Centrum výzkumu konkurenční schopnosti české ekonomiky
Research Centre for Competitiveness of Czech Economy

WORKING PAPER No. 10/2006

Czech Business Cycle Stylized Facts

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June 2006

Centrum výzkumu konkurenční schopnosti české ekonomiky
Research Centre for Competitiveness of Czech Economy

Working Papers of the Research Centre for Competitiveness of Czech Economy are issued with support of MŠMT project Rresearch centres 1M0524.

ISSN 1801-4496

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CZECH BUSINESS CYCLE – STYLIZED FACTS

Abstract:

This paper deals with identification of stylized facts of Czech business cycle. Empirical time series are decomposed into trend and cyclical component using bandpass filter. Cross-correlations between cyclical component of GDP and various time series are computed. The cyclical behaviour of the series is determined, leading and lagging indicators are identified. Finally, the Granger causality between GDP and other aggregate variables is tested. All these characteristics are presented in charts and commented. Several main conclusions about behaviour of variables over the cycle are summarized, which helps to judge implications of alternative economic theories. Distinctions between stylized facts in the Czech Republic and other developed countries are also discussed.

Abstrakt:

Tato studie se zabývá identifikací stylizovaných fakt českého hospodářského cyklu. Empirické časové řady jsou dekomponovány na trendovou a cyklickou složku pomocí bandpass filtru. Mezi cyklickými složkami HDP a různými časovými řadami jsou spočítány kroskorelace. Je určeno chování veličin během cyklu a jsou identifikovány veličiny, které cyklus předbíhají nebo se za ním zpožďují. Nakonec je testována Grangerova kauzalita mezi HDP a ostatními agregátními veličinami. Všechny tyto charakteristiky jsou prezentovány v tabulkách a komentovány. Jsou zhrnuty hlavní závěry o chování veličin během cyklu, což pomáhá posoudit implikace alternativních ekonomických teorií. Jsou rovněž diskutovány rozdíly mezi stylizovanými fakty v České republice a ostatních vyspělých zemí.

Recenzoval: doc. Ing. Osvald Vašíček, CSc.

1 INTRODUCTION*

Stylized facts are empirical regularities which may not be rigorously exact always and everywhere, but they capture some important features in the economies we observe.

This paper tries to identify some stylized facts of Czech business cycle. Comparison of model implications with stylized facts is useful for judgement of alternative economic theories and this paper contributes to it. Additionally, coincidence with stylized facts in other countries suggests that macroeconomic models or theories successfully applied to foreign economies can be used also for our economy. In the opposite case, when stylized facts differ, we can conclude that some institutional factors play important role and they are worth examining.

The analysis is inspired primarily by work of Stock and Watson (1999) and Kydland and Prescott (1990) who used data of United States. Similar, but not so detailed analysis can be found in many textbooks of Macroeconomics, e.g. Barro (1997) or Williamson (2005).

The paper is organized as follows. Section 2 introduces the reader into filtration of time series and discusses advantages and drawbacks of various filters. Section 3 briefly describes data used for analysis and their transformation and presents several statistics describing business cycle fluctuations. Section 4 deals with composition of GDP, while Section 5 focuses on behaviour of real and nominal variables over the cycle. The differences among theories and facts in other countries are outlined here. Final section discusses limitations of the analysis, summarizes main conclusions and suggests prospects for further research.

*I thank to Ivo Burger, Jan Čapek, Hana Fitzová, Michal Kvasnička, Karel Musil, Jiří Polanský, Petr Sklenář and Osvald Vašíček for useful comments and suggestions.

2 ISOLATING THE CYCLICAL COMPONENT – FILTRATION

The definition of business cycle fluctuations adopted in this paper is the deviation of actual time series from their long-run trends. These cyclical fluctuations are referred to as growth cycles.[1]

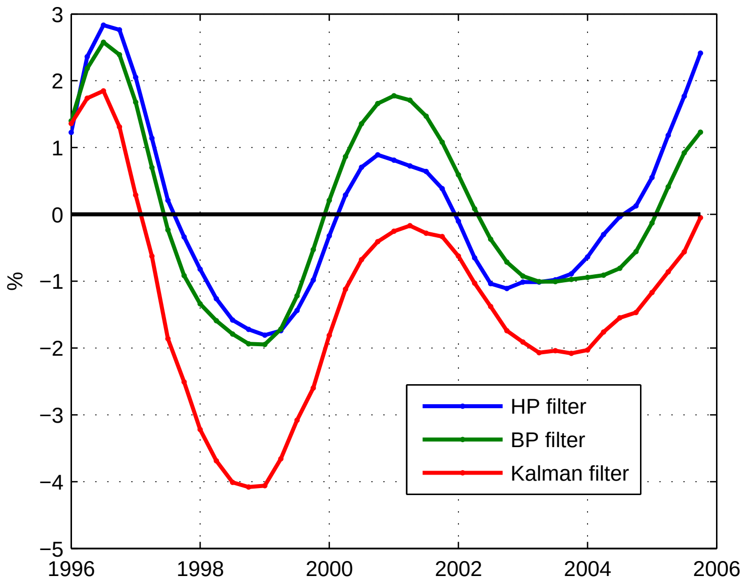
The linear filter is used to distinguish between the trend and cyclical components of economic time series. Here, I adopt the perspective of Baxter and King (1999) which draws on the theory of spectral analysis of time series data. The cyclical component can be thought of as those movements in the series associated with periodicities within a certain range of business cycle duration. I define this range of business cycle periodicities to be between six and thirty two quarters.[2] The ideal filter would preserve these fluctuations but would eliminate all other fluctuations, both the high frequency fluctuations (periods less than six quarters) associated for example with measurement error and the low frequency fluctuations (periods exceeding eight years) associated with trend growth. This ideal filter cannot be implemented to finite data sets because it requires an infinite number of past and future values of the series. However, a feasible (finite-order) filter can be used to approximate this ideal filter.

One widely used filter among macroeconomists is Hodrick-Prescott (1997) filter. However, this filter passes much of the high-frequency noise into the business cycle frequency band. The filter used in this study is bandpass filter designed by Christiano and Fitzgerald (1999) which mitigates this problem. Important problem of this filter (and univariate filters generally) is that data at the beginning and the end of time series are relatively poorly estimated.By contrast, multivariate filters, like Kalman filter, reduce end-of-sample uncertainty.[3] Kalman filter is an example of multivariate filters and is based on structural model. Essentially, it uses information from other time series such as inflation, real exchange rate, interest rate etc. For comparison, GDP gap estimated using three above mentioned filters is shown in Figure 1. The estimation by Hodrick-Prescott and bandpass filters differ only a little. Output gap estimated by the Kalman filter has similar pattern but is shifted downwards and it implies that the Czech economy has been under its potential since 1997. It sharply contradicts estimation made by univariate filters. The main advantage of Kalman filter is also its main disadvantage. It relies on structural (behavioural) equations and it makes it fragile against any error in the model structure. In addition, setting of parameters of the model, initial conditions of state variables and noise variances influence the resulting estimate. The reason why I do not use this filter is its complexity. I need

[1]For discussion between classical and growth business cycles see e.g. Stock and Watson (1998).
[2]This setting is in accordance with Stock and Watson (1998) for better comparison of the results.
[3]Kalman filter is successfully used in the Czech National Bank's Forecasting and Policy Analysis System. For more details see Beneš, Hlédik and Vlček (2005).

to estimate cyclical component of many variables and application of Kalman filter thus requires to build many structural models. The time series are filtered by bandpass filter in spite of the fact that end-of-sample estimates are not reliable.

