WORKING PAPERS

Measuring the Similarities of Economic Developments in Central Europe: A Correlation between the Business Cycles of Germany, Hungary, the Czech Republic and Croatia

Velimir Šonje
Igeta Vrbanc

Croatian National Bank

W – 3 September 2000

Published by
Croatian National Bank
Public Relations and Publishing Department
Trg burze 3, 10000 Zagreb
Phone: 4564-555
Phone: 4922-070, 4922-077
Fax: 4873-623

Web
http://www.hnb.hr

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Printed by
Poslovna knjiga d.o.o., Zagreb

Printed in 350 copies

ISSN 1332–1900

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MEASURING THE SIMILARITIES OF ECONOMIC DEVELOPMENTS IN CENTRAL EUROPE: A CORRELATION BETWEEN THE BUSINESS CYCLES OF GERMANY, HUNGARY, THE CZECH REPUBLIC AND CROATIA

Summary

Following the research by Laurence Boone and Mathilde Maurel (1998, 1999) on the monetary union of the Central European countries with Germany and the European Union, scholarly curiosity has led us to investigate the relationship between the Croatian and German economies, as well as between the Croatian economy and the average European Union economy. Boone and Maurel (1999) concluded that the benefits of a common monetary policy for transition countries outweigh its costs.

This paper determines the relationship between the Croatian and German economies and compares the Croatian economy with the economy of two advanced transition countries. The authors compared the economies by comparing business cycles illustrated by unemployment cycles in selected countries. Using the Hodrick-Prescott filter to detrend the time series of unemployment in Germany, Hungary, the Czech Republic and Croatia, the authors showed that there is a close correlation between cyclical unemployment fluctuations in all these countries and cyclical unemployment fluctuations in Germany. They also showed that there is a similarity between business cycles responses in three selected countries during the 24 months following the initial shock coming from the German economy and even more similarity between their responses to the shock during the first 12 months. The authors were cautious in drawing the conclusions that the results show that the selected countries are the optimum currency area as defined by Mundell. They warn about the possibility that cyclical coordination is endogenous, i.e. that it is the consequence of the implicit or explicit pegging of the exchange rates of advanced transition countries to the German mark exchange rate during a major part of the analyzed period (1992-1999). However, the importance of the results on cyclical coordination in considering the optimal exchange rate regime is not denied in this paper. The most important achievement of this research is that findings regarding Croatia, which showed a close convergence between Croatian and German unemployment, are added to the already known results on the close convergence of cyclical fluctuations in Central Europe.

JEL: E50; E32; P52
Key words: exchange rate policy; optimum currency area; business cycle; Hodrick-Prescott

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The authors wish to thank Dr. Alen Belullo for useful remarks on the draft version of this paper. These remarks have led to a jointly written paper that will, hopefully, be published soon. Any opinions expressed in this paper are entirely the authors' responsibility.

Contents

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MEASURING THE SIMILARITIES OF ECONOMIC DEVELOPMENTS IN CENTRAL EUROPE: A CORRELATION BETWEEN THE BUSINESS CYCLES OF GERMANY, HUNGARY, THE CZECH REPUBLIC AND CROATIA

1. Introduction

The international coordination of business cycles is one of the most important preconditions for a country's accession to the monetary union. A country abandoning its national currency or giving up the possibility of manipulating its value will not lose the ability to use monetary policy for counter-cyclical impact providing there is a convergence of cyclical fluctuations in the monetary union or the international system of fixed exchange rates (Mundell, 1961). As well, there are countries in which currency weakening promotes recession impulses due to the lack of the culture of stability and confidence. Hence, by fixing exchange rates or entering the monetary union, these countries simply create the preconditions for the counter-cyclical impact of the monetary policy (Hausmann et al, 1999; Calvo, 1999).

These issues are currently the focus of macroeconomic research and debates worldwide. There are, however, no indications that a consensus will be reached soon. Barry Eichengreen (1996) sees consensus on "fluctuating exchange rates are here to stay", while Guillermo Calvo (1999) ambitiously speaks of "a renewed arrangement of the mosaic at the turn of the millenium", of course, on behalf of fixed exchange rates and monetary unions. Robert Mundell (1999) continues to plead for fixing the exchange rates of countries close to Europe to the Euro. However, Paul Masson (1999) and Frederick Mishkin (1999a, 1999b) warn about exposure to speculative attacks and other weaknesses of the fixed exchange rate system. They speak in favor of more flexible exchange rate regimes like the direct targeting of low inflation.

Different opinions will remain present although heated discussions over the previous months have awakened the hope that the amount of knowledge on the choice of optimal exchange rate regimes will soon be greater. The authors of this paper do not want to join that discussion but rather assess whether the business cycles of Central European countries are correlated.

Research on the convergence of cyclical unemployment fluctuations conducted by Laurence Boone and Mathilde Maurel (1998, 1999) at the London Centre for Eco-

nomic Policy Research (CEPR) was the first of that type to include some of the Central European transition countries. The results showed a high degree of convergence of cyclical unemployment fluctuations between Germany and the four transition countries who are first round candidates for joining the EU. The percentage of the change in unemployment explained by cyclical unemployment fluctuations in Germany was highest in Hungary (86%), then followed Slovakia (83%) and the Czech Republic (63%). The lowest percentage of change was found in Poland (55%), but even this correlation can be considered high.

What is especially interesting in the above mentioned research is that the degree of correlation between the four transition countries and Germany was higher than the degree of correlation between Germany, Spain and Italy, and lower than between Germany and France. German unemployment shocks accounted for 43% of Spanish, 18% of Italian and as much as 91% of the French cyclical unemployment variance. Despite significant differences in the strength of relations and degree of economic development,[1] all these countries decided in favor of the Euro although from the point of cycles coordination, they had significantly fewer reasons than advanced transition countries have today.

