde{\lambda}) - lnL(\tilde{\lambda}_0)) = 2\left[(-282.42) - (-294.89)\right] = 24.94$. At the 1% significance level, the critical value is given by $\chi^2_{0.99}(4) = 13.28$. The rejection of the null-hypothesis means that the LR test suggests the adoption of a MSIH.[27] Both the AIC and the BIC indicate to use the MSIH, too. After testing this model against other specifications, I decided to stick with the MSIH(4)-AR(7).[28]

The estimation output of the MSIH is given in column 3 of table 4. In addition, column 'United States' of table 6 (p.52) provides the corresponding regime switching probabilities. The approach identifies two moderate growth regimes and two regimes with extraordinary growth similar to the MSI(4). The means of the moderate regimes ($\nu_2$, $\nu_3$) imply annualized growth rates of about –8.1% during recessions and 9.8% during upturns. The annualized growth rates implied by $\nu_1$ and $\nu_4$ are much higher. These coefficients are still reasonable though, since industrial production is often much more volatile than GDP. Note that the low value of $p_{22}$, which is the probability of remaining in regime 2 conditional on being in regime 2, reflects the low persistence of this state. The estimation yields that most of the AR coefficients are neg-

[27]These tests implicitly require the regime-preserving hypothesis $\nu_1 \neq \nu_2 \neq \nu_3 \neq \nu_4$. The number of degrees of freedom is given by the difference in restrictions. It is equal to four, because in the case of MSI(4) homogeneity is assumed in four states.

[28]The MSIH was tested against the following specifications: MSIH(4)-AR(6), MSIH(4)-AR(8), and MSIH allowing for state-dependent AR terms MSI*A*H(4)-AR(7). MSIH(4)-AR(6) was rejected by LR, AIC, and BIC. The algorithm of the program was inable to obtain numerically stable estimates for the MSIH(4)-AR(8). On the MSIAH(4)-AR(7) the resulting test statistics are contradictory: The LR test rejects the null of state-independent AR coefficients at the 5% level, whereas AIC and BIC yield lower values for the MSIH than for the MSIAH.

Table 4: Estimation of different MSI(n)-AR(p) for US IPM

| **Coefficient** | MSI(3)-AR(7) | MSI(4)-AR(7) | MSIH(4)-AR(7) |
|---|---|---|---|
| *Regime-dependent intercepts* | | | |
| $\nu_1$ | -2.498 | -3.529 | -2.704 |
| $\nu_2$ | 0.790 | -0.160 | -0.697 |
| $\nu_3$ | 11.472 | 1.989 | 0.786 |
| $\nu_4$ | | 11.532 | 4.911 |
| *Regime-independent AR coefficients* | | | |
| $\alpha_1$ | 0.275 | 0.258 | 0.228 |
| $\alpha_2$ | -0.151 | -0.209 | -0.134 |
| $\alpha_3$ | -0.109 | -0.105 | -0.112 |
| $\alpha_4$ | -0.177 | -0.210 | -0.072 |
| $\alpha_5$ | -0.053 | -0.130 | -0.110 |
| $\alpha_6$ | -0.136 | -0.177 | -0.179 |
| $\alpha_7$ | 0.045 | 0.017 | 0.181 |
| *Persistence of regimes: transition probabilities* | | | |
| $p_{11}$ | 0.875 | 0.829 | 0.907 |
| $p_{22}$ | 0.954 | 0.890 | 0.502 |
| $p_{33}$ | 0.577 | 0.865 | 0.965 |
| $p_{44}$ | | 0.596 | 0.506 |
| *Variances, regime-dependent and independent* | | | |
| $\sigma^2$ | 3.27 | 2.28 | |
| $\sigma_1^2$ | | | 2.28 |
| $\sigma_2^2$ | | | 0.02 |
| $\sigma_3^2$ | | | 2.85 |
| $\sigma_4^2$ | | | 40.32 |
| *Number of months in recession, 1925–1936* | | | |
| # rec. month | 42 | 31+55 | 34+14 |
| # obs. | 136 | 136 | 136 |
| ln$L$ | -302.34 | -294.89 | -282.42 |
| LM rejected | yes | yes | yes |

*Notes:* “LM rejected” refers to the rejection of the $H_0$ of a linear model using the Davies test. I added together the number of months in recession, which are due to different regimes.

ative, which accounts for the fluctuations of the series around the conditional intercepts. Note that allowing for state-dependent heteroskedasticity reveals huge differences in error variances between the states (cf. the different $\sigma$ in column 4). Table 4 also shows that relaxing the model w.r.t. heterogeneity leads to substantial changes in the estimates of the intercepts.

Apparently, regime 2 must be regarded as a transitory state during the interwar period. Two findings add to this suggestion: First, the corresponding switching probabilities $p_{21}$, $p_{23}$, and $p_{24}$ are comparably high (cf. table 6). Second, figure 5 depicts that the US economy was driven by regime 2 primarily when switching from the exceptionally bad regime 1 back into growth.[29] This is the case in early 1931 and late 1932. In mid 1933, a period of very strong growth is impeded by moderate decline. This interruption is interesting as it highlights the point in time, when recovery of the US economy fell behind other economies.

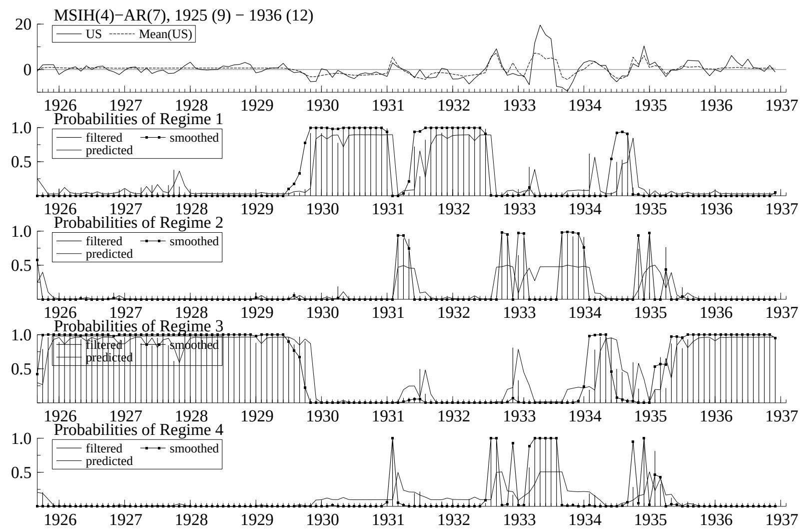


Figure 5: MSIH(4)-AR(7) yields outlier and transitory states for the US

Considering figure 5, the inferred growth rates are reasonable. Up until September 1929, the MSI(4) model yields unambigous evidence that the moderate rate growth regime prevailed. According to the smoothed series, the conditional probability of being in regime 1 is persistently above 0.5 since October 1929.[30] This dating is in accordance with the one provided by the

[29]The growth rate amounted to –28.0% p.a. during regime 1.

[30]Note that the smoothed probability takes into account the information of the entire data set, the filtered (unsmoothed) series indicates the state probability of the economy

NBER. The Great Crash at Wall Street occurred at the end of the same month. It is unlikely, however, that the crash had a retrospective effect on industrial production. The MS model is further evidence that Black Thursday was a consequence of the perceived downturn in the real-economy rather than causal to its decline.

The model dates the end of the first stage of the Depression to January 1931 and its second stage to the period May 1931 to June 1932. This dating is independent from using a model with four or three states. Only from March 1935 on, the US economy was persistently more likely to be in an expansionary state than in recession. The conditional means $\nu_1$ and $\nu_3$ are in accordance with the presumption that the downturn was harsh, whereas growth, even after the 1932, was rather modest. These findings contradict the NBER's dating, which finds the end to the Great Depression in the US already in 1933.

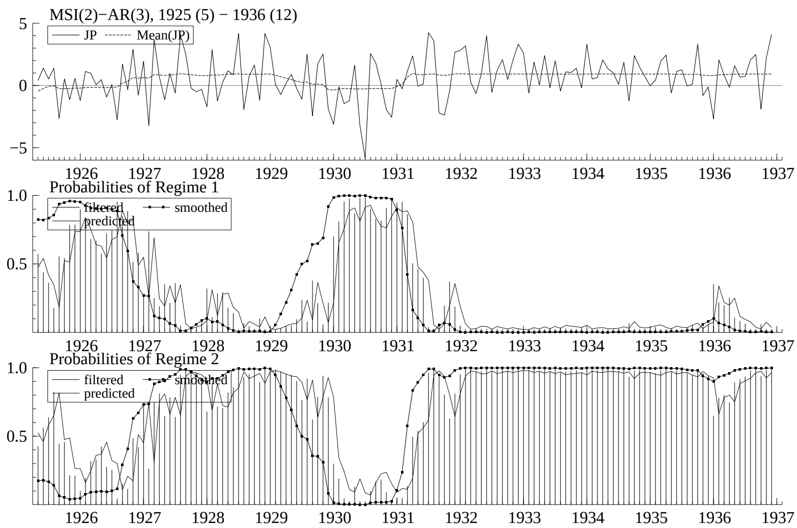


Figure 6: Japan experiences only a single-dip recession, MSI(2)-AR(3)

Figure 6 shows the estimated regimes for the Japanese interwar economy. There are several notable differences to the development in the US, the most important of which is the existence of stable regimes in a regular two-state pattern. Like many other countries, Japan was subject to a recession in 1926. This finding suggests a global dimension of this early contraction, even

at time $t$ based only on the information available at time $t$ (for details see Artis, Krolzig, and Toro 2004).

though evidence for the US is mixed.[31] The estimation yields that Japan was much shorter affected by the world economic crisis than any other country. The economy jumpstarted in January 1931. This month marks the early end of the recession in Japan. Thereafter, Japan experienced prolonged growth - a striking contrast to the frequent regime shifts governing the development of US IPM between 1931 and 1935.