Figure 1: Estimated output gap



Source: Data CSO, CNB, author's filtration

3 DATA AND SUMMARY STATISTICS

I use data from the Czech National Bank and the Czech Statistical Office databases.[4] The data series are seasonally adjusted using Kalman smoother. Frequency of data is quarterly; sample period is from 1995Q1 to 2005Q4.

Most of the series were transformed by taking logarithms. Because net exports and change in inventory stock can be negative (and taking logarithms is thus impossible) share to GDP was computed. Interest rate, unemployment rate and inflation rates are used without transformation. The cyclical components, usually referred to as gaps, are expressed as percentage deviations from trends.

Although the business cycle is defined by comovements across many sectors and series, fluctuations in aggregate output are at the core of the business cycle. The cyclical component of real GDP is a useful proxy for the overall business cycle and is a useful benchmark for comparisons across series. The comovement between each series and real GDP is therefore examined.

The cyclical component of each series is plotted along with the cyclical component of output in Figures 5 – 8 in Appendix. The cycle of output is always depicted by blue line, cyclical component of candidate variable is green. Note that the vertical scales of the plots differ. Relative amplitudes can be seen by comparing the series to aggregate output. The visual judgement provides some preliminary information of behaviour of the series.[5]

3.1 CROSS-CORRELATIONS

The degree of comovement is quantitatively measured by cross-correlation of the cyclical component of each series with the cyclical component of real GDP. The magnitude of correlation coefficient indicates whether the variable is procyclical, countercyclical, or acyclical. The correlation is also calculated with phase shift up to five periods (forward and backward) which indicates if the variable is leading or lagging the cycle of GDP.

Specifically, the correlation is computed between y_t and x_{t+k}, where y_t is the gap of GDP and x_{t+k} is the gap of relevant variable (both filtered by bandpass filter and expressed as deviations from trend values). A large positive correlation indicates procyclical behaviour of the series; a large negative correlation indicates countercyclical behaviour. A value of zero indicates absence of correlation: acyclical behaviour. For $k < 0$, the variable leads and for $k > 0$, the variable lags the cycle of output by k quarters. For example, if for some series the correlation is positive but maximum is at $k = -2$, it indicates that the variable is procyclical and tends to peak 2 quarters before the real GDP.

[4]Time series of German and Slovak GDP were obtained from Bundesbank and OECD Statistical database, respectively.

[5]Specifically, the variables are positively correlated, when output is high (low) and the variable X is high (low) as well. In the case of negative correlation, when output is high (low) the variable X tend to be low (high).

Further, the test of statistical significance of correlation coefficient is made.[6] The results are presented in Tables 2 – 3. For better orientation, the largest absolute value of correlation coefficient is underlined, correlation coefficient that is statistically different from 0 is emphasized in bold. In next section, I also distinguish if the variable is weakly ($|\rho| < 0.5$) or strongly ($0.5 < |\rho|$) correlated. This distinguishing is subjective and is not statistically tested.

Standard deviations of the cyclical component of each of the series are used as a measurement of variability. These values are also shown in Tables 2 and 3.

3.2 CAUSALITY

Finally, the Granger (1969) causality between the cyclical component of GDP and candidate variable is tested. The causality is examined in both directions. The test is based on adding of past values of explanatory variables into regression equation and testing if these variables improve explanatory power of the regression. Concretely, to test whether X causes Y, we proceed as follows. First, we test the null hypothesis "X does not cause Y" by running two regressions:

$$\textit{Unrestricted regression} \quad Y_t = \alpha_0 + \sum_{i=1}^{m} \alpha_i Y_{t-i} + \sum_{i=1}^{m} \beta_i X_{t-i} + \varepsilon_t \qquad (1)$$

$$\textit{Restricted regression} \quad Y_t = \alpha_0 + \sum_{i=1}^{m} \alpha_i Y_{t-i} + \varepsilon_t \qquad (2)$$

and use the sum of squared residuals from each regression to calculate F statistic[7] and test whether the group of coefficients β_1, $\beta_2, \ldots, \beta_m$ is significantly different from zero. If they are, we can reject the hypothesis that "X does not cause Y". Second, test the null hypothesis "Y does not cause X" by running the same regressions as above, but switching X and Y and testing whether lagged values of Y are significantly different from zero. To conclude that X causes Y, we must reject the hypothesis "X does not cause Y" and accept the hypothesis "Y does not cause X." The number of lagged

[6] The hypothesis of uncorrelation of the variables (which is equivalent to $\rho = 0$) is tested. The test statistic follows t-distribution; the test is two-tailed with 95 percent confidence intervals: $t_{stat} = \frac{\rho}{\sqrt{1-\rho^2}}\sqrt{n-2}$, where ρ is correlation coefficient and n is number of observations.

[7] The F statistic is computed using the formula:

$$F_{stat} = (n-k)\frac{\mathsf{ESS}_R - \mathsf{ESS}_{UR}}{m(\mathsf{ESS}_{UR})}$$

where ESS_R and ESS_{UR} are the sums of squared residuals in the restricted and unrestricted regressions, respectively; n is the number of observations; k is the number of estimated parameters in the unrestricted regression; and m is the number of parameter restrictions. This statistic is distributed as $F(m, n-k)$. The significance level is 5 %. For more details about the test see e.g. Pindyck and Rubinfeld (1998).

variables (m) is set from one to five which corresponds to the phase shift calculated for correlations. It tells us if the result is sensitive to the choice of m. However, extra care must be taken when interpreting Granger causality test results. As Stock and Watson (1998) say: "Granger causality is not the same thing as causality as it is commonly used in economic discourse. For example, a candidate variable might predict output growth not because it is a fundamental determinant of output growth, but simply because it reflects information on some third variable which is itself a determinant of output growth. Even if Granger causality is interpreted only as a measure of predictive content, it must be borne in mind that any such predictive content can be altered by inclusion of a additional variables."

In this study, I test only bivariate relationships. If the word "cause" occurs in text, bear in mind that better interpretation of this statement is "X helps to predict Y" and do not forget that some variable Z can be the "true" determinant of behaviour of Y.

