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Evaluation of Macroeconomic Forecasting Accuracy

Bachelor thesis

Prague 2011

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Date of defense: **2011**

Bibliographic Record

Polák, Zdeněk. *Evaluation of Macroeconomic Forecasting Accuracy.* Prague, 2011. Bachelor Thesis (Bc.) Charles University, Faculty of Social Sciences, Institute of Economic Studies. Supervisor: PhDr. Ing. Jiří Skuhrovec

Abstract

This thesis deals with real GDP growth forecasting. It includes comparison of predictive performance of OECD, IMF, European Commission, and Ministry of Finance of the Czech Republic in period between 2000 and 2010. Forecast errors for Central European countries are analyzed and compared to forecast errors for G7 countries, which has never been done before. Organizations are benchmarked based on summary statistics, comparison with naïve forecast, and directional and sign accuracy.

Results of the analysis show that forecasts for expansion period are more accurate than forecasts for recession period. Furthermore, hypothesis that forecasts for G7 countries are on average more accurate than forecasts for Central European countries is not confirmed. This is particularly interesting for the Ministry of Finance of the Czech Republic, which did not outperform other organizations in forecasts for the Czech Republic and apparently has no comparative advantage in predicting economic development of the Czech Republic.

Abstrakt

Tato práce se zabývá predikcemi růstu reálného HDP. Práce obsahuje analýzu predikcí publikovaných OECD, IMF, Evropskou komisí a Ministerstvem financí České republiky mezi lety 2000 a 2010. Hlavním přínosem práce je srovnání přesnosti predikcí pro země střední Evropy se zeměmi, které jsou členy G7. K porovnání přesnosti predikcí jsou použity popisné statistiky, srovnání s naivními prognózami a správnost předpovědi změny ve směru vývoje a správnost předpovědi znaménka.

Podle výsledků jsou predikce v období konjunktury přesnější než predikce v období recese. Hypotéza, že predikce pro země G7 jsou přesnejší než predikce pro země střední Evropy, se nepotvrdila. To je zvláště pozoruhodné v případě Ministerstva financí České republiky, jehož predikce nepředčily predikce ostatních organizací, a které tak nemá výhodu v predikcích ekonomického vývoje České republiky.

Keywords

forecast, prediction, accuracy, real GDP growth, IMF, OECD, European Commission, Ministry of Finance of the Czech Republic

Klíčová slova

předpověď, predikce, přesnost, růst reálného HDP, IMF, OECD, Evropská komise, Ministerstvo financí České republiky

JEL Classification

E37, E66, R11

Declaration

1. I hereby declare that I compiled this thesis independently, using only the listed resources and literature.
2. I declare that this thesis has not been used to obtain any other degree.
3. I agree that this thesis is made available for educational and research purposes.

Prague, 29th May 2011

Zdeněk Polák

Acknowledgments

I would especially like to thank PhDr. Ing. Jiří Skuhrovec for supervising this thesis and providing me with priceless advice and comments.

I also thank Terka Šteflová and Mirka Mičáková for their valuable suggestions and grammatical corrections.

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Předpokládaný název BP:

Evaluation of Macroeconomic Forecasting Accuracy

Charakteristika tématu, současný stav poznání, případné zvláštní metody zpracování tématu:

In the beginning of 21st century advanced economies were less volatile than they were by the mid-1980s. This phenomenon was named the Great Moderation. Increasing stability of macroeconomic variables enabled more accurate GDP growth forecasting. But when in 2007 financial crisis began many economists failed to predict it and similarly did organizations engaged in macroeconomic forecasting. The projections forecasted mild growth while the real economy faced recession.

Struktura BP:

Abstrakt
The aim of this thesis is to evaluate accuracy of different organizations, which deal with macroeconomic forecasting. It analyzes how much one year GDP real growth forecasts differ from the actual realized numbers and whether the error differs between advanced economies and Central European countries. It also explores whether the forecasting is more accurate when the economy is steadily growing in comparison with the beginning of recession. The examined period is 2001-2008. Prediction accuracy is compared for two groups of countries: advanced economies from G7 and Central European countries. I use data from IMF World Economic Outlook, OECD Economic Outlook, European Commission Economic Forecast and local public authorities.

Osnova
Introduction
Methodology of macroeconomic forecasting
Description of the data
Evaluation of macroeconomic forecasting accuracy for each organization
Conclusions

Seznam základních pramenů a odborné literatury:

1. Batchelor, R., 2000, The IMF and OECD versus Consensus Forecasts, Working paper, City University Business School, London
2. Blix, M., et al., 2001, How Good is the Forecasting Performance of Major Institutions?, Sveriges Riksbank Economic Review, No. 3/2001, pp.38-68
3. Chen, H., et al., 2009, Constructing Forecast Confidence Bands During the Financial Crisis, IMF Working Paper, No. 09/214
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Datum zadání:	June 2010
Termín odevzdání:	June 2011

Podpisy konzultanta a studenta:

V Praze dne 3.6.2010

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1 Introduction

"...the ability to produce accurate predictions of the course of the economy in the near-term future is probably the main criterion by which the public judges the usefulness of our entire profession."

Victor Zarnowitz (1986)

Gross domestic product (GDP) is used as a variable, which measures economic well-being, although higher GDP does not have to mean higher living standard. Variable "real GDP growth" addresses the change of GDP over time. In this thesis is used version of real GDP growth, which measures relative annual growth, i.e., the percentage growth over the last year. GDP growth is a prominent variable in economic statistics. Maximization of GDP growth is seen as the main goal of policy-makers. Media, analysts, companies, politics, and even public pay attention to this indicator.

Demand for economic statistics grew steeply after the Second World War. Increasing interest had begun by public and private research institutions, followed by media, trade unions and multinational corporations. Most decisions of investors are based on the outlook of economy.

When it comes to supply side of GDP forecasts, there is a broad spectrum of organizations, from which one can choose. There are supranational organizations such as the Organization for Economic Cooperation and Development (OECD), the International Monetary Fund (IMF), or the European Commission (EC). There are national bodies such as the Ministry of Finance of the Czech Republic (MF) and we can select also from large number of private organizations producing economic forecasts. Some are publicly available, for others subscription is needed.

Motivation for this topic was the overwhelming surprise when the recession came to most developed countries in 2009. Now we know that in 2007 economic boom maintained its peak, 2008 was the year before recession and in 2009 real GDP declined in almost all developed countries. In 2007 firms were planning expansion, extended production facilities and took loans. Banks were eager to provide loans and only little controlled, who the borrower was and whether he was able to repay the loan. When the first signs of coming recession appeared in 2008, it seemed that nobody had anticipated it. The change was so rapid that one day people lived in economic boom and the next day woke up in the world,

where some of large banks and insurance companies either had to be bailed out or went bankrupt.

This thesis investigates real GDP growth forecasts of 4 organizations. Initially, I analyze methodology that organizations use to produce their forecasts. Later, quantitative methods are employed to evaluate organization's predictive performance both individually for each organization and among each other. Two main questions I want to resolve are: Is there organization that systematically outperforms others? And how well did organizations perform in predicting the recession in 2009?

Contribution of this paper lies in two parts. First, my goal is to compare forecasting results for G7 countries with the results for Central European countries. No work until this date focused on the Czech Republic or Central Europe in detail. In literature prevails examining of G7 countries or general attitude, when no country or region is given priority. Second, sample includes the latest decade from 2000 to 2010. Reasons for choosing such period were data availability and presence of both stable and turbulent periods within sample.

I investigate three hypotheses that stem from forecasting literature and intuitive thinking. My hypotheses are:

1. Forecasts for G7 countries are on average better than forecasts for Central European countries.
2. Forecasts in the whole period 2000-2010 are rather more accurate than those after 2008.
3. Forecasts for all countries are more accurate as the forecast time horizon shortens.

This thesis is structured in the following way. Next section provides review of recent literature. Section three describes methodology used by examined organizations to forecast real GDP growth. It is essential to know, how the forecasts are produced, to identify, which methodology generates the best results. Section four addresses the biggest issue of GDP growth forecasting, turning points. The fifth section includes description of examined data. Section six reveals methodology used in this thesis to assess accuracy of forecasters. The seventh section presents results and evaluation of forecasters. And the last section summarises main findings.

2 Formerly undertaken evaluations

Papers dealing with evaluation of macroeconomic forecasting include many macroeconomic variables. As my thesis focuses on GDP growth forecasting only, this review of the literature is entirely devoted to GDP forecasting, although papers generally address also one or more variables from the following list: inflation, output gap, current account balance, or export and import.

The evaluation of macroeconomic forecasting is widely popular topic among economic researchers. There exist rows of evaluations for IMF World Economic Outlook going to 1980's (Kenen and Schwarz, 1986) and the same holds for OECD Economic Outlook (Llewellyn and Arai, 1984).

Three different types of organizations publish forecasts. The first group are international organizations including IMF, OECD, and EC. Secondly, public institutions such as ministries of finance or statistical offices publish forecasts. The last group are private companies such as banks and insurance companies.

In this thesis are examined three major representatives of international organizations (OECD, IMF, EC) and one national public institution (MF). I chose OECD and IMF, because they are perceived as leading institutions, whose forecasts are taken as the key sources of future GDP development (Blix, 2001; Timmermann, 2006). Media that want to publish macroeconomic forecasts mostly cite OECD and IMF, although they could use many other sources. EC and MF were selected, because they produce forecasts for desired countries and their data are easily accessible. MF is also used as a benchmark to international organzations..

IMF and OECD forecasts are published twice per year, in spring and in autumn. Every issue includes at least projections on current year and next year. Intuitively forecasts on current year should be more accurate than those on next year, because more information is available. Papers agree upon that uniformly (Loungani, 2000; Vogel, 2007). As was mentioned in the Introduction, this is one of the hypotheses I want to verify.

Literature usually compares GDP growth forecasts from OECD or IMF with Consensus Economics or individual private forecasts. They usually assess forecasts accuracy according to one or more from following evaluation criteria: forecast error summary statistics, comparison with naïve forecasts, tests for unbiasedness and efficiency, and

testing for directional accuracy. I use in this thesis three of mentioned evaluation criteria, which are described later in section six.

Many studies attempt to find the best forecaster. There does not exist one universal forecaster, whose forecasts are predominantly more accurate than projections of other forecasters. Every single period and country have its forecasting winner. Blix (2001) shows that the most renowned institutions are not the best and the most accurate are less known banks and associations.

Based on his analysis, Blix (2001) suggests that projections of private forecasters have higher forecasting performance than those published by IMF and OECD in all surveyed parameters. This statement caused reaction of OECD, which published a note and questioned the methodology used by Blix (Lenain, 2002). The reason for dispute was the chosen period. Blix opted for a month of forecast that according to Lenain did not correspond with reality. The printed version of OECD Economic Outlook is published in June, but the preliminary version is published already in May. Lenain believed that the OECD projections should be compared with May projections of private forecasters. If the May projections of private forecasters was used for comparison, OECD would rank more successful (Lenain, 2002). This issue is addressed further in this thesis.