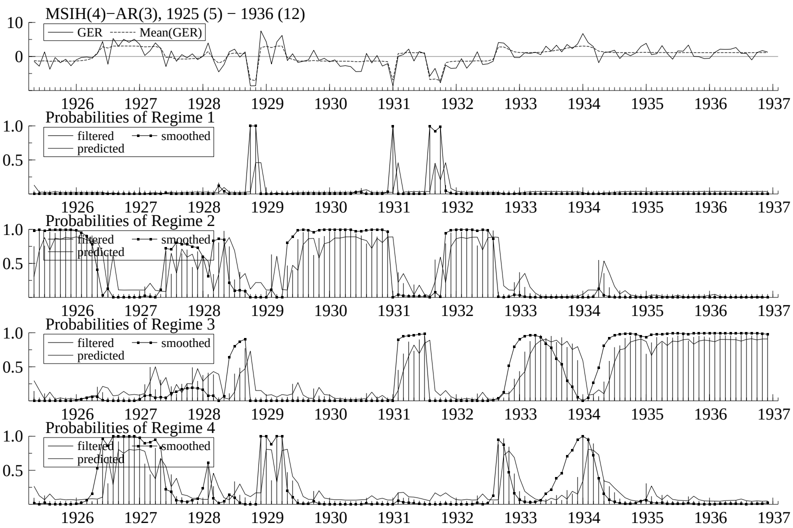


Figure 7: MSIH(4)-AR(3) displays two outlier states for German economy

After the US, it is certainly Germany's economic development in the interwar period that has attracted the most intensive research. This was probably due not only to the exceptional economic decline, but also to the political aftermath of the Great Depression. The empirical strategy suggests the adoption either of a MSIAH(4)-AR(7) or a MSIH(4)-AR(3).[32] Again, I am adopting the more parsimonious MSIH(4)-AR(3). Independent from the model chosen, the filtered and smoothed regime probabilities indicate that negative innovations recurrently depressed the German economy already between 1925 and 1928. One recession, beginning in May 1927, is found for Germany but for no other country. The date coincides with the crash at the Berlin stock market. There are further shocks in spring 1928 as well as particularly adverse shocks in September 1928. The overall picture of the German economy appears gloomy long before the Depression finally began.

[31] In case of the US, I obtain evidence of a recession between 1925 and 1929 only from the pseudo-NBER approach, but not from the MS-AR estimation.

[32] Whereas the LR test and AIC prefer the MSIAH, the BIC suggests the use of the MSIH since it penalizes the use of additional parameters more strongly.

The MSIH dates beginning of the Great Depression in Germany to May 1929, which is very early. It indicates the first stage of the depression in Germany three month in advance of Japan and almost half a year ahead of the US. The model suggests a high probability of recovery already since February 1931, which causes a pronounced double-dip pattern in case of Germany. In June 1931 gold reserves of the Reichsbank plunged to the statutory minimum. During three month, from August 1931 to October 1931, the German economy is in deep recession according to the high probability of outlier state 1. The corresponding regime implies a conditional mean of $\nu_1 = -6.843$, which gives an annualized growth rate of –57.3%. In contrast to the first stage of the Great Depression, this major shock occurs with a lag of several months on the development in the US. In November 1931 the economy switches back into the normal recessionary regime 2, for which a conditional intercept of $\nu_2 = -1.307$ is estimated. From September 1932 onwards, the German economy is constantly in one of the two expansionary regimes. The coefficients related to recessions, $\nu_2$, as well as the coefficients of the conditional intercept during expansions, $\nu_3 = 1.081$ and $\nu_4 = 2.961$, are reasonable estimates. They imply annualized growth rates of –14.6%, 13.8%, and 41.9% during contractions or expansions, respectively. The last figure seems unrealistic at first, but it represents the boost to expansion in September 1932 and at the turn 1933/1934. Thus, regime 4 characterizes the striking performance of the German economy after the aforementioned long-lasting recession. Additionally, the latter of these upturns coincides with strong recovery in the US.

The impact of the British miners' strike in 1926 complicates the analysis of interwar IPM in the UK. The 42% decline in IPM in May 1926 and the subsequent recovery with an increase in the index of 20%-odd per month in December 1926 and January 1927 dominate the identification of regimes. The estimation strategy suggests the adoption of a MSIH(4)-AR(7), which does not deliver reasonable regimes, however. This model dates the beginning of the contractionary regime in Britain to March 1927 and its end to July 1932. An alternative model is the MSIAH(4)-AR(3) that is depicted in figure 8. The latter model finds a high probability for the recessionary regimes 2 and 4 between 1927 and as 1932 as well. Yet, it identifies three separate contractions during the same period. Neither of the two models is able to fully capture the outlier states. The MSIH does not yield sensible conditional intercepts for the recessionary state. The test statistics remain inconclusive on which model to prefer. Thus, I computed a MSI model leaving out the exceptional year of 1926.[33] The model yields three separate recessions between

[33] If the sample period is restricted to 1927-1936, a simple MSI(2)-AR(7) suffices to

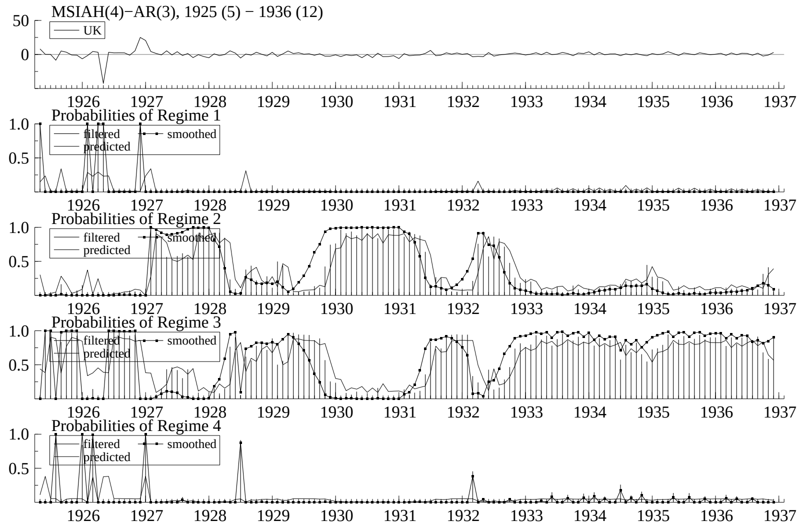


Figure 8: UK miner's strike requires 4-state model, MSIAH(4)-AR(3)

1927 and 1932. The dating of recessions is very similar to the one provided by the MSIAH(4)-AR(7) for the period 1925-1936 (cf. figure 45). Therefore, I am adopting the latter specification, even though it is less parsimonious than the MSIH.

The beginning of the depression's first part is dated to August 1929 and its end to April 1931, i.e. several month behind Germany and in advance of the US. British IPM recovered substantially between June 1931 and February 1932, i.e. with a 4-5-month lag on Germany and Japan. The second stage of the Depression is evident between February 1932 and July 1932, which is a lot later than in the US and Germany. The conditional intercept of regime 2 $\nu_2$ is equal to –0.907 implying annual growth of –10.4% during recessions, whereas $\nu_3 = 1.09$ yields an annualized growth rate of about 13.9%. In comparison to most other countries, the decline in Britain was moderate and the second 'dip' lasted less long. The UK was more superficially affected by the Great Depression than other countries.

These results make it difficult to reason that Britain's exit from the gold standard in September 1931 was a prerequisite for an eventual recovery as claimed by Eichengreen (2004).[34] First, economic recovery likely began sev-

describe the development of IPM.

[34] Additionally to leaving gold, however, it "was also necessary also (sic!) to abandon the ethos of the gold standard that encouraged the continued pursuit of restrictive policies" and thereby prevented the resumption of rapid growth (Eichengreen 1992, p.289).

eral months before Britain's exit from the gold standard. Second, when Britain had finally left gold, this step could not prevent the economy from sliding back into recession in February 1932. Third, the recession in Britain between 1929 and 1931 was far from being as as deep as in the US, Germany, or Poland - although these countries adhered to the gold standard as well. As Britain's financial position was weak as well it is certainly not the reason for any difference in the severity of the decline (cf. Eichengreen 1992).

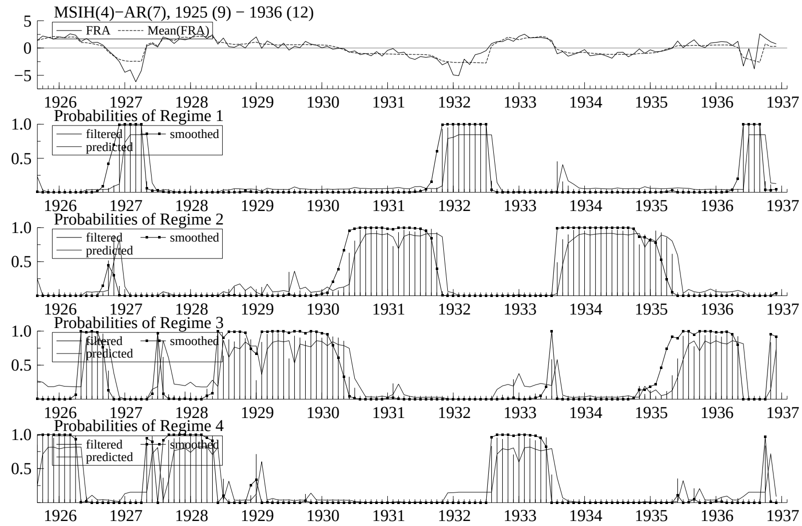


Figure 9: Frequent regime shifts in French economy acc. to MSIH(4)-AR(7)

After the dissolution of the interwar gold standard, several countries, led by France, decided to remain on gold. Among these countries were Poland, Belgium, and Czechoslovakia. Adherence to this Gold Bloc is often blaimed as the main reason, why these countries suffered particularly badly during the Great Depression. This analysis confirms this suggestion at least concerning the duration of the recession. As apparent from the initial MSM(2), a two-state model is not appropriate for the French interwar economy. It is neither in the case of Belgium and Poland. However, even the four-state model seems too restrictive to distinguish between certain periods of more modest and more rapid growth or decline, respectively. Still, the MS-approach reveals important differences in their respective economic development. Different from all other countries IPM in France showed very little variation and was still declining as of March 1935. During the 1920s, the economy lagged the development in all other economies by at least half a year. Interestingly, the French economy recovered strongly since August 1932, which coincided with the development in Germany and Britain rather than with the course of

IPM in its fellow Gold Bloc member states. If one interprets the beginning of regime 1 as a sign of the second stage of the depression in France, then the economic deterioration coincided with the overall double-dip pattern as well.