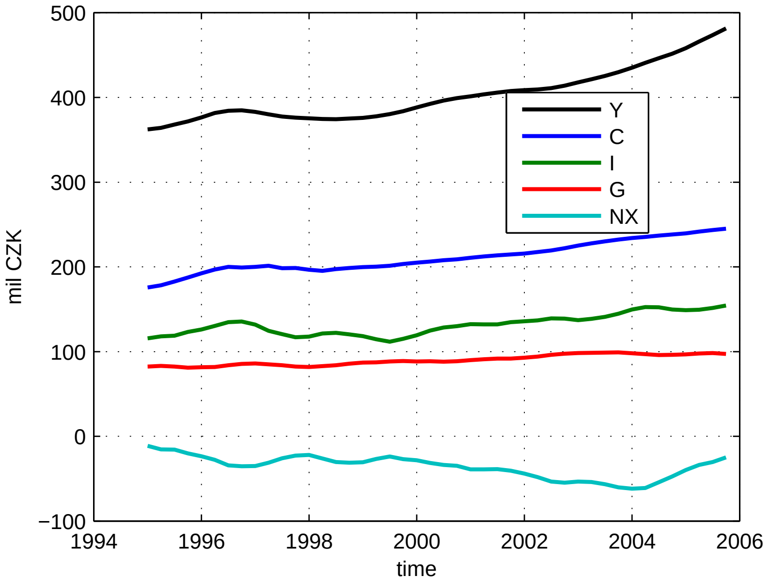
The results of Granger causality test are presented in Tables 4 – 7. Tested hypothesis H_0 is quoted in the first column, the F statistic and p value respectively are presented for every lag in next columns. p value indicates at what level of significance the hypothesis H_0 can be rejected. If its value is lower than 5% (which corresponds to rejection of the hypotheses H_0 at 5 % significance level) it is emphasised in bold.[8]

[8] The rule of thumb is when bolded p value for one direction is followed by non-bolded value for opposite direction, the Granger causality is proved in the first direction. If both values are bolded or nonbolded the result is ambiguous and we can not talk about causal relationship between the variables.

4 GDP AND ITS COMPONENTS

Before examination of cyclical behaviour of various time series, it is useful to look at the composition of real GDP. In Figure 2 is depicted real GDP and its components in accordance with national accounting identity $Y = C+I+G+NX$.[9] The data are in millions of CZK (constant prices of 1995). However, percentage shares of individual components to GDP provide more

Figure 2: GDP & its components, 1995Q1–2005Q4



Source: Data CSO, author's calculation

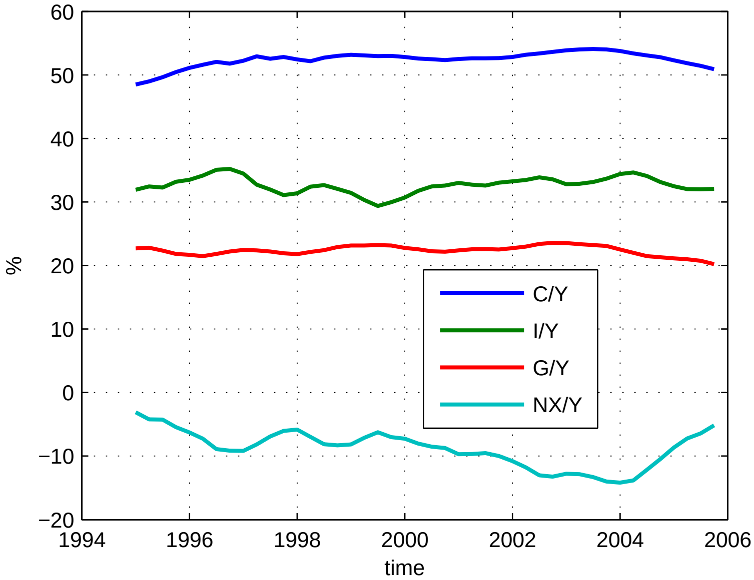
interesting view. They are depicted in Figure 3. Average shares over the whole period are quoted in Table 1.[10]

Consumption comprises the largest part of GDP, its share is 52 %. This is common fact also in other countries. The share of investment is 33 %. Compared to e.g. United States where investment form only about 20 % it is quite large number. Government expenditures are 22 % of total GDP. Decrease of

[9]Output Y is the sum of consumption C, investment I, government expenditures G, and net exports NX. Here, the investment includes change in inventories and net acquisition of valuables; government expenditures include expenditures of nonprofit institutions.

[10]The Czech Statistical Office uses the method of chain-linking of quarterly data with the annual overlap to compute real values of GDP and its components. This convention is adopted by all EU Member States. While this method brings more accurate description of economic developments, it involves the loss of additivity: chain-linked components of GDP will usually not sum to chain-linked GDP. That is the reason why the sum of percentage shares of the components is not 100 %.

Figure 3: Components of GDP, 1995Q1–2005Q4 (share in %)



Source: Data CSO, author's calculation

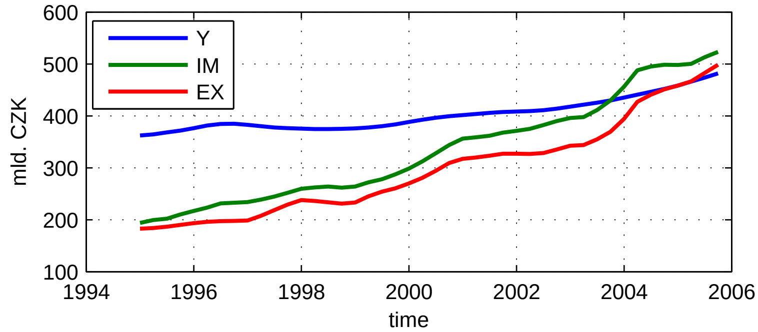
Table 1: Components (average shares in %)

C	I	G	NX
52	33	22	-9

Source: Data CSO, author's calculation

this ratio that is seen in last two years is caused mostly by rapid growth rate of GDP than by decrease of government expenditures. Average share of net exports (export minus imports) is -9 %. There is apparent increase of net exports in last two years that reflects improving current account deficit. An interesting fact is increasing openness of the Czech economy during the time. It is illustrated in Figure 4. At the beginning of observed period (in 1995), the share of imports and exports to GDP was 55 % and 51 % respectively. In recent years, imports and exports exceeded total GDP (with shares 109 % and 103 % respectively). Average shares during the whole period are 82 % for imports and 73 % for exports. These numbers indicate that the Czech republic is very open country and international trade plays important role in determining the growth of GDP. However, it also means that our country can be more vulnerable to external shocks and business cycle fluctuations can stem from world markets.

Figure 4: GDP, exports and imports



Source: Data CSO, author's calculation

5 BUSINESS CYCLE STYLIZED FACTS

This section presents stylized facts about Czech business cycle. Cross correlations of real variables with real GDP are quoted in Table 2, nominal variables are presented in Table 3. Results of test of Granger causality can be checked in Tables 4 and 5 in Appendix. Conclusions about behaviour of variables over the cycle are summarized and distinctions between stylized facts in the Czech republic and other developed economies are mentioned.[11] The relationship between economic theory and facts is discussed.

5.1 REAL FACTS

First, we look at the behaviour of GDP gap. Value of first order autocorrelation coefficient is 0.92 which is quite high compared e.g. to the United States where this value is about 0.85. It indicates certain persistence and rigid behaviour of this variable. For example, when shock hits the economy, it takes more time for GDP to return to its potential level.

Consumption and investment are both strongly procyclical and lag output by one quarter. Correlation of consumption with output is lower than it is usual in developed countries. Consumption is often more stable (measured by standard deviation) which is theoretically explained by smoothing behaviour of economic agents. In the case of the Czech republic, consumption is more volatile than output which again contradicts observations in other countries. Causality between consumption and output was not proved. Investment is much more volatile than output. Granger causality test shows weak predictive power from investment to output (only for one lag). Change of inventory stock (measured as share to GDP) is rather procyclical and lags output by one quarter. Its volatility is the smallest of all GDP components. GDP helps to predict change in inventory stock when five lags are considered (for lower significance level it was proved even for four lags).

