MINISTRY OF FINANCE
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MINISTRY OF FINANCE
WORKING PAPERS

COMPOSITE LEADING INDICATORS: A CONTRIBUTION TO THE ANALYSIS OF THE CZECH BUSINESS CYCLE

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No. 1/2011
ISSN 1804-8056

Composite Leading Indicators: A Contribution to the Analysis of the Czech Business Cycle

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August 2011

Abstract

This paper reviews two approaches to short-term forecasting of macroeconomic variables. First, it outlines the methodology for constructing non-model based composite leading indicators that are used for predicting turning points in the business cycle. Second, it discusses time series models often employed to forecast actual values of macroeconomic variables. Composite leading indicators with 6 months, 5 months, 4 months, and 3 months respective leads are presented. The presence of variables related to the external environment, especially Germany, in these indices confirm the hypothesis that these variables should be useful for tracking the Czech business cycle. A parsimonious specification of a single equation model is able to produce satisfactory 1-quarter-ahead forecasts of quarterly real GDP growth in the Czech Republic. To address the variable selection problem and the multicollinearity problem inherent in single equation models with observed variables, principal components are used to estimate a few latent factors in the spirit of Dynamic Factor Models. The results show that this approach is also useful in predicting quarterly real GDP growth 1-quarter-ahead, although it fails to predict the turbulent dynamics in the first half of 2009.

Keywords: Composite Leading Indicators, Short-Term Forecasting, Principal Components, Czech Business Cycle.

Abstrakt

Studie prezentuje dva přístupy k predikci makroekonomických veličin. První část studie se věnuje metodě předstihových kompozitních indikátorů, které se používají k identifikaci bodů zvratu v hospodářském cyklu. Předstihové indikátory s 6, 5, 4 a 3 měsíčním předstihem jsou sestaveny. Přítomnost veličin vztahujících se k externímu prostředí, především k Německu, potvrzuje hypotézu, že tyto proměnné by měly být užitečné pro mapování českého hospodářského cyklu. Druhá část studie se zabývá konstrukcí regresních modelů pro predikci hodnot makroekonomických veličin. Poměrně jednoduché jednorovnicové modely jsou schopny uspokojivě predikovat reálný růst HDP jedno čtvrtletí dopředu. Protože jednorovnicové modely trpí problémem výběru proměnných a multikolinearitou, je též použita metoda základních komponent ve smyslu dynamických faktorových modelů. Výsledky ukazují, že tento postup je užitečný pro predikci reálného růstu HDP jedno čtvrtletí dopředu, i přesto že nedokáže předpovědět turbolentní růstovou dynamiku v první polovině roku 2009.

Klíčová slova: kompozitní předstihové indikátory, krátkodobá predikce, základní komponenty, český hospodářský cyklus.

JEL classification: E32, E37.

The paper was reviewed on August 1, 2011 by:

Marie Hörmannová	Czech Statistical Office,
Miroslav Kalous	Czech National Bank,
Vít Pošta	Ministry of Finance of the Czech Republic.

The author wishes to thank the above mentioned referees for their helpful comments and suggestions for further research.

The views expressed in the paper do not necessarily reflect those of the Ministry of Finance of the Czech Republic. All errors are my own.

Contents

1 Introduction

Short-term forecasting of crucial macroeconomic variables belongs to the standard toolbox of modern macroeconomic policy making. The number of time series covering different sectors of the economy recorded by statistical agencies is quite large. Not surprisingly, a considerable amount of information about future economic development can be extracted from the wealth of data that is now available. In particular, there exist a number of time series that record information about early stage of the production process, expectations of economic agents, foreign demand, etc. that all predetermine the actual trajectory of the economy in the near future. There are a number of techniques that are utilized to extract the early information that is useful in predicting the future movement in aggregate economic activity.

This study reviews and applies two related approaches to short-term forecasting. Non-model based composite leading indicators identify turning points in the business cycle. Time series models are used for forecasting actual values of macroeconomic variables. In this paper, I forecast quarterly real GDP growth. While composite leading indicators popular for their simplicity and ease of interpretation are able to track the business cycle quite well, they are only able to identify turning points in the cycle. They provide useful but not sufficient information about the economy. For central banks and central government institutions like the Ministry of Finance, it is also important to be able to predict levels of macroeconomic variables, especially GDP. Various time series models are employed for this purpose. Unfortunately, not all methods can be fruitfully used for forecasting in the Czech context due to a still relatively short time span of macroeconomic time series. The 1990s were a period of radical changes in the structure of the economy and using data from that period is always problematic. In addition, interesting variables for short-term forecasting such as new industry orders or industry revenues are only available since 2000. Due to these limitations, I constrain the empirical exercises in this paper to the 2000-2010 period. In light of the fact that the Czech economy is characterized as small and open, to a large extent dependent on the economic development in Germany, I investigate variables related to the external environment for their predictive properties.

In the non-model based section, I present composite leading indicators with 6 months, 5 months, 4 months, and 3 months respective leads. The variables that enter the indicators fall foremost in the early stage of production and expectation sensitive categories of variables suitable for construction of composite leading indicators. The presence of variables related to the external environment, especially Germany, confirm the hypothesis that these variables should be useful for tracking the Czech business cycle.

Models designed to forecast quarterly real GDP growth are twofold. First, I consider simple single equation models that employ a handful of time series as explanatory variables. The well-known shortcoming of these models is that they must be kept quite

simple due to sample size concerns. In addition, the explanatory variables suitable for forecasting quarterly real GDP are all by definition related to the business cycle and thus multicollinearity is a big problem. Given the vast number of series that can potentially enter these models, variable selection is also a very significant challenge. Despite these disadvantages, some parsimonious specifications can deliver quite good 1-step-ahead forecasts as is shown in the empirical section on single equation models.

The most recent trend in short-term macroeconomic forecasting that has delivered satisfactory results in the literature is the use of principal components as a dimension reduction technique. The idea behind this approach is that a large number of time series, all potentially including useful information about the economy, can be reduced to a handful of latent factors that can then be used in regression models in place of the original variables. It has been shown that these latent factors can be estimated by principal components. In line with the literature, I also uncover that principal components models are useful in short-term forecasting of GDP growth.

The paper is organized as follows. Section 2 reviews the existing literature. The methodology used for constructing non-model based composite leading indicators and for building time series models for short-term forecasting is outlined in Section 3. Section 4 presents the empirical application of the considered models to the Czech business cycle and to predicting quarterly real GDP growth. Section 5 concludes.

2 Brief Review of the Existing Literature

The literature on building, use, and forecasting ability of composite leading indicators and on short-term macroeconomic forecasting is very rich. For an excellent comprehensive review of this literature, please consult Marcellino (2006). More than 70 years have passed since Burns and Mitchell started to work on constructing their composite leading indicator for the US economy in the 1930s at the NBER (Marcellino, 2006). The development of new econometric techniques and ever increasing computing power have significantly broadened the array of methods available for model building and forecast evaluation.

Despite these advances, composite leading indicators in the original NBER tradition still remain the starting point in business cycle modelling due to their simplicity and ease of interpretation. Moore (1983) notes that the composite leading indicator will never perfectly follow the path of the business cycle, but that it nevertheless remains a useful predictor of aggregate movements in the US economy. Auerbach (1981) states that the US composite leading indicator is strongly significant in predicting cyclical variables. Meanwhile, Diebold and Rudebusch (1991) warn that the predictive ability of the composite leading indicator is diminished if preliminary and partially revised

data is used for evaluating predictive ability. Fichtner et al. (2009) show that the outside environment is ever more important for accurately predicting economic activity. The lesson of their paper is that variables from the outside environment should enter a composite leading indicator for a small and open economy. Although they must be interpreted with caution, non-model composite leading indicators still provide very valuable information about the cyclical behavior of the economy. All the necessary techniques for constructing these indices can be found in OECD (2008a).

Time series forecasting methods for predicting macroeconomic time series for the euro area and for the new EU Member States are used in a pair of related papers by Marcellino et al. (2003) and Banerjee et al. (2004). Autoregressive models, single equation models with exogenous variables, vector autoregressions, and single equation models based on principal components are used for forecasting. The last set of models using principal components is a static version of Dynamic Factor Models (DFM) that have proved increasingly popular in recent years.

In particular, Stock and Watson (2002) showed that Dynamic Factor Models can be approximated by static representations estimated by principal components. I take advantage of this approach in this paper as well and briefly outline the derivation of the static representation of the DFM model presented in Stock and Watson (2002) in the methodology section below. Artis et al. (2005) use the DFM model to predict prices, real aggregates, and financial variables and find that the factor models improve the forecasts as compared to more traditional time series methods. Matheson (2011) also uses a variant of the DFM model for forecasting GDP growth for advanced and emerging countries and arrives at similar results as Artis et al. (2005), namely that the DFM model produces good GDP growth forecasts relative to a range of time series models.