The selected MSIH(4)-AR(7) indicates a high probability of being in one of the different recessionary states between May 1930 and July 1932.[35] Eichengreen (1992, p.255) states that "[t]hrough the end of 1930 [...] France remained a prosperous island in a sea of depression." Obviously, this island was flooded somewhat earlier. Recovery in France is interrupted very early by another recession taking place between August 1933 and March 1935. The French economy experiences relatively mild recessions, for which the conditional mean is $\nu_2 = -0.781$. Growth during expansion is very sluggish with a conditional mean of merely $\nu_3 = 0.379$. Whereas most other countries experience continued expansion of IPM until 1936, we even find another contraction, the beginning of which is dated to June 1936, i.e. two month after the general strike in France took place. The end of this contraction is dated to September 1936, i.e. one month after France's decision to dissolve its commitment to gold.

A much stronger contraction took place in Belgium at about the same time.[36] This coincidence could suggest periodic transmission of shocks between the French and the Belgian economy. Yet, considering the course of IPM in Belgium over the whole interwar period, the cycle appears to follow more closely the pattern found for Britain and the US (cf. figure 41). Instead of the expected co-movement with France, the MSIH(3)-AR(5) gives a high probability for the Belgian economy being in recessions already from October 1929 to May 1930 and again between September 1931 and June 1932. Similar to other countries, industrial production in Belgium displays a double-dip. In addition, the Belgian economy is subject to two major drops in IPM on a month-to-month basis, namely in April 1932 and between March and May 1936. The recessions identified take place during the Great Depression and are quite short, but very deep. Growth regime 3 seems to represent a reaction to a preceding exceptional fall in IPM.

The results from MS models for the Central European countries differ somewhat from the results for the Western economies discussed before. The Republic of Poland provides the prime example of the Central European malaise during the interwar period. Unlike Germany, there is no evidence of

[35]The AIC favors a model with state-dependent AR terms, i.e. a MSIAH, which is however is rejected by the LR test and the BIC.

[36]I was not able to find any reference to this event in the literature.

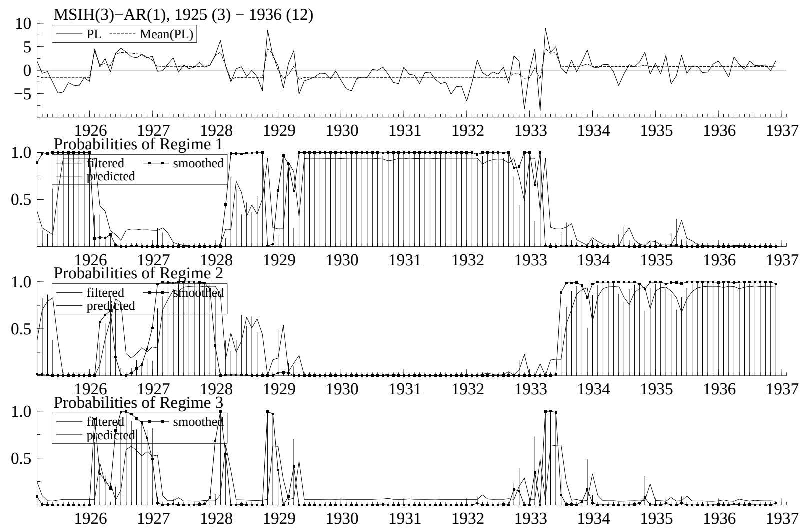


Figure 10: MSIH(3)-AR(1) finds Poland subject to longest lasting recession

an outlier contractionary state. Instead, the selected MSIH(3)-AR(1) specification yields a high probability of being in recession for almost the entire period between 1928 and 1932. With the exception of a few months at the turn of the year 1929, the Polish economy was in recession for about 50 consecutive month (cf. figure 10). What is more, the coefficient for the recessionary regime $\nu_1 = -1.858$ is one of the lowest across the entire sample. It implies an annualized growth rate rate of the Polish economy of –20.2% on average during this period. Although Poland remained on gold after 1931, the economy developed more similarly to the German or British cycle than to the French business cycle. One might speculate if the Polish business cycle was mainly driven by Germany's economy. Both the dating of pre-Depression fluctuations and the prolonged boom after 1932 are quite similar. Yet, post-Depression growth in Poland of 11.6%, given by $\nu_2 = 0.916$, is less dynamic than in Germany at that time.

The course of IPM in the Republic of Austria can be modelled by a MSI(2)-AR(7). Apart from an early and short contraction in 1926, the model yields only few regime shifts. The beginning of the Depression in Austria is dated to September 1929 (cf. figure 42). Measured by the smoothed probabilities of the MS model, Austria's economy uninterruptedly declined between 1929 and 1933. Only the filtered probabilities suggest the beginning of that upturn in 1931, which actually took place in other countries at about the same time. The absence of the double-dip pattern in Austria might be due to the failure of Creditanstalt that occured in May 1931. Creditanstalt's failure is regarded a major blow to the Central European banking system as a whole (see e.g. Wandschneider 2005).

The Czechoslovakian business cycle developed similarly to Poland and Austria, i.e. the Austria-Hungary's further sucessor states. Being the successor state that comprised the most industrialized part of the empire, it suffered from long-lasting decline of IPM over the whole period. Different from its neighbors, including Germany, the recessions identified are less devastating with an annualized growth rate of –9.5% at least until 1931. In addition, contractions since 1931 appear to be due to a shifts into a regime of much stronger decline, i.e. regime 1. The economy is subject to frequent regime shifts both before 1929 and still long after 1933 (cf. figure 39). Contrary to the development in Austria and Poland, the MSIH(4)-AR(9) provides evidence that Czechoslovakia took part in the worldwide upturn in the midst of the Great Depression as well.

As far as the remaining countries are concerned, we find the following. The world economic crisis affects the Swedish economy merely by stagnation. The MS approach yields a two-state model. It gives that the country was only superficially affected by the Great Depression, even less strongly than Japan though for a longer period of time. In case of Hungary and Finland, the EM algorithm did not converge when fitting the likelihood. Thus, it was not possible to obtain an appropriate MS model for these countries.

# 4 Inferences on the global crisis

Until now I have analyzed business cycles in the interwar period country by country. This section aims at putting together previous results in order to make inferences on the global depression. Choosing a descriptive approach, I transformed each IPM series into a binary time series, where 1 indicates that a recessionary regime prevails and 0 indicates that an expansionary regime prevails.[37] Figure 11 gives the number of countries in recession in a particular month, i.e. the sum over the binary time series. The graph summarizes the scope of the Great Depression and is based on the results from the individual MS-AR estimation.[38] The figure is an impressive image of the extraordinary nature of the downturn at global level.


Figure 11: Countries in recession acc. to MS-AR dating

Making a distinction between an international and a regional cycle is naturally subject to choice. Thus, I chose 50% as threshold level that separates the former from the latter. Under this assumption, the early decline in 1925

[37]For countries with more than two regimes I make a dichotomous distinction between expansion and contraction based on a smoothed regime probabilities greater than 0.5. If, at a certain point in time, the country was likely in recession – or in an outlier recession state – the respective time series observation is set to 1, otherwise it is set to 0.

[38]Finland and Hungary were excluded from this overview. The total number of countries is thus ten.

indicates the beginning of an international business cycle. In late 1925 40%–60% of the countries in the sample are found to be in recession. Between 1926 and mid-1929 this share provides evidence of a global boom as it is always ranging from 10% to 30% and even decreases to 0% in December 1928. The share of countries in recession rises sharply from 20% in April 1929, to 50% in August and reaches 90% in October 1929.

In comparison to the first downturn in 1925, the following decline has a different scale. At the peak of the series 100% of the countries in the sample are in recession. Taking into account the months, during which at least 90% of all countries in the sample are in recession, we end up with a period of more than one and a half year of uninterrupted downturn between September 1929 and January 1931. The international cycle displayed the double-dip pattern that was visible in many of the single-country analysis as well. It was caused by the temporary upturn in 1931, during which the share of countries in recession fell to 50% in June 1931. As for being such a regular pattern observed in many countries' business cycle, the temporary upturn has attracted little attention in the literature or has perhaps been overlooked. Considering annual data, but without an explicit geographical focus, Eichengreen (1992, pp.258-259) expects that in 1931

> "[after] two years of decline, the market's self-equilibrating tendencies should have asserted themselves. [...] Far from improving, however, the situation deteriorated markedly in the second half of 1931."

Following the short-lived recovery, there is another year during which again 80% to 90% of the countries are in recession. Recovery of the global economy is underway since August 1932, when the critical share falls below 50%. The improvement is, however, weak and instable in many countries. This development is contrary to what one observes after recessions in the post-WWII period. Impeded recovery is one main reason for the poor economic performance of the Western world during the interwar period.

Some countries departed from the general pattern. Although there are signs of recovery in 1931 in Austria and Sweden as well, the likelihood for being in recession overweighs. The French economy did not recover in 1931 at all. Instead, it slided further into recession. Interestingly, the beginning of it's outlier recession state is dated precisely at the same time, when most other countries begin to decline again after the temporary recovery. Yet, there is no immediate link between adherence to the Gold Standard and country-differences in the course of IPM. [[depict correlation between number of months in/ depth of recession and number of months adhering to GS after 1930.]] The double-dip in IPM, which occurs in the US, Germany, and the UK, but also in Belgium. In only two countries there is no sign of a double dip at all, namely in Japan, where recovery remained uninterrupted since 1931 and in Poland, where the economy remains in the same contractionary state all the time.

The entire period could roughly be divided into three phases. All countries in the sample, except for Sweden, were in recession around the turn of the year 1926. Evidence of a recession in the US at that time is mixed. Since 1926 the global economy expanded until fall 1929 and contracted until mid 1932. Independent of the approach used, I find that all of the countries got into recession between early 1929 (e.g. Germany) and late 1929 (e.g. the US). A special case is France, which was in recession probably first in early 1930. With a huge variation in time, IPM began to pick up in most countries in 1932. Although a global expansion seems underway after the summer of 1932, several countries, including the US, recovered first in 1933 and some did even later. The economic downturn in several countries at the end of 1936 indicates an early end to this second business cycle.

From the binary time series I computed Pearson's contingency coefficient (PCC) as a simple, non-parametric measure of business cycle co-movement. The extent of regime co-movement refers to months in recession coinciding for a pair of countries.[39] The resulting correlations are similar to the findings of AKT (2004) for European countries between 1970 and 2001. If a contingency coefficient of 0.5 is a threshold level for high contemporaneous correlation, business cycles in Europe display a high degree of co-movement. Yet, also the course of business cycles in Japan and in the US was highly correlated with that of many European economies. Recessions in the US coincide with those in every European economy, except with the ones in Germany and Britain. The highest correlations across the entire sample are found between Sweden on the one hand and Austria as well as Poland on the other hand.