Government expenditures are acyclical variable (the correlation coefficient is not statistically significant), which corresponds with behaviour in other states. Apart from this statistical assessment, slight negative correlation occurs two or three quarters before the cycle of output. It means that when government increases its expenditures, GDP tends to fall half a year later. Taking opposite action, decrease of government expenditures is followed by expansion of output. Even if the correlation is weak, Granger causality test shows that government expenditures help to predict output for lags of two and four quarters (for other lags, the result is unclear). The question whether the government creates political business cycle cannot be resolved based on these results. This issue will be subject for further research.

Exports are weakly positively correlated and leads the cycle of GDP by two quarters. Imports are strongly procyclical and coincide with the cycle. The behaviour of imports is in accordance with economic theory – the volume of

[11] United States are usually used as a reference economy.

Table 2: Cyclical behaviour of real variables

Variable x	Volatility (% Std.)	Cross Correlation of Real GDP with variable $x(t+k)$ $t-5$	$t-4$	$t-3$	$t-2$	$t-1$	t	$t+1$	$t+2$	$t+3$	$t+4$	$t+5$
Gross domestic product	1.26	-0.13	0.15	**0.45**	**0.72**	**0.92**	**1.00**	**0.92**	**0.72**	**0.45**	0.15	-0.13
Consumption	1.60	**-0.45**	-0.23	0.03	0.28	**0.48**	**0.59**	**0.59**	**0.51**	**0.38**	0.22	0.08
Investment	2.43	**-0.45**	-0.23	0.04	**0.31**	**0.51**	**0.63**	**0.64**	**0.58**	**0.49**	**0.40**	**0.32**
Stock change (share to GDP)	0.75	-0.17	-0.06	0.07	0.24	**0.42**	**0.57**	**0.63**	**0.55**	**0.36**	0.11	-0.10
Government expenditures	1.57	-0.09	-0.16	-0.20	-0.20	-0.14	-0.06	0.03	0.08	0.07	0.04	0.02
Exports	3.69	0.18	0.30	**0.37**	**0.40**	**0.39**	**0.34**	0.27	0.20	0.11	0.01	-0.12
Imports	2.88	-0.13	0.06	0.24	**0.39**	**0.50**	**0.56**	**0.56**	**0.49**	**0.36**	0.20	0.02
Net Exports (share to GDP)	1.77	**0.37**	**0.36**	**0.32**	0.24	0.13	0.03	-0.08	-0.15	-0.18	-0.19	-0.22
Real wage	1.60	-0.15	-0.00	0.15	0.28	**0.36**	**0.37**	**0.33**	0.23	0.10	-0.05	-0.17
Real interest rate (3M)	1.41	**-0.59**	**-0.60**	**-0.55**	**-0.47**	**-0.34**	-0.17	0.02	0.21	**0.37**	**0.45**	**0.44**
Real money balances (M1/CPI)	5.19	0.03	0.18	0.29	**0.37**	**0.40**	**0.38**	**0.33**	0.25	0.15	0.06	-0.01
Employment	1.17	-0.30	-0.05	0.23	**0.48**	**0.65**	**0.70**	**0.62**	**0.49**	**0.36**	0.26	0.20
Labor productivity (Y/L)	0.95	0.19	0.26	**0.31**	**0.37**	**0.43**	**0.47**	**0.45**	**0.35**	0.15	-0.12	-0.42
Unemployment	0.62	**0.62**	**0.41**	0.14	-0.17	**-0.45**	**-0.68**	**-0.81**	**-0.86**	**-0.83**	**-0.74**	**-0.58**
German GDP	0.62	0.17	**0.32**	**0.45**	**0.55**	**0.61**	**0.63**	**0.59**	**0.49**	**0.35**	0.16	-0.05
Slovak GDP	0.64	**-0.32**	**-0.32**	-0.27	-0.20	-0.11	-0.01	0.07	0.14	0.18	0.19	0.16

imports depends positively on domestic income.[12] Exports should depend on foreign income and moderate positive correlation with domestic output may come from synchronization of business cycles across countries in the region. From the causality test in Table 4 is seen that output helps to predict imports; it was proved for lags from two to four quarters. It again supports above mentioned theory. Both exports and imports are much more volatile than output. Net exports (share to GDP) is weakly procyclical and leading variable and helps to predict output for one and two lags.

Real wage is weakly procyclical and coincident variable. This is consistent with behaviour of the real wage in other countries. From the point of view of economic theory, this stylized fact is in favour of real business cycle theory and monetary approach with sticky prices (rather than wages) assumption. However, from the Figure 6 is apparent that behaviour of the real wage relative to output is changing over time. Till late 1990s it is a procyclical variable, but from the year 2000 it behaves in countercyclical manner.[13] It may reflect some structural changes on labor and/or goods markets. Only time will tell if the change of behavioural pattern is permanent or accidental.

Behaviour of real interest rate is rather tricky. The largest negative value of correlation coefficient is for shift of four quarters ahead, which indicates countercyclical and leading real interest rate. However, real interest rate is not contemporaneously correlated with the cycle of output and additionally there is rather important positive correlation four or five quarters behind the cycle of output. The real interest rate is usually assumed as leading indicator and that agrees. Monetary policy actions influence real interest rate (through controlling nominal interest rate) and subsequently influence real economic activity. However, the test of Granger causality fails the hypothesis that the real interest rate causes output.

Real money balances are moderately procyclical and lead the cycle by one quarter.[14] The Granger causality test does not confirm monetarist view that money causes cycle. Real money balances are the most volatile variable.

Employment is strongly procyclical and coincident variable. Its volatility is only slightly smaller than volatility of output. Labor productivity is weakly procyclical and also coincides with cycle of output. Both these stylized facts are consistent with real business cycle theory and are common in other countries. Unemployment is strongly countercyclical and lags output by two quarters. This high negative correlation with output supports well known Okun's law. Standard deviation of unemployment rate is about half of standard deviation of output. It is the least volatile variable. None of these three

[12] Beside dependence on real exchange rate.

[13] The correlation coefficients computed for the first and second half of the sample period are 0.80 and -0.87, respectively (without leading or lagging the cycle of output).

[14] I chose monetary aggregate M1 as the most suitable representation of money; for real expression it is deflated by CPI. Analysis of other monetary aggregates is carried out in next subsection.

variables has predictive content for output.

Due to high openness of Czech economy, it is worth to examine relationship between Czech and foreign economies. The main trade partner of the Czech republic is Germany; the Slovak republic is considered as the both republics constituted former Czechoslovakia. The cycle of our GDP is strongly and contemporaneously correlated with German output. The Granger causality was proved only for lag of three quarters in direction from Czech to German economy. High correlation is in accordance with our assumptions, but we would expect causality in opposite direction (from German to Czech output) as the German economy is engine for our country. Correlation with Slovak output is weak and mostly unsignificant. Relatively important negative numbers of correlation occurs about one year before the cycle in the Czech republic. Granger causality was not proved for neither lag and direction.

5.2 NOMINAL FACTS

In theory, money plays an important role in the determination of the price level and, because of various nominal frictions in the economy, can result in movements in real quantities. In practice, quantifying this link is difficult because this requires defining and measuring "money". Here, I consider four measures of money: money base, monetary aggregates M1 and M2 and so called quasi money (difference between M2 and M1).[15] The aggregates are inspected in levels and growth rates.