The main difference between France on the one hand and Spain and Italy on the other is that by exiting the ERM and allowing the depreciation of their exchange rates in 1992/93, the two latter countries made an adjustment of their exchange rates that did not lead to inflation and an increase in interest rates. Inflation remained low, and interest rates dropped. Contrary to that, France did not at that time adjust its exchange rate. Starting from 1987, France strongly fixed the franc to the German mark in order to avoid the negative consequences of high inflation that occurred in the 1980s. The data in Table 1 shows that compared to other countries, France did not "pay the price". On the contrary, France experienced rapid growth following the European currency crises in the early 1990s. A comparison of France with Spain and Italy (countries that allowed a significant weakening of their currencies) does not show the supposed advantage of exchange rate relaxation and the transition to a more liberal regime of domestic monetary policy in Spain and Italy. On the contrary, all the selected countries went through a period of growing unemployment during the 1990s.

The data in Table 1 also shows that 1993 was the critical year in which all the selected countries recorded a decrease in real GDP of approximately equal intensity (–1.2% in Spain and Italy, –1.3% in France). Under the burden of re-unification, Germany also recorded a drop in GDP of an equal intensity in that year (–1.2%). Bearing in mind the insensitivity of annual data on real GDP and unemployment in Spain, France, Italy and Germany to their different exchange rate policies, it is questionable whether the impact of the international transmission of crises mechanisms (coming in this case from Germany) even on such large economic systems was not much stronger than the offsetting (counter-cyclical) impacts of national monetary and exchange rate policies. This begs the question: if the factors of the international transmission of business cycles are so important and domineering over national monetary policies in such large economic systems, is not their role even more significant in the small open

1 Spanish GDP per capita at the moment of entering the euro zone was half that of Germany.

economies of Central European transition countries? This question will be addressed in this paper and the authors will show that the answer is positive. Furthermore, it will be shown that the Croatian economy is extremely sensitive to exogenous macroeconomic shocks coming from Germany.

Table 1: Exchange rate, real output and unemployment in Spain, Italy and France 1991 – 1998

Year	Spain			Italy			France		
	E[a]	y[b]	U%	E[a]	y[b]	U%	E[a]	y[b]	U%
1991	103.9	2.3	16.3	1241	1.1	10.9	5.64	0.8	9.4
1992	102.5	0.7	18.4	1235	0.6	10.7	5.30	1.2	10.3
1993	127.5	–1.2	22.7	1578	–1.2	10.2	5.66	–1.3	11.6
1994	134.0	2.1	24.2	1612	2.2	11.3	5.55	2.8	12.3
1995	124.7	2.9	22.9	1629	2.9	12.0	4.99	2.1	11.7
1996	126.7	2.4	22.2	1543	0.9	12.1	5.12	1.6	12.4
1997	146.5	3.5	20.8	1704	1.5	12.3	5.84	2.3	12.5
1998	149.0	3.8	18.8	1731	1.4	12.3	5.88	3.1	11.6

[a] Average annual nominal exchange rate of the national currency versus the USD.
[b] Annual real GDP growth rate.
Source: World Economic Outlook, May 1999, IMF: Washington.

An introductory comparison between France, Italy and Spain indicates that the strength of relations between real shocks might not be an exogenous phenomenon. Convergence between real developments may partly be explained as a consequence of the chosen exchange rate policy. This hypothesis is supported by the fact that the franc remained closely tied to the German mark during the 1990s, while the lira and peso exited the ERM in the early 1990s. Therefore, the correlation of unemployment fluctuations could have been much stronger between Germany and France than between Germany, Spain and Italy. However, this should not induce us to conclude too easily that the choice of exchange rate policy is the major and only determinant of cycle coordination. It can also be a product of historical circumstances, i.e. directions of trade in goods and factors of production.

Three important lessons can be learned from this. First, a degree of business cycle coordination is not the most important indicator influencing the decision whether to enter (or not) the monetary union or some other international agreement on exchange rate policy. The functioning of economies within the monetary or exchange rate agreement or even their closeness and connection in trade may lead to the cyclical coordination of economic activity (Frankel and Rose, 1998).

Second, and this conclusion is stressed by Boone and Maurel (1998, 1999), the degree of cyclical coordination can also be a consequence of historical relations. It can also be a consequence of the fact that all selected countries in which a high degree of cyclical coordination was established (France, Central European transition countries) did in some way peg their exchange rates to the DM, which was a part of their struggle against inflation (Begg, 1996; Bufman and Leiderman, 1999). It can also be a conse-

quence of historical connections, and the structure of trade in goods and factors of production. In that way both the institutional and geographic factors can determine the optimal exchange rate regime and the degree of cyclical coordination. Still, it is difficult to determine cause and effect relationships regarding these issues.

Third, considering the size of the national economy, structure of international trade, in which the EU accounts for 60%, and the policy of implicitly pegging the kuna to the German mark, it is possible to expect a very high degree of cyclical correlation between Croatia and Germany, as well as between Croatia and other Central European transition countries where their correlation with Germany acts as an intermediary. These relations are examined in this paper. It should, however, be emphasized once again that the method used in this type of research does not ensure the direct identification of the causes of cyclical coordination.

The major problem in this type of research is how to separate the cyclical components from the structural and fundamental components of developments in macroeconomic variables. This distinction is important because experience warns us that monetary policy can effectively influence only the cyclical component of economic developments.[2] This may be due to the significantly different causes of structural and cyclic developments. The first type of developments may, for example, be under the dominant influence of institutional organization of the labor market. The same common shock causing an increase in demand in two countries of the same magnitude can in one of them, where labor unions are weak, cause a rise in employment (while unit costs of labor will grow more slowly). Simultaneously, in the other country, where labor unions are strong, the shock will be completely neutralized by the growth in wages. Employment in the latter country will not grow. For that reason, it is first necessary to establish fundamental structural trends in data. They reflect phenomena that are not cyclical and which probably can not be influenced by monetary policy. It should then be assumed that the residual part of the phenomenon, from which the trend component is left out, comprises the cyclical component that is being analyzed.