The lowest correlations are found between the French and other European economies. They remain strikingly low with regard to other Gold Bloc members, even when the sample is split at the turn 1929 to 1930. Splitting the sample suggest, moreover, that the Great Depression had an integrating effect, since co-movement was generally higher after 1930 than beforehand.[40] There is a certain probability of an international cycle, since the correlations indicate co-movement between the output series. Starting in 1926, one

[39]The PCC is computed according to the formula in AKT 2004, i.e. it is corrected to be in the range of 0–100 and can be read in percentage terms.

[40]Since the resulting sub-samples are fairly short, I do not interpret the figures in detail.

and a half international business cycles were completed until 1937. However, a test of the hypothesis that the Great Depression represented a common cycle in Europe, or internationally, requires a more objective measure than a threshold level of correlation. Compared to the results in AKT (2004), the commonality of business cycles in European countries during the inter-war period was lower for France and higher for Britain than it was in the post-WWII period.

From the analysis, one can infer on additional stylized facts:

(a) Average growth rates –negative and positive– are large compared to the post-WWII period. In addition, there is evidence of exceptionally adverse, i.e. outlier, recessionary regimes in several economies during the Great Depression. Something similar has not been detected for any economy after WWII.[41]

(b) The analysis gives that all countries in the sample, except Sweden, were in recession between 1925 and the beginning of the Great Depression. Evidence for the US is mixed.

(c) A second negative shock in the 1920s is observed in Germany, Poland, Czechoslovakia, and to a lesser extent as well in Sweden. It is seemingly absorbed, though, since all the former three countries return to expansion after a few months.

(d) A worldwide upturn took place in the midst of the Great Depression in 1931, in which only few countries did not take part, e.g. France. The duration of this recovery, though, differed greatly across countries. Recovery in the US was extremly brief, whereas IPM in the UK was in expansion for almost one year until March 1932. As the only country in the sample, Japan managed to escape the second stage completely.

(e) Germany and the UK experienced persistent growth since summer 1932. Continued recovery began much later in all other countries. We observe two different groups of countries. In one group, e.g. in the US, the depression ended relatively early, but recovery was interrupted frequently afterwards. The other group, e.g. Czechoslovakia and France, experiences a continued decline, i.e. the absence of fundamental recovery.

(f) It appears that countries in Central Eastern Europe were affected particularly negatively. In comparison to most other countries in the sample, the economic downturn in Poland, Czechoslovakia, and Austria was larger, prevailed longer, and recovery was sluggish.

[41] This conclusion refers to the studies of Hamilton (1989, 2005), Krolzig (1997), and AKT (2004).

# 5 Conclusions

This study views the troubled interwar period, and in particular the Great Depression, through the lens of business cycle analysis. It aims at delivering the first consistent dating of cyclical macroeconomic fluctuations for a large set of countries. A second aim was to derive some stylized facts on international similarities and systematic differences in the course of the crisis, e.g. specific to certain groups of countries. The data set comprises 10 European countries, the US, and Japan.

The analysis yields the following results. All of the three empirical approaches applied indicate that an unusually strong economic downturn, i.e. Great Depression, occured at the turn of the decade. In contrast to similar research on the postwar period, there is evidence of a particularly adverse economic state, expressed either by a change in long-term growth or as a extraordinary growth state. This finding is expressed by the fact that it the preferred MS model of aggregate industrial activity in several countries allows for four growth states.[42] Comparing these finding to post-WWII studies, which analyze business cycles at international level and rely on a similar methodology, emphasizes the distinctive nature of the Great Depression by its severity, duration, and geographical scope.

The adverse impact of the crisis on an economy did not coincide with its degree of industrialization. Highly industrialized countries belong both to the group of worst and least affected countries, cf. the US and the UK. Considering the case of Poland and France or Japan, the same is true for less industrialized countries as well. It seems, though, that Central Europe - with the exception of Hungary - suffered more than Western Europe and Skandinavia during the Great Depression, and perhaps even more than the US. This finding is due to the high persistence of recessions in Central Europe, which was probably due to their weak economies through the entire 1920s (e.g. Landau and Tomaszewski 1986).

In how far is it possible to regard the Great Depression as an extraordinary downturn in the global business cycle? As of 1930, IPM declined in every country in the sample, regardless of belonging to the core of industrial activity or to its periphery. At the peak of the recession, ten out of ten countries considered are found to be in recession. In the mid-1920s already, the coincidence of recessions around the world implies economic co-movement

[42]Two four state models are due to strikes before the Great Depression (in the UK) and thereafter (in France). This is certainly a drawback from using sensitive IP data without smoothing them first.

not only within Europe but also between Europe, the US, and Japan. In order to measure commonality of business cycles I computed PCC for each country pair. The results yield a high degree of co-movement between most countries during the sample period, i.e. from 1925 to 1936. High correlations are found not only among European economies but also between certain European economies on the one and and Japan as well as the US on the other hand.

A further result is that impeded growth after 1932 was an international phenomenon, which was not limited to one or two countries. Inspite of being an important determinant of the *lost decade* the economic difficulties in many countries after 1932 are usually not considered as part of the Great Depression. Particularly, the sharp decline in French IPM since August 1933 and in the US and Czechoslovakian after May 1934 deserves further attention.

Neither result can be easily explained with the international monetary framework. An immediate link between adherence to the Gold Standard and the charactistics of the depression is not visible from the cross-country analysis. There are substantial differences in the course of the recession even between the Gold Bloc members, notably France, Poland, Belgium, and, until 1934, Czechoslovakia. It remains sketchy how much the monetary tightening in the US could have contributed the recessions in the ROW and if there existed a link between going off gold and escaping the crisis. High correlation of business cycles is nither very consistent with Eichengreen's hypotheis as well, since it requires a high co-movement of business cycle, except for the US and perhaps for France.

Taken together, the study underlines that the Great Depression was extraordinary not only in its impact on single countries, but on the global economy as a whole. Further research can integrate the results of this study into the investigation of the global transmission of real and monetary shocks. The analysis also emphasizes the necessity of a more technical analysis of co-movement in order to extract the common business cycle component in the world economic crisis. Thus, the results point to the potential outcome of a MS-Vector Autoregression, which could estimate a common regime-shifts representing the international business cycle during the interwar period.

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## 6.1 Data sources

All IP data used in this paper were taken from XXX.

In order to obtain samples of the same length and frequency for each country, I had to manipulate data in case of four countries, namely the UK, Japan, Hungary, and Finland. Taking percent differences, I investigated series of country-specific physical production in certain industries for their correlation with IPM. I selected one or several series, for which I computed the highest correlation. Thereafter, I used this information to interpolate or extrapolate, respectively, the missing data.

**UK:** Data on IPM is only available at quarterly frequency. The contemporaneous correlation between IPM and a composite series of coal, steel, and iron production between 1925 and 1936 was calculated to be 0.83, with only minor correlations a lag before and after. The composite series consists of indexed and equally weighted series for each product and was averaged over quarters. The variation in the monthly production series was then used to interpolate a monthly IPM series.

**Japan:** Data on IPM is not available for 1925. The contemporaneous correlation between IPM and coal production between 1925 and 1936 was calculated to be 0.63, with no significant correlations before and after. The monthly production series was then used to estimate monthly IPM in 1925 via linear regression.

**Hungary:** Data on IPM is not available for 1925 and 1926. The contemporaneous correlation in quartely figures between IPM and a composite series of brown coal and iron ore production as well as railway shipments was calculated to be only 0.42. First the composite series for 1925 and 1926 was used to estimate quarterly IPM during this period via linear regression. The variation in the monthly production series was then used interpolate a monthly IPM series.

**Finland:** Data on IPM is not available for 1925 and 1926. As data on relevant production is neither available for this period, I had to resort to the physical amount of shipments by Finish railways. The contemporaneous correlation in quartely figures between IPM and shipments was calculated to be only 0.41, making it still the most closely correlated series during the period 1927-1934. First the composite series for 1925 and 1926 was used to estimate quarterly IPM during this period via linear regression. The variation in the monthly production series was then used interpolate a monthly IPM series.