Studies dealing with composite leading indicators and short-term forecasting for the Czech Republic include the following. Czesaný and Jeřábková (2009) construct leading, coincident, and lagging composite leading indicators. The component series that they suggest to include in the composite leading indicator are Labour Productivity in Industry, Change in Inventories, Exports of Goods and Services, Gross Value Added in Industry, EU-15 GDP, Interest Rate Spread, Index of Industrial Production, and the Composite Confidence Indicator. Pošta and Valenta (2011) construct a composite leading indicators with 3 months and 5 months respective leads using business surveys. From the short-term forecasting literature, Banerjee et al. (2004) predict GDP growth, inflation, and interest rates using standard time series methods and the factor model. They note that factor models produce better results than other forecasting methods. Arnoštova et al. (2010) forecast quarterly GDP up to 3 quarters ahead by averaged vector autoregressions, bridged equations, two versions of a principal components model, a Kalman smoother dynamic factor model, and a generalized dynamic factor model. The standard principal components model is the best up to 3 quarters ahead. At the shortest horizon, ČNB's historical forecasts performed better than the principal com-

ponents model.

3 Methodology

3.1 Non-Model Based Composite Leading Indicators

Despite its frequent criticism as "measurement without theory" the non-model based methodology for constructing composite leading indicators pioneered by Burns and Mitchell in the 1930s remains a principal point of reference for constructing composite leading indicators of the business cycle. The Conference Board and the OECD publish non-model based leading indices of economic activity for the U.S. and OECD member countries, respectively. The undeniable advantage of the non-model based approach is its simplicity that make the indices easy to construct and easy to understand by policy makers as well as the general public.

The first step in constructing a composite leading indicator is to choose a reference series that conforms well to the business cycle and that is timely available, ideally on a monthly basis, without major revisions in the future. The OECD uses the Index of Industrial Production as the reference series for constructing composite leading indicators for the member countries (OECD, 2008b). However, using the index of industrial production as a single coincident indicator is not without problems as it covers a relatively small fraction of GDP in the service oriented economies of the developed nations. Other variables such as the volume of sales of the manufacturing, wholesale and retail sectors, or real personal income less transfers that co-determines consumption decisions and aggregate spending, or the number of employees on nonagricultural payrolls are sometimes used to approximate the movements in the business cycle (Marcellino, 2006). Bierbaumer-Polly (2010) uses quarterly real gross value added excluding forestry and agriculture as his reference series of the Austrian business cycle. Given the shortcomings of using any particular series, it is sometimes preferred to use a constructed index of coincident indicators as a proxy for the evolution of GDP (Marcellino, 2006).

The selection of the leading component series is governed by the following criteria (OECD, 2008b, p. 5):

"*economic relevance*
There must exist a sound justification grounded in economic theory explaining why the indicator exhibits a leading relationship with respect to the reference series.

practical consideration
Monthly series are preferred to quarterly (*frequency*). Series should not be subject to frequent future revisions (*revision*). Series should be published promptly after the pe-

riod they refer to (*timeliness*). Long continuous series are preferred to short series with many breaks (*length*)."

According to economic rationale, potential leading indicators are classified as follows (OECD, 2008b, p. 5):

"*early stage*
Variables pertaining to the early stage of production such as new orders and construction approvals.

rapidly responsive
Variables responding rapidly to economic shocks such as average hours worked, profits, and stocks.

expectation sensitive
Variables sensitive to expectations such as raw material prices, stock prices, and expectations based on business and confidence surveys.

prime movers
Variables related to monetary policy and foreign economic development such as money supply, terms of trade, and exchange rates."

The composite leading indicator for the Czech Republic composed by the OECD contains the following component series: Stocks of Finished Goods in Manufacturing (% balance), Selling Prices in Manufacturing: Future Tendency (% balance), Consumer Prices: Future Tendency (%), Share Prices: PX Index (2000=100), Total Retail Sales (volume) (2000=100), and Monetary Aggregate M2 (CZK) (OECD, 2011a).

The exact steps performed for constructing non-model based composite leading indicators for the Czech Republic are described in detail in the section on empirical analysis.

3.2 Model Based Approach: Short-Term Forecasting

3.2.1 Simple Autoregressive Models

Marcellino et al. (2003) and Banerjee et al. (2004) use a handful of autoregressive models to forecast macroeconomic variables for the Euro area and the new EU member countries, respectively.

The autoregressive forecasting models are all in the form of a linear projection of an h-step-ahead variable, y_{t+h}^h, on t dated predictors. The choice of a multi-period direct forecasting model as opposed to the iterated forecast model, in other words a one period

model iterated forward, is influenced by Stock and Watson (2002) who used the direct forecasting framework in their dynamic factor model (DFM).

$$y_{t+h}^h = \mu + \alpha(L)y_t + \beta(L)'Z_t + \varepsilon_{t+h}^h \tag{1}$$

where $\alpha(L)$ is a scalar lag polynomial and $\beta(L)$ is a vector lag polynomial (Marcellino et al., 2003)).

The benchmark model is the autoregressive forecast where the lag length is determined by the AIC starting at the maximum lag length of 2 for quarterly data. The next natural step is to perform the autoregressive forecast with exogenous regressors Z_t as specified in (1).

3.2.2 Vector Autoregressive Models

The model specified in (1) can easily be cast into a vector form where y_t is an $(m \times 1)$ vector of appropriately transformed coincident indicators and Z_t is a $(n \times 1)$ vector of leading indicators:

$$\begin{pmatrix} y_{t+h}^h \\ Z_{t+h}^h \end{pmatrix} = \begin{pmatrix} c_{y_t} \\ c_{Z_t} \end{pmatrix} + \begin{pmatrix} e(L) & F(L) \\ g(L) & H(L) \end{pmatrix} \begin{pmatrix} y_t \\ Z_t \end{pmatrix} + \begin{pmatrix} \varepsilon_{y_{t+h}}^h \\ \varepsilon_{Z_{t+h}}^h \end{pmatrix} \tag{2}$$

where $e(L), g(L), F(L), H(L)$ are matrix lag polynomials (Marcellino, 2006). Vector autoregressions are a standard tool of macroeconomic forecasting. Unfortunately, it would be very difficult to specify a meaningful VAR model in the short quarterly sample from 2000 onwards. I leave an application of the VAR model to a possible extension of the paper that would perhaps work with a longer sample.

3.2.3 Dynamic Factor Models (DFM)

A common feature of the forecasting models described above was their reliance on a few pre-selected time series to forecast the value of the reference variable. Stock and Watson (2002) outline a dynamic factor model approach where the information present in many time series is approximated by a few common estimated factors. They reduce the dimension of the data by non-parametric estimation by averaging methods.

Stock and Watson (2002) derive an approximate dynamic factor model as follows.

Let X_t be a collection of N predictor time series measured at time $t = 1, ..., T$ and y_{t+1} a scalar series to be forecasted. The relationship between X_t and y_{t+1} is determined by the dynamic factor model with $\overline{r}$ common dynamic factors f_t,

$$y_{t+1} = \beta(L)f_t + \gamma(L)y_t + \varepsilon_{t+1} \tag{3}$$

with

$$X_{it} = \lambda_i(L)f_t + e_{it} \tag{4}$$

for $i = 1, ..., N$ where $(e_t = (e_{1t}, ..., e_{Nt})'$ is the $(N \times 1)$ idiosyncratic disturbance and $\beta(L)$, $\gamma(L)$, and $\lambda_i(L)$ are lag polynomials in nonegative powers of L. It is assumed that $E(\varepsilon_{t+1}|f_t, y_t, X_t, f_{t-1}, y_{t-1}, X_{t-1}, ...) = 0$. Thus, if the dynamic factors f_t, $\beta(L)$, and $\gamma(L)$ were known then the minimum MSE forecast would be $y_{T+1} = \beta(L)f_T + \gamma(L)y_T$. If the lag polynomials are assumed to have finite lag orders of at most q, equations (3) and (4) can be rewritten as,

$$y_{t+1} = \beta' F_t + \gamma(L)y_t + \varepsilon_{t+1} \tag{5}$$

with

$$X_t = \Lambda F_t + e_t \tag{6}$$

where $F_t = (f_t', ..., f_{t-q}')'$ is $(r \times 1)$, where $r \leq (q+1)\overline{r}$, the i^{th} row of Λ in (6) is $(\lambda_{i0}, ..., \lambda_{iq})$, and $\beta = (\beta_0, ..., \beta_q)'$. The factors F_t in this static representation of the dynamic factor model can be estimated by principal components which I take advantage of in the empirical section of the paper.