The following section presents results obtained after detrending by use of the Hodrick-Prescott filter, i.e. by applying the same method as that used by Boone and Maurel (1999), which makes these results comparable to theirs. The results show that there is a close cyclical correlation between advanced transition countries and Germany (confirming the results obtained by Boone and Maurel). They also show that there is a very similar temporal pattern of unemployment response in Croatia, the Czech Republic and Hungary to the German macroeconomic shock if we consider the first 24 and 12 months after the shock. This, however, does not apply for the shock transmission after 36 months.

In this paper, the authors show that Central Europe is the optimum currency area, as defined by Mundell (1961), but warn that the decision on the currency regime should not be based solely on the criterion of cyclical coordination. There are two reasons for this. First, cycles coordination may be endogenous, i.e. a product of a previous decision that in some way pegged the exchange rate to the exchange rate of the cur-

2 It is, naturally, being assumed that the reader accepts the view that monetary policy can have real effects in a short period. For readers who believe in the absolute neutrality of monetary policy, its mentioning in this context is redundant.

rency applied in a larger monetary area (country or union). Second, cycles coordination may be a product of deeper structural and/or historical connections. The second reason is an additional argument in favor of forming a monetary union or some similar currency arrangement. The first reason would be an argument against union in the case that it could be proven that greater flexibility of the exchange rate and a more lax monetary policy might smooth the impact of domestic and "imported" cyclical fluctuations. However, this would be very difficult to prove. This type of argumentation goes beyond the scope of this paper in which the applied method does not make possible the analysis of the causes and scope of cyclical coordination. The authors' goal is modest: proving the existence of a close correlation between business cycles in Central Europe.

2. Results of the Empirical Analysis

In this section the authors will use the methodological approach used by Boone and Maurel (1999). One of the main conclusions of their research is that the benefits of the integration of transition countries into the European Union, and into the consequent EMU will outweigh the costs due to the similarity between their business cycles. It is assumed that monetary policy acts primarily to smooth fluctuations in the business cycles. The time series were, consequently, decomposed into their trend and cyclical components. It is assumed that the cyclical component is correlated with demand shocks, which are not expected to have a permanent effect on output and unemployment. The authors of this research have accepted this method and its assumptions. The only innovation herein is that Croatia and two advanced transition countries (the Czech Republic and Hungary) and the analysis of their reactions are included. An additional difference in the results is possible because Boone and Maurel used unemployment time series starting from 1990 and ending in 1997, while the time series used in this research start in January 1992 and end in October 1999.

The figures in Appendix 1 present unemployment rates in their original form. It is observable that the unemployment rate in all countries contains a significant trend component. Original data were seasonally adjusted and then the Hodrick-Prescott filter was used to detrend the series (Appendix 5). Appendix 2 presents significantly different unemployment trends in the selected countries, which were obtained by using the Hodrick-Prescott filter. In Croatia and the Czech Republic, following a drop in the unemployment trend up to 1995 and 1996 respectively, unemployment started rising. The German unemployment trend was on the increase till the end of 1997/beginning of 1998, after which it began to drop. Following a two-year increase in Hungarian unemployment, it decreased over the remaining period. The authors of this paper are presently not interested in causes of demonstrated differences in unemployment fluctuations. The presented trends point out that it is necessary to detrend the data on unemployment in order to extract the cyclical component and analyze it. The cyclical component was obtained by deducting the trend value according to Hodrick-Prescott from the original series. The cyclical component of four series is presented in the graphs in Appendix 3. Let us remember that the cyclical component of unemployment in the selected countries will approximate their business cycles. In the following text

the authors will determine the manner in which the business cycles in the three countries react to the German business cycle shock to discover if there are similarities in their reactions.

Prior to taking these two steps of the analysis, it was necessary to model the process that generated the cyclical component of German unemployment. The process had to be identified and characterized. For that purpose, the authors used the ARMA(p,q) modeling process. Besides two basic tools of process identification, auto-correlation function and partial auto-correlation function, the authors chose the AR(1) model. Thus, the following model describes the cyclical component of German unemployment:

$$(U)_{G,t} = \alpha_G (U)_{G,t-1} + \varepsilon_{G,t} \tag{1}$$

where U stands for cyclical unemployment, subscript G stands for Germany, while residuals $\varepsilon_{G,t}$ present the German shock causing the cyclical fluctuations of German unemployment (Appendix 4). This series of residuals was used for regressions to be computed in the first step of the analysis. Two positive shocks are visible in Appendix 4, a stronger one in May 1994, and a weaker one in January 1997, as well as a negative shock in May 1995.

In the first step of the analysis, the business cycle fluctuations (the cyclical component of unemployment) in each of the selected countries were regressed to the common German shock (residuals in equation (1)) which is lagged, where the number of lags is 36, 24 and 12, or presented symbolically:

$$U_{Z,t} = \sum_{k=0}^{p} \beta_{Z,k} \varepsilon_{G,t-k} + u_{Z,t} \tag{2}$$

where Z = Croatia, the Czech Republic and Hungary, and p = 36, 24, 12. These regressions will show the extent to which the unemployment fluctuations in three selected countries can be explained by the German shock. The determination coefficient of the regressions presented in equation (2) will indicate the percentage of variance within the business cycle of the analyzed countries that can be explained by the German shock. Lags p = 36, 24, 12 were used to determine if the parameters were robust or resistant to the change in lag. The vector of coefficients $\beta_{Z,k}$ represents the response function of the selected countries' business cycles to the German shock.

Table 2 presents determination coefficients in equation (2) at lags 36, 24 and 12 for the German shock. A higher value of determination coefficient indicates lower costs of forming a monetary union. As can be observed, for all three countries a high percentage of variance of their business cycle can be explained, i.e. there is a strong linear correlation between the German unemployment shock and the unemployment cycles of selected countries at all lags. The similarity of these results to those obtained by Boone and Maurel (1999) can also be observed. On the basis of their criterion, it follows that the degree of monetary policy autonomy in these countries in relation to Germany should be low. It can also be seen that sensitivity to the chosen number of lags is not significant.