Similar dispute between OECD and evaluator of forecasts appeared already in 2000 (Batchelor, 2000). Batchelor alleged OECD that projections of Consensus Economics are more accurate. OECD published press release, in which the differences between OECD and private companies forecasts were explained. OECD based its argumentation on 2 facts. First, Consensus Economics forecasts are simple arithmetic average of large number individual predictions, thus from the law of large numbers follows that on average, they should be more accurate than individual forecasts. Second, forecasts of private companies serve different purposes than OECD forecasts. OECD considers its forecasts as conditional projections rather than forecasts, because OECD forecasts underlie various assumptions. These assumptions are described in next section.

On the other hand Loungani (2000) found "near-perfect collinearity between private and official (multilateral) forecasts in the case of growth forecasts for the period under study."

The biggest issue for the forecasters is the prediction of turning points. This is the reason why I devoted section four to turning points. Loungani (2000) and Blix (2001) found that forecasters rarely identify a downturn until it really begins. My results presented

in section six confirm this finding. Blix (2001) also indicates herd behavior among forecasters: “It appears that the forecasters make the same mistake initially and then follow the same revision path.”

All three leading international institutions, the EC, IMF and OECD, use equilibrium macroeconomic models, which failed to predict the economic downturn in 2007. Bezemer (2009) suggests replacing currently used equilibrium macroeconomic models with accounting models, which were able to forecast financial crisis starting in 2007 and the following economic recession. Forecasting recessions is the most visible flaw of equilibrium macroeconomic models and Bezemer shows that links between micro accounting and economy can do better.

Papers rarely address topics regarding fundamental questions of forecasting and if they do, they devote only little space to them. It might be one of the reasons why macroeconomic forecasting calls such an outrage among non-economist. Zarnowitz (1991) in its introductory part of “Has macro-forecasting failed?” answers the question “What to Ask, Why, and How?” It is important to realize that: “Any maker or user of economic forecasts must always be prepared to be wrong, even if the errors are, at best, relatively small and unpredictable.” (Zarnowitz, 1991).

We can not expect from forecasts what they can not bring. Errors in forecasts are natural and can not be completely avoided. What institutions engaged in forecasts can and should do is improve their models according to latest performance and learn from past experience. Blix (2001) sees “the need of regularly assessing the forecasting performance of institutions. Only in this way will forecasters’ influence in the public domain stand in proportion to the quality of their assessments.”

3 Methodology of real GDP forecasting

I have chosen 4 organizations that produce regular macroeconomic forecasting reports. These are the OECD, the IMF, the EC, and the MF. The criteria for selection were regular publishing of real GDP growth forecasts for world wide countries (with exception of MF), high reputation of organization, and long tradition of macroeconomic forecasting along with free access to data.

MF is an exception from the world wide forecasts criterion and I selected it as a comparative organization, which might arguably outperform other organizations in forecasts for the Czech Republic due to better knowledge of regional conditions. Forecasts for other countries of MF should be similarly accurate on average. MF produces real GDP growth forecasts only for Germany, France, the United Kingdom, Austria, the USA, Hungary, Poland, Slovakia, and the Czech Republic.

I sent an e-mail to all mentioned organizations asking for information about their forecasting methodology. The organizations provided me with general information. The rest of information in this chapter follows from web pages and papers of respective organizations.

Forecasting exercise is similar in all organizations in two ways. First, projections of OECD, IMF and EC benefit from country expert views of various professionals and specialists. Their forecasts are discussed and adjusted during the forecasting procedure, thus forecasts are not only dependant on economic and statistical models. Projections of the MF are also discussed with experts, but not in such a range and there are not specialists for every region. Second, forecasts are prepared on a set of assumptions, which concerns in all cases exchange and interest rates and oil prices.

3.1 Organization for Economic Cooperation and Development[1]

Macroeconomic forecasts of OECD are produced by the Economics Department. Forecasts are based on combination of information from number of models and expert judgement. The main used model is INTERLINK world economic model. INTERLINK is large global model, which for each OECD member country links together a number of small and medium-sized quarterly macroeconomic models. The model treats the world economy as a coherent and integrated unit. Development in each economy, international trade and exchange rates, and financial flows are determined simultaneously and on a globally consistent basis. Emphasis is therefore put on international economic linkages through trade and financial conditions.

INTERLINK model is neo-classical in terms of structural specification and equilibrium properties. The model has also New Keynesian elements, which reflect presence of real and nominal rigidities in wage and price setting. Among New Keynesian elements can be included dynamic adjustment of output, employment, and non-oil prices to long-term equilibrium. This means that adjustment after shock will lead through output and employment disequilibria before the equilibrium is restored.

The OECD's projection assumptions concern nominal exchange rates, path of oil and non-oil commodity prices, and mandated macroeconomic policies. "Fiscal policy assumptions are based on current legislation as well as announced measures and stated policy intentions where they are embodied in well-defined programs with legislative support. Monetary policies are assumed to be set in line with stated objectives, notably as regards maintaining or achieving low inflation. Nominal exchange rates against the US dollar are generally assumed to remain constant at the level prevailing on a prespecified cut-off date. Crude oil prices are typically assumed to remain constant in nominal terms based on average prices during the period leading up to the cut-off date; other commodity prices are typically assumed to remain constant in real terms." (Vogel, 2007).

[1] Sources:
Giovannini, E., 2008, Understanding Economic Statistics: an OECD Perspective, OECD Publishing, Paris.
Pain, N., et al., 2005, The New International Trade Model, OECD Economic Department Working Papers, No. 440, August.
Sedillot, F. and N. Pain, 2005, Indicator models for real GDP growth in the major economies, OECD Economic Studies, No. 40, 2005/1.
Website of OECD, http://www.oecd.org/eco/sources-and-methods

The OECD differentiates itself from other forecasting organizations and names three features that distinguish the OECD forecasts.

1. Forecasts of the OECD underlie various assumptions mentioned above. Thus they are considered as conditional projections rather than forecasts. OECD describes its philosophy: "Projections provide answers to questions like: *What is likely to happen in country X if the government implements mandated fiscal measures?*, or, *On mandated policies, what kind of imbalances or pressure points are likely to develop over the next two years, e.g., in the form of widening current account imbalances or higher unemployment?*" (OECD website).
2. The OECD declares its projections to be consistent at international level, which means that projections for all countries are produced using the same process. Production process starts with exchange of views among OECD country experts and topic specialists. The process continues with predetermined iteration process using the OECD's INTERLINK world economic model. Lastly, projections are discussed between country and international trade experts.
3. Government experts and policy makers participate in projection's making. This serves as a reality-check. Conclusions of OECD are compared to views on the economy development of representatives of government and central bank, who benefit from the familiarity with local conditions. Thus OECD consults its projections also with the MF and may adjust projections according to findings of MF.

The accuracy of OECD forecasts was formerly assessed in works Vogel (2007), Lenain (2002), and Koutsogeorgopoulou (2000).

3.2 International Monetary Fund[2]

Forecasts are produced by World Economic Studies Division of IMF Research Department. Methodology of IMF used for production of forecasts is different for each country and depends on individual country desks[3]. Though every country desk stems from common assumptions and uses them as a basis for its projections.

[2] Sources:
Website of IMF, http://www.imf.org/external/pubs/ft/weo/faq.htm
[3] Country desk is a department, where officers are dedicated to one particular country.

Projections of IMF are based on assumptions concerning following variables: real effective exchange rates, policies of national authorities, price of oil in current and next year, the six-month London interbank offered rate (LIBOR) on U.S. dollar deposits, the three-month euro deposit rate, the six-month Japanese yen deposit rate. Values of variables in every report are set according to market expectations at the time of the forecast.

IMF forecasting performance was evaluated in works of Timmermann (2006), Artis (1997), and Barrionuevo (1993).

3.3 European Commission[4]

Directorate-General for Economic and Financial Affairs (DG ECFIN) is responsible for forecasts in EC. More specifically Unit A4: Forecasts and Economic Situation. There is not used one centralised model. Main part of the forecasting work, however, is undertaken by country desks, which use judgmental approach and statistical methods to varying degrees.

Production of forecasts for each publication lasts about two months and more than 60 employees take part in the exercise. Forecasts are prepared in 3 stages, which result in preliminary, provisional and final sets of forecasts. In the final stage of preparation are involved member states. Bilateral and multilateral meetings between national experts and DG ECFIN are arranged as well as fact-finding missions in member states.

Assumptions concern averages from 10-day reference period for exchange and interest rates and for oil prices. The 10-day reference period should prevent volatility during one specific trading day. Attention is paid to ensure consistency in trade flows for goods and services at the level of member states of EU and units of the EU and the world.

For evaluation of alternative scenarios econometric model simulations are used. The main model is DG ECFIN's QUEST model, which is Dynamic Stochastic General Equilibrium model for open economy. It is New Keynesian model, which respects frictions in goods, labour, and financial markets. Various versions of QUEST model exist. They differ according to regional and sector purposes.

[4] Sources:
Keereman, F., 1999, The track record of the Commission Forecasts, Economic Papers No. 137 (European Commission, Directorate-General for Economic and Financial Affairs), October
Melander, A., Sismanidis, G. and Grenouilleau, D., 2007, The track record of the Commission's forecasts – an update, Economic Papers 291, European Commission.
Website of EC, http://ec.europa.eu/economy_finance/eu/forecasts/index_en.htm

Performance of the EC's forecasts was assessed by Melander et al. (2007) and Keereman (1999).

3.4 Ministry of Finance of the Czech Republic[5]

Forecasts are prepared by the Financial Policy Department of the Czech Ministry of Finance. Production of forecasts has 3 stages, in which MF combines output of macroeconomic model with expert judgment.

The first stage of production concerns thorough statistical analysis of past development of economy. Forecasts from last publication are compared with corresponding actual (realized) values and resulting errors are analysed for their sources.

Variables that are needed in forecasting exercise, but are not available yet, are estimated using indicators of economic activity. Views on near future are formed by leading indicators and business cycle surveys conducted by the Czech Statistical Office.

In the second stage is used macroeconomic model. MF utilizes simple Dynamic Stochastic General Equilibrium model of the Czech economy, which is called HUBERT. It describes the behaviour of four main subjects in the economy: households, firms, government, and world. HUBERT includes some features of New Keynesian economics such as imperfect competition, habit formation of households, nominal and real rigidities. The model is intended for simulations and regular macroeconomic forecasting. The results of HUBERT are key input of forecasting process.

In the last stage, the results of the model are investigated in the context of both domestic and foreign economic and political developments. Expert judgment examines development of potential GDP, position in business cycle, and expected economic development in main trade partner countries. Prognosis is based on assumptions about the influence of fiscal, monetary, and also other economic policies.