# A Recession dating according to the 2-quarters approach (% change month to month)

Figure 12: United States

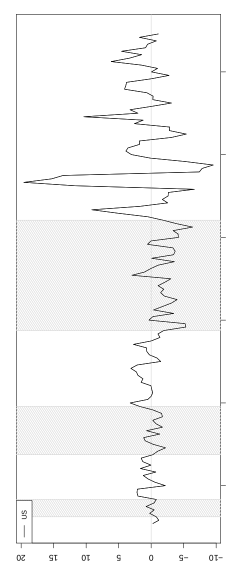



Figure 13: Sweden

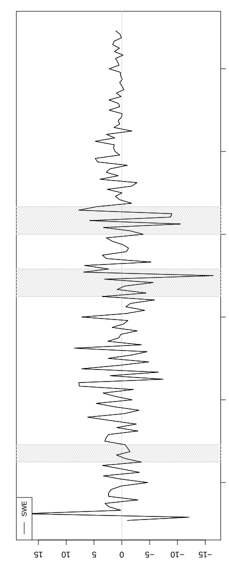



Figure 14: France

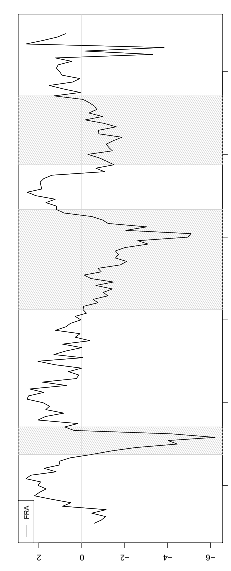



Figure 15: Czechoslovakia

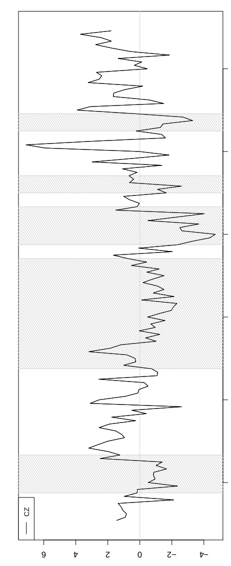


Figure 16: Poland


Figure 17: Belgium


Figure 18: Austria

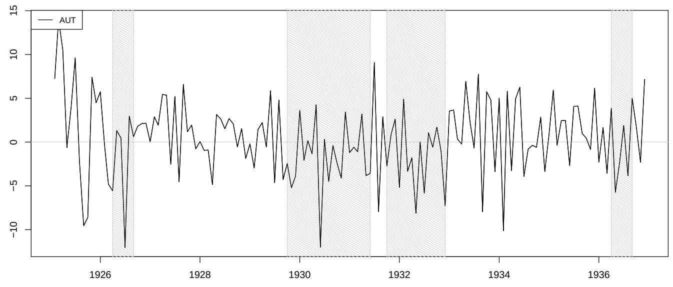



Figure 19: Germany

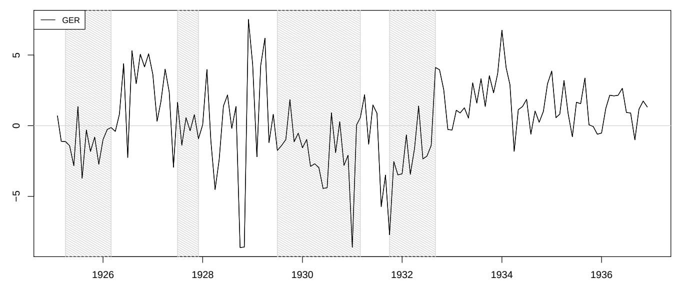


Figure 20: Britain

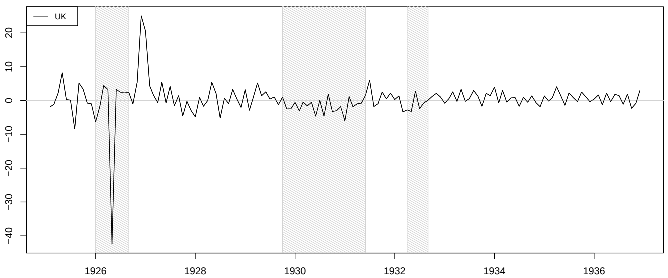



Figure 21: Finland

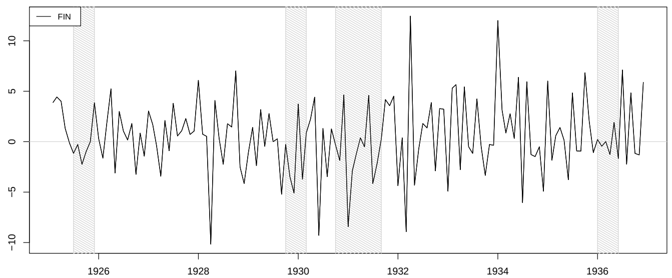



Figure 22: Hungary

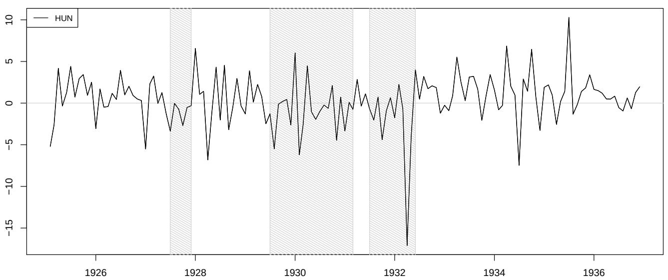
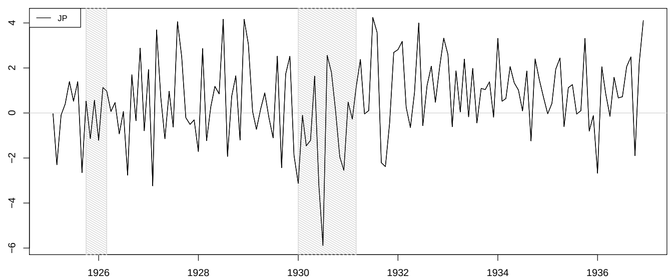



Figure 23: Japan



# B Regime probabilities from MSM(2)-AR(7) model (Kalman filtered and smoothed)

Figure 24: United States

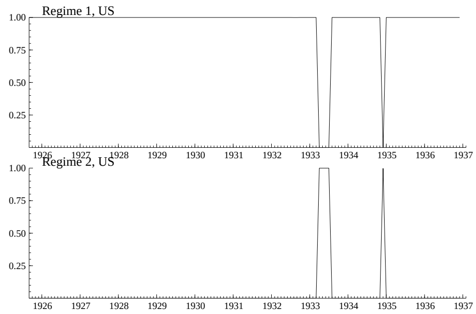



Figure 25: Japan

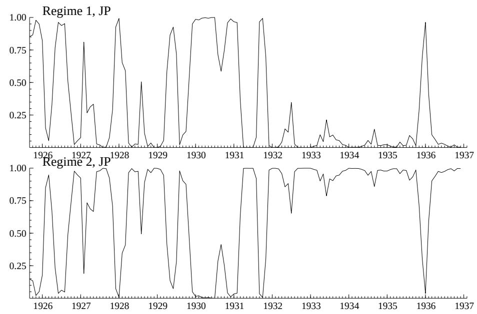



Figure 26: Britain

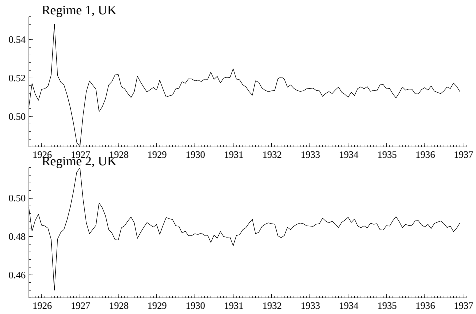



Figure 27: Germany

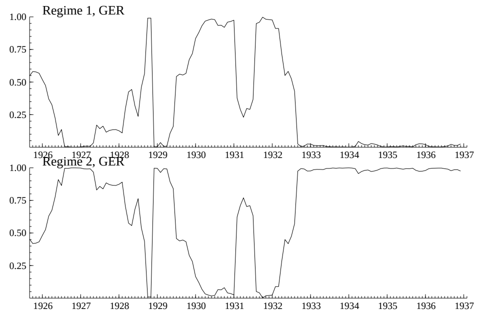



Figure 28: Austria

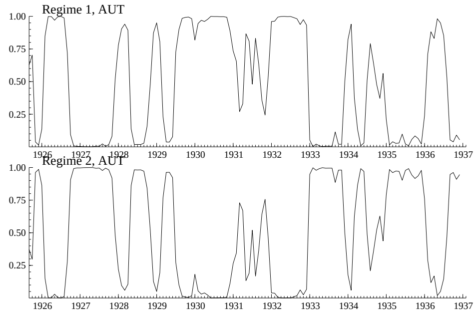



Figure 29: Hungary

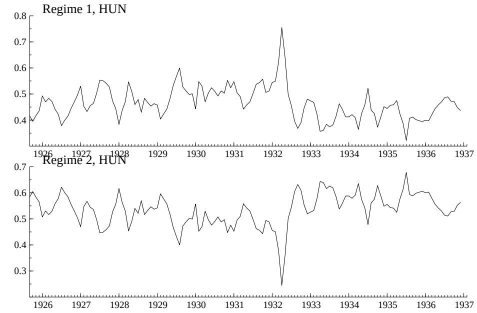


Figure 30: Czechoslovakia

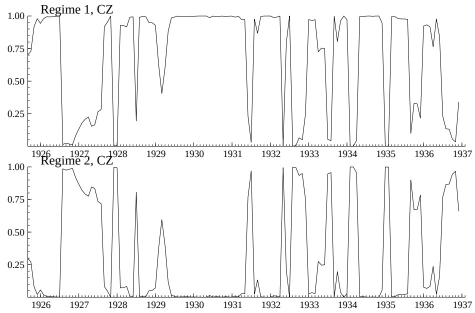



Figure 31: Poland

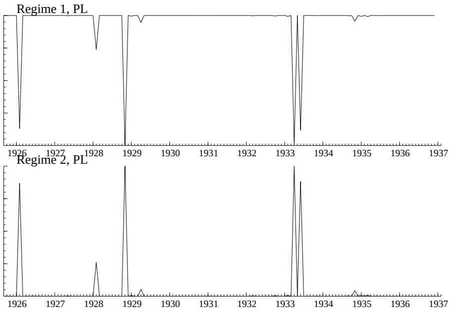



Figure 32: France

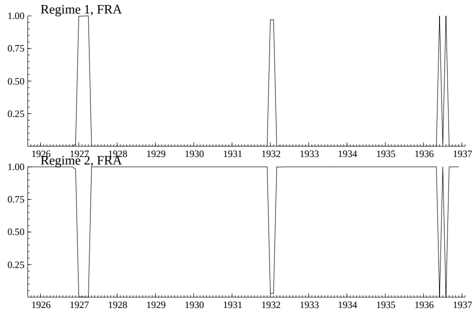



Figure 33: Belgium

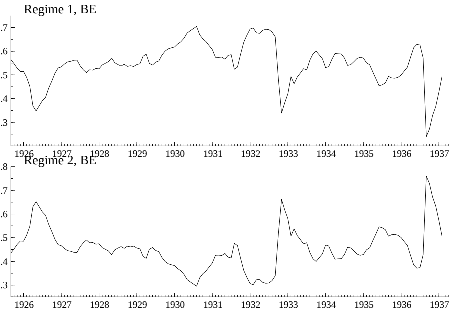



Figure 34: Finland

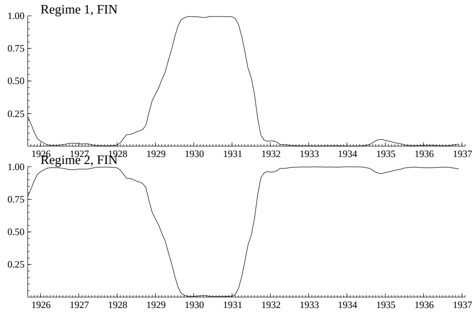



Figure 35: Sweden

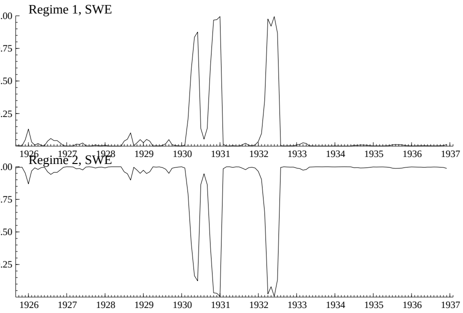


Table 5: Regimes obtained from an MSM(2)-AR(7)