Table 2: Determination coefficients in equation (2)

	36 lags	24 lags	12 lags
Croatia	0.97	0.90	0.79
Czech Republic	0.97	0.95	0.94
Hungary	0.88	0.82	0.83

In the second step the authors analyzed the similarity between the unemployment responses of transition countries to the common shock by examining the correlation between vectors of coefficients from regression (2). Along with a high linear correlation from the previous step, there should be a similarity between the impulse responses of selected countries (positive and high correlations) in order to justify the monetary union. The correlation between vectors of coefficients may indicate a positive and/or negative, as well as weak and/or strong correlation. If the correlations are positive and higher, the two countries are more similar in terms of the relative responses to the common shock. It is necessary to test correlation coefficients $r(\beta_{Z,k}, \beta_{Z1,k})$ for $Z \quad Z1$. These coefficients are presented in Tables 3, 4 and 5.

Table 3: Correlation between vectors of the three countries' impulse responses to the German shock (36 lags)

	Croatia	Czech Republic	Hungary
Croatia	1.00		
Czech Republic	–0.03	1.00	
Hungary	0.47	–0.62	1.00

The results presented in Table 3 do not indicate that these three countries together form a homogenous group of countries. The correlation of their responses does not have the same sign, which means that they react differently to the common shock. The Czech Republic does not react in the same direction as Croatia and Hungary, while the reactions of Croatia and Hungary are strikingly similar. A negative correlation among countries may result from the different time spans needed for shock transmission or from asymmetrical output developments.

Table 4: Correlation between the vectors of the three countries' impulse responses to the German shock (24 lags)

	Croatia	Czech Republic	Hungary
Croatia	1.00		
Czech Republic	0.14	1.00	
Hungary	0.75	0.04	1.00

The three transition countries form a homogenous group of countries (their responses are positively correlated), i.e. they react to the German shock in a similar way. At the same time, the criterion of the desired positive correlation between functions of

impulse responses is satisfied. A great similarity between the Croatian and Hungarian reactions is observable. The results in Table 4 are closer to the results of Boone and Maurel (1999).

Table 5: Correlation between the vectors of the three countries' impulse responses to the German shock (12 lags)

	Croatia	Czech Republic	Hungary
Croatia	1.00		
Czech Republic	0.73	1.00	
Hungary	0.28	0.21	1.00

The correlation between the vectors at 12 lags shows homogeneity and the greatest similarity between the impulse responses of the three selected countries.

The results of the correlations from the last two tables indicate that the selected transition countries and Germany make the optimum currency area as defined by Mundell (1961). This conclusion should be interpreted with caution because cyclical coordination can be a consequence of pegging the exchange rates to the DM. The correlation between the vectors of impulse responses to the German shock at 36 lags did not show that the three selected countries form a homogenous group.

3. Conclusion

According to the authors' view, the most important contribution of this analysis is the finding that the degree of cyclical coordination between Germany and Croatia is very high. In addition, a high percentage of the business cycle fluctuations of the selected transition countries can be explained by the German shock. Furthermore, impulse responses to the common shock are correlated at 24 and 12 lags, which mostly confirms the findings of Boone and Maurel (1999) on the similarities between the responses of the selected countries to the common shock. In other words, over a period of two years as well as one year, all three selected countries reacted in a similar way, thus forming a homogenous group of countries. However, there is no positive correlation between impulse response functions with a 36-month delay in the transition of the common shock.

The authors are aware that a degree of similarity may have resulted from the fact that the selected countries have in some way already pegged their currencies to the German mark. If the currencies are pegged, business cycle fluctuations are actually more similar because a common monetary policy has already been adopted. Therefore, the causes of macroeconomic shock correlation may reflect exchange rate regimes which, due to the currencies being pegged to the DM, make the cycle coordination endogenous (make the "import" of the German cycle possible). The reasons may, however, be of a much deeper, structural nature: historical connections, transfers, the structure of trade in goods, services and factors of production. All of these influence cyclical coordination. It is not possible to distinguish between causes or to make conclusions about their correlation on the basis of this analysis. Therefore, it is not possible to reach tenable conclusions concerning the "optimality" of a currency area on the

basis of this analytical method, although it provides some indications that should be studied in the future. Let us repeat that one of the conclusions reached by Boone and Maurel (1999) was that the benefits of joining the EU or EMU would be high for Central European countries from the point of view of the similarity between their economic cycles. According to these authors, the transition process and real convergence would be accelerated by a stable exchange rate regime. The costs of pegging the currencies of transition countries relate to the degree of asymmetry of economic cycles. Since it has been shown that this degree is low, the costs of pegging currencies would be low as well. These authors hold firmly that the benefits from pegging currencies would be higher than the costs.

Anyway, the shortness of the time series and the low quality of data on unemployment limits the possible conclusions. The possibility of detecting spurious cyclicality by using the Hodrick-Prescott filter can not be overlooked. Hence, the authors would like to mention five possible directions for further research, that could lead to better understanding of the subject. First, the quality of measuring unemployment should be improved. Second, it is necessary to assess the sensitivity of results to data filtering techniques. It is necessary to make further analytical efforts in order to distinguish between the trend component and the cyclical component, as well as to explain fluctuations of the trend component and the causes of these fluctuations. Third, it is necessary to expand this research to other macroeconomic series. For example, although the problem of data quality equally relates to industrial production statistics, it is even now possible to start research into cyclical coordination on the basis of these data. Fourth, it is necessary to increase the number of countries included in the research. The member-countries of the Central European Initiative (CEI) seem to be an interesting sample for a research project into the similarities of response functions. The CEI includes Austria and Italy, all advanced transition countries (except the Baltic states), but also countries that are lagging behind in the transition process (Bulgaria, Bosnia and Herzegovina, Albania, Romania). The CEI also includes three countries that are members of the Euro zone, so a sample including the EU-11 and the CEI would be most interesting for further research. Fifth, regarding research on Croatia, we could leave the level of aggregate data and descend to lower levels of aggregation (individual branches) to determine which branches are the most sensitive to external macroeconomic shocks, whether that sensitivity is expected and most present in branches whose products are mostly traded in international trade.