The forecasts are regularly assessed against the forecasts of other organizations. Twice a year, in May and November, MF organizes a survey of forecasts of macroeconomic development in the Czech Republic, the so-called Colloquium.

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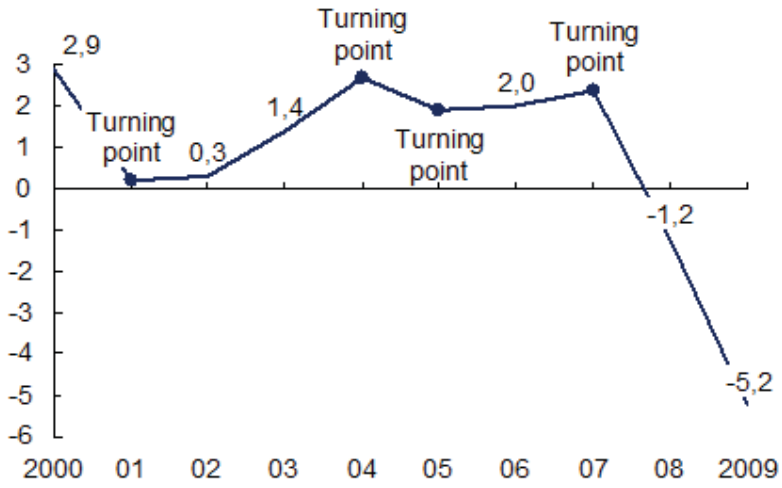
[5] Sources:
Stork, Z., Vavra, M. and J. Zavacka (2009): HUBERT: A DSGE model of the Czech economy. Ministry of Finance of the Czech Republic, Working paper, 2/2009
Website of MF, http://www.mfcr.cz/cps/rde/xchg/mfcr/xsl/makro_pre.html

The colloquium in November 2010 was based on forecasts of 15 institutions, representatives of financial institutions (Atlantic, Bank of America Merrill Lynch, ČSOB, Generali PPF Asset Management, ING, Komerční banka, Patria, Raiffeisen, UniCredit), public institutions (Czech National Bank, Ministry of Finance, Ministry of Industry and Trade, Ministry of Labour and Social Affairs), a research centre (CERGE-EI) and the Union of Czech and Moravian Production Co-operatives. Also, the forecasts of IMF and OECD were added to make the survey more representative. The November 2010 Colloquium concluded that with few exceptions the MF forecasts do not differ significantly from the average of other institutions' forecasts.

4 Turning points and recessions

A turning point is defined as a point, where local or global extremum lies. In case of annual real GDP growth it can be either a point, where values of real GDP growth in both preceding and following years are higher than in the actual year, or both lower than in the actual year.

Figure 1. Turning points
Real GDP growth for Japan, 2000-2009.



Source: Author, based on data from OECD Economic Outlook (May 2010)

The importance of forecasting lies in the correct forecasting of turning points. Identifying turning points is important, because turning points lead to recessions and announce recoveries. In this thesis is recession defined as a year when real GDP growth declines (has negative value).

There are two types of recessions. The first type are recessions that come fast, e.g., recession in Japan in 2008 (see Figure 1). Turning point is very close to recession and recession in not predictable from past development of GDP. These recessions are very hard to predict even one year ahead. The second type are recessions that come slowly and gradually, e.g., recession in Germany in 2003 (see Table 1). Turning point appears many years before the recession. Intuitively, this type of recessions should be easier to predict (which is not the case of Germany in 2003, when forecast error of all organizations was high).

There is a number of reasons why recessions are hard to predict. The reasons do not only address the very difficulty of forecasting, but also the incentives that the forecasters are exposed to. I discuss each reason, whether it is legitimate and whether it justifies high forecast errors in recessions. Literature offers following explanations.

1. *Forecasters do not have enough information to produce accurate forecast.* This is true, but it is one of the features of forecasts, that part of the information is missing. Otherwise we would be interested in statistics and not forecasts.

2. *Macroeconomic models are built to work well on average, but fail in forecasting recessions.* This statement is true, but explains only partly, why recessions are hard to predict. Forecasters do not use only macroeconomic models in forecasting exercise. They also involve expert judgement and interviews with country experts, which should eliminate the fact that macroeconomic models work well on average, but fail in forecasting recessions.

3. *Recessions are rare events, which are worthy to neglect.* Utility function of forecasters is asymmetric. Optimistic forecasts are more welcomed than the pessimistic ones and forecasters can maximise their utility with forecasting continuous growth all the time. They are safe in period of expansion and when recession comes, they admit it was unpredictable. National institutions such as ministries of finance or central banks might neglect recessions also from the reason that their forecasts may become self-fulfilling prophecies. First, the pessimistic forecast itself might cause recession, when initially there was no recession on the way. Second, optimistic forecast might enhance economic growth. My results show that the MF is the most optimistic forecaster (for both current year and year ahead forecasts) in case of Germany, Hungary, and the UK. But the differences from other organizations are not large.

4. *Forecasters tend to herd behaviour.* Forecasts of various organizations do not differ much in good times, when the forecast error is low. That is logical. But also in bad times, forecasts are almost similar only with little difference and forecast error is high by everyone. Many forecasters are discouraged to produce pessimistic forecasts, because recessions are worthy to neglect as was mentioned in previous paragraph. Thus they pull the “herd” to optimistic forecasts. It is unpleasant to be the only one, who made mistake. It seems that the idea of

possible mistake is worse than eventual gain from justification. In other words, outlier forecasts are not common.

Loungani and Trehan (2002) conclude that some of turning points are hard to predict, because they are results of shocks that are themselves unpredictable. In case of unpredictable events, e.g., September 11 attacks, it is understandable that the event was not included in assumptions during production of forecast and consequently forecast error is high. But not every recession is caused by unpredictable events. However, forecasters very rarely predict the recession before it actually comes. Vogel (2007) notes that spring current year forecasts of OECD anticipate correctly 76% of turning points. In case of year ahead forecast the share is only 6%. Forecasts were for G7 countries in period 1991-2006.

Loungani (2002) found that the end of recession and the beginning of recovery is successfully predicted in most cases. He also mentioned that multiyear recessions are not very common and it is safe for forecasters to predict growth in the next year after recession. Only a small part of recessions in the industrialized world lasts longer than one year. The recession in 2009 was not an exception and confirmed that recessions mostly last only one year. In 2010 was real GDP of most countries growing again.

There are leading indicators that can help in forecasting turning points. Leading indicators such as stock market returns, building activity, volume of public contracts, or index of consumer expectations may detect rising recession before it actually comes. The problem is that these indicators do not have 100% validity and forecast recession even when there is no crisis coming.

5 Description of data

Description of data is key methodological concern in the field of macroeconomic forecasting. For example, individual sections devoted to description of data are in works of Timmermann (2006) and Loungani (2000). When it comes to evaluation of forecast accuracy it is important to consider, on which date are forecasts published and how did GDP growth development in examined period and countries look like.

Forecasts of IMF are published twice a year in World Economic Outlook, which is usually released in April and October. [6] In case of IMF real GDP growth is not adjusted for working day effects.

OECD publishes its forecast in semi-annual publication called OECD Economic Outlook and it is usually released in June and December. [7] Real GDP growth is seasonally and working-day-adjusted annual rate.

Forecasts of EC are published twice a year as well in publication called European Economic Forecast usually in April and October. [8] Concise, interim forecasts are released several weeks before these. The Commission's annual GDP forecasts are not adjusted for the number of working days, nor seasonally adjusted.

On the contrary from other organizations examined in this thesis forecasts of the Czech MF are published on a quarterly basis. Forecasts are released in publication called Macroeconomic Forecast usually in January, April, July, and October. [9] Real GDP growth data are seasonally adjusted.

5.1 Data set

Examined data set consists from real GDP data forecasts for 11 years and 9 countries. Data from OECD and EC are complete. Few observations are missing in data from IMF and MF. In IMF data set are missing data for the Czech Republic and Slovakia for 2000, because IMF began reporting real GDP growth for these two countries in 2001. Data set

[6] Data of IMF can be accessed from: *http://www.imf.org/external/ns/cs.aspx?id=28*
[7] Data of OECD are available from: *http://stats.oecd.org/Index.aspx?DataSetCode=EO88_INTERNET*
[8] Data of European Commission can be accessed from:
http://ec.europa.eu/economy_finance/publications/european_economy/forecasts_en.htm
[9] Data of MF since 2002 are available on:
http://www.mfcr.cz/cps/rde/xchg/mfcr/xsl/macroeconomic_forecast.html. Macroeconomic Forecast data before year 2002 are from library of MF.

from MF is complete until 2008. In 2009 MF halted production of forecasts for Japan. Japan was removed, because its significance for macroeconomic development of the Czech Republic is low.

I use data sources beginning in year 2000 and the last year from that I use publications is 2010. The first current year forecasts are for year 2000 and the first year ahead forecasts are for 2001. Last forecasts are for year 2009. I could not use forecasts for 2010, because actuals for 2010 will be published in 2011. That gives 20 biannual observations for current year forecasts and 18 biannual observations for year ahead forecasts in case that no datum is missing. Analysis of forecast error for 2009 recession is done using forecasts for 2008 and 2009.

In this thesis I focus on nine countries, which are divided into two groups. The first group contains five countries that are members of G7: France, Germany, Japan, the United Kingdom, and the United States of America. Second group includes four countries from Central Europe (CE): Czech Republic, Slovakia, Poland, and Hungary.

Why did I choose particularly these countries? I wanted to analyse forecast error for CE countries and compare the predictive performance with forecast error of other group of countries, which was never done before. Vogel (2007) puts it: "Additionally, it might be interesting to consider forecasting accuracy for small open economies, where volatility in the underlying realisation is typically higher." Criterion for selection was also the availability of data in case of all four organizations.

All analysis conducted in this thesis applies only on selected countries. All selected countries except Poland were touched by the 2009 recession but for example China or India were far from real GDP growth decline.

5.2 Real GDP growth development in examined countries

It is important to look at real GDP growth in chosen countries in past years before doing analysis of forecast error. As was already mentioned, forecasting the turning points is the biggest challenge for forecasters. Predictive performance can be highly influenced by instable economic period.

From Table 1 can be seen that economies of countries in my selection were growing most of the period. In 2001 and 2002 the performance of economies slowed down

markedly in all countries except Slovakia and Japan and then accelerated until 2006. Slovakia speeded up its boost from 2000 till 2007.

Japan underwent the period differently than all other countries. In 2001 came also the slow down of real GDP growth, but growth of Japanese economy was weak in comparison with other countries and did not overcome 3% during whole period. Contrary from other countries, recession came to Japan already in 2008.

CE countries fell into recession very fast. The difference between real GDP growth in 2008 and 2009 makes more than 10 percentage points in case of Slovakia and more than 6 percentage points in case of the Czech Republic and Hungary, which suggests high forecast error. Exception was Poland, where real GDP growth in 2009 slowed, but did not decline. Exceptional was also gentle real GDP decline in Germany in 2003.