| **Coefficient** | **Germany** | **Austria** | **Japan** | **Finland** | **US** | **Sweden** | **CZ** | **Belgium** | **Poland** | **Hungary** | **France** | **Britain** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Regime-dependent means* | | | | | | | | | | | | |
| $\mu_1$ | -2.29 | -1.82 | -0.74 | -0.86 | -0.02 | -3.71 | -0.78 | -0.23 | 0.04 | 0.02 | -3.53 | 0.30 |
| $\mu_2$ | 1.41 | 1.99 | 1.19 | 0.82 | 1.15 | 0.73 | 2.21 | 0.97 | 7.70 | 0.61 | 0.16 | 0.41 |
| *Regime-independent AR coefficients* | | | | | | | | | | | | |
| $\alpha_1$ | 0.233 | -0.694 | -0.464 | -0.414 | 0.660 | -0.501 | 0.431 | -0.248 | 0.208 | 0.015 | 0.575 | 0.106 |
| $\alpha_2$ | -0.015 | -0.427 | -0.390 | -0.147 | -0.183 | -0.284 | 0.197 | -0.114 | -0.096 | -0.070 | 0.177 | 0.026 |
| $\alpha_3$ | 0.039 | -0.456 | -0.183 | -0.163 | 0.033 | -0.061 | -0.213 | -0.094 | 0.454 | -0.031 | 0.208 | 0.056 |
| $\alpha_4$ | 0.110 | -0.493 | 0.077 | -0.192 | -0.139 | -0.006 | 0.364 | -0.039 | -0.002 | -0.026 | -0.004 | 0.091 |
| $\alpha_5$ | -0.138 | -0.261 | 0.230 | -0.097 | -0.029 | 0.152 | 0.211 | 0.049 | 0.045 | 0.124 | -0.017 | 0.107 |
| $\alpha_6$ | 0.106 | -0.265 | 0.433 | -0.146 | -0.103 | 0.134 | -0.158 | - | -0.087 | 0.048 | -0.048 | 0.022 |
| $\alpha_7$ | 0.097 | -0.072 | 0.268 | -0.062 | 0.207 | -0.007 | -0.148 | - | 0.035 | -0.075 | -0.082 | -0.310 |
| *Persistence of regimes: transitions probabilities and expected duration of recessions* | | | | | | | | | | | | |
| $p_{11}$ | 0.895 | 0.795 | 0.703 | 0.945 | 0.984 | 0.635 | 0.871 | 0.778 | 0.968 | 0.724 | 0.492 | 0.759 |
| duration | 10 | 5 | 3 | 18 | 62 | 3 | 8 | 5 | 31 | 4 | 2 | 4 |
| $p_{22}$ | 0.959 | 0.810 | 0.876 | 0.986 | 0.598 | 0.965 | 0.715 | 0.734 | 0.000 | 0.760 | 0.968 | 0.744 |
| $\sigma^2$ | 5.02 | 8.27 | 1.76 | 10.85 | 4.71 | 8.70 | 1.21 | 35.06 | 4.53 | 9.00 | 0.59 | 23.23 |
| # obs. | 136 | 136 | 136 | 136 | 136 | 136 | 136 | 136 | 136 | 136 | 136 | 136 |
| ln$L$ | 308.84 | 253.13 | 362.39 | 266.13 | 312.65 | 270.83 | 372.38 | 193.21 | 313.72 | 282.95 | 445.82 | 219.41 |
| LM rejected | yes | yes | yes | yes | yes | yes | yes | no | yes | no | yes | no |

*Notes:* "LM rejected" refers to the rejection of the $H_0$ of a linear model using the likelihood ratio test.