Money base is not contemporaneously correlated with the cycle and is very volatile. The highest negative cross-correlation is five quarters before cycle of output, positive correlation occurs several lags behind the cycle. Strong negative correlation could refute theories that explain cycles as a consequence of monetary expansion. But as was mentioned above, changes in financial sector have made the task of measuring money difficult. Therefore, let's look at other aggregates before making final conclusions.

Monetary aggregate M1 is weakly procyclical and coincides with output. Monetary aggregate M2 behaves in similar fashion but is more correlated and less volatile. Quasi money is weakly procyclical and lags two or three quarters. The test of Granger causality (Table 6) for the levels of money did not prove causal relationship in any direction. The situation becomes more interesting when we consider the growth rates. Growth rate of money base is strongly procyclical and slightly leads the cycle. The growth rates of monetary aggregates are only weakly correlated, but also lead the cycle of output (by four or five quarters). From the tests of Granger causality it is apparent that the growth rate of money base helps to predict output. This result is relatively robust to the setting of number of lags.[16] Growth rates

[15]Money base is the sum of currency in circulation and reserves, M1 is the sum of currency in circulation and overnight deposits; M2 is the sum of M1, deposits with an agreed maturity of up to two years, and deposits redeemable at notice of up to three months.

[16]The hypothesis of causality was accepted for lags of one, two and four quarters.

Table 3: Cyclical behaviour of nominal variables

Variable x	Volatility (% Std.)	Cross Correlation of Real GDP with variable $x(t+k)$ $t-5$	$t-4$	$t-3$	$t-2$	$t-1$	t	$t+1$	$t+2$	$t+3$	$t+4$	$t+5$
Money base	5.86	**-0.78**	**-0.70**	**-0.52**	-0.28	-0.02	0.21	**0.36**	**0.44**	**0.46**	**0.44**	**0.41**
Monetary aggregate M1	4.59	-0.11	0.03	0.15	0.25	**0.31**	**0.33**	**0.32**	0.28	0.23	0.18	0.15
Monetary aggregate M2	2.05	-0.29	-0.09	0.12	0.29	**0.40**	**0.45**	**0.45**	**0.43**	**0.40**	**0.37**	0.31
Quasi money	3.21	-0.27	-0.12	0.04	0.19	0.29	**0.35**	**0.36**	**0.37**	**0.37**	**0.34**	0.25
Growth rate of MB	1.60	0.11	**0.34**	**0.55**	**0.69**	**0.72**	**0.63**	**0.44**	0.22	0.03	-0.07	-0.11
Growth rate of M1	1.74	**0.36**	**0.37**	**0.34**	0.27	0.17	0.06	-0.05	-0.11	-0.11	-0.07	-0.01
Growth rate of M2	0.92	**0.46**	**0.42**	**0.32**	0.18	0.04	-0.07	-0.11	-0.11	-0.11	-0.12	-0.17
Consumer price index	1.28	**-0.54**	**-0.64**	**-0.65**	**-0.60**	**-0.50**	**-0.36**	-0.20	-0.01	0.20	**0.42**	**0.59**
Deflator GDP	1.75	**-0.32**	**-0.50**	**-0.63**	**-0.70**	**-0.72**	**-0.69**	**-0.58**	**-0.41**	-0.19	0.06	0.31
Inflation rate y/y (CPI)	1.83	**-0.39**	**-0.39**	**-0.32**	-0.22	-0.09	0.04	0.15	0.25	**0.34**	**0.42**	**0.44**
Inflation rate q/q (CPI)	2.36	**-0.32**	-0.24	-0.13	-0.01	0.10	0.19	0.26	**0.33**	**0.39**	**0.40**	**0.33**
Inflation rate (GDP deflator)	0.64	**-0.51**	**-0.49**	**-0.42**	**-0.31**	-0.18	-0.03	0.14	**0.32**	**0.49**	**0.60**	**0.61**
Nominal wage	1.41	**-0.66**	**-0.57**	**-0.42**	-0.23	-0.05	0.10	0.20	0.26	0.29	**0.32**	**0.34**
Wage inflation	0.37	0.27	**0.40**	**0.48**	**0.48**	**0.40**	0.27	0.14	0.04	-0.01	-0.02	0.00
Nominal interest rate (3M)	1.90	**-0.79**	**-0.83**	**-0.78**	**-0.64**	**-0.43**	-0.17	0.10	**0.35**	**0.56**	**0.69**	**0.72**
Nominal interest rate (1Y)	1.74	**-0.72**	**-0.77**	**-0.72**	**-0.60**	**-0.42**	-0.20	0.03	0.26	**0.47**	**0.62**	**0.69**

of monetary aggregates M1 and M2 have predictive content for output only for lag of four and three quarters, respectively. These results indicates that monetary non-neutrality can play important role in business cycle theories.

Price level expressed by consumer price index is strongly countercyclical and leads the cycle by three quarters. However, the correlation is changing with the phase shift; there is quite large positive correlation five quarters behind output. It can indicate that prices are rigid and adjust only slowly to clear the market. However, this observation is ruled out when we look at behaviour of GDP deflator. This measure of prices is strongly countercyclical and leads output by one quarter. These facts are similar also in other countries and contradict traditional Keynesian view of procyclical price level. Both consumer price index and GDP deflator help to predict fluctuations in output, but only for one lag.

Inflation rate expressed by consumer price index (in year-on-year or quarter-on-quarter expression) is not contemporaneously correlated with the cycle. Considering phase shift, there is moderate positive correlation for lags of four or five quarters. It can be again explained by price stickiness, but the lag of one year is disputable. Rather important negative correlation five or four quarter before the cycle is hard to explain. Similar behaviour exhibits inflation rate expressed by deflator of GDP, only the correlation is stronger. Inflation rate expressed by deflator has predictive content for output only for lag of one quarter; for CPI y/y inflation is this relationship not stable (there is a relation even in opposite direction for lags of two and three quarters). There was not proved any connection for CPI q/q inflation.

Nominal wage is countercyclical and leading indicator, slightly positive correlation occurs several quarters behind the cycle of GDP which can indicate certain wage stickiness. On the other hand wage inflation behaves weakly procyclically with lead of two or three quarters. The results of Granger causality for these nominal variables are ambigous and are not robust to the setting of number of lags. Nominal wage and wage inflation help to predict output only for lag of one quarter.

Nominal interest rate behaves similarly to the real interest rate, only the correlation is more striking. Low interest rates are followed by expansion of output with lag of approximately one year and five quarters behind the peak of output interest rates are high. There is not substantial difference between behaviour of interest rate for three months deposits and one year deposits. Nominal interest rate Granger causes output when four quarters are considered.

In many theories, economic agents are interested in real variables; nominal factors (such as nominal interest rate or nominal wage) play only supplementary role. The same is valid for aggregate level and thus the analysis of these nominal variables provides only little guideline for judgement among theories.

6 CONCLUSION

The analysis I made in this paper is empirical and is connected with some statistical difficulties. The results are influenced a lot by filtration method. Another setting of bandpass filter or using of other filters can produce different results. Another problem is that the time span of Czech data is rather short and at most two cycles can be identified. These issues contribute to difficult interpretation of the results. Further research will be aimed at examination of robustness of the results to filtration method.

Main conclusions of the research can be summarized in following points. The Czech economy is very open and thus vulnerable to potential external shocks. On the other hand, international trade can be source for the growth rate of our economy. Actually, international trade already plays important role. The value of exports and imports has exceeded the value of goods and services produced in our country in recent years. The trade depends on many factors such as foreign output, terms of trade or real exchange rate. The relationship between these variables and international trade will be also subject for further research.