In the spirit of equation (1), the direct h-step-ahead forecast y_{t+h}^h is formed by

$$y_{t+h}^h = \alpha_h + \beta_h(L)F_t + \gamma_h(L)y_t + \varepsilon_{t+h}^h \tag{7}$$

where the coefficients differ depending on how many periods ahead we forecast as denoted by the subscript h.

y_{t+h}^h and y_t is defined as follows

$$y_{t+h}^h = (100/h)\ln(Y_{t+h}/Y_t) \quad y_t = 100\ln(Y_t/Y_{t-1}) \tag{8}$$

where Y is quarterly real GDP.

4 Empirical Analysis

The empirical analysis applies the methods described above and tests their power in modelling the Czech business cycle and in short-term forecasting of Czech quarterly real GDP growth. Because a substantial number of the time series considered, namely data on new industry orders and industry revenues, begin in 2000, the data sample used for the analysis begins in 2000 and ends in 2010. In addition, modeling the Czech business cycle before 2000 is problematic due to the transition period that took place in the 1990s. The data sources include the Czech Statistical Office, the Czech National Bank, the Ministry of Labour and Social Affairs, the Prague Stock Exchange, CES-IFO, Eurostat, and Bloomberg. The dataset aims at the widest coverage of the economy possible. The data can be classified into the following categories: Confidence Surveys, Construction, Industry, Services, GDP and its components, Labour Market, Prices, International, and Finance. The majority of the collected time series is in monthly frequency and the rest is recorded quarterly. The time series considered are listed in Table 15 in the Appendix.

4.1 Non-Model Based Composite Leading Indicators

In constructing the composite leading indicators of the Czech business cycle, I follow the standard methodology as in OECD (2008a). Series not published in constant prices are deflated by their respective price indices. If not adjusted from source, data are seasonally adjusted by the TRAMO-SEATS procedure. To mitigate the end point bias of the Hodrick-Prescott filter that is later used to extract the cyclical component, each series is modelled by a simple ARIMA model with maximum AR term set at 2 and maximum MA term set at 3. Using this ARIMA specification, each series is forecasted one year ahead. Including the forecasted values, a Hodrick-Prescott filter[1] is applied to extract the cyclical component. For monthly frequency, the cyclical component is further smoothed by the Hodrick-Prescott filter with $\lambda = 13.93$. This λ value is used by the OECD to filter out cyclical components with cycle length shorter than 12 months. The λ value is calculated by $\lambda = [4(1 - cos(\omega_0))^2]^{-1}$ where $\omega_0 = 2\pi/\tau$ and τ equals the number of months (OECD, 2011b). The smoothed cycle is then normalized. For quarterly frequency, the unsmoothed cycle is first converted to monthly frequency by cubic spline interpolation. The second application of the Hodrick-Prescott filter with $\lambda = 13.93$ is done on monthly data and finally the series is normalized.

The choice of the reference series is crucial for constructing composite leading indicators. The Index of Industrial Production that is available monthly is usually used as the reference series in more advanced economies. However, this variable does not approximate the Czech business cycle very well as is apparent from Figure 1.

[1] $\lambda = 14400$ for monthly frequency, $\lambda = 1600$ for quarterly frequency

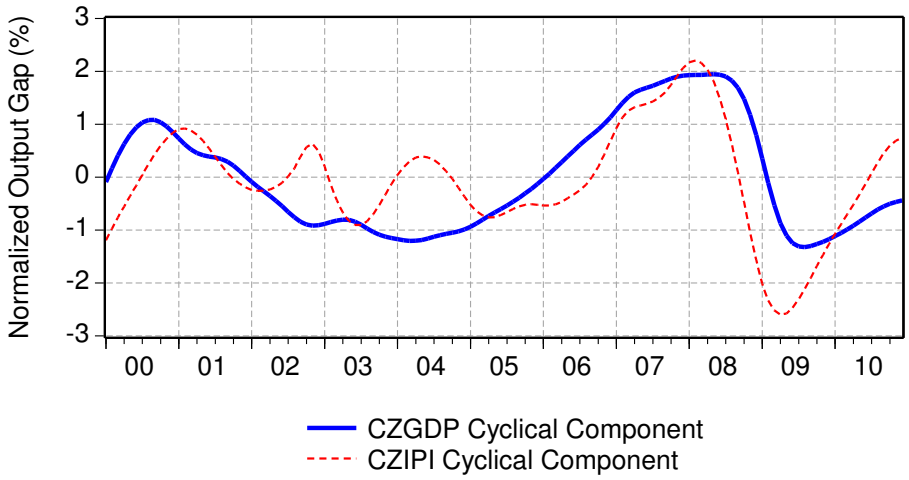

Figure 1: Cyclical Component of CZGDP and CZIPI

Given the unsuitability of the Index of Industrial Production for tracking the Czech business cycle, I opted out for real seasonally adjusted GDP interpolated to monthly frequency to serve as my reference series.

To limit the number of potential candidate series to enter the composite leading indicator, I first perform bivariate Granger causality tests (12 lags) between the cyclical component of real GDP in monthly frequency and each series considered. This pre-selection procedure limits the number of candidate series to 102. The correlation coefficient $\rho(j)$ with 20 leads and lags $j \in \{0, \pm 1, ..., \pm 20\}$ is examined to uncover co-movement between the candidate series and the reference series. Counter-cyclical series whose contemporaneous cross-correlation with the reference series is negative are inverted before they enter the composite leading indicator. The lead/lag of each series vis-a-vis the reference series is determined on the basis of highest absolute cross-correlation $|\rho(j)|$. Only series with minimum absolute cross-correlation of 0.55 as in Jacobs et al. (1997) enter the composite leading indicator. To ensure that a maximum number of series can be used for an indicator with a specific lead, series with a longer lead are lag shifted. For instance, a series with a 6 months lead is lagged by 2 months to enter a 4 months leading indicator.

Aggregation of component series into the composite leading indicator is performed by two methods both of which are reported. The first is simple averaging of component series. The second relies on weights derived from principal components analysis. The method for deriving weights from principal components is described in detail in OECD (2008a). I briefly review only the main steps here. Principal components are derived from the candidate series and only components with an eigenvalue larger than 1 are kept for further analysis. Principal components coefficients are rotated. Weights are derived from factor loadings that are simple correlation coefficients between the original

variables and rotated principal components. The two methods of aggregation produce almost identical results.

Based on the leads of the candidate series vis-à-vis the reference series, I am able to construct 5 composite leading indicators with respective leads of 6, 5, 4, and 3 months. Due to a large number of series with a lead of 3 months and higher, it is possible to construct two indicators with a lead of 3 months. One encompasses all suitable series with a minimum lead of 3 months and the other excludes series coming from confidence surveys and the financial market to only include "hard data" from the real economy.

The composite leading indicator with a 6 months lead depicted in Table 1 and Figure 2 consists of only two component series. Stock market indices, namely the Czech PX Stock Price Index and the German DAX Stock Price Index, are usually thought of as containing expectations about future economic activity. Based on theoretical priors, these two variables are ex-ante expected to have the longest lead and fall into the expectations sensitive category.

Table 1: Composite Leading Indicator: 6 Months Lead

Component Series	Lead	Country	Category
PX Stock Price Index	6	Czech Rep.	Expectations
DAX Stock Price Index	6	Germany	Expectations

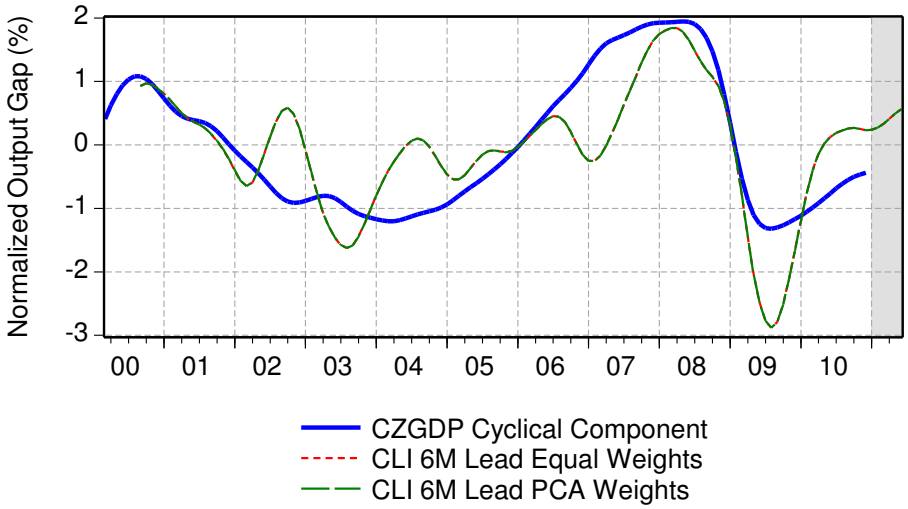

Figure 2: Composite Leading Indicator: 6 Months Lead

A 5 months lead composite leading indicator is presented in Table 2 and Figure 3. In addition to the series that enter the 6 months composite leading indicator, Confidence

Indicator in Czech Industry, Non-Domestic New Industry Orders - Total, and Revenues - Manufacture of Motor Vehicles, Trailers, and Semi-Trailers in the Czech Republic enter into the indicator with a 5 months lead. Confidence Indicator in Czech Industry is expected to show up, as the confidence surveys are designed to tell us something about the future tendency in the economy. Non-Domestic New Industry Orders - Total falls into the early stage of production category and confirms the export oriented nature of the Czech economy. Revenues - Manufature of Motor Vehicles, Trailer, and Semi-Trailers verifies the well-known concentration of the Czech economy in this industrial sector and reflects foremost foreign demand as most of the manufactured vehicles are exported.