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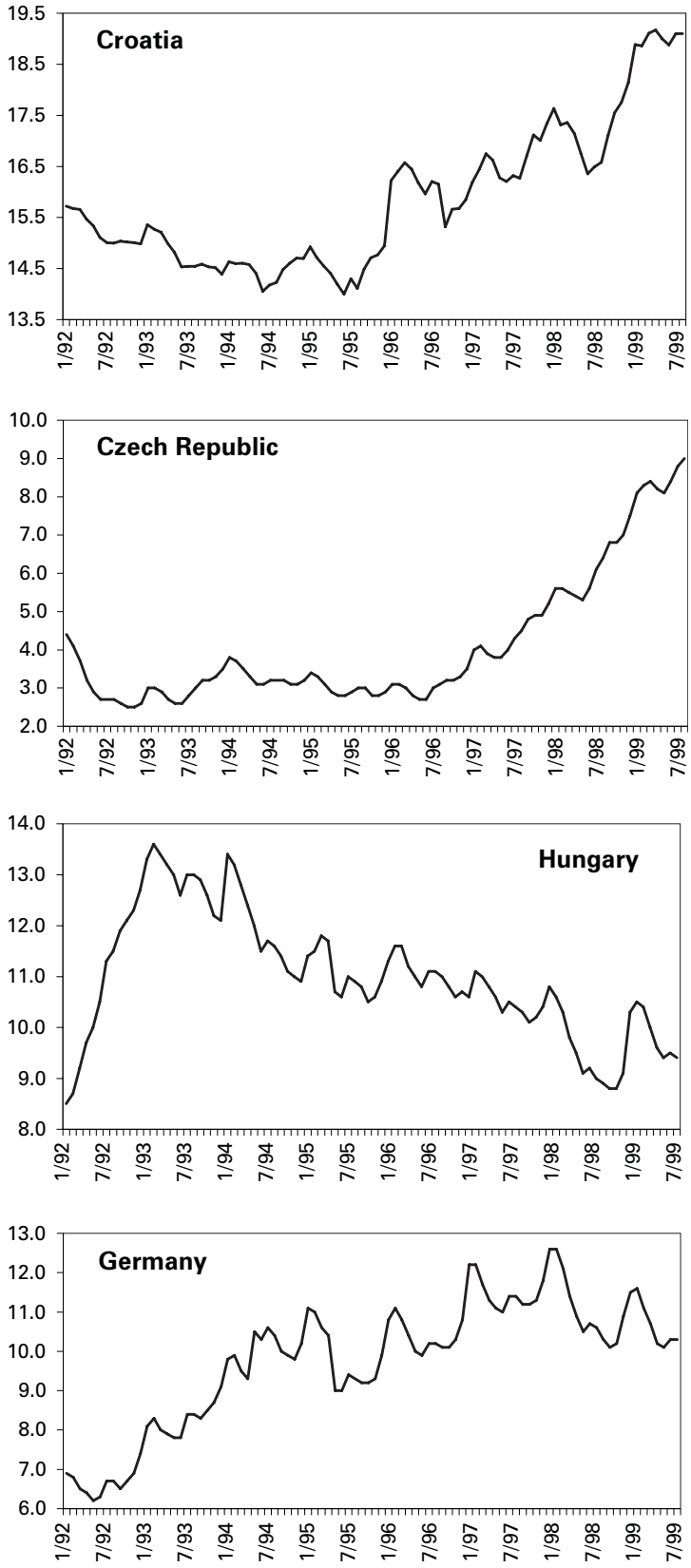
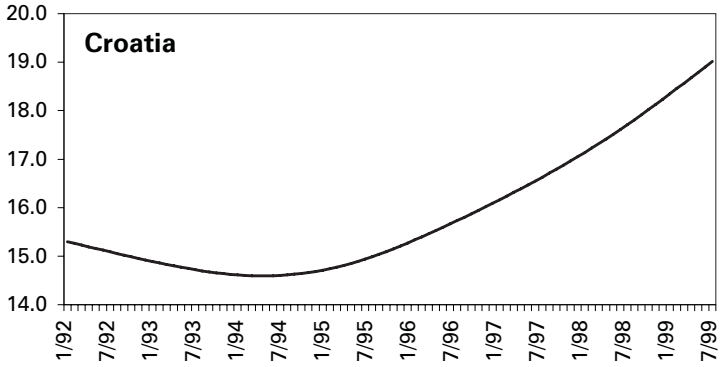
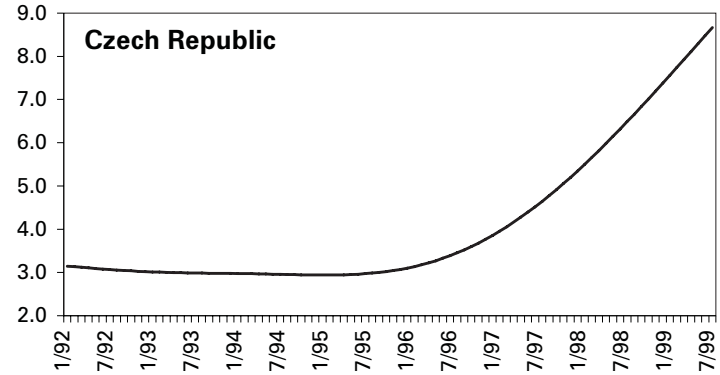
Appendix 1. Unemployment Rates (in percent, original data)