From the point of economic theory, one must unfortunately say that there does not exist any single theory that explains everything. Many stylized facts are in favor of real business cycle theory that emphasise real factors as the source of business cycle fluctuations. However, monetary variables and nominal rigidities may also substantially contribute to cyclical fluctuations. Tests of Granger causality indicate that some nominal variables have influence on real output. These issues deserve more detailed examination.

Mixed results relate to political business cycle and the problem if government expenditures have impact on fluctuations of output. This relationship may be revealed when we divide the whole period into subsamples according to periods of elections and examine it separately. It is also topic for further research.

7 APPENDIX

The figures show cyclical component of GDP (blue line) and cyclical component of candidate variable (green line). Boths variables are expressed as percentage deviations from trends.

The tables presents Granger causality test. The F statistic quoted for every lag is distributed as $F(m, n-k)$ where m is the number of parameter restrictions, n is number of observations, k is the number of estimated parameters in the unrestricted regression.

The data are from CSO and CNB databases, filtration and calculations are made by author.

Figure 5: GDP components

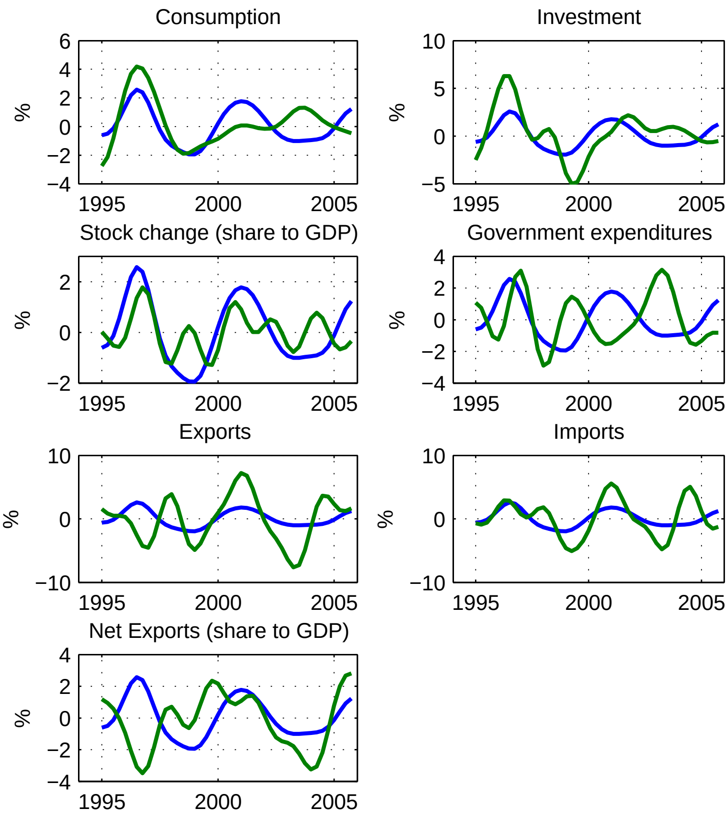


Figure 6: Real variables, foreign GDP

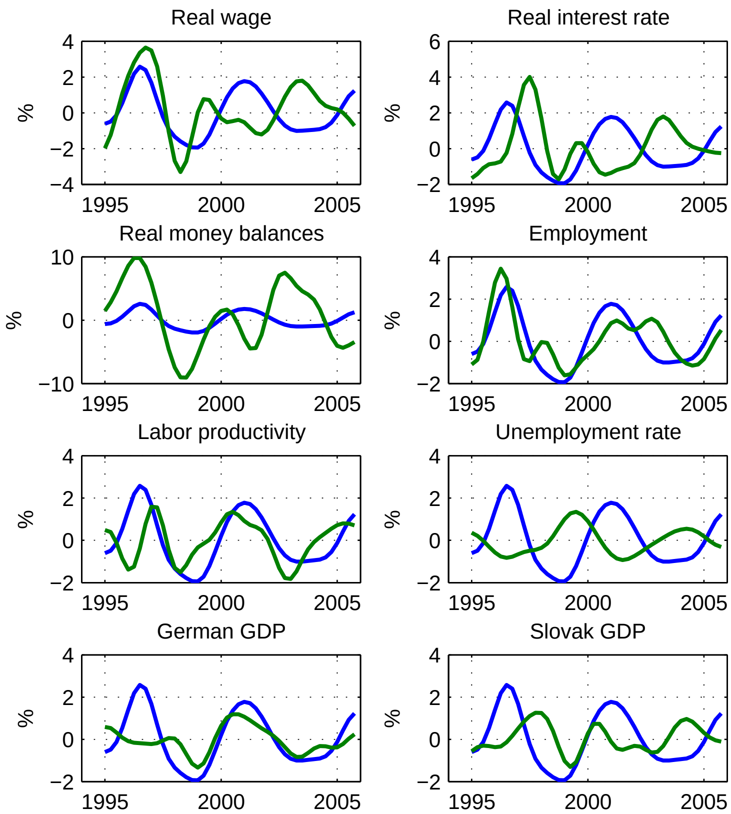


Figure 7: Nominal variables

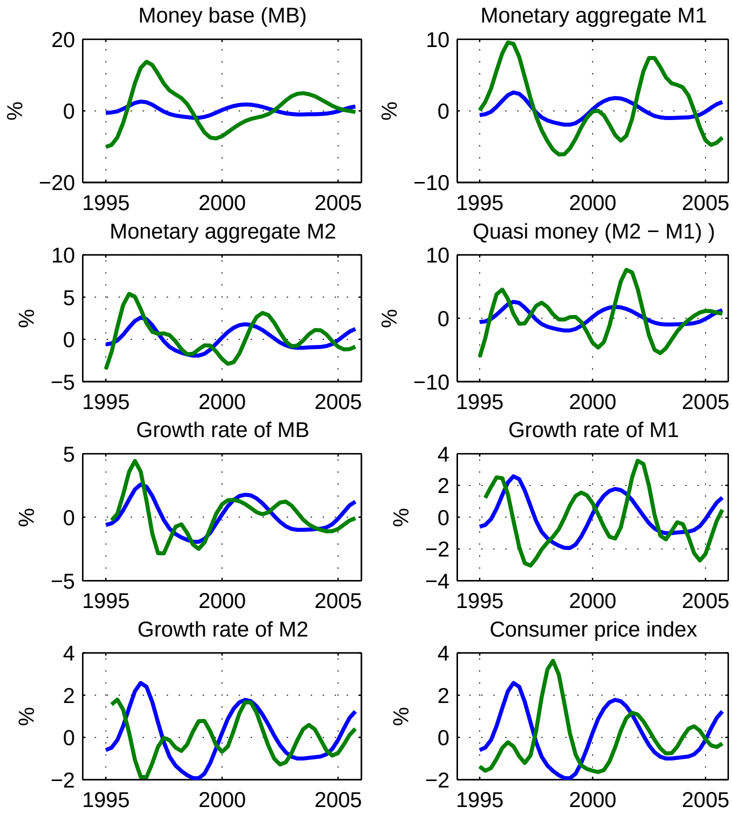


Figure 8: Nominal variables

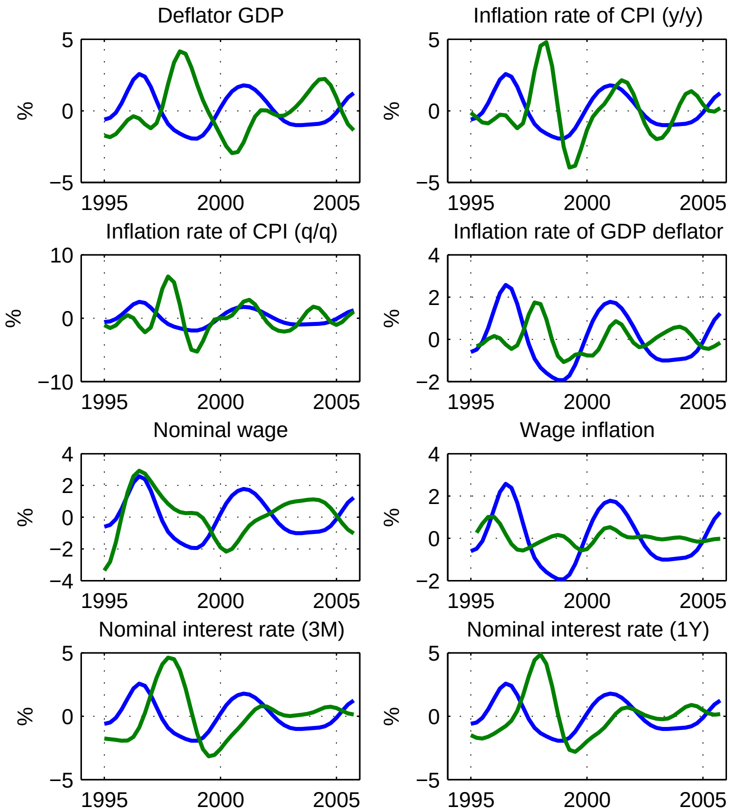


Table 4: Granger causality test – components of GDP

	1 lag		2 lags		3 lags		4 lags		5 lags	
Hypothesis H_0	F(1,40)	p value	F(2,37)	p value	F(3,34)	p value	F(4,31)	p value	F(5,28)	p value
Consumption $\nrightarrow$ GDP	3.7996	0.0583	4.5404	**0.0172**	1.1133	0.3573	55.5930	**0.0000**	45.1355	**0.0000**
HDP $\nrightarrow$ Consumption	1.8911	0.1767	4.7659	**0.0144**	0.7787	0.5141	15.1050	**0.0000**	9.2594	**0.0000**
Investment $\nrightarrow$ GDP	4.1330	**0.0487**	8.8228	**0.0000**	4.7412	**0.0072**	10.5586	**0.0000**	12.5924	**0.0000**
GDP $\nrightarrow$ Investment	2.1971	0.1461	4.3754	**0.0197**	3.9837	**0.0156**	3.2074	**0.0258**	25.0290	**0.0000**
Stock change $\nrightarrow$ GDP	8.7741	**0.0051**	18.6615	**0.0000**	13.5353	**0.0000**	2.7511	**0.0456**	1.1606	0.3529
GDP $\nrightarrow$ Stock change	5.4201	**0.0250**	39.9194	**0.0000**	19.6700	**0.0000**	23.0255	**0.0000**	19.6273	**0.0000**
Government exp. $\nrightarrow$ GDP	2.9656	0.0928	5.6618	**0.0072**	10.7230	**0.0000**	3.0101	**0.0330**	14.8063	**0.0000**
GDP $\nrightarrow$ Government exp.	0.7641	0.3873	0.3361	0.7167	14.6652	**0.0000**	1.6224	0.1935	46.3505	**0.0000**