Table 2: Composite Leading Indicator: 5 Months Lead

Component Series	Lead	Country	Category
PX Stock Price Index	6	Czech Rep.	Expectations
DAX Stock Price Index	6	Germany	Expectations
Non-Domestic New Industry Orders - Total	5	Czech Rep.	Early Stage
Confidence Indicator Industry	5	Czech Rep.	Expectations
Revenues - Manufacture of Motor Vehicles, etc.	5	Czech Rep.	Foreign Demand

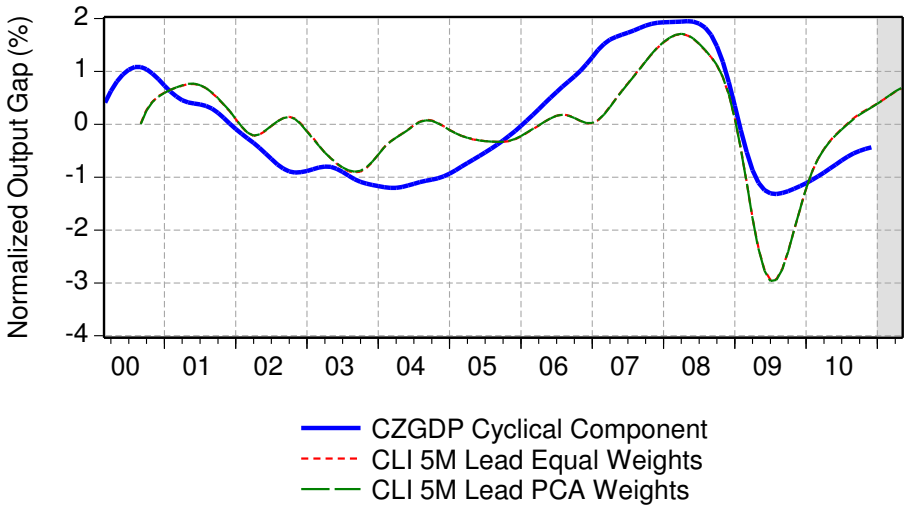

Figure 3: Composite Leading Indicator: 5 Months Lead

Table 3 and Figure 4 show a 4 months lead composite leading indicator. As compared to the 5 months lead composite leading indicator, the Composite Confidence Indicator in the Czech Republic replaces the Confidence Indicator in Industry, as the scope of the former, which encompasses business and consumer confidence, is larger. Export Revenues - Durable Consumer Goods goes in line with the export orientation of the

Czech economy and mirrors foreign demand. CES-Ifo Index of Business Situation in Germany strengthens the previously uncovered dependence of the Czech economy on the economic development in Germany. New Industry Orders - Manufacturing in the Euro area EA17 also falls into the category of explanatory variables indicating the importance of foreign demand.

Table 3: Composite Leading Indicator: 4 Months Lead

Component Series	Lead	Country	Category
PX Stock Price Index	6	Czech Rep.	Expectations
DAX Stock Price Index	6	Germany	Expectations
Non-Domestic New Industry Orders - Total	5	Czech Rep.	Early Stage
Confidence Indicator Composite	4	Czech Rep.	Expectations
Revenues - Manufacture of Motor Vehicles, etc.	5	Czech Rep.	Foreign Demand
Export Revenues - Durable Consumer Goods	4	Czech Rep.	Foreign Demand
CES-Ifo Index Business Situation in Trade and Industry	4	Germany	Expectations
New Industry Orders - Manufacturing	4	EA17	Foreign Demand

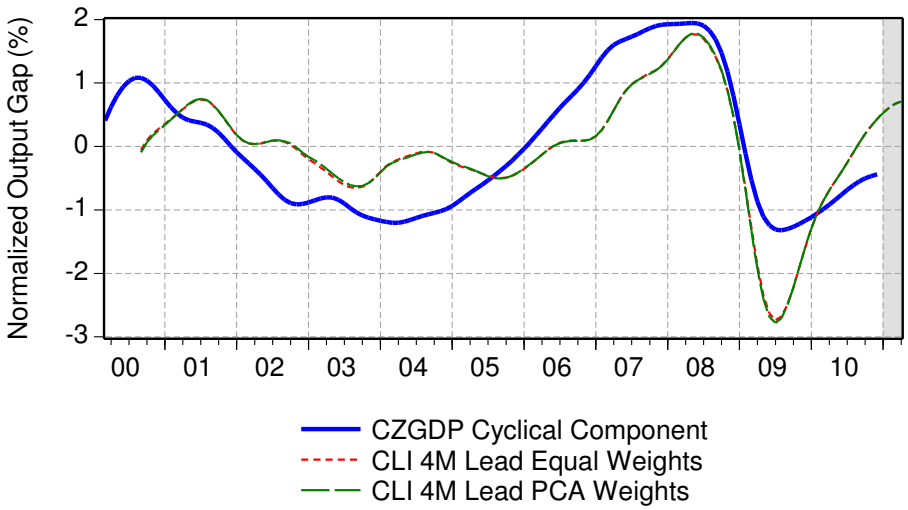

Figure 4: Composite Leading Indicator: 4 Months Lead

The series that additionally enters the 3 months leading indicator displayed in Table 4 and Figure 5 reinforces the relationships described. Exports Trade Balance referring to the export output as a whole further confirms how dependent the Czech economy is on the outside environment.

The last composite leading indicator that I construct is an alternative to the 3 months indicator and relies only on the so called "hard data" from the real economy. That is, I exclude variables from confidence surveys and the stock market. These results are

Table 4: Composite Leading Indicator: 3 Months Lead

Component Series	Lead	Country	Category
PX Stock Price Index	6	Czech Rep.	Expectations
DAX Stock Price Index	6	Germany	Expectations
Non-Domestic New Industry Orders - Total	5	Czech Rep.	Early Stage
Confidence Indicator Composite	4	Czech Rep.	Expectations
Revenues - Manufacture of Motor Vehicles, etc.	5	Czech Rep.	Foreign Demand
Export Revenues - Durable Consumer Goods	4	Czech Rep.	Foreign Demand
CES-Ifo Index Business Situation in Trade and Industry	4	Germany	Expectations
New Industry Orders - Manufacturing	4	EA17	Foreign Demand
Exports Trade Balance	3	Czech Rep.	Foreign Demand

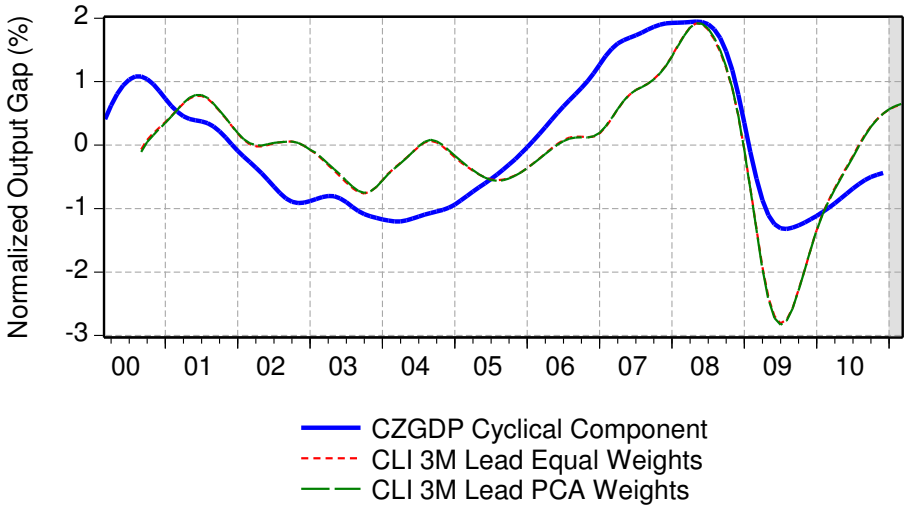

Figure 5: Composite Leading Indicator: 3 Months Lead

shown in Table 5 and Figure 6.