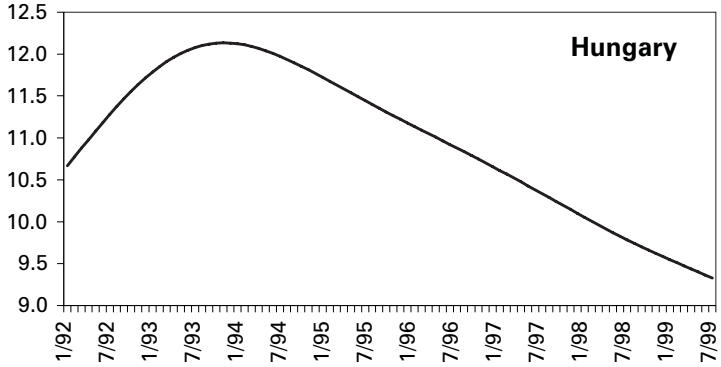


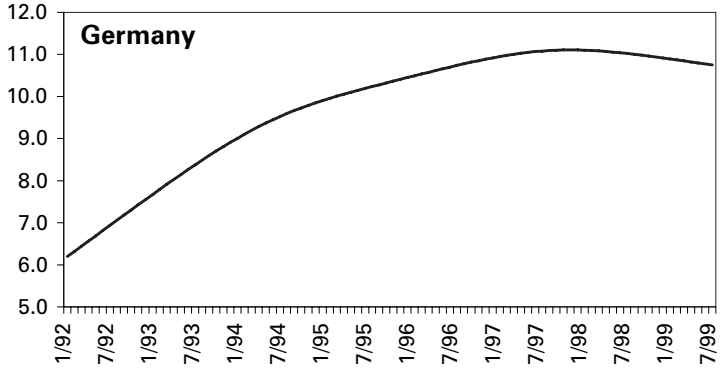
Source: The Vienna Institute Monthly Report,The Vienna Institute for Comparative Economic Studies, various issues (Main Economic Indicators, OECD, various issues)

Appendix 2. The Hodrick-Prescott Trend of the Seasonally Adjusted Unemployment Rate (in percent)

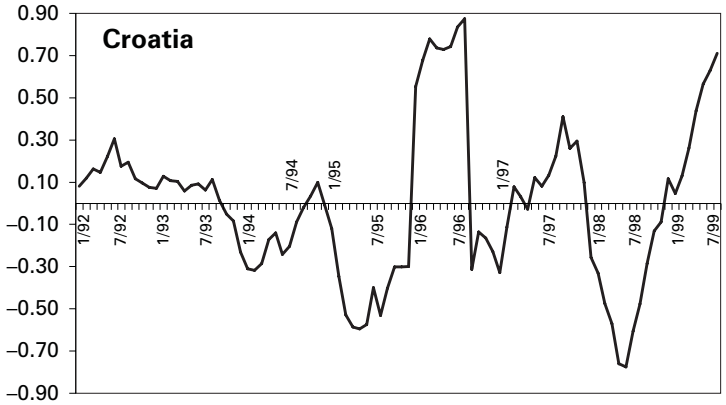


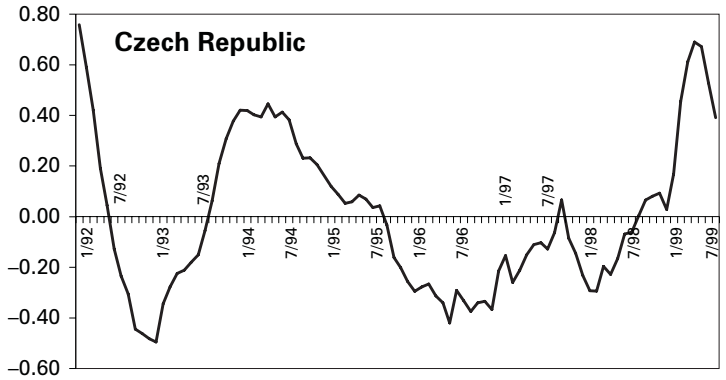


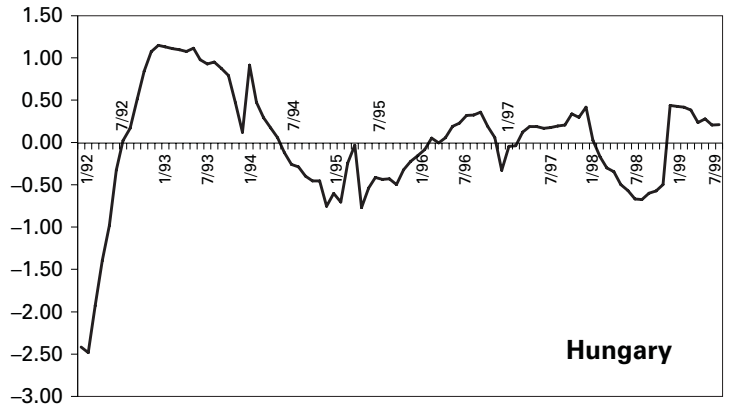


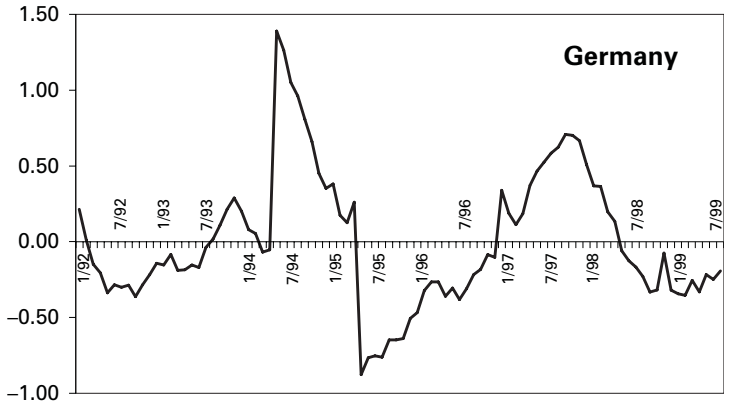


Appendix 3. The Cyclical Component of Unemployment (in percent)