# C Results from MS approach using country-specific models

Figure 36: United States

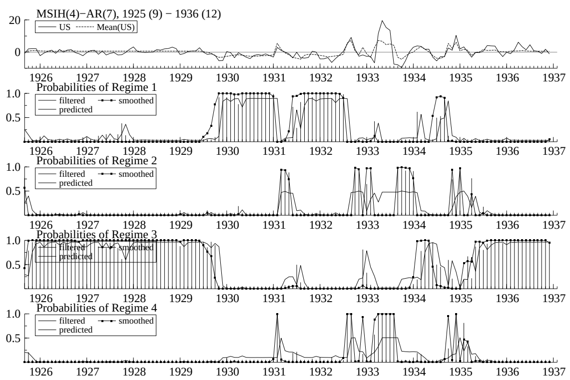



Figure 37: Sweden

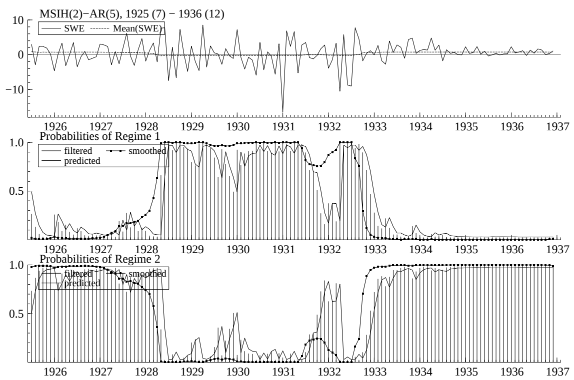



Figure 38: France

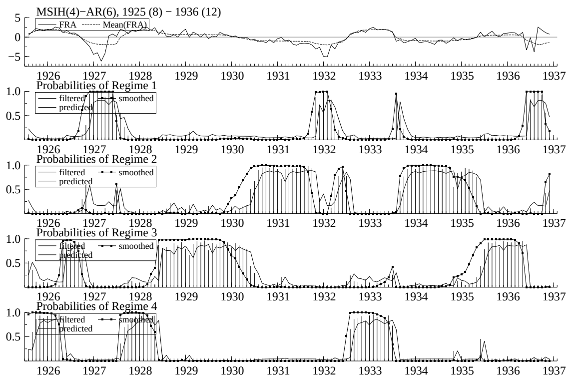



Figure 39: Czechoslovakia

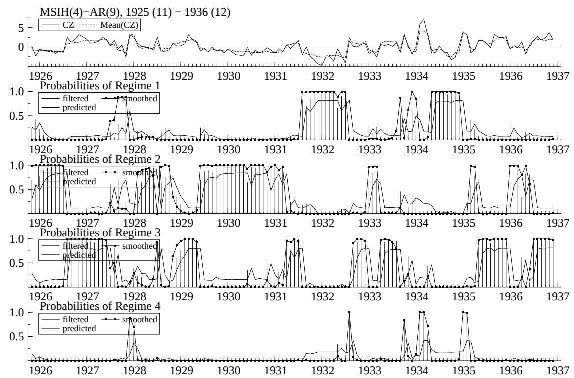


Figure 40: Poland

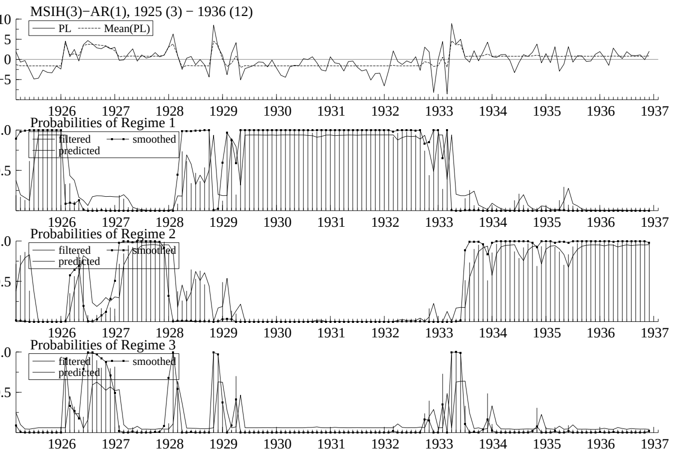



Figure 41: Belgium

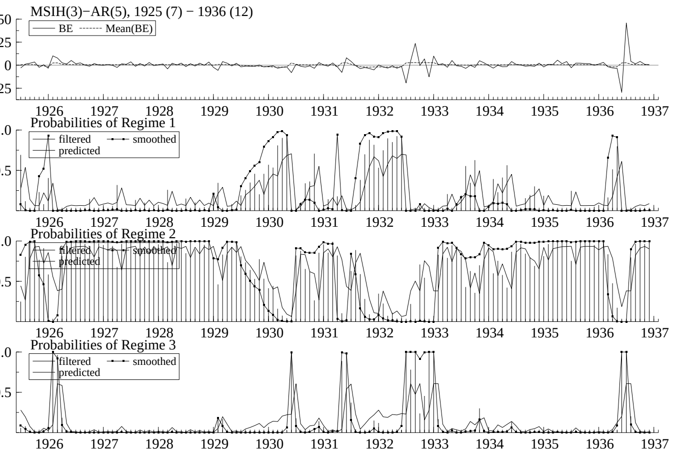



Figure 42: Austria

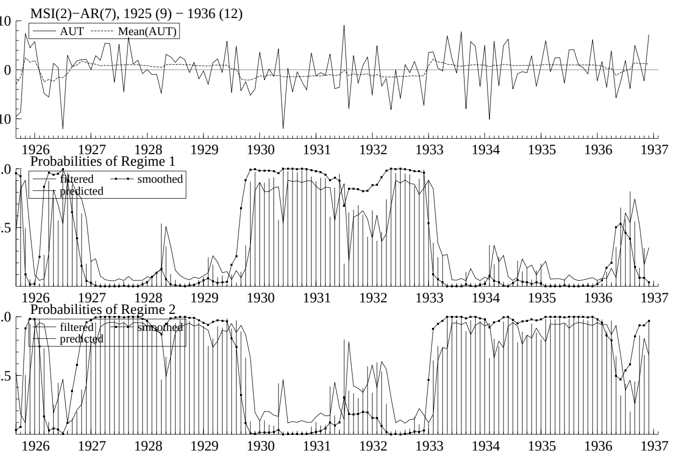



Figure 43: Germany

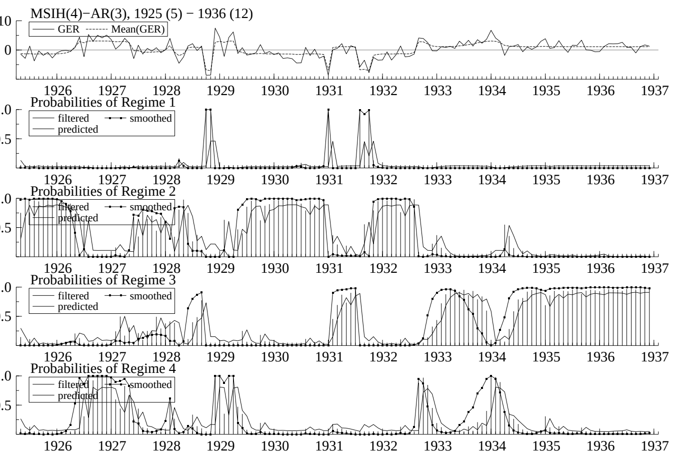


Figure 44: Britain

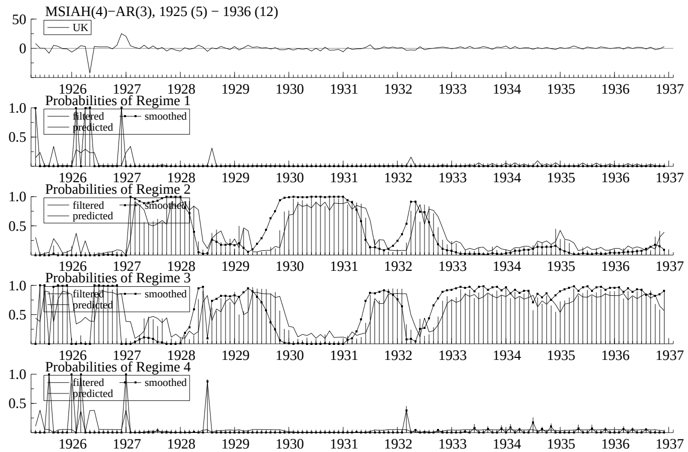



Figure 45: Britain, 1927-1936

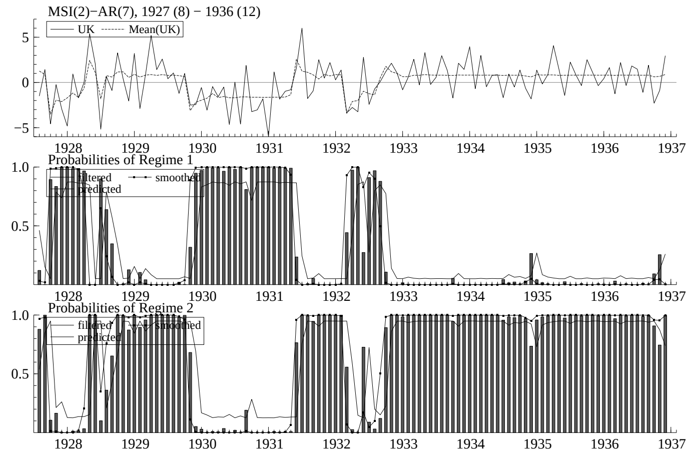



Figure 46: Finland

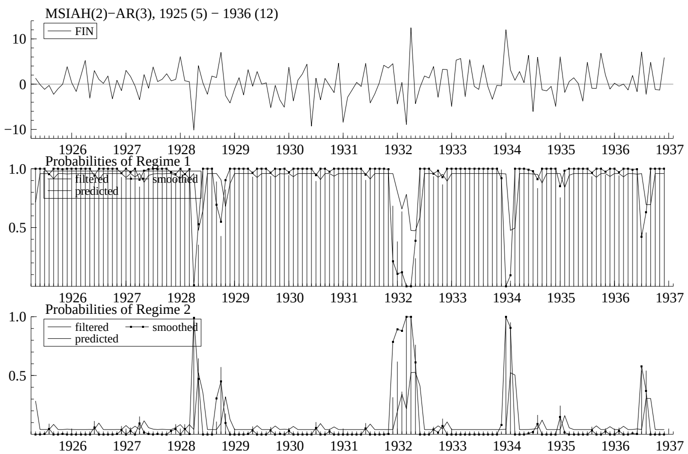



Figure 47: Japan

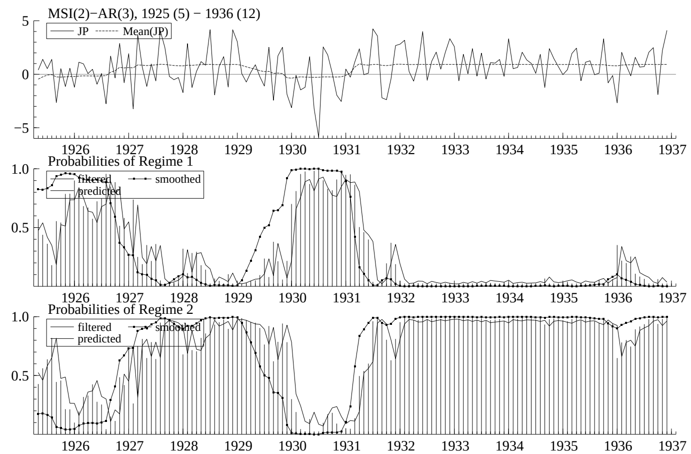


Table 6: (a) Regimes obtained from individual MSI(n)-AR(p)

| **Coefficient** | **Germany** MSIH(4)-AR(3) | **Austria** MSI(2)-AR(7) | **Japan** MSI(2)-AR(3) | **Finland** MSIAH(2)-AR(3) | **Unites States** MSIH(4)-AR(7) | **Sweden** MSIH(2)-AR(5) |
|---|---|---|---|---|---|---|
| *Intercepts and AR coefficients depending on regime 1* | | | | | | |
| $\nu_1$ | -6.843 | -2.891 | -0.424 | 0.388 | -2.704 | -0.315 |
| $\alpha_{11}$ | | | | -0.273 | | |
| $\alpha_{12}$ | | | | 0.020 | | |
| $\alpha_{13}$ | | | | 0.130 | | |
| *Intercepts and AR coefficients depending on regime 2* | | | | | | |
| $\nu_2$ | -1.307 | 2.148 | 1.419 | 3.223 | -0.697 | 0.983 |
| $\alpha_{21}$ | | | | -0.098 | | |
| $\alpha_{22}$ | | | | 0.598 | | |
| $\alpha_{23}$ | | | | -2.127 | | |
| *Intercepts and AR coefficients depending on regime 3* | | | | | | |
| $\nu_3$ | 1.081 | | | | 0.786 | |
| $\alpha_{31}$ | | | | | | |
| $\alpha_{32}$ | | | | | | |
| $\alpha_{33}$ | | | | | | |
| *Intercepts and AR coefficients depending on regime 4* | | | | | | |
| $\nu_4$ | 2.961 | | | | 4.910 | |
| $\alpha_{41}$ | | | | | | |
| $\alpha_{42}$ | | | | | | |
| $\alpha_{43}$ | | | | | | |
| *Regime-independent AR coefficients* | | | | | | |
| $\alpha_1$ | 0.031 | -0.424 | -0.188 | | 0.228 | -0.195 |
| $\alpha_2$ | 0.014 | -0.104 | -0.202 | | -0.134 | -0.220 |
| $\alpha_3$ | -0.006 | -0.156 | -0.147 | | -0.112 | 0.077 |
| $\alpha_4$ | | -0.202 | | | -0.072 | -0.050 |
| $\alpha_5$ | | -0.030 | | | -0.110 | 0.093 |
| $\alpha_6$ | | -0.177 | | | -0.179 | |
| $\alpha_7$ | | -0.045 | | | 0.181 | |
| *Transition probabilities and expected duration of recessions in months* | | | | | | |
| $p_{11}$ | 0.461 | 0.909 | 0.930 | 0.959 | 0.908 | 0.972 |
| duration | 2 | 11 | 14 | 24 | 11 | 36 |
| $p_{12}$ | 0.025 | 0.047 | 0.019 | 0.472 | 0.075 | 0.018 |
| $p_{13}$ | 0.039 | | | | 0.028 | |
| $p_{14}$ | 0.000 | | | | 0.000 | |
| $p_{21}$ | 0.218 | 0.091 | 0.070 | 0.041 | 0.000 | 0.028 |
| $p_{22}$ | 0.897 | 0.953 | 0.981 | 0.528 | 0.503 | 0.982 |
| duration | 10 | | | | 2 | |
| $p_{23}$ | 0.000 | | | | 0.006 | |
| $p_{24}$ | 0.110 | | | | 0.478 | |
| $p_{31}$ | 0.153 | | | | 0.000 | |
| $p_{32}$ | 0.020 | | | | 0.199 | |
| $p_{33}$ | 0.932 | | | | 0.966 | |
| $p_{34}$ | 0.082 | | | | 0.015 | |
| $p_{41}$ | 0.169 | | | | 0.092 | |
| $p_{42}$ | 0.058 | | | | 0.224 | |
| $p_{43}$ | 0.029 | | | | 0.000 | |
| $p_{44}$ | 0.809 | | | | 0.507 | |
| *Variances, dependent and independent of regime* | | | | | | |
| $\sigma^2$ | | 11.62 | 2.76 | | | |
| $\sigma_1^2$ | 4.17 | | | 8.68 | 2.28 | 12.50 |
| $\sigma_2^2$ | 1.65 | | | 1.21 | 0.02 | 3.45 |
| $\sigma_3^2$ | 2.72 | | | | 2.85 | |
| $\sigma_4^2$ | 6.10 | | | | 40.32 | |
| # obs. | 140 | 136 | 140 | 140 | 136 | 138 |
| ln$L$ | -312.34 | -375.94 | -277.21 | -358.56 | -282.42 | -343.23 |
| **Recessions** | 1925:5-1926:4(2) | 1925:9-1925:10 | 1925:5-1926:10 | 1925:5-1928:3 | 1925:9-1925:9(2) | 1928:4-1932:9 |
| **identified** | 1927:6-1928:1(2) | 1926:3-1926:9 | 1929:8-1931:2 | 1928:5-1931:11 | 1929:10-1931:1(1) | |
| | 1928:3-1928:5(2) | 1929:9-1933:1 | | 1932:6-1933:12 | 1931:3-1931:5(2) | |
| | 1928:10-1928:11(1) | 1936:5-1936:6 | | 1934:3-1936:6 | 1931:6-1932:7(1) | |
| | 1929:5-1930:12(2) | | | 1936:8-1936:12 | 1932:10-1932:11(2) | |
| | 1931:1-1931:1(1) | | | | 1933:1-1933:2(2) | |
| | 1931:8-1931:10(1) | | | | 1933:9-1934:1(2) | |
| | 1931:11-1932:8(2) | | | | 1934:6-1934:9(1) | |
| | | | | | 1934:11-1934:11(2) | |
| | | | | | 1935:1-1935:1(2) | |

*Notes:* "LM rejected" refers to the rejection of the $H_0$ of a linear model using the likelihood ratio test.