Table 5: Composite Leading Indicator: 3 Months Lead Real Economy

Component Series	Lead	Country	Category
Non-Domestic New Industry Orders - Total	5	Czech Rep.	Early Stage
Revenues - Manufacture of Motor Vehicles, etc.	5	Czech Rep.	Foreign Demand
Export Revenues - Durable Consumer Goods	4	Czech Rep.	Foreign Demand
New Industry Orders - Manufacturing	4	EA17	Foreign Demand
Exports Trade Balance	3	Czech Rep.	Foreign Demand

All in all, the composite leading indicators presented in this paper approximate the Czech business cycle in the studied time period fairly well with a small exception of 2004 when all the indicators more or less flag an extra peak in the cycle which may be

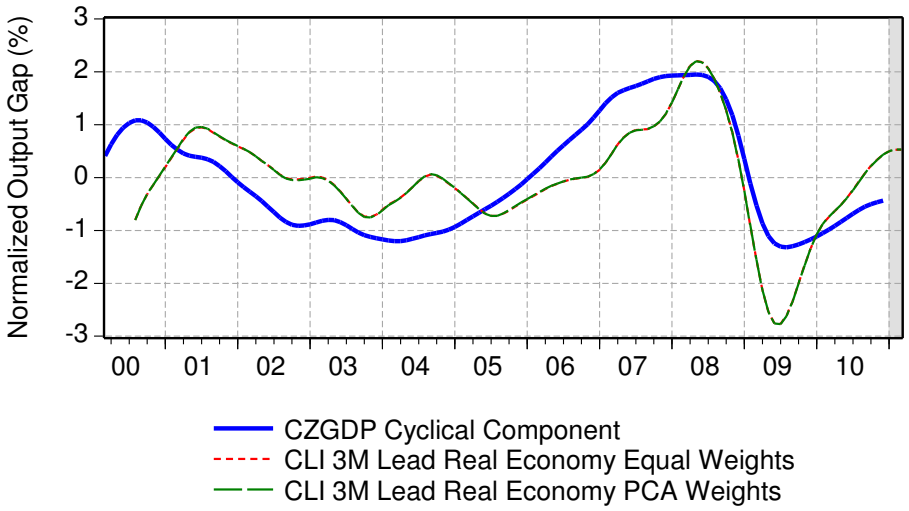

Figure 6: Composite Leading Indicator: 3 Months Lead Real Economy

explained by inflated expectations related to the entry of the Czech Republic into the EU in May 2004.

4.2 Model Based Short-Term Forecasting

In the previous section, the constructed composite leading indicators were able to flag turning points in the business cycle. However, they tell us nothing about the actual level of future economic activity. The empirical exercise in this section is meant to fill in this gap. The models presented here predict directly the level of economic activity. Since the most important variable in macroeconomic modelling is quarterly real GDP, I predict this variable directly and this time work with time series in quarterly frequency. In contrast to the previous section, I convert series in monthly frequency to quarterly frequency by summing or averaging.

To achieve stationarity, the dependent variable is the average growth rate of quarterly real GDP. The explanatory variables are differenced as needed.To test the stability of the proposed models, I perform the Chow Forecast Test, testing for a breakpoint in 2009q1. The reason for choosing the Chow Forecast Test over the more traditional Chow Breakpoint Test is the short sample period. The Chow Forecast Test uses the full length of the sample 2000q1-2010q4 and the estimated equations have a fixed lag length of 4. Under the null hypothesis, the forecasting relationship is stable.

The quality of the forecasts is evaluated on the basis of pseudo-out-of-sample forecasting exercise. The lag length and variable selection (after necessary initial judgement calls

about which variables to include) are made based on the Akaike information criterion. Forecast evaluation is performed on the basis of a pseudo out-of-sample forecasting exercise for the 2009q1-2010q4 period. The forecasts are completely recursive meaning that the model specification and lag length is selected by the Akaike information criterion and the equation coefficients are re-estimated at each step of the forecast. This means that principal components in the principal components models are also re-estimated at each step. The window at which the model gets evaluated gets extended by one quarter as the forecast moves one step ahead. In addition to model specifications selected on the basis of the Akaike information criterion, supplemental specifications where insignificant variables have been dropped are reported. These specifications are marked as "drop" in the presentation of results. The estimation procedure uses HAC (heteroskedasticity autocorrelation consistent) standard errors. The infrastructure of the modelling exercise is able to perform h-steps-ahead forecasts. I present results for 1-quarter-ahead and 2-quarters-ahead.

The quality of the forecasts is judged on the basis of standard forecast evaluation criteria. I report the Root Mean Squared Error (RMSE), the Mean Absolute Error (MAE), the Mean Absolute Percentage Error (MAPE), and the Theil Inequality Coefficient. Naturally, the smaller the forecast errors the better the forecast. The closer the Theil Inequality Coefficient to 0 the better the forecast (Vogelvang, 2005, pp. 148-150).

4.2.1 Single Equation Models

The advantage of single equation models is their simplicity and ease of economic interpretation. This advantage comes naturally at a cost. Given the short sample length of quarterly time series in the Czech Republic, the model has to be kept relatively parsimonious. Furthermore, the variables that enter as predictors of future GDP growth are likely to be correlated, as they are more or less related to the underlying business cycle, which I took advantage of in the previous section on non-model based indicators. Bearing in mind the number of series that can potentially predict real quarterly GDP growth, the greatest challenge in using single equation models is a correct choice of the predictor variables.

The specifications of the single equation models are explained in Tables 6 and 7. The maximum lag length for both the AR term and the explanatory variables is set at 4. For 1-quarter-ahead forecasts, I include the explanatory variables listed in Table 6 one at a time with the AR terms in Models 1-11. Models 12-16 contain a combination of explanatory variables based on the forecast performance in the simpler Models 1-11. Similarly for 2-quarters-ahead forecasts, I include the explanatory variables listed in Table 7 one at a time with the AR terms in Models 1-11. Models 12-16 contain a combination of explanatory variables based on the forecast performance in the simpler Models 1-11.

The results of the Chow Forecast Test of stability of the forecasting relations are reported in Table 8. For the 1-quarter-ahead forecasts, we cannot reject the null hypothesis of stability at the 5% level of significance for Model 4 and Models 11-16. With regards to the 2-quarters ahead forecasts, all the specifications prove to be unstable.

Table 6: Single Equation Model 1-Quarter-Ahead Forecast: Specification

	AR	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16
AR Term	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Confidence Indicator Composite CZ	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Confidence Indicator Industry CZ	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	4	4
Non-Domestic New Industry Orders - Total CZ	-	-	-	4	-	-	-	-	-	-	-	-	-	4	4	4	4
PX Stock Price Index CZ	-	-	-	-	4	-	-	-	-	-	-	-	4	4	4	4	4
Export Revenues - Durable Consumer Goods CZ	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	4
Revenues - Manufacture of Motor Vehicles etc. CZ	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-
Exports Trade Balance CZ	-	-	-	-	-	-	-	4	-	-	-	-	4	4	4	4	4
DAX Stock Price Index DE	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-
CES-Ifo Index Business Situation DE	-	-	-	-	-	-	-	-	-	4	-	-	-	-	4	4	4
New Industry Orders - Manufacturing DE	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-
New Industry Orders - Manufacturing EA17	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-

Table 7: Single Equation Model 2-Quarters-Ahead Forecast: Specification

	AR	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14
AR Term	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Confidence Indicator Composite CZ	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-
Confidence Indicator Industry CZ	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-
Non-Domestic New Industry Orders - Total CZ	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-
PX Stock Price Index CZ	-	-	-	-	4	-	-	-	-	-	-	-	4	4	4
Export Revenues - Durable Consumer Goods CZ	-	-	-	-	-	4	-	-	-	-	-	-	-	-	4
Revenues - Manufacture of Motor Vehicles etc. CZ	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-
Exports Trade Balance CZ	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-
DAX Stock Price Index DE	-	-	-	-	-	-	-	-	4	-	-	-	4	4	4
CES-Ifo Index Business Situation DE	-	-	-	-	-	-	-	-	-	4	-	-	-	4	4
New Industry Orders - Manufacturing DE	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-
New Industry Orders - Manufacturing EA17	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-