Exports $\nrightarrow$ GDP	2.1299	0.1523	2.9984	0.0621	6.4160	**0.0015**	5.5152	**0.0018**	18.6112	**0.0000**
GDP $\nrightarrow$ Exports	0.0810	0.7774	1.6829	0.1997	8.0791	**0.0003**	5.0524	**0.0030**	42.2627	**0.0000**
Imports $\nrightarrow$ GDP	0.4727	0.4957	0.1465	0.8642	0.3914	0.7599	1.5685	0.2073	8.7841	**0.0000**
GDP $\nrightarrow$ Imports	0.9053	0.3471	7.6211	**0.0017**	3.8272	**0.0183**	14.1293	**0.0000**	36.5758	**0.0000**
Net Exports $\nrightarrow$ GDP	8.3259	**0.0063**	5.0868	**0.0112**	16.5392	**0.0000**	5.0052	**0.0031**	7.5559	**0.0001**
GDP $\nrightarrow$ Net exports	1.4889	0.2295	0.2341	0.7925	14.6609	**0.0000**	16.0963	**0.0000**	12.9358	**0.0000**

Table 5: Granger causality test – real variables

Hypothesis H_0	1 lag		2 lags		3 lags		4 lags		5 lags	
	$F(1,40)$	p value	$F(2,37)$	p value	$F(3,34)$	p value	$F(4,31)$	p value	$F(5,28)$	p value
Real wage $\nrightarrow$ GDP	0.0184	0.8929	0.3196	0.7285	1.7640	0.1726	115.1709	**0.0000**	65.1101	**0.0000**
GDP $\nrightarrow$ Real wage	0.0187	0.8920	0.3919	0.6785	5.0113	**0.0055**	14.2933	**0.0000**	5.1524	**0.0018**
Real interes rate $\nrightarrow$ GDP	14.7032	**0.0004**	1.5363	0.2286	4.7887	**0.0069**	17.5851	**0.0000**	6.5959	**0.0004**
GDP $\nrightarrow$ Real interes rate	6.6584	**0.0136**	2.4319	0.1018	4.7563	**0.0071**	12.5432	**0.0000**	8.9836	**0.0000**
Real money balances $\nrightarrow$ GDP	0.2400	0.6269	0.1891	0.8285	0.6162	0.6092	2.2142	0.0904	2.2445	0.0776
GDP $\nrightarrow$ Real money balances	0.6286	0.4325	0.4359	0.6499	1.3039	0.2891	1.9604	0.1253	1.4068	0.2523
Employment $\nrightarrow$ GDP	0.0000	0.9992	34.6869	**0.0000**	24.7552	**0.0000**	10.7967	**0.0000**	16.0169	**0.0000**
GDP $\nrightarrow$ Employment	0.2151	0.6453	9.1657	**0.0006**	5.3650	**0.0039**	6.4080	**0.0007**	11.1714	**0.0000**
Labour productivity $\nrightarrow$ GDP	0.0000	0.9992	34.6869	**0.0000**	24.7552	**0.0000**	10.7967	**0.0000**	16.0169	**0.0000**
GDP $\nrightarrow$ Labour productivity	0.7514	0.3912	14.2232	**0.0000**	9.0126	**0.0002**	22.5608	**0.0000**	20.5958	**0.0000**
Unemployment $\nrightarrow$ GDP	33.7104	**0.0000**	11.4809	**0.0001**	8.4516	**0.0002**	3.0254	**0.0324**	12.1859	**0.0000**
GDP $\nrightarrow$ Unemployment	48.8339	**0.0000**	8.4388	**0.0010**	17.2257	**0.0000**	40.2478	**0.0000**	25.9113	**0.0000**
German GDP $\nrightarrow$ GDP	0.5334	0.4694	3.4598	**0.0419**	0.8207	0.4915	10.9516	**0.0000**	19.0774	**0.0000**
GDP $\nrightarrow$ German GDP	0.2935	0.5910	4.5321	**0.0174**	4.3390	**0.0108**	6.2986	**0.0008**	13.9555	**0.0000**
Slovak GDP $\nrightarrow$ GDP	3.5230	0.0678	0.3179	0.7297	0.7605	0.5241	10.1752	**0.0000**	6.2485	**0.0005**
Slovak GDP $\nrightarrow$ GDP	1.0941	0.3018	0.6303	0.5380	0.4610	0.7113	7.0913	**0.0004**	61.7738	**0.0000**