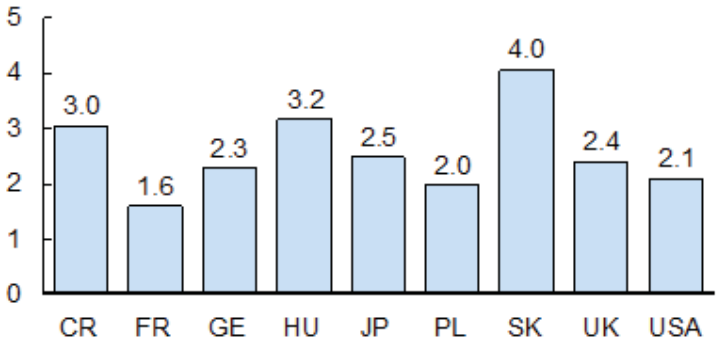
Table 1. Real GDP growth development

											Forecast	
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
CR	3.9	2.4	1.8	3.6	4.3	6.4	7.0	6.1	2.3	-4.1	2.0	3.0
France	4.1	1.8	1.1	1.1	2.3	1.9	2.4	2.3	0.3	-2.5	1.7	2.1
Germany	3.5	1.4	0.0	-0.2	0.7	0.9	3.4	2.6	1.0	-4.9	1.9	2.1
Hungary	4.9	4.3	4.4	4.2	4.6	3.7	4.1	1.0	0.4	-5.7	1.2	3.1
Japan	2.9	0.2	0.3	1.4	2.7	1.9	2.0	2.4	-1.2	-5.2	3.0	2.0
Poland	4.3	1.2	1.4	3.9	5.3	3.6	6.2	6.8	5.0	1.8	3.1	3.9
Slovakia	1.4	3.5	4.6	4.8	5.0	6.7	8.5	10.6	6.2	-4.7	3.6	3.9
UK	3.9	2.5	2.1	2.8	3.0	2.2	2.9	2.6	0.5	-4.9	1.3	2.5
USA	4.1	1.1	1.8	2.5	3.6	3.1	2.7	2.1	0.4	-2.4	3.2	3.2
G7	3.7	1.4	1.1	1.5	2.5	2.0	2.7	2.4	0.2	-4.0	2.2	2.4
CE	3.6	2.9	3.1	4.1	4.8	5.1	6.5	6.1	3.5	-3.2	2.5	3.5

Source: Author, based on data from OECD Economic Outlook (May 2010)

Real GDP growth of CE countries between 2001 and 2008 was twice as high as in G7 countries. Standard deviation (see Figure 2) in actual values is again higher for CE countries, except Poland. The highest standard deviation show actual values for Slovakia, Hungary, and the Czech Republic. Lowest standard deviation has Japan, France, and Poland.

Figure 2. Standard deviation in actual values



Source: OECD Economic Outlook

6 Methodology for assessing the accuracy of forecasts

This section presents basic concepts and statistical indicators, which are used in section seven for assessing the accuracy of forecasts. Described methodology should ensure that forecasters are evaluated under the same conditions, or at least obstructions to the fair evaluation are known.

6.1 Basic concepts

Non-trivial issue is, which actual number should be the forecast compared with. Real GDP data are often revised. They are replaced in next publications even for several times. Goh and Lawrence (2006) mention that revisions may be caused by updated information, methodological changes, introduction of new weights or rebasing. Table 2 displays magnitude of revisions in case of Japan. Average revision makes 0.6 percentage points, which results in the question, what number to use as the actual value. I decided to compare forecasts with first available actual numbers, which is conventional view in the literature (Koutsogeorgopoulou, 2000; Vogel, 2007). It means that IMF forecast for 2009 is compared with first available actual number for 2009, which was published in 2010. Reason for usage of first available actual number is that forecasters attempt to forecast the course of economy and can not consider also later revisions.

Table 2. Real GDP growth revisions, Japan

Year	Minimal actual value	Maximal actual value	%-point difference
2000	1.5	2.8	1.3
2001	-0.1	0.4	0.5
2002	-0.4	0.3	0.7
2003	1.4	2.4	1
2004	2.3	2.7	0.4
2005	1.9	2.6	0.7
2006	2	2.4	0.4
2007	2.1	2.4	0.3
2008	-1.2	-0.7	0.5
		High	1.3
		Low	0.3
		Average	0.6

Source: Author, based on data from European Economic Forecast, EC

Forecasts of every organization are compared with respective actual numbers, i.e., forecasts of IMF with actuals published by IMF, forecasts of OECD with actual numbers of OECD, and so on. Differences in actual numbers among organizations are not large, but it would not be fair to compare forecasts of each organization with actual numbers of one chosen organization.

There are two difficulties that obstruct full comparability of data. First, forecasts are published on different dates (see Table 3). Some of the organizations can then utilize also newer information to produce their forecasts. In the case of IMF and OECD the difference can make 2 months, which leads to significant advantage of OECD. Second, actual numbers of the EC appear in autumn publications, while actuals of the OECD, the IMF, and the MF are published already in spring publications. For example, EC published actual numbers for year 2009 in November 2010 publication, while OECD published actual numbers for year 2009 already in May 2010 publication. Given the fact that both organizations publish their data twice a year, in spring and in autumn, publication of actual data lasts EC half year longer than OECD. That implies that forecasts from one year are compared with actual number in spring release in case of the OECD and with actual number in autumn release in case of the EC. It does not imply advantage for any of the organizations.

Table 3. Date of forecast publication

	Spring	*Autumn*
World Economic Outlook (IMF)	April	September/October
OECD Economic Outlook	May/June	November/December
European Economic Forecast (EC)	March/April	October/November
Macroeconomic Forecast (MF)	March/April	September/October

Source: Author, based on web sites of respective organizations

In my analysis I focus on current year forecasts and year ahead forecasts. For current year spring and autumn forecasts from the same year publications are used, e.g., for evaluation of current year forecasts in 2007 data from spring and autumn publications in 2007 are used, which are compared with first available actual. For evaluation of year ahead forecasts are used spring and autumn publications from last year, e.g., for evaluation of year ahead forecasts for 2008 are used data from spring and autumn 2007 publications and they are compared with initial actual.

6.2 Statistical indicators of forecasting accuracy

In literature, various methods are used to benchmark forecasting accuracy. I use 3 types of methods to assess the accuracy of forecasts: summary statistics, comparison with naïve projection, and directional and sign accuracy. Melander et al. (2007) evaluated forecast accuracy based on the same methods and moreover used tests on bias and efficiency.

Summary statistics describe the size of forecast error. I use following summary statistics: mean error, mean square error, root mean square error, mean absolute error, and mean absolute percentage error.

Comparison with naïve projection is useful for assessment, whether forecasting method produce better forecasts than much simpler methods, e.g., using last actual observation as the forecast for next period or forecast equal to 0. If not, then forecasting method is to be rejected because it cannot outperform the most simple naïve projections. I conducted comparison with naïve projection using two Theil's U statistics, which were proposed in Theil (1958) and Theil (1966).

In case of real GDP growth directional and sign accuracy may be more important than the forecast value (Melander et al., 2007). Users of forecasts can not utilize numeric value. From strategic perspective they orientate according to development in longer period, which can be addressed by directional and sign accuracy indicators.

Definitions of forecast accuracy indicators except Theil's U statistics follow definitions in Cipra (2008). Current year real GDP growth forecasts are denoted $\hat{y}_t$, year ahead forecasts are denoted $\hat{y}_{t-1}$, and actual values are denoted y_t.

6.2.1 Summary statistics

Forecast error is the most basic indicator, which compares forecast for given year with respective actual value. There are two ways how to express forecast error e_t. One way to express forecast error is $e_t = y_t - \hat{y}_t$. Alternatively, forecast error can be defined as $e_t = \hat{y}_t - y_t$.

Both ways are used, which was confirmed by survey conducted by Green and Tashman (2008). Eleven members of the International Institute of Forecasters took part in the survey. Seven, which is more then half of them, were in favor of calculating forecast error

using the first way $e_t = y_t - \hat{y}_t$. They explained it by statistical convention, ease of statistical calculation, investment in software that adhered to statistical convention, and pragmatism. It is also intuitive when assessing performance against a budget, because a negative value indicates that a budget is sufficient and has not been exceeded. Four respondents preferred definition $e_t = \hat{y}_t - y_t$. They argued that it was more intuitive that a positive error represented an overestimation and a negative error an underestimation. I decided to use forecast error defined as $e_t = y_t - \hat{y}_t$, i.e., actual value minus forecast. As was mentioned, this definition is used more frequent.

Mean error (ME) is the simplest indicator of forecast accuracy. It is computed as a sum of differences between actual values and forecasts. ME can take positive and negative values, and thus it shows, whether the forecast on average was overestimated or underestimated, which can indicate bias in forecast. Negative sign means that forecast was overestimated. Positive sign displays that forecast was underestimated. Intuitively forecasters are rather optimistic and I expect that their forecasts are overestimated. Since positive and negative values are summed it can cause a situation when forecast errors would offset each other and thus showing low ME. ME of optimal forecast is zero but this situation can also happen when forecast errors offset each other perfectly.

$$ME = \frac{1}{h}\sum_{t=n+1}^{n+h}(y_t - \hat{y}_t)$$

Mean squared error (MSE) penalize forecasters for high errors. It takes into account that high forecast errors are deemed more harmful than low differences. The desirable property of MSE is that positive and negative values can not cancel each other out. MSE has a different unit of measurement than the actual data. To gain the same unit of measurement the actual data would have to be squared. The lowest possible value of MSE is 0 for forecast equal to outcome. MSE does not have upper bound.

$$MSE = \frac{1}{h}\sum_{t=n+1}^{n+h}(y_t - \hat{y}_t)^2$$

Root mean squared error (RMSE) is an alternative version to MSE, which has the same unit of measurement as the actual data. RMSE still put relatively high weight on large errors, because forecast errors are squared before they are averaged.

$$RMSE = \sqrt{\frac{1}{h}\sum_{t=n+1}^{n+h}(y_t - \hat{y}_t)^2}$$

Mean absolute error (MAE) weighs all forecast errors equally, without considering their direction.

$$MAE = \frac{1}{h}\sum_{t=n+1}^{n+h}|y_t - \hat{y}_t|$$

RMSE is always larger or equal to the MAE. The higher the difference between them, the larger the variance in the individual errors in the sample. If the RMSE is equal to MAE, then all the errors have the same magnitude. RMSE and MAE have minimum value 0 and there is no upper bound.