Table 8: Single Equation Model: Chow Forecast Test 2009q1

1-Quarter Ahead		2-Quarters Ahead	
	F-test p-value		F-test p-value
AR	0.0003	AR	0.0000
Model1	0.0018	Model1	0.0000
Model2	0.0085	Model2	0.0001
Model3	0.0068	Model3	0.0005
Model4	0.5872	Model4	0.0029
Model5	0.0137	Model5	0.0002
Model6	0.0204	Model6	0.0005
Model7	0.0269	Model7	0.0028
Model8	0.0011	Model8	0.0000
Model9	0.0003	Model9	0.0000
Model10	0.0250	Model10	0.0039
Model11	0.2777	Model11	0.0047
Model12	0.8580	Model12	0.0001
Model13	0.4245	Model13	0.0000
Model14	0.4058	Model14	0.0167
Model15	0.6901		
Model16	0.7251		

The forecasting properties of the proposed models are further tested in a pseudo-out-of-sample forecasting exercise. The results of this exercise are reported in Tables 9 and 10 for the 1-quarter and 2-quarters-ahead forecasts respectively. The evaluation criteria are expressed relative to the benchmark AR model. Thus a value lower than 1 means that the model has better out-of-sample forecasting properties than the benchmark AR model. Visual inspection of forecasted and actual values provides further information on the quality of the forecast. Figures 7, 8, 9, and 10 in the Appendix show how the forecasts perform over the 2009q1-2010q4 forecast sample.

When forecasting 1-quarter-ahead, the specifications that improve the most on the AR model benchmark are Model 4 and Model 12. In Model 4, the AR terms are augmented by the PX Stock Price Index. Model 12 includes both the PX Stock Price Index and Export Trade Balance in addition to the AR terms. Stock prices reflect expected present discounted value of future earnings (Stock and Watson, 2003). Export Trade Balance captures foreign demand that is crucial for a small open economy. Considering these theoretical priors, it is not a huge surprise that these two variables possess significant predictive power when forecasting real GDP growth 1-quarter ahead.

The forecast performance greatly deteriorates when the forecast horizon is extended to two quarters into the future. The confidence bounds are much larger. In particular, the models have serious trouble catching the decline in economic activity in 2009. While inspecting the graphs in Figures 9 and 10, it becomes obvious that the models capture the decline in 2009 with a lag and that has a negative impact on their forecasting performance. Perhaps in more stable economic times, the 2-quarters-ahead forecasts will

also be more accurate.

Table 9: Single Equation Model: 1-Quarter-Ahead Forecasting Performance

	RMSE	MAE	MAPE	Theil Inequality Coeff.
AR	1.00	1.00	1.00	1.00
AR drop	0.88	0.66	0.50	1.06
Model1	1.05	1.11	1.13	0.86
Model1drop	1.17	1.03	1.02	0.99
Model2	0.88	0.90	0.77	0.90
Model2drop	0.98	0.94	0.87	0.99
Model3	0.85	0.88	0.97	0.79
Model3drop	0.88	0.80	0.76	0.86
Model4	0.37	0.45	0.47	0.39
Model4drop	0.32	0.38	0.42	0.33
Model5	0.89	0.78	0.67	1.01
Model5drop	0.87	0.77	0.61	1.03
Model6	1.03	1.29	1.49	0.79
Model6drop	1.13	1.44	1.71	0.80
Model7	0.77	0.88	0.94	0.76
Model7drop	0.66	0.70	0.76	0.67
Model8	1.10	1.18	1.23	1.09
Model8drop	1.02	0.87	0.82	1.06
Model9	0.85	0.96	0.95	0.80
Model9drop	0.82	0.94	1.00	0.74
Model10	1.00	1.00	1.00	1.00
Model10drop	0.88	0.66	0.50	1.06
Model11	1.00	1.00	1.00	1.00
Model11drop	0.88	0.66	0.50	1.06
Model12	0.35	0.43	0.52	0.33
Model12drop	0.36	0.46	0.57	0.34
Model13	0.44	0.52	0.72	0.40
Model13drop	0.46	0.52	0.74	0.40
Model14	0.44	0.52	0.72	0.40
Model14drop	0.46	0.52	0.74	0.40
Model15	0.55	0.71	0.96	0.49
Model15drop	0.39	0.49	0.66	0.36
Model16	1.24	1.21	1.04	1.04
Model16drop	0.67	0.69	0.67	0.71

Table 10: Single Equation Model: 2-Quarters-Ahead Forecasting Performance

	RMSE	MAE	MAPE	Theil Inequality Coeff.
AR	1.00	1.00	1.00	1.00
AR drop	0.89	0.71	0.08	1.05
Model1	1.19	1.33	1.65	0.85
Model1drop	0.99	0.98	1.02	0.88
Model2	1.03	0.98	0.50	1.06
Model2drop	0.93	0.86	0.55	1.04
Model3	1.00	1.00	1.00	1.00
Model3drop	0.89	0.71	0.08	1.05
Model4	0.79	0.83	1.05	0.76
Model4drop	0.62	0.56	0.38	0.67
Model5	0.97	0.87	0.91	1.00
Model5drop	0.96	0.87	1.20	0.96
Model6	1.00	1.00	1.00	1.00
Model6drop	0.89	0.71	0.08	1.05
Model7	1.00	1.00	1.00	1.00
Model7drop	0.89	0.71	0.08	1.05
Model8	0.87	0.81	0.20	0.95
Model8drop	0.66	0.59	0.18	0.81
Model9	0.93	1.04	0.84	0.92
Model9drop	0.97	1.03	0.21	0.92
Model10	1.00	1.00	1.00	1.00
Model10drop	0.89	0.71	0.08	1.05
Model11	1.00	1.00	1.00	1.00
Model11drop	0.89	0.71	0.08	1.05
Model12	0.92	0.92	0.40	0.96
Model12drop	0.65	0.53	0.10	0.97
Model13	1.13	1.16	1.41	0.90
Model13drop	0.45	0.42	0.24	0.54
Model14	1.04	0.96	1.24	0.81
Model14drop	0.70	0.69	1.00	0.73

4.2.2 Models Based on Principal Components

In this section, I follow the estimation procedure presented in Stock and Watson (2002). As described in the theoretical section, principal components are employed to reduce the dimensionality of the data and concentrate most of the crucial information in the dataset into a few principal components that can be used in a single equation model. What can be changed is the maximum lag length of the AR term p, the maximum lag length of the principal components m, and the maximum number of principal components included in the model k. The model specifications are explained in Table 11. The labels of the models stand for the following specifications. The AR model stands for an autoregressive model with a maximum lag length of 4.The labels of the models reflect their structure where PC stands for principal components, AR for the autoregressive terms, and k for the maximum number of principal components included. For

instance, PC(1)-AR(2), k=10 contains a maximum of 10 principal components of maximum lag length 1, and AR terms of maximum lag length 2. The specifications labeled as "stacked" refer to models where the principal components have been derived from contemporaneous values of the variables and from their lags. Stock and Watson (2002) justify this step on the grounds that the estimated factors F_t could include lags of the dynamic factors f_t and that the estimation of F_t may be improved by stacking the lags of the series next to their contemporaneous values before principal components are applied.

Table 11: PC Model: Specification

	Max. Lag Length AR term p	Max. Lag Length PCs m	Max. No. of PCs k
AR	4	0	0
PC(1)-AR(2), k=10	2	1	10
PC(1), k=10	0	1	10
PC(2), k=10	0	2	10
PC(4)-AR(4), k=1	4	4	1
PC(4)-AR(4), k=2	4	4	2
PC(4)-AR(4), k=3	4	4	3
PC(4)-AR(4), k=4	4	4	4
PC(4), k=1	0	4	1
PC(4), k=2	0	4	2
PC(4), k=3	0	4	3
PC(4), k=4	0	4	4
PC(1)-AR(2), k=10 Stacked	2	1	10
PC(1), k=10 Stacked	0	1	10

Table 12: PC Model: Chow Forecast Test 2009q1

1-Quarter Ahead		2-Quarters Ahead	
	F-test p-value		F-test p-value
AR	0.0003	AR	0.0000
PC(1)-AR(2), k=10	0.1632	PC(1)-AR(2), k=10	0.0087
PC(1), k=10	0.0487	PC(1), k=10	0.0031
PC(2), k=10	0.1941	PC(2), k=10	0.1397
PC(4)-AR(4), k=1	0.0149	PC(4)-AR(4), k=1	0.0006
PC(4)-AR(4), k=2	0.0062	PC(4)-AR(4), k=2	0.0001
PC(4)-AR(4), k=3	0.1032	PC(4)-AR(4), k=3	0.0122
PC(4)-AR(4), k=4	0.1556	PC(4)-AR(4), k=4	0.0109
PC(4), k=1	0.0108	PC(4), k=1	0.0034
PC(4), k=2	0.0050	PC(4), k=2	0.0003
PC(4), k=3	0.0154	PC(4), k=3	0.0022
PC(4), k=4	0.0090	PC(4), k=4	0.0004
PC(1)-AR(2), k=10 Stacked	0.1632	PC(1)-AR(2), k=10 Stacked	0.0087
PC(1), k=10 Stacked	0.0487	PC(1), k=10 Stacked	0.0097