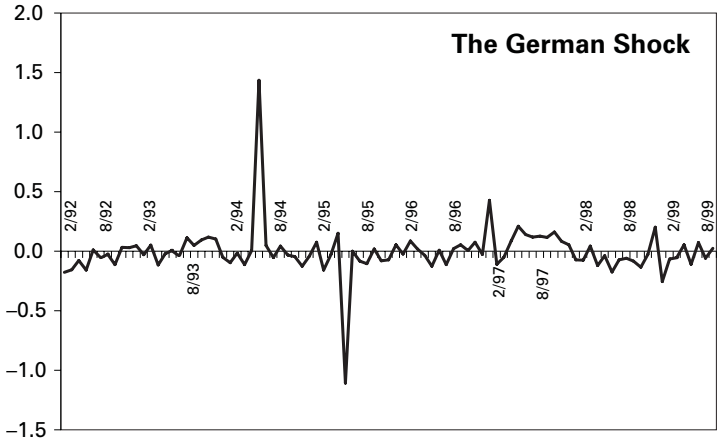








Appendix 4. The German Shock (Residual AR(1) of the Cyclical Unemployment Model) (in percent)



Appendix 5. Hodrick-Prescott Filter

There is a long tradition of economists' efforts to decompose the time series into permanent and transitory components. These efforts have been especially concentrated within the real business cycle (RBC) school. The most popular filter-based method is the one recommended by Hodrick and Prescott (1980). They started from the Lucas theory (1981), according to which aggregate economic variables experience repeated fluctuations around their long-term growth-paths. In the mentioned paper they investigated postwar U.S. business cycles. The heterogeneous empirical part and the thesis in the paper by Hodrick and Prescott (1980) are not the subject of this Appendix except in that related to computing the growth component of the observed time series. The Hodrick-Prescott statistical approach did not utilize a standard time series analysis because their prior knowledge concerning the processes generating the data was not of the variety that would permit them to specify a probability model as required for the application of that analysis. Their attention was more focused on economic theory. The basic hypothesis, based upon growth theory considerations, was that the growth component of the aggregate economic time series varies smoothly over time.

Hodrick and Prescott started from the position that the observed time series is the sum of the cyclical and growth components. They also assumed a seasonal component that was removed in advance. Computing the cyclical component is just a matter of calculating the difference between the observed values and the estimated growth component. The Hodrick-Prescott (HP) filter is the algorithm for computing the growth component. The filter has become popular in applied macroeconomics over the last fifteen years. The conceptual framework used by Hodrick and Prescott is the following: a given time series y_t is the sum of a growth component g_t and a cyclical component c_t, symbolically:

$$y_t = g_t + c_t, \text{ for } t = 1, \ldots, T.$$

The measure of the smoothness of the growth component $\{g_t\}$ is the sum of the squared second difference. The c_t are deviations from g_t, and it is assumed that over long time periods, their average is near zero. The programming problem for determining the growth component is:

$$\underset{\{g_t\}_{t-1}^{T}}{Min} \sum_{t=1}^{T} c_t^2 + \lambda \sum_{t=1}^{T} \left[(g_t - g_{t-1}) - (g_{t-1} - g_{t-2})\right]^2 ,$$

where $c_t = y_t - g_t$. The parameter λ is a positive number which "penalizes" variability in the growth component series. The larger the value of λ, the smoother is the solution series. For an extremely large , at the optimum all the $g_{t+1} - g_t$ must be arbitrarily near some constant β and therefore the g_t arbitrarily near $g_0 + \beta t$. This implies that the limit of solutions to the minimization problem, as λ approaches infinity is the least squares fit of a linear time trend model.

The data analyzed by Hodrick and Prescott (1980) were transformed to logarithms so the change in the growth component, $g_t - g_{t-1}$, corresponds to a growth rate.

If the cyclical component and the second differences of the growth components were identically and independently distributed, normal variables with means zero and variances σ_1^2 and σ_2^2 (which they usually are not), the conditional expectation of the g_t, given the observations, would be the solution to the minimization problem when $\sqrt{\lambda} = \frac{\sigma_1}{\sigma_2}$.

Kalman's filtering technique was used to compute conditional estimates of g_t with given y_t. According to Hodrick and Prescott (1980), a 5 percent cyclical component is approximately equal to a one-eighth of 1 percent change in the growth rate in a quarter. This led them to select $\sqrt{\lambda} = 5 / (1 / 8) = 40$ or $\lambda = 1600$ as a value for the smoothing parameter. One issue was how sensitive are the results to the selected value of λ. The HP1600 filter is almost a standardized way of drawing a smoothed trend curve through a cyclical series.

The second member of the above sum, $((g_{t+1} - g_t) - (g_t - g_{t-1}))$, or $\Delta^2 g_t$, is the approximation of the second derivation of the g in time t. There are two opposites in the Hodrick-Prescott minimization problem. On the one hand they tried to minimize the sum of cyclical residuals squared, and on the other hand, they wanted to minimize the sum of squared $\Delta^2 g_t$. The smoothness parameter λ gives a relative weight to these two opposites. The value of the parameter, $\lambda = 1600$, is questionable in practice when the series is cyclical, because the above result is acceptable only if the cyclical component (c) is a white-noise process. It is not surprising that the actual value of λ, $\hat{\lambda} = \frac{\sum_{t=1}^{T} \frac{(\hat{c}_t - \hat{\bar{c}})^2}{T}}{\sum_{t=2}^{T-1} \frac{(\hat{\Delta}^2 g_t - \hat{\bar{\Delta}}^2 g)^2}{T-2}}$, is different from the a priori value of λ if the series is cyclical.

When the HP filter is applied to the cyclical series, one should not look for the optimum value of λ based on results obtained by Hodrick and Prescott (1980). The value of λ should instead be determined by the filtering procedure. As a result of consequent empirical investigations, the recommended value of λ equals 100 for annual, 1600 for quarterly and 14400 for monthly data.