Mean absolute percentage error (MAPE) expresses forecast error as a percentage. The minimum value is 0 and means perfect forecast. MAPE lower than 100% means that forecast is better than random walk model with forecasts always equal to 0 ($\hat{y}_t = 0$), i.e., pemanently with MAPE=100%. MAPE has no upper bound.

$$MAPE = \frac{100}{h}\sum_{t=n+1}^{n+h}\left|\frac{y_t - \hat{y}_t}{y_t}\right|$$

6.2.2 Comparison with naïve projection

Henry Theil defined two error measures. The first measure was proposed in Theil (1958). U1 compares the forecast with simple no-change model. U1 falls between 0 and 1. Value 0 means perfect predictive performance. Value 1 means that forecast is not better than just using last actual observation as a forecast. Bliemel (1973) analyzed U1 and concluded that it “has little or no value as an index to assess forecast accuracy”. The value

of 1 will be obtained only when a forecaster applies the simple no-change model. All other forecasts would lead to U1 value lower than 1, regardless of whether the forecast method led to better or worse performance than the naïve no-change model. Bliemel (1973) suggested applying later version of Theil's statistic U2.

Theil's U-statistic 1 is defined as:

$$U1 = \frac{\sqrt{\sum_{t=n+1}^{n+h}(y_t - \hat{y}_t)^2}}{\sqrt{\sum_{t=n+1}^{n+h}\hat{y}_t^{\,2}} + \sqrt{\sum_{t=n+1}^{n+h}y_t^{\,2}}}$$

The second measure was proposed in Theil (1966). U2 shows whether the forecast is better than simple forecast, which is 0 all the time. For U2 holds that value equal to 0 confirms perfect forecast. Value lower than 1 means that forecast beat the naïve forecast and value higher than 1 means that forecast is worse than naïve forecast.

Theil's U-statistic 2 is given by the equation:

$$U2 = \frac{\sqrt{\sum_{t=n+1}^{n+h}(y_t - \hat{y}_t)^2}}{\sqrt{\sum_{t=n+1}^{n+h}y_t^{\,2}}}$$

6.2.3 Directional and sign accuracy

Percentage of sign correct forecasts (PSC) examines how many per cent of time is sign of forecast predicted correctly.

$$PSC = \frac{100}{h}\sum_{t=n+1}^{n+h} z_t \text{ , where } z_t = \begin{cases} 1 \text{ for } y_t \cdot \hat{y}_t > 0 \\ 0 \text{ otherwise} \end{cases}$$

Percentage of directional accuracy correct forecasts (PDA) describes whether the forecaster correctly anticipates acceleration and deceleration of real GDP growth. It is a measure of ability to forecast correctly turning points.

$$PDA = \frac{100}{h}\sum_{t=n+1}^{n+h} z_t \text{ , where } z_t = \begin{cases} 1 \text{ for } (y_t - y_{t-1}) \cdot (\hat{y}_t - y_{t-1}) > 0 \\ 0 \text{ otherwise} \end{cases}$$

PSC and PDA range between 0% and 100%. Success rate of PSC and PDA should exceed 50% as a minimum (Melander et al., 2007). Accuracy of 50% addresses the fact that accuracy lower than 50% would signify superiority of coin tossing.

Aggregated values of indicators for G7 and CE countries are calculated as simple averages of respective countries.

6.3 Best forecaster

For evaluation of forecasters among each other I designed following methodology. Forecasters are evaluated according to sum of summary statistics (SSS), sum of Theil's coefficients (STC), and sum of percentages of directional accuracy and sign correct forecasts (SPD + SCF).

In SSS is each statistic in sum divided by respective standard deviation (SD), because each statistic in SSS has different metric (ME values are around 0, while MAPE can reach hundreds). In SSS formula is used average value of SD of all organizations. Mean error (ME) in SSS is in absolute value, because other statistics are positive. From SSS is excluded RMSE, because it has the same validity as MSE.

Best forecaster has the least sum of summary statistics and the least sum of Theil's coefficients. Sum of percentages of directional accuracy and sign correct forecasts should be the highest. All three sums are evaluated individually and based on them are selected best forecasters for each country.

$$SSS_t = \frac{|ME_t|}{SD_t^{ME_t}} + \frac{MSE_t}{SD_t^{MSE_t}} + \frac{MAE_t}{SD_t^{MAE_t}} + \frac{MAPE_t}{SD_t^{MAPE_t}}$$

$$STC_t = U1_t + U2_t$$

$$SPD_t + SCF_t = PSC_t + PDA_t$$

7 Evaluation of macroeconomic forecasting accuracy

In this section I use the proposed methodology to evaluate examined forecasters. First, hypotheses put forward in Introduction are verified. Second, common characteristics, which hold for forecasts of all organizations, are described. Third part presents predictive performance for each organization individually. And lastly, this section compares predictive performance of all forecasters among each other.

7.1 Verification of hypotheses

1. *Forecasts for G7 countries are on average better than forecasts for Central European countries.*

This hypothesis addresses the issue that forecasts for Central European countries have never been examined before. Forecasting for G7 countries have long tradition and thus might arguably be more accurate than forecasts for Central European countries.

I can not confirm or reject this hypothesis. Results are ambiguous and it depends on selected statistical indicator, whether this hypothesis holds.

In absolute values forecast error for G7 countries is lower than for CE countries. But taking into account percentage error, forecasts for CE countries are far more accurate. It can be explained by the fact that real GDP of CE countries is growing faster than in G7 countries, thus the actual numbers are higher. Higher numbers are more difficult to forecast and thus the forecast error is bigger. But in the percentage expression it is conversely. Higher GDP growth numbers partly eliminate forecast error and so the percentage error in case of CE countries is low. Forecast error equal to 1 in case of 5 per cent GDP growth results in 20% percentage error. But the same forecast error in case of 1 per cent GDP growth gives 100% percentage error. From this observation can be concluded that higher absolute forecast error in case of CE countries is just a matter of metric and not better performance.

Theil's U indicators are little bit lower for CE countries. But the difference is negligible. PSC is again better for CE countries, but forecasts are directionally more accurate (PDA indicator) for G7 countries.

Table 4. G7 versus CE forecasts

	ME		MSE		RMSE		MAE		MAPE	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
G7	-0.1	-0.9	0.4	3.7	0.5	1.9	0.4	1.3	49	167
CE	0.2	-0.6	0.8	8.5	0.9	2.9	0.7	2.0	28	73

	Theil's U1		Theil's U2		PSC		PDA	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
G7	0.11	0.42	0.23	0.80	93	87	84	67
CE	0.10	0.32	0.20	0.62	99	93	84	53

Source: Author's calculations using OECD Economic Outlook data

2. *Forecasts in the whole period 2000-2010 are rather more accurate than those after 2008.*

This hypothesis investigates, how well did organizations perform in predicting the recession in 2009. Literature suggests that forecasting performance in recessions is considerably worse.

Based on my results I confirm this hypothesis. Forecasts for the whole period are more accurate almost in all statistics than forecasts for 2008 and 2009. In case of current year forecasts the deterioration is not so bad. But in case of year ahead forecasts the performance of forecasters in recession period is much worse, e.g., MSE statistics are twice as high or even more (see tables in Annex). Exceptions, which do not confirm this hypothesis, are some of the PSC and PDA statistics, but in this case they are not as much important, because I have only 4 observations for the recession period.

3. *Forecasts for all countries are more accurate as the forecast time horizon shortens.*

As might be expected, forecast for tomorrow will be more accurate than forecasts for next year.

The results of conducted analysis confirm also this hypothesis. As the time horizon shortens forecasts are more superior in comparison with naïve forecasts, forecast errors are on average smaller, signs of errors are predicted more successfully and directional accuracy is better in case of all organizations. Difference between current year and year ahead forecast accuracy is even higher in the recession period as was mentioned by previous hypothesis.

7.2 Common characteristics

Current year mean error statistic shows (see Table 5) that on average forecasts for some countries were overestimated in examined period and for some countries underestimated. CE countries are more likely to be underestimated. Forecasts of all organizations were on average underestimated in case of the Czech Republic, Poland and Slovakia. All organizations on average overestimated forecasts for France, Hungary and the United Kingdom.

From mean error statistic can be seen that forecasters are on average in year ahead horizon more optimistic than the reality. Almost all year ahead forecasts are on average overestimated. Exception is year ahead forecast for Japan produced by MF. Forecasts of MF for Japan were on average a little underestimated.

In this respect is remarkable year ahead mean error in case of Slovakia. Almost zero value in case of all organizations (see Table A. 7 in Annex) would signify that organizations perfectly forecasted year ahead real GDP growth for Slovakia. But looking on other summary statistics discloses that it was just coincidence and forecast errors summed up on zero. Having the most volatile real GDP growth development, non-percentage forecasts for Slovakia are the least accurate in chosen sample of countries. On the other hand, mean absolute percentage error for Slovak forecasts belongs to the lowest among all organizations.

Table 5. Mean error statistic

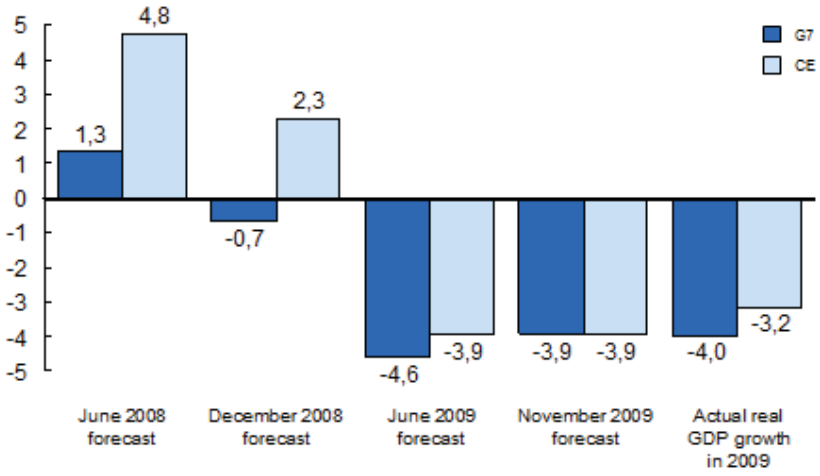
-	negative value of mean error (overestimation)
+	positive value of mean error (underestimation)

	OECD		IMF		EC		MF	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
CR	+	-	+	-	+	-	+	-
France	-	-	-	-	-	-	-	-
Germany	-	-	+	-	-	-	-	-
Hungary	-	-	-	-	-	-	-	-
Japan	-	-	+	-	-	-	+	+
Poland	+	-	+	-	+	-	+	-
Slovakia	+	-	+	-	+	-	+	-
UK	-	-	-	-	-	-	-	-
USA	-	-	+	-	-	-	-	-
G7	-	-	-	-	-	-	-	-
CE	+	-	+	-	+	-	+	-

Source: Author's calculations

Next common thing is that neither of organizations had forecasted the 2009 recession before it actually appeared. EC and IMF forecasted negative real GDP values for 2009 for few countries already in October 2008 publication, but the numbers were still overestimated and forecast error high. The same applies for OECD Economic Outlook published in December 2008. OECD even in December 2008 publication forecasted positive 4% real GDP growth for Slovakia in 2009. The actual value for Slovak real GDP growth in 2009 is -4.7%. MF began forecasting negative numbers for 2009 real GDP growth in its 2009 spring publication. This time horizon could hardly do for users of forecasts.