Table 13: PC Model : 1-Quarter-Ahead Forecasting Performance

	RMSE	MAE	MAPE	Theil Inequality Coeff.
AR	1.00	1.00	1.00	1.00
AR drop	0.88	0.66	0.50	1.06
PC(1)-AR(2), k=10	0.81	0.80	0.89	0.73
PC(1)-AR(2), k=10 drop	0.90	0.93	1.07	0.77
PC(1), k=10	0.81	0.80	0.92	0.71
PC(1), k=10 drop	0.79	0.85	0.97	0.76
PC(2), k=10	0.63	0.76	0.82	0.60
PC(2), k=10 drop	0.69	0.76	0.79	0.71
PC(4)-AR(4), k=1	0.90	0.86	0.91	0.81
PC(4)-AR(4), k=1 drop	0.68	0.62	0.59	0.70
PC(4)-AR(4), k=2	1.13	1.27	1.60	0.89
PC(4)-AR(4), k=2 drop	0.87	0.89	1.03	0.89
PC(4)-AR(4), k=3	1.00	1.10	1.36	0.77
PC(4)-AR(4), k=3 drop	0.76	0.73	0.87	0.64
PC(4)-AR(4), k=4	1.03	1.10	1.42	0.77
PC(4)-AR(4), k=4 drop	0.87	0.89	0.90	0.80
PC(4), k=1	0.72	0.75	0.86	0.69
PC(4), k=1 drop	0.68	0.63	0.61	0.70
PC(4), k=2	0.83	0.86	1.03	0.67
PC(4), k=2 drop	0.75	0.78	0.79	0.69
PC(4), k=3	0.88	0.90	1.13	0.67
PC(4), k=3 drop	0.79	0.68	0.81	0.63
PC(4), k=4	0.74	0.76	0.88	0.61
PC(4), k=4 drop	0.64	0.62	0.73	0.54
PC(1)-AR(2), k=10 Stacked	0.81	0.80	0.89	0.73
PC(1)-AR(2), k=10 Stacked drop	0.90	0.93	1.07	0.77
PC(1), k=10 Stacked	0.81	0.80	0.92	0.71
PC(1), k=10 Stacked drop	0.79	0.85	0.97	0.76

The stability of the forecasting relation is again tested by the Chow Forecast Test, testing for a breakpoint in 2009q1 as displayed in Table 12. For 1-quarter-ahead forecast, the Chow Forecast Test does not reject the null hypothesis of coefficient stability at the 5% level for the following specifications: PC(1)-AR(2), k=10, PC(2), k=10, PC(4)-AR(4), k=3, PC(4)-AR(4), k=4, and PC(1)-AR(2), k=10 Stacked. According to the Chow Forecast Test, specifications that include AR terms and a larger number of principal components are more stable. According to the Chow Forecast Test for 2-quarters-ahead forecast, the forecasting relations are only stable in the PC(2), k=10 specification that includes 10 principal components with 2 lags.

With respect to the 1-quarter-ahead forecasting performance displayed in Table 13, the models based on principal components improve moderately on the benchmark AR model. However, the charts in Figures 11 and 12 comparing the forecasted values to actual values confirm that these models fail to predict the severe decline in economic activity in the first half of 2009. The forecasting performance improves after the tur-

bulent first half of 2009. In particular, the model relying only on the first principal component and the AR terms up to lag length of 4 does reasonably well in predicting real GDP growth 1-quarter-ahead in a more stable economic environment since the third quarter of 2009.

The forecasting performance for the 2-quarters-ahead forecast horizon deteriorates significantly. Table 14 shows that the variants of the PC model improve upon the benchmark AR model, but only slighly. As Figures 13 and 14 confirm there is one exception though. The PC(2), k=10 specification where statistically insignificant variables have been dropped decreases the RMSE by over 40 percent relative to the benchmark. Visual inspection of the graphs also indicates that this specification does reasonably well in forecasting real GDP growth 2-quarters-ahead past the turbulent period in 2009.

Table 14: PC Model : 2-Quarters-Ahead Forecasting Performance

	RMSE	MAE	MAPE	Theil Inequality Coeff.
AR	1.00	1.00	1.00	1.00
AR drop	0.89	0.71	0.08	1.05
PC(1)-AR(2), k=10	0.90	0.81	1.07	0.90
PC(1)-AR(2), k=10 drop	0.88	0.86	0.74	0.86
PC(1), k=10	0.90	0.81	1.07	0.90
PC(1), k=10 drop	0.88	0.86	0.74	0.86
PC(2), k=10	1.05	1.03	2.29	0.77
PC(2), k=10 drop	0.58	0.50	1.05	0.64
PC(4)-AR(4), k=1	0.73	0.72	1.30	0.72
PC(4)-AR(4), k=1 drop	0.85	0.88	0.87	0.79
PC(4)-AR(4), k=2	1.08	1.14	1.11	0.87
PC(4)-AR(4), k=2 drop	1.09	1.18	1.02	0.90
PC(4)-AR(4), k=3	1.08	1.14	1.11	0.87
PC(4)-AR(4), k=3 drop	1.09	1.18	1.02	0.90
PC(4)-AR(4), k=4	1.08	1.13	1.11	0.87
PC(4)-AR(4), k=4 drop	1.09	1.18	1.02	0.90
PC(4), k=1	0.85	0.91	0.92	0.71
PC(4), k=1 drop	0.88	0.88	1.01	0.78
PC(4), k=2	0.91	0.89	1.82	0.69
PC(4), k=2 drop	0.79	0.72	1.71	0.69
PC(4), k=3	0.93	0.91	0.74	0.88
PC(4), k=3 drop	0.95	0.96	0.78	0.90
PC(4), k=4	1.08	1.18	1.78	0.78
PC(4), k=4 drop	1.09	1.09	1.78	0.85
PC(1)-AR(2), k=10 Stacked	0.90	0.81	1.07	0.90
PC(1)-AR(2), k=10 Stacked drop	0.88	0.86	0.74	0.86
PC(1), k=10 Stacked	0.90	0.81	1.07	0.90
PC(1), k=10 Stacked drop	0.88	0.86	0.74	0.86

5 Conclusion

The analysis undertaken in this paper showed that augmenting composite leading indicators based on business surveys by variables from the early stage of production, the financial market, and the external environment is useful in constructing these indices of the Czech business cycle. With respect to weighting procedures, composite leading indicators based on weights derived from principal components analysis do not differ much from composite leading indicators aggregated by equal weights. The constructed composite leading indicators track the Czech business cycle reasonably well with the exception of 2004 when they flag an extra peak. This can perhaps be explained on the basis of inflated expectations linked to the entry of the Czech Republic into the EU in May 2004.

With respect to short-term forecasting of quarterly real GDP growth, it is possible to construct a parsimonious single equation model with good forecasting properties 1-quarter-ahead as evaluated in the 2009-2010 pseudo out-of-sample forecasting exercise. Together with AR terms, the PX Stock Price Index and Export Trade Balance are useful predictors of quarterly real GDP growth. As documented in other studies, principal components models are a very useful tool for short-term forecasting, but based on the time series considered in this study they were unable to predict the severe decline in economic activity in the first half of 2009. None of the models considered were able to predict the contraction of the economy in the first half of 2009 2-quarters-ahead. Perhaps a different modelling technique could perform better in the 2-steps-ahead forecast horizon, but there is also a real possibility that the time series considered did not capture the external shock fast enough to be able to produce satisfactory 2-quarters ahead forecasts of real GDP growth.

The paper can be improved and extended in a number ways. First, since the sample period includes the substantial decline in economic activity in 2009 and subsequent recovery in 2010, it should be tested whether the uncovered correlations are stable in the pre-recession and post-recession period when more data becomes available. Second, the principal components model undeniably showed potential for short-term forecasting. This model can be further enhanced by improving the selection procedure of variables that enter the estimation of principal components. Such refined approach could perhaps produce satisfactory results even for 2-quarters-ahead forecasts and for the turbulent period in 2009. Third, working with a few variables that reach as far back as 1996 would allow the use of a VAR model. Last but not least, the outlined methodology can be fruitfully exploited for forecasting of other macroeconomic time series such as inflation, interest rates, the unemployment rate, and the budget deficit.