The HP filter is a symmetrical two-sided filter at the middle of the sample, with end-points having more leverage. Observations at the middle of the sample receive a low weight, while the last observation receives a high weight.

The application of the HP filter has been criticized by several authors. King and Rebelo (1993) showed that the HP filter, when applied to large samples, contains centered fourth differences and makes the time series stationary, that can by differencing be turned into permanent even if they are of a higher integration order. This is an often neglected but undesirable characteristic. There is no clear economic reason why cyclical residuals should be proportional to the fourth differences of the trend-component. This calls into question the application of the HP filter. It has also been shown that the estimated sum of squared $\Delta^2 g_t$ is extremely cyclical in time, i.e. change in the HP in the growth rate is often extremely cyclical.

Harvey and Jaeger (1993) as well as Cogley and Nason (1995a) showed that spurious cyclicality is induced when the HP filter is applied to a random walk process, i.e. if the series does not contain the cyclical component. It is not surprising to observe spu-

rious cyclical behavior in this situation, as one is fitting a smooth trend curve to the data when the actual trend is not smooth. The HP filter has not been shown to generate spurious cycles when there is a cyclical component in the series.

Since it is impossible to know the real nature of the trend component in macroeconomic series, a procedure for extracting the dominant cyclical component from the series has been established. For this purpose the MNC (Multivariate Normal Cyclical) filter (Reeves, J.J., et al, 1996) that successfully extracts the cyclical component from the series has been developed. This approach to extracting the cyclical component from the series is statistically justified due to the application of the method of maximum credibility with restrictions. A much better confirmation of the existence of the cyclical component is the approach in which both the HP filter and MNC estimate are used, i.e. the analysis of the HP cyclical residual and the corresponding MNC estimate of the dominant cyclical component of the time series.

Baxter and King (1995) recently suggested the application of a filter (BK filter) by which a business cycle component is successfully extracted from the macroeconomic time series. By comparing the HP and BK filters, it has been concluded that they are both usable in identifying the frequencies of the business cycle time series if the spectrum has a peak at these frequencies. However, a peak in the spectrum of macroeconomic time series is most often at lower frequencies and their spectrum decreases monotonically at higher frequencies. Hence, the conditions necessary for a good approximation of the cyclical component by use of the HP and BK filters are rarely seen in practice.

In most cases there is an agreement that the macroeconomic time series consists of permanent and cyclical components. The peak of the series spectrum will, therefore, be at zero frequency, while the peak of the cyclical component will be at business cycle frequencies. For example, the permanent component could be driven by a random-walk technological process with drift, while transitory monetary and fiscal shocks can generate a cyclical component with a peak in its spectrum at business cycle frequencies. If this is true, then the HP filter may be able to adequately capture the cyclical component.

From a purely statistical point of view, the application of the HP filter to cyclical series has not been confirmed. The HP filtering is justified only if the series contains a slowly changing trend and irregular white noise. It has been proven that the HP filter is statistically justified by the minimization of the mean squared error or by an estimate made by a method of maximum credibility only if the detrended series is a white-noise process. There is in the literature a new derivation of the HP minimization process where a method of maximum credibility evaluation is applied. This generalizes the HP minimization problem.

Use of the HP filter for extracting the cyclical component of macroeconomic series is not justified because the following assumptions are usually not met in practice: 1) Transitory and permanent components are not correlated. (This means that the trend and cyclical components are generated by different economic forces, which is often incompatible with business cycles models.); 2) The original time series is integrated with the order of integration equal to two. (This is not often the case in macroeconomic time series. The usual assumption is the process with the order of integration

equal to one.); 3) The transitory component is a white noise process. (This is also questionable.); 4) The parameter controlling the smoothness of the trend is satisfactory. (The application of the HP filter showed that it is difficult to determine its value precisely.)

A drawback of the HP filter is that the choice of the smoothness parameter is arbitrary, and it influences the estimate. In other words, information on a cycle changes together with the smoothness parameter. Further doubts regarding the usefulness of the HP filter relate to the decomposition of the time series into trend and cycle. For example, it is well known that the accuracy of decomposition varies depending on various processes generating observations and various groups of observations (King and Rebelo, 1993; Harvey and Jaeger, 1993). Kydland and Prescott (1990) point out that any definition of the trend and cycle is necessarily statistical and that decomposition is a representation of data. This representation is useful if it discovers an interesting form in the data. Moreover, the HP filter is a statistical tool that does not take into consideration the economic and structural information of the series. Laxton and Tetlow (1992) proposed an extended HP filter that includes economic information and belongs to a multivariant time series analysis. In economic theory there are alternative methods for detrending, e.g. the Cochrane method (1994) based on the permanent income theory and Blanchard and Quah structural decomposition (1989). The cyclical component can also be obtained in a univariate or multivariate representation by using the Beveridge-Nelson (1981) decomposition.

Unfortunately, there is no consensus on the best filter in macroeconomic analysis, but the choice of the filtering procedure should be “covered” by a theoretical model.

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The first page of the manuscript should contain the article title, first and last name of the author and his/her academic degree, name of the institution with which the author is associated, author's co-workers, and the complete mailing address of the corresponding author to whom a copy of the manuscript with requests for corrections shall be sent.

Additional information, such as acknowledgments, may be included in the first page. If this information is extensive, it is preferred to incorporate it within the text, whether at the end of the introductory section or in the special section preceding the list of references.

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Tables, figures and charts that are a constituent part of the paper must be well laid out, containing: number, title, units of measurement, legend, data source, and footnotes. The footnotes referring to tables, figures and charts should be indicated by lower-case letters (a,b,c…) placed right below. When the tables, figures and charts are subsequently submitted, it is necessary to mark the places in the text where they should be inserted. They should be numbered in the same sequence as in the text and should be referred to in accordance with that numeration. If the tables and charts were previously inserted in the text from other programs (Excel, Lotus…), these databases in the Excel format should also be submitted (charts must contain the corresponding data series).

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ISSN 1331–8586