Figure 3. Real GDP growth in 2009
Forecast averages and actual value.



Source: Author, based on data from OECD Economic Outlook

The high mean absolute percentage error in case of Germany, which reaches more than 400% by all forecasters, is also worth mentioning (see Table 6). It was caused by a large forecast error in the beginning of 21st century, when forecasters predicted growth, but German economy rather stagnated. In addition, forecast errors during the 2009 recession were also large.

Table 6. Mean absolute percentage error

	OECD		IMF		EC		MF	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
CR	22	52	24	59	27	60	24	58
France	54	144	49	202	48	136	64	212
Germany	70	402	84	475	74	405	86	447
Hungary	47	115	43	96	37	90	53	106
Japan	96	183	97	157	197	410	88	136
Poland	33	84	41	100	43	98	39	95
Slovakia	13	42	16	47	16	41	24	52
UK	16	51	19	61	23	66	27	65
USA	9	54	13	51	60	181	16	66
G7	49	167	52	189	81	239	56	186
CE	28	73	31	75	31	72	35	78

Source: Author's calculations

Except Japan sign of real GDP growth was correctly forecasted in more than 75% cases for all countries. It holds both for current year and year ahead forecasts. This statistic is remarkable in case of Poland. Forecasters in the beginning of 2009 expected that Poland would also fall into recession. But Poland sustained growth and thus current year forecast sign accuracy is 95%, while year ahead sign accuracy is 100%. In the 2000-2009 period, the real GDP growth was positive most of the time. Having 9 countries and 10 actual values for each country, only 10 out of 90 observations were negative. It was quite easy to forecast the sign of real GDP growth. Forecasters were wrong mainly in the recession year 2009.

Current year forecasts for all countries are better than naïve no-change forecast. All Theil's U1 coefficients are lower than 0.3, which can be interpreted as high forecasting power. Theil's U2 coefficients are lower than 1. In case of year ahead forecasts comparison with naïve forecast is worse. U2 coefficient for some countries is higher than 1, thus it would be more reasonable to use no-change forecast. In the recession period 2008-2009, U2 coefficient is higher than 1 for all countries except Poland.

7.3 Performance of individual organizations

7.3.1 Performance of OECD

Current year real GDP growth forecasts of OECD were on average overrated for France, Germany, Hungary, Japan, and the United Kingdom. Forecasts for the Czech Republic and

Slovakia were underrated and forecasts for Poland and the USA approximately summed up on zero.

Table 7. Selected summary statistics, OECD

	ME		MSE		RMSE		MAE		MAPE	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
CR	0.3	-0.5	0.9	8.9	1.0	3.0	0.8	2.1	22	52
France	-0.1	-1.0	0.2	2.3	0.5	1.5	0.3	1.1	54	144
Germany	-0.1	-1.2	0.4	4.8	0.6	2.2	0.4	1.7	70	402
Hungary	-0.2	-1.6	0.5	7.7	0.7	2.8	0.5	1.8	47	115
Japan	-0.1	-0.8	1.1	6.3	1.0	2.5	0.8	1.8	96	183
Poland	0.0	-0.3	1.1	4.1	1.1	2.0	0.8	1.8	33	84
Slovakia	0.6	-0.1	0.8	13.3	0.9	3.7	0.7	2.3	13	42
UK	-0.1	-0.8	0.1	3.5	0.4	1.9	0.3	1.1	16	51
USA	0.0	-0.6	0.1	1.7	0.2	1.3	0.2	0.9	9	54
G7	-0.1	-0.9	0.4	3.7	0.5	1.9	0.4	1.3	49	167
CE	0.2	-0.6	0.8	8.5	0.9	2.9	0.7	2.0	28	73

Source: Author's calculations using OECD Economic Outlook data

Year ahead forecasts of OECD beat naïve no-change forecasts for all countries. U2 coefficient is lower than 1, but in case of Japan and Germany only little is missing to threshold value of 1.

Sign accuracy is lower than 80% only for Japan in current year and year ahead forecasts. Directional accuracy is for current year forecasts good for every country. Year ahead forecasts are directionally inaccurate in case of Hungary and Japan.

In recession period 2008-2009 are current year forecasts 100% sign correct for all countries except Japan (50%) and Poland (75%). All year ahead forecasts are sign correct less than 80% of time except Poland (100%). Directional accuracy of current year forecasts is full 100% for all countries except Hungary (50%). Poor current year directional accuracy in case of Hungary was caused by the fact that OECD forecasted accelerating GDP growth in 2008, while it actually began to slow down as the recession was coming. Directionally inaccurate are year ahead forecasts for France, Hungary, Japan, and the USA.

7.3.2 Performance of IMF

IMF current year forecast is on average overestimated for France, Hungary, and the United Kingdom. As was already mentioned, year ahead forecasts for all countries are on average overestimated.

Table 8. IMF summary statistics

	ME		MSE		RMSE		MAE		MAPE	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
CR	0.4	-0.5	1.1	10.9	1.1	3.3	0.9	2.4	24	59
France	-0.2	-1.2	0.2	2.4	0.4	1.5	0.3	1.2	49	202
Germany	0.0	-1.3	0.3	5.8	0.6	2.4	0.4	1.9	84	475
Hungary	-0.4	-1.8	1.0	10.3	1.0	3.2	0.8	2.0	43	96
Japan	0.1	-0.8	1.2	6.1	1.1	2.5	0.9	1.7	97	157
Poland	0.1	-0.5	1.3	5.1	1.1	2.3	0.9	1.9	41	100
Slovakia	0.6	-0.1	1.6	16.7	1.3	4.1	1.0	2.7	16	47
UK	-0.2	-0.9	0.2	4.3	0.4	2.1	0.3	1.3	19	61
USA	0.1	-0.7	0.1	1.6	0.4	1.3	0.3	0.9	13	51
G7	0.0	-1.0	0.4	4.1	0.6	2.0	0.5	1.4	52	189
CE	0.2	-0.7	1.2	10.8	1.1	3.2	0.9	2.3	31	75

Source: Author's calculations based on IMF World Economic Outlook data

In case of year ahead prediction for Germany the naïve no-change forecast outperform forecast produced by IMF. For other countries current year and year ahead forecasts of IMF are superior to naïve no-change forecast.

Current year sign accuracy is full 100% for all countries except Germany (90%), Japan (75%), and Poland (95%). Year ahead sign accuracy is higher than 80% for all countries except Japan (67%). Directional accuracy is higher than 50% for all countries for current year. Year ahead forecasts directional accuracy is lower than 50% or equal for the Czech Republic (38%), France (33%), Hungary (39%), and Slovakia (50%).

In recession period 2008-2009, current year forecasts are 100% sign correct for all countries except Japan (50%) and Poland (75%). In case of year ahead forecasts have all forecasts correct sign in less than 80% of time. Only Poland has 100% year ahead sign accuracy, because it did not fall in recession. Directional accuracy of current year forecasts is full 100% for all countries except Hungary (50%). For year ahead forecasts is directional accuracy lower than 50% or equal in case of the Czech Republic (50%), France (25%), Hungary (0%), and Japan (50%).

7.3.3 Performance of European Commission

Current year forecasts of EC for France, Germany, Hungary, Japan, the United Kingdom, and the USA were on average overestimated. Underestimated were forecasts for the Czech Republic, Poland and Slovakia.

Table 9. EC summary statistics

	ME		MSE		RMSE		MAE		MAPE	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
CR	0.2	-0.7	1.3	9.5	1.2	3.1	1.0	2.3	27	60
France	-0.2	-1.1	0.3	2.3	0.5	1.5	0.4	1.2	48	136
Germany	-0.1	-1.1	0.3	4.9	0.6	2.2	0.4	1.8	74	405
Hungary	-0.3	-1.7	0.4	9.3	0.7	3.1	0.5	2.0	37	90
Japan	-0.1	-0.8	0.7	4.8	0.9	2.2	0.7	1.7	197	410
Poland	0.1	-0.6	1.6	4.3	1.3	2.1	0.9	1.9	43	98
Slovakia	0.6	-0.1	1.3	13.4	1.2	3.7	0.9	2.3	16	41
UK	-0.2	-1.0	0.2	3.6	0.5	1.9	0.4	1.2	23	66
USA	-0.2	-0.7	0.3	2.4	0.6	1.6	0.4	1.2	60	181
G7	-0.2	-0.9	0.4	3.6	0.6	1.9	0.5	1.4	81	239
CE	0.2	-0.8	1.2	9.1	1.1	3.0	0.8	2.1	31	72

Source: Author's calculations using EC European Economic Forecast data

Naïve no-change forecast outperformed year ahead forecasts of EC for France, Germany, Hungary, and Japan. Value of U2 coefficient for the United Kingdom is 0.99 and thus no-change forecast can be considered as equally accurate.

Sign accuracy of current year forecasts is lower than 80% only for Japan. Sign accuracy of year ahead forecasts is poor for Germany and Japan. Directional accuracy is fair for current year forecasts for every country. Year ahead forecasts are directionally inaccurate in case of the Czech Republic, France, Hungary, and Japan.

Recession 2008-2009 current year forecasts are 100% sign accurate except Japan (50%) and Poland (75%). Only year ahead sign accurate forecasts are those for Poland. Current year forecasts 100% directional accuracy holds for all countries except Hungary (50%). Directionally accurate are year ahead forecasts for Germany, Poland, Slovakia, and United Kingdom.

7.3.4 Performance of the Ministry of Finance of the Czech Republic

Current year forecasts of MF were on average overestimated for France, Germany, Hungary and the United Kingdom.

Relatively small values of evaluating statistics in case of Japan are caused by the fact that MF removed Japan from forecasting exercise in 2009. In years 2008 and 2009 when

other organizations had the biggest errors MF data for Japan are missing. From this reason I do not consider MF as the best forecaster for Japan, although MF has the best results of evaluating statistics for Japan.

Naïve no-change forecast would do better in forecasting year ahead real GDP growth of Germany. Other forecasts of MF outperform no-change forecasts.