## Table 7: (b) Regimes obtained from individual MSI(n)-AR(p)

| **Coefficient** | **Czechoslovakia**<br>MSIH(4)-AR(9) | **Belgium**<br>MSIH(3)-AR(5) | **Poland**<br>MSIH(3)-AR(1) | **Hungary** | **France**<br>MSIH(4)-AR(6) | **Britain**<br>MSIAH(4)-AR(3) |
|---|---|---|---|---|---|---|
| *Intercepts and AR coefficients depending on regime 1* | | | | | | |
| $\nu_1$ | -1.616 | -2.030 | -1.858 | | -1.842 | 0.249 |
| $\alpha_{11}$ | | | | | | 1.417 |
| $\alpha_{12}$ | | | | | | -9.521 |
| $\alpha_{13}$ | | | | | | 3.078 |
| *Intercepts and AR coefficients depending on regime 2* | | | | | | |
| $\nu_2$ | -0.831 | 0.560 | 0.916 | | -0.781 | -0.907 |
| $\alpha_{21}$ | | | | | | -0.106 |
| $\alpha_{22}$ | | | | | | 0.297 |
| $\alpha_{23}$ | | | | | | -0.042 |
| *Intercepts and AR coefficients depending on regime 3* | | | | | | |
| $\nu_3$ | 1.329 | 2.563 | 4.328 | | 0.379 | 1.097 |
| $\alpha_{31}$ | | | | | | -0.090 |
| $\alpha_{32}$ | | | | | | -0.063 |
| $\alpha_{33}$ | | | | | | -0.023 |
| *Intercepts and AR coefficients depending on regime 4* | | | | | | |
| $\nu_4$ | 3.542 | | | | 1.477 | -2.014 |
| $\alpha_{41}$ | | | | | | 1.105 |
| $\alpha_{42}$ | | | | | | -1.100 |
| $\alpha_{43}$ | | | | | | -0.836 |
| *Regime-independent AR coefficients* | | | | | | |
| $\alpha_1$ | 0.098 | 0.055 | -0.155 | | 0.148 | |
| $\alpha_2$ | 0.115 | 0.017 | | | 0.118 | |
| $\alpha_3$ | -0.035 | 0.008 | | | 0.123 | |
| $\alpha_4$ | 0.207 | -0.002 | | | -0.128 | |
| $\alpha_5$ | -0.008 | -0.028 | | | -0.089 | |
| $\alpha_6$ | -0.036 | | | | 0.127 | |
| $\alpha_7$ | -0.012 | | | | 0.044 | |
| $\alpha_8$ | -0.016 | | | | | |
| $\alpha_9$ | 0.192 | | | | | |
| *Transition probabilities* | | | | | | |
| $p_{11}$ | 0.818 | 0.754 | 0.940 | | 0.846 | 0.236 |
| duration | 5 | 4 | 17 | | 6 | 1 |
| $p_{12}$ | 0.000 | 0.063 | 0.001 | | 0.000 | 0.000 |
| $p_{13}$ | 0.072 | 0.010 | 0.185 | | 0.000 | 0.012 |
| $p_{14}$ | 0.182 | | | | 0.015 | 0.340 |
| $p_{21}$ | 0.000 | 0.016 | 0.000 | | 0.040 | 0.000 |
| $p_{22}$ | 0.843 | 0.936 | 0.960 | | 0.931 | 0.908 |
| duraction | 6 | | | | 14 | 11 |
| $p_{23}$ | 0.114 | 0.382 | 0.173 | | 0.029 | 0.028 |
| $p_{24}$ | 0.211 | | | | 0.002 | 0.281 |
| $p_{31}$ | 0.000 | 0.231 | 0.060 | | 0.035 | 0.383 |
| $p_{32}$ | 0.157 | 0.002 | 0.039 | | 0.059 | 0.092 |
| $p_{33}$ | 0.814 | 0.607 | 0.642 | | 0.868 | 0.904 |
| $p_{34}$ | 0.187 | | | | 0.038 | 0.379 |
| $p_{41}$ | 0.182 | | | | 0.000 | 0.381 |
| $p_{42}$ | 0.000 | | | | 0.000 | 0.000 |
| $p_{43}$ | 0.000 | | | | 0.173 | 0.055 |
| $p_{44}$ | 0.419 | | | | 0.827 | 0.000 |
| *Regime-dependent variances* | | | | | | |
| $\sigma_1^2$ | 1.90 | 1.74 | 5.71 | | 1.98 | 0.00 |
| $\sigma_2^2$ | 0.43 | 4.66 | 2.13 | | 0.49 | 4.75 |
| $\sigma_3^2$ | 0.70 | 295.84 | 3.24 | | 0.57 | 3.42 |
| $\sigma_4^2$ | 2.16 | | | | 0.29 | 0.44 |
| # obs. | 134 | 138 | 142 | | 136 | 140 |
| ln$L$ | -235.48 | -357.13 | -322.97 | | -161.44 | -304.79 |
| **Recessions identified** | 1925:11-1926:7(2)<br>1927:9-1927:11(1)<br>1928:2-1928:6(2)<br>1928:8-1928:10(2)<br>1929:6-1931:3(2)<br>1931:8-1932:7(1)<br>1933:1-1933:3(2)<br>1933:9-1933:9(1)<br>1933:11-1934:1(1)<br>1934:5-1934:12(1)<br>1935:3-1935:4(2)<br>1936:1-1936:6(2) | 1925:12-1926:1<br>1929:10-1930:5<br>1931:4-1931:4<br>1931:9-1932:6<br>1936:3-1936:5 | 1925:3-1926:1<br>1928:4-1928:10<br>1929:1-1933:3 | | 1926:10-1926:10(2)<br>1926:11-1927:4(1)<br>1930:5-1931:9(2)<br>1931:10-1932:7(1)<br>1933:8-1935:3(2)<br>1936:6-1936:9() | 1925:8-1925:8(4)<br>1926:1-1926:1(4)<br>1926:3-1926:3(4)<br>1927:1-1927:1(4)<br>1927:2-1928:3(2)<br>1928:7-1928:7(4)<br>1929:9-1931:5(2)<br>1932:3-1932:8(2) |

*Notes:* "LM rejected" refers to the rejection of the $H_0$ of a linear model using the likelihood ratio test.

Table 8: Contemporaneous cross-correlation of high probability of being in recession

| Country pair | Germany | Austria | Japan | Unites States | Sweden | Czechoslovakia | Belgium | Poland | France | Britain |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Contingency coefficients for the entire period 1925:7-1936:12 | | | | | | |
| Germany | 100.0 | | | | | | | | | |
| Austria | 47.6 | 100.0 | | | | | | | | |
| Japan | 50.9 | 60.6 | 100.0 | | | | | | | |
| United States | 41.2 | 70.9 | 22.2 | 100.0 | | | | | | |
| Sweden | 69.7 | 80.2 | 40.9 | 72.3 | 100.0 | | | | | |
| Czechoslovakia | 47.3 | 40.7 | 38.6 | 50.9 | 44.9 | 100.0 | | | | |
| Belgium | 54.3 | 56.1 | 24.0 | 54.6 | 61.8 | 49.1 | 100.0 | | | |
| Poland | 68.4 | 68.6 | 42.8 | 58.3 | 81.2 | 38.7 | 49.2 | 100.0 | | |
| France | 6.0 | 18.9 | 16.3 | 58.3 | 35.5 | 7.2 | 14.5 | 10.7 | 100.0 | |
| Britain | 63.6 | 45.3 | 44.3 | 33.8 | 56.3 | 23.0 | 33.4 | 35.2 | 18.7 | 100.0 |
| | | | | Contingency coefficients for the period 1925:7-1929:12 | | | | | | |
| Germany | 100.0 | | | | | | | | | |
| Austria | 9.1 | 100.0 | | | | | | | | |
| Japan | 11.9 | 81.6 | 100.0 | | | | | | | |
| United.States | 37.2 | 63.5 | 47.3 | 100.0 | | | | | | |
| Sweden | 44.5 | 29.5 | 21.4 | 57.3 | 100.0 | | | | | |
| Czechoslovakia | 30.7 | 29.9 | 36.3 | 19.8 | 34.1 | 100.0 | | | | |
| Belgium | 41.6 | 36.7 | 52.6 | 76.4 | 49.2 | 43.0 | 100.0 | | | |
| Poland | 44.9 | 3.2 | 20.1 | 39.8 | 59.5 | 30.7 | 44.5 | 100.0 | | |
| France | 41.1 | 36.7 | 38.4 | 18.9 | 29.5 | 60.9 | 21.3 | 59.0 | 100.0 | |
| Britain | 31.8 | 6.6 | 20.9 | 25.8 | 2.4 | 5.3 | 33.2 | 41.3 | 36.1 | 100.0 |
| | | | | Contingency coefficients for the period 1930:1-1936:12 | | | | | | |
| Germany | 100.0 | | | | | | | | | |
| Austria | 82.6 | 100.0 | | | | | | | | |
| Japan | 72.7 | 61.2 | 100.0 | | | | | | | |
| United.States | 70.2 | 70.9 | 47.0 | 100.0 | | | | | | |
| Sweden | 90.5 | 92.5 | 68.7 | 73.0 | 100.0 | | | | | |
| Czechoslovakia | 63.2 | 44.3 | 48.9 | 62.9 | 48.5 | 100.0 | | | | |
| Belgium | 69.2 | 59.8 | 19.6 | 44.6 | 63.0 | 51.1 | 100.0 | | | |
| Poland | 82.6 | 94.9 | 61.2 | 75.2 | 92.5 | 44.3 | 53.6 | 100.0 | | |
| France | 36.8 | 24.2 | 26.4 | 55.7 | 44.0 | 36.7 | 13.1 | 17.4 | 100.0 | |
| Britain | 80.0 | 77.9 | 83.3 | 59.6 | 85.8 | 45.9 | 41.4 | 77.9 | 30.6 | 100.0 |

*Notes:* Pearson's contingency coefficient given in percentage terms and normalized to the interval 0 to 100 (cf. AKT(2004) App.2).

## Diskussionsbeiträge des Fachbereichs Wirtschaftswissenschaft der Freien Universität Berlin

### 2007

2007/1 BESTER, Helmut / Daniel KRÄHMER
Delegation and Incentives
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