Table 6: Granger causality test – nominal variables

	1 lag		2 lags		3 lags		4 lags		5 lags	
Hypothesis H_0	F(1,40)	p value	F(2,37)	p value	F(3,34)	p value	F(4,31)	p value	F(5,28)	p value
Money base (MB) $\nrightarrow$ GDP	24.5629	**0.0000**	8.1831	**0.0011**	5.5262	**0.0034**	9.5379	**0.0000**	23.0601	**0.0000**
GDP $\nrightarrow$ Money base M0	15.9710	**0.0003**	3.7767	**0.0322**	4.6692	**0.0078**	2.9393	**0.0360**	5.1761	**0.0017**
Monetary aggregate M1 $\nrightarrow$ GDP	0.1128	0.7388	1.1919	0.3150	0.2669	0.8488	3.5319	**0.0174**	6.1335	**0.0006**
GDP $\nrightarrow$ Monetary aggregate M1	0.0279	0.8681	1.2191	0.3071	0.4028	0.7519	2.8346	**0.0411**	2.4785	**0.0559**
Monetary aggregate M2 $\nrightarrow$ GDP	0.5220	0.4742	9.9357	**0.0004**	4.9944	**0.0056**	28.6140	**0.0000**	25.8060	**0.0000**
GDP $\nrightarrow$ Monetary aggregate M2	0.8949	0.3498	11.5300	**0.0001**	9.6411	**0.0001**	10.7129	**0.0000**	12.3380	**0.0000**
Quasi money (M2 - M1) $\nrightarrow$ GDP	0.4883	0.4887	6.1540	**0.0049**	5.9232	**0.0023**	2.9727	**0.0346**	4.3027	**0.0050**
GDP $\nrightarrow$ Quasi money (M2 - M1)	1.3221	0.2570	12.7947	**0.0001**	9.3192	**0.0001**	8.3828	**0.0001**	13.2155	**0.0000**
Growth rate of MB $\nrightarrow$ GDP	9.8077	**0.0033**	18.9068	**0.0000**	25.6243	**0.0000**	23.0953	**0.0000**	67.0982	**0.0000**
GDP $\nrightarrow$ Growth rate of MB	2.9655	0.0930	2.9954	0.0626	3.7135	**0.0209**	1.9404	0.1294	5.2320	**0.0017**
Growth rate of M1 $\nrightarrow$ GDP	4.0298	0.0517	2.5203	0.0945	2.6894	0.0623	12.0893	**0.0000**	5.2973	**0.0016**
GDP $\nrightarrow$ Growth rate of M1	1.4003	0.2438	0.3097	0.7356	0.3229	0.8088	1.6617	0.1849	3.2831	**0.0192**
Growth rate of M2 $\nrightarrow$ GDP	3.0006	0.0911	6.0051	**0.0056**	4.1027	**0.0140**	54.8742	**0.0000**	33.9225	**0.0000**
GDP $\nrightarrow$ Growth rate of M2	0.3448	0.5604	5.6055	**0.0076**	2.4411	0.0817	9.4510	**0.0000**	6.6801	**0.0004**

Table 7: Granger causality test – nominal variables (continued)

	1 lag		2 lags		3 lags		4 lags		5 lags	
Hypothesis H_0	F(1,40)	p value	F(2,37)	p value	F(3,34)	p value	F(4,31)	p value	F(5,28)	p value
Consumer price index $\nrightarrow$ GDP	12.9217	**0.0009**	5.9770	**0.0056**	6.5424	**0.0013**	22.7268	**0.0000**	22.9172	**0.0000**
GDP $\nrightarrow$ Consumer price index	3.2472	0.0791	28.1291	**0.0000**	15.5092	**0.0000**	7.7178	**0.0002**	12.2587	**0.0000**
Deflator GDP $\nrightarrow$ GDP	5.9199	**0.0195**	9.2055	**0.0006**	6.1439	**0.0019**	17.1578	**0.0000**	11.2459	**0.0000**
GDP $\nrightarrow$ Deflator GDP	0.5358	0.4684	17.6881	**0.0000**	16.1990	**0.0000**	3.9009	**0.0112**	8.6784	**0.0000**
Inflation rate (CPI, y/y) $\nrightarrow$ GDP	5.5007	**0.0241**	0.6852	0.5103	2.1741	0.1091	60.3536	**0.0000**	37.0638	**0.0000**
GDP $\nrightarrow$ Inflation rate (CPI, y/y)	2.3236	0.1353	7.1664	**0.0023**	4.0707	**0.0142**	7.0366	**0.0004**	6.6311	**0.0003**
Inflation rate (CPI, q/q) $\nrightarrow$ GDP	1.7709	0.1908	4.8772	**0.0132**	10.6461	**0.0000**	32.2587	**0.0000**	22.4719	**0.0000**
GDP $\nrightarrow$ Inflation rate (CPI, q/q)	1.7280	0.1962	9.2902	**0.0005**	11.1684	**0.0000**	6.7074	**0.0005**	6.2090	**0.0005**
Inflation rate (deflator) $\nrightarrow$ GDP	8.1229	**0.0069**	6.8701	**0.0030**	10.9993	**0.0000**	19.4531	**0.0000**	13.5563	**0.0000**
GDP $\nrightarrow$ Inflation rate (deflator)	3.7242	0.0609	18.3103	**0.0000**	11.7201	**0.0000**	6.1296	**0.0010**	21.2993	**0.0000**
Nominal wage $\nrightarrow$ GDP	9.8860	**0.0031**	8.6600	**0.0008**	2.5063	0.0755	6.1697	**0.0009**	3.8160	**0.0092**
GDP $\nrightarrow$ Nominal wage	3.2887	0.0773	7.4182	**0.0020**	4.9415	**0.0059**	23.3437	**0.0000**	25.1161	**0.0000**
Wage inflation $\nrightarrow$ GDP	6.7806	**0.0130**	5.9680	**0.0058**	2.7074	0.0611	8.4312	**0.0001**	4.7591	**0.0030**
GDP $\nrightarrow$ Wage inflation	1.6323	0.2089	4.5143	**0.0178**	1.6635	0.1938	9.3195	**0.0001**	8.5348	**0.0001**
Nominal interest rate $\nrightarrow$ GDP	53.3053	**0.0000**	1.1963	0.3137	5.5963	**0.0031**	6.3696	**0.0007**	7.6817	**0.0001**
GDP $\nrightarrow$ Nominal interest rate	48.8317	**0.0000**	1.5446	0.2268	7.6607	**0.0005**	0.5412	0.7066	14.1994	**0.0000**

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