Table 10. MF summary statistics

	ME		MSE		RMSE		MAE		MAPE	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
CR	0.2	-0.5	1.1	10.7	1.1	3.3	0.9	2.3	24	58
France	-0.2	-1.2	0.3	2.8	0.5	1.7	0.4	1.3	64	212
Germany	-0.2	-1.4	0.3	6.6	0.6	2.6	0.4	1.9	86	447
Hungary	-0.5	-1.9	1.2	12.0	1.1	3.5	0.8	2.1	53	106
Japan	0.1	0.1	1.0	1.9	1.0	1.4	0.8	1.1	88	136
Poland	0.2	-0.5	1.5	4.8	1.2	2.2	0.9	2.0	39	95
Slovakia	0.6	0.0	2.0	19.5	1.4	4.4	1.2	3.0	24	52
UK	-0.2	-1.1	0.4	5.1	0.6	2.3	0.5	1.4	27	65
USA	0.0	-0.8	0.2	2.8	0.4	1.7	0.3	1.2	16	66
G7	-0.1	-0.9	0.4	3.8	0.6	1.9	0.5	1.4	56	186
CE	0.1	-0.7	1.5	11.8	1.2	3.3	0.9	2.3	35	78

Source: Author's calculations using MF Macroeconomic Forecast data

Both current year and year ahead forecasts of MF are sign accurate almost for all countries. A little bit under 80% threshold are only Germany (78%) and Japan (79%). Current year forecasts are directionally inaccurate for Japan (50%) and year ahead for the Czech Republic, France, Hungary, Japan, and Slovakia.

In recession period 2008-2009 current year forecasts were sign inaccurate only for Poland. On the other hand Poland was the only country, for which were year ahead forecasts sign accurate. Directional accuracy of current year forecasts was under 55% for Hungary (50%) and directional accuracy of year ahead forecasts for the Czech Republic, France, Hungary, and USA.

7.4 Comparison of performance

Forecasts of OECD should outperform forecasts of all other organizations because of the date of release. OECD Economic outlook is released latest from publications of examined organizations and thus OECD can utilize more information during the forecasting exercise. The difference in date of release is not large, but in case that

unexpected event should happen in the meantime, it can save huge amount of forecast error.

Table 11 shows that OECD really is the best forecaster for most countries. IMF was the best in far less indicators and in case of 2 indicators EC was the best forecaster. MF did not succeed in any of the examined countries and indicators.

Table 11. Best forecasters in the whole period 2000-2010

	Sum of summary statistics	Sum of Theil's coefficients	Sum of percentages of directional accuracy and sign correct forecasts
CR	OECD	OECD	OECD
France	OECD	IMF	OECD
Germany	EC	OECD	OECD
Hungary	OECD	OECD	OECD
Japan	OECD	OECD	OECD
Poland	OECD	IMF	OECD
Slovakia	OECD	OECD	EC
UK	OECD	OECD	OECD
USA	OECD	IMF	IMF and OECD

Source: Author's calculations

In period 2008-2009, which address the 2009 recession, OECD again confirmed its information advantage and appeared the best forecaster in most countries and for most indicators (see Table 12). OECD was not as superior in this period as in the whole 2000-2010. In many cases, IMF was also the best forecaster. In few cases did it pay off to use forecasts of EC. In case of one indicator for Poland, the best forecasts was provided by MF (by this indicator were the same accurate also forecasts of IMF).

The forecasts of MF for the Czech Republic were not better than forecasts of other organizations. The conducted analysis even displays that other organizations have done better in forecasting real GDP growth for the Czech Republic. It did not prove that access to local information has advantageous effect on doing real GDP growth forecasts.

Not even the period 2008-2009 confirmed superiority of home organization forecasts. For the Czech Republic were the best forecasters IMF and OECD. The users of forecasts for the Czech Republic can easily rely on forecasts of OECD or IMF and should not waste time on chasing individual forecast for the Czech Republic from the MF.

Table 12. Best forecasters in period 2008-2009

	Sum of summary statistics	Sum of Theil's coefficients	Sum of percentages of directional accuracy and sign correct forecasts
CR	IMF	IMF	OECD
France	IMF	IMF	OECD
Germany	IMF	IMF	IMF
Hungary	EC	EC	OECD
Japan	EC	EC	IMF, EC and OECD
Poland	OECD	OECD	IMF and MF
Slovakia	OECD	OECD	IMF, EC and OECD
UK	OECD	OECD	IMF, EC and OECD
USA	OECD	OECD	IMF, EC and OECD

Source: Author's calculations

MF forecasted the recession in 2009, i.e., the latest from all organizations. Other organizations forecasted negative real GDP growth numbers for few countries already in 2008. MF began forecasting negative numbers in 2009.

There is a question, what causes higher absolute value forecast error in case of Central European economies: is it unfamiliarity of supranational organizations with local conditions in non-G7 countries or is it only the subject of higher volatility in real GDP growth development? Conducted analysis suggests that the second option is correct. Japan as a G7 member had in the examined period very volatile economic development. It did not prove in standard error, but the GDP was accelerating and decelerating in case of Japan more often than in case of other countries. Summary statistics of Japan was close to values of CE countries and directional and sign accuracy was even worse. In comparison with naïve forecast Japan was one of the countries with the highest values.

As was already mentioned, it has to be pointed out that these results can be applied only on examined countries in given period. In other period or for other countries the results could be completely different and the best forecaster could be other organization.

8 Conclusions

This thesis describes the issue of real GDP growth forecasting. On a sample of nine countries predictive performance of four organizations in period between 2000 and 2010 was shown.

In absolute terms, forecasts for examined G7 countries are more accurate than forecasts for Central European countries. Economic development of Central European countries was more volatile and thus forecasting more difficult. But taking into account percentage error, forecasts for Central European countries are comparably accurate and in some cases even more accurate than forecasts for G7 countries.

Results show that some prediction series are outperformed by naïve forecasts. In case of year ahead forecast it would be better for some countries to use naïve forecast. It proved more during the 2009 recession, when naïve forecast exceeded year ahead forecasts for all countries that fell in recession. Poland did not fall into recession and also in 2008-2009 period forecasts for Poland outperformed naïve forecast. Forecasts for current year outperform naïve no-change forecast.

It turned out that sign of real GDP growth was correctly forecasted in 98% of current year cases and in 90% of year ahead cases. Directional accuracy was lower and highly depended on volatility of period.

Few dare to forecast negative numbers at time when last forecasts were positive. Recession in 2009 was first forecasted in autumn 2008 forecasts release only for few countries. Range of recession was not forecasted before 2009.

For recession period 2008-2009 holds that current year forecast was rather accurate, but one year ahead forecast did not anticipate the recession at all. For Central European countries the forecast errors were very high, for G7 countries only little bit lower.

In case of the Ministry of Finance of the Czech Republic my analysis did not show that local authority is doing better in forecasting real GDP growth. Forecasts of OECD were more accurate almost in all performed indicators and forecasts of other organizations were never considerably worse. This suggests that knowledge of local conditions in the Czech Republic is on good level in supranational organizations and higher error in case of Central European countries is arguably caused by large volatility of level of economic activity than lack of information.

This thesis can be extended in a number of ways. Forecast error investigation can be expanded by efficiency and bias tests. More countries, longer period, and other key macroeconomic variables can be used in analysis. Also, it would be fruitful to gather data from more national authorities and examine the hypothesis whether their forecasts for home country are more accurate than forecasts of supranational organizations, which however seems not to be the case of MF.

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Annex

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Evaluation criteria in whole period 2000-2010

Table A. 1 Czech Republic

	ME		MSE		RMSE		MAE		MAPE	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	0.3	-0.5	0.9	8.9	1.0	3.0	0.8	2.1	22	52
IMF	0.4	-0.5	1.1	10.9	1.1	3.3	0.9	2.4	24	59
EC	0.2	-0.7	1.3	9.5	1.2	3.1	1.0	2.3	27	60
MF	0.2	-0.5	1.1	10.7	1.1	3.3	0.9	2.3	24	58

	Theil's U1		Theil's U2		PSC		PDA	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	0.11	0.36	0.22	0.66	100	89	75	56
IMF	0.12	0.39	0.23	0.71	100	88	56	38
EC	0.14	0.38	0.26	0.72	100	89	75	50
MF	0.13	0.39	0.24	0.72	100	89	70	33

Source: Author's calculations

Table A. 2 France

	ME		MSE		RMSE		MAE		MAPE	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	-0.1	-1.0	0.2	2.3	0.5	1.5	0.3	1.1	54	144
IMF	-0.2	-1.2	0.2	2.4	0.4	1.5	0.3	1.2	49	202
EC	-0.2	-1.1	0.3	2.3	0.5	1.5	0.4	1.2	48	136
MF	-0.2	-1.2	0.3	2.8	0.5	1.7	0.4	1.3	64	212

	Theil's U1		Theil's U2		PSC		PDA	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	0.12	0.38	0.24	0.85	100	94	85	56
IMF	0.11	0.38	0.22	0.87	100	89	90	33
EC	0.13	0.40	0.28	0.91	100	89	95	50
MF	0.12	0.41	0.26	0.96	100	89	95	28

Source: Author's calculations

Table A. 3 Germany

	ME		MSE		RMSE		MAE		MAPE	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	-0.1	-1.2	0.4	4.8	0.6	2.2	0.4	1.7	70	402
IMF	0.0	-1.3	0.3	5.8	0.6	2.4	0.4	1.9	84	475
EC	-0.1	-1.1	0.3	4.9	0.6	2.2	0.4	1.8	74	405
MF	-0.2	-1.4	0.3	6.6	0.6	2.6	0.4	1.9	86	447

	Theil's U1		Theil's U2		PSC		PDA	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	0.13	0.53	0.26	1.00	90	83	90	67
IMF	0.12	0.57	0.25	1.01	90	83	90	56
EC	0.12	0.58	0.24	1.08	90	78	90	67
MF	0.13	0.62	0.26	1.17	90	78	80	61

Source: Author's calculations

Table A. 4 Hungary

	ME		MSE		RMSE		MAE		MAPE	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	-0.2	-1.6	0.5	7.7	0.7	2.8	0.5	1.8	47	115
IMF	-0.4	-1.8	1.0	10.3	1.0	3.2	0.8	2.0	43	96
EC	-0.3	-1.7	0.4	9.3	0.7	3.1	0.5	2.0	37	90
MF	-0.5	-1.9	1.2	12.0	1.1	3.5	0.8	2.1	53	106

	Theil's U1		Theil's U2		PSC		PDA	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	0.09	0.37	0.19	0.77	100	94	75	39
IMF	0.13	0.43	0.26	0.86	100	89	65	39
EC	0.08	0.42	0.17	0.84	100	89	70	39
MF	0.14	0.46	0.28	0.94	100	89	60	39

Source: Author's calculations

Table A. 5 Japan

	ME		MSE		RMSE		MAE		MAPE	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	-0.1	-0.8	1.1	6.3	1.0	2.5	0.8	1.8	96	183
IMF	0.1	-0.8	1.2	6.1	1.1	2.5	0.9	1.7	97	157
EC	-0.1	-0.8	0.7	4.8	0.9	2.2	0.7	1.7	197	410
MF	0.1	0.1	1.0	1.9	1.0	1.4	0.8	1.1	88	136

	Theil's U1		Theil's U2		PSC		PDA	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	0.09	0.37	0.19	0.77	100	94	75	39
IMF	0.13	0.43	0.26	0.86	100	89	65	39
EC	0.08	0.42	0.17	0.84	100	89	70	39
MF	0.14	0.46	0.28	0.94	100	89	60	39

Source: Author's calculations

Table A. 6 Poland

	ME		MSE		RMSE		MAE		MAPE	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	0.0	-0.3	1.1	4.1	1.1	2.0	0.8	1.8	33	84
IMF	0.1	-0.5	1.3	5.1	1.1	2.3	0.9	1.9	41	100
EC	0.1	-0.6	1.6	4.3	1.3	2.1	0.9	1.9	43	98
MF	0.2	-0.5	1.5	4.8	1.2	2.2	0.9	2.0	39	95

	Theil's U1		Theil's U2		PSC		PDA	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	0.13	0.24	0.25	0.47	95	100	100	61
IMF	0.14	0.27	0.27	0.41	95	100	80	78
EC	0.15	0.25	0.30	0.51	95	100	75	67
MF	0.15	0.26	0.29	0.52	95	100	80	67

Source: Author's calculations

Table A. 7 Slovakia

	ME		MSE		RMSE		MAE		MAPE	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	0.6	-0.1	0.8	13.3	0.9	3.7	0.7	2.3	13	42
IMF	0.6	-0.1	1.6	16.7	1.3	4.1	1.0	2.7	16	47
EC	0.6	-0.1	1.3	13.4	1.2	3.7	0.9	2.3	16	41
MF	0.6	0.0	2.0	19.5	1.4	4.4	1.2	3.0	24	52

	Theil's U1		Theil's U2		PSC		PDA	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	0.08	0.32	0.15	0.58	100	89	85	56
IMF	0.11	0.34	0.20	0.63	100	88	78	50
EC	0.10	0.34	0.19	0.62	100	89	85	67
MF	0.13	0.38	0.24	0.70	95	89	70	39

Source: Author's calculations

Table A. 8 United Kingdom

	ME		MSE		RMSE		MAE		MAPE	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	-0.1	-0.8	0.1	3.5	0.4	1.9	0.3	1.1	16	51
IMF	-0.2	-0.9	0.2	4.3	0.4	2.1	0.3	1.3	19	61
EC	-0.2	-1.0	0.2	3.6	0.5	1.9	0.4	1.2	23	66
MF	-0.2	-1.1	0.4	5.1	0.6	2.3	0.5	1.4	27	65

	Theil's U1		Theil's U2		PSC		PDA	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	0.07	0.36	0.13	0.68	100	94	95	83
IMF	0.08	0.40	0.16	0.75	100	94	100	72
EC	0.09	0.38	0.18	0.73	100	94	90	67
MF	0.12	0.43	0.23	0.82	100	89	90	78

Source: Author's calculations

Table A. 9 USA

	ME		MSE		RMSE		MAE		MAPE	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	0.0	-0.6	0.1	1.7	0.2	1.3	0.2	0.9	9	54
IMF	0.1	-0.7	0.1	1.6	0.4	1.3	0.3	0.9	13	51
EC	-0.2	-0.7	0.3	2.4	0.6	1.6	0.4	1.2	60	181
MF	0.0	-0.8	0.2	2.8	0.4	1.7	0.3	1.2	16	66

	Theil's U1		Theil's U2		PSC		PDA	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	0.04	0.23	0.08	0.47	100	94	95	78
IMF	0.06	0.22	0.11	0.39	100	89	95	83
EC	0.09	0.31	0.19	0.62	100	94	80	72
MF	0.07	0.29	0.15	0.59	100	89	80	83

Source: Author's calculations

Evaluation criteria in recession period 2008-2009

Table A. 10 Czech Republic

	ME		MSE		RMSE		MAE		MAPE	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	-0.7	-4.9	1.4	32.7	1.2	5.7	0.9	4.9	32	130
IMF	-0.6	-4.7	0.5	34.0	0.7	5.8	0.7	4.7	19	118
EC	-1.2	-5.4	2.7	38.5	1.7	6.2	1.6	5.4	54	151
MF	-1.0	-5.2	2.1	38.8	1.5	6.2	1.4	5.2	39	130

	Theil's U1		Theil's U2		PSC		PDA	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	0.15	0.73	0.34	1.63	100	50	100	75
IMF	0.09	0.72	0.20	1.54	100	50	100	50
EC	0.22	0.77	0.49	1.83	100	50	100	50
MF	0.18	0.74	0.39	1.67	100	50	100	50

Source: Author's calculations

Table A. 11 France

	ME		MSE		RMSE		MAE		MAPE	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	-0.5	-2.4	0.7	6.6	0.9	2.6	0.7	2.4	182	344
IMF	0.0	-2.2	0.3	5.4	0.5	2.3	0.4	2.2	38	164
EC	-0.4	-2.5	0.5	7.2	0.7	2.7	0.6	2.5	114	282
MF	-0.1	-2.5	0.4	7.0	0.6	2.7	0.5	2.5	52	184

	Theil's U1		Theil's U2		PSC		PDA	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	0.22	0.75	0.48	1.44	100	75	100	50
IMF	0.14	0.70	0.32	1.43	100	50	100	25
EC	0.18	0.76	0.38	1.45	100	50	100	50
MF	0.16	0.77	0.36	1.62	100	50	100	0

Source: Author's calculations

Table A. 12 Germany

	ME		MSE		RMSE		MAE		MAPE	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	0.0	-3.0	0.6	13.7	0.8	3.7	0.6	3.0	39	102
IMF	0.1	-3.1	0.2	15.4	0.5	3.9	0.4	3.1	18	82
EC	0.0	-3.2	0.2	15.6	0.5	3.9	0.5	3.2	23	95
MF	-0.5	-3.8	0.3	20.8	0.6	4.6	0.5	3.8	41	126

	Theil's U1		Theil's U2		PSC		PDA	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	0.10	0.72	0.22	1.05	100	75	100	75
IMF	0.06	0.77	0.13	1.08	100	75	100	100
EC	0.07	0.76	0.14	1.15	100	50	100	75
MF	0.08	0.83	0.16	1.27	100	50	100	75

Source: Author's calculations

Table A. 13 Hungary

	ME		MSE		RMSE		MAE		MAPE	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	-0.3	-4.7	1.3	29.2	1.1	5.4	1.1	4.7	170	368
IMF	-1.3	-5.5	3.1	40.6	1.8	6.4	1.5	5.5	126	269
EC	-0.8	-5.3	0.8	40.2	0.9	6.3	0.8	5.3	102	231
MF	-1.6	-6.0	4.5	47.9	2.1	6.9	1.9	6.0	195	325

	Theil's U1		Theil's U2		PSC		PDA	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	0.13	0.82	0.28	1.34	100	75	50	25
IMF	0.21	0.89	0.39	1.42	100	50	50	0
EC	0.09	0.88	0.19	1.33	100	50	50	0
MF	0.25	0.92	0.47	1.55	100	50	50	0

Source: Author's calculations

Table A. 14 Japan

	ME		MSE		RMSE		MAE		MAPE	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	-0.5	-4.2	2.4	21.0	1.6	4.6	1.3	4.2	137	239
IMF	-0.6	-4.3	1.8	22.2	1.3	4.7	1.1	4.3	138	200
EC	-0.6	-4.1	1.3	19.3	1.2	4.4	1.0	4.1	111	246
MF	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

	Theil's U1		Theil's U2		PSC		PDA	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	0.19	0.88	0.42	1.24	50	25	100	25
IMF	0.17	0.91	0.36	1.27	50	0	100	50
EC	0.15	0.84	0.31	1.19	50	25	100	25
MF	NA	NA	NA	NA	NA	NA	NA	NA

Source: Author's calculations

Table A. 15 Poland

	ME		MSE		RMSE		MAE		MAPE	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	0.3	-1.4	1.6	3.1	1.3	1.8	1.0	1.4	44	68
IMF	0.6	-1.4	1.7	3.0	1.3	1.7	1.0	1.4	50	75
EC	0.7	-1.6	2.5	4.0	1.6	2.0	1.1	1.6	56	85
MF	0.8	-1.8	3.3	4.4	1.8	2.1	1.3	1.8	67	91

	Theil's U1		Theil's U2		PSC		PDA	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	0.16	0.21	0.34	0.48	75	100	100	75
IMF	0.18	0.21	0.36	0.49	75	100	100	100
EC	0.21	0.23	0.43	0.53	75	100	100	75
MF	0.24	0.24	0.51	0.58	75	100	100	100

Source: Author's calculations

Table A. 16 Slovakia

	ME		MSE		RMSE		MAE		MAPE	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	-0.1	-5.4	0.7	48.6	0.9	7.0	0.8	5.4	14	112
IMF	-0.9	-5.6	1.9	53.1	1.4	7.3	0.9	5.6	18	118
EC	-0.6	-5.4	1.6	53.9	1.3	7.3	1.1	5.4	21	111
MF	-1.2	-6.7	3.2	69.2	1.8	8.3	1.6	6.7	30	138

	Theil's U1		Theil's U2		PSC		PDA	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	0.07	0.58	0.15	1.24	100	50	100	100
IMF	0.12	0.60	0.24	1.30	100	50	100	100
EC	0.11	0.62	0.23	1.30	100	50	100	100
MF	0.15	0.63	0.32	1.48	100	50	100	75

Source: Author's calculations

Table A. 17 United Kingdom

	ME		MSE		RMSE		MAE		MAPE	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	-0.5	-3.3	0.4	14.8	0.6	3.8	0.5	3.3	47	162
IMF	-0.6	-3.7	0.5	18.0	0.7	4.2	0.6	3.7	50	184
EC	-0.8	-3.5	0.7	16.4	0.9	4.1	0.8	3.5	66	199
MF	-1.1	-4.0	1.4	21.4	1.2	4.6	1.1	4.0	73	191

	Theil's U1		Theil's U2		PSC		PDA	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	0.09	0.72	0.18	1.10	100	75	100	75
IMF	0.10	0.78	0.20	1.21	100	75	100	75
EC	0.13	0.74	0.24	1.14	100	75	100	75
MF	0.18	0.82	0.33	1.30	100	50	100	75

Source: Author's calculations

Table A. 18 USA

	ME		MSE		RMSE		MAE		MAPE	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	0.0	-1.8	0.1	4.3	0.3	2.1	0.2	1.8	14	104
IMF	0.2	-2.0	0.2	4.7	0.4	2.2	0.4	2.0	30	110
EC	-0.4	-2.3	0.4	5.8	0.6	2.4	0.5	2.3	104	277
MF	0.0	-2.7	0.2	9.0	0.4	3.0	0.4	2.7	27	153

	Theil's U1		Theil's U2		PSC		PDA	
	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$	$\hat{y}_t$	$\hat{y}_{t-1}$
OECD	0.07	0.57	0.14	1.11	100	75	100	50
IMF	0.11	0.60	0.23	1.14	100	50	100	75
EC	0.15	0.67	0.32	1.25	100	75	100	50
MF	0.10	0.73	0.22	1.61	100	50	100	25

Source: Author's calculations