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6 Appendix

Table 15: Time Series Considered

Variable	Country	Freq.	Category
Industry Production Index (average month of 2005=100) Constant Prices	CZ	M	Industry
Confidence Indicator Industry	CZ	M	Confidence Surveys
Confidence Indicator Construction	CZ	M	Confidence Surveys
Confidance Indicator Trade	CZ	M	Confidence Surveys
Confidence Indicator Services	CZ	M	Confidence Surveys
Confidence Indicator Business	CZ	M	Confidence Surveys
Confidence Indicator Consumers	CZ	M	Confidence Surveys
Confidence Indicator Composite	CZ	M	Confidence Surveys
New Industry Orders Basic Indices Current Prices (average month of 2005=100) Industry Total	CZ	M	Industry
New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Textiles	CZ	M	Industry
New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Wearing Apparel	CZ	M	Industry
New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Paper and Paper Products	CZ	M	Industry
New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Chemicals and Chemical Products	CZ	M	Industry
New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Basic Pharmaceutical Products and Pharmaceutical Preparations	CZ	M	Industry
New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Basic Metals	CZ	M	Industry
New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Fabricated Metal Products except Machinery and Equipment	CZ	M	Industry
New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Computer, Electronic and Optical Products	CZ	M	Industry
New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Electrical Equipment	CZ	M	Industry
New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Machinery and Equipment	CZ	M	Industry
New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Motor Vehicles, Trailers and Semi-Trailers	CZ	M	Industry
New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Other Transport Equipment	CZ	M	Industry
Domestic New Industry Orders Basic Indices Current Prices (average month of 2005=100) Industry Total	CZ	M	Industry
Domestic New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Textiles	CZ	M	Industry
Domestic New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Wearing Apparel	CZ	M	Industry
Domestic New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Paper and Paper Products	CZ	M	Industry
Domestic New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Chemicals and Chemical Products	CZ	M	Industry
Domestic New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Basic Pharmaceutical Products and Pharmaceutical Preparations	CZ	M	Industry
Domestic New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Basic Metals	CZ	M	Industry

Continued on next page

Table 15 – continued from previous page

Variable	Country	Freq.	Category
Domestic New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Fabricated Metal Products except Machinery and Equipment	CZ	M	Industry
Domestic New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Computer, Electronic and Optical Products	CZ	M	Industry
Domestic New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Electrical Equipment	CZ	M	Industry
Domestic New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Machinery and Equipment	CZ	M	Industry
Domestic New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Motor Vehicles, Trailers and Semi-Trailers	CZ	M	Industry
Domestic New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Other Transport Equipment	CZ	M	Industry
Non-Domestic New Industry Orders Basic Indices Current Prices (average month of 2005=100) Industry Total	CZ	M	Industry
Non-Domestic New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Textiles	CZ	M	Industry
Non-Domestic New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Wearing Apparel	CZ	M	Industry
Non-Domestic New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Paper and Paper Products	CZ	M	Industry
Non-Domestic New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Chemicals and Chemical Products	CZ	M	Industry
Non-Domestic New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Basic Pharmaceutical Products and Pharmaceutical Preparations	CZ	M	Industry
Non-Domestic New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Basic Metals	CZ	M	Industry
Non-Domestic New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Fabricated Metal Products except Machinery and Equipment	CZ	M	Industry
Non-Domestic New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Computer, Electronic and Optical Products	CZ	M	Industry
Non-Domestic New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Electrical Equipment	CZ	M	Industry
Non-Domestic New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Machinery and Equipment	CZ	M	Industry
Non-Domestic New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Motor Vehicles, Trailers and Semi-Trailers	CZ	M	Industry
Non-Domestic New Industry Orders Basic Indices Current Prices (average month of 2005=100) Manufacture of Other Transport Equipment	CZ	M	Industry
Construction Production Index (average month of 2005=100) Constant Prices	CZ	M	Construction
Number of Building Permits Granted Total	CZ	M	Construction
Approximate Value of Constructions Current Prices	CZ	M	Construction
Revenues Basic Indices Current Prices (average month of 2005=100) Industry Total	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Mining and Quarrying	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Mining of Coal and Lignite	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Other Mining and Quarrying	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Manufacturing	CZ	M	Industry

Continued on next page

Table 15 – continued from previous page

Variable	Country	Freq.	Category
Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Food Products	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Beverages	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Textiles	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Wearing Apparel	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Leather and Related Products	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Wood and Related Products	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Paper and Paper Products	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Printing and Reproduction of Recorded Media	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Coke and Refined Petroleum Products	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Chemicals and Chemical Products	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Basic Pharmaceutical Products and Pharmaceutical Preparations	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Rubber and Plastic Products	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Other Non-Metallic Mineral Products	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Basic Metals	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Fabricated Metal Products except of Machinery and Equipment	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Computer, Electronic, and Optical Products	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Electrical Equipment	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Machinery and Equipment	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Motor Vehicles, Trailers, and Semi-Trailers	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Other Transport Equipment	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Furniture	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Other Manufacturing	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Repair and Installation of Machinery and Equipment	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Electricity, Gas, Steam, and Airconditioning Supply	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Capital Goods	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Durable Consumer Goods	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Intermediate Goods	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Non-Durable Consumer Goods	CZ	M	Industry
Revenues Basic Indices Current Prices (average month of 2005=100) Energy Production	CZ	M	Industry

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Table 15 – continued from previous page

Variable	Country	Freq.	Category
Export Revenues Basic Indices Current Prices (average month of 2005=100) Industry Total	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Mining and Quarrying	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Mining of Coal and Lignite	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Other Mining and Quarrying	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Manufacturing	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Food Products	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Beverages	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Textiles	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Wearing Apparel	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Leather and Related Products	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Wood and Related Products	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Paper and Paper Products	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Printing and Reproduction of Recorded Media	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Coke and Refined Petroleum Products	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Chemicals and Chemical Products	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Basic Pharmaceutical Products and Pharmaceutical Preparations	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Rubber and Plastic Products	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Other Non-Metallic Mineral Products	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Basic Metals	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Fabricated Metal Products except of Machinery and Equipment	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Computer, Electronic, and Optical Products	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Electrical Equipment	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Machinery and Equipment	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Motor Vehicles, Trailers, and Semi-Trailers	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Other Transport Equipment	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Furniture	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Other Manufacturing	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Repair and Installation of Machinery and Equipment	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Electricity, Gas, Steam, and Airconditioning Supply	CZ	M	Industry

Continued on next page

Table 15 – continued from previous page

Variable	Country	Freq.	Category
Export Revenues Basic Indices Current Prices (average month of 2005=100) Capital Goods	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Durable Consumer Goods	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Intermediate Goods	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Non-Durable Consumer Goods	CZ	M	Industry
Export Revenues Basic Indices Current Prices (average month of 2005=100) Energy Production	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Industry Total	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Mining and Quarrying	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Mining of Coal and Lignite	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Other Mining and Quarrying	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Manufacturing	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Food Products	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Beverages	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Textiles	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Wearing Apparel	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Leather and Related Products	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Wood and Related Products	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Paper and Paper Products	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Printing and Reproduction of Recorded Media	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Coke and Refined Petroleum Products	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Chemicals and Chemical Products	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Basic Pharmaceutical Products and Pharmaceutical Preparations	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Rubber and Plastic Products	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Other Non-Metallic Mineral Products	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Basic Metals	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Fabricated Metal Products except of Machinery and Equipment	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Computer, Electronic, and Optical Products	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Electrical Equipment	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Machinery and Equipment	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Motor Vehicles, Trailers, and Semi-Trailers	CZ	M	Industry

Continued on next page

Table 15 – continued from previous page

Variable	Country	Freq.	Category
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Other Transport Equipment	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Manufacture of Furniture	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Other Manufacturing	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Repair and Installation of Machinery and Equipment	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Electricity, Gas, Steam, and Airconditioning Supply	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Capital Goods	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Durable Consumer Goods	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Intermediate Goods	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Non-Durable Consumer Goods	CZ	M	Industry
Domestic Revenues Basic Indices Current Prices (average month of 2005=100) Energy Production	CZ	M	Industry
Retail Trade except for Motor Vehicles and Motorcycles (2005=100) Index of Deflated Turnover	CZ	M	Services
PX Stock Price Index (April 5,1994 = 1000) Average Month	CZ	M	Finance
Trade Balance Exports (Customs Statistics) Billions CZK	CZ	M	International
Trade Balance Imports (Customs Statistics) Billions CZK	CZ	M	International
Exports of Food and Live Animals Millions CZK	CZ	M	International
Exports of Beverages and Tobacco Millions CZK	CZ	M	International
Exports of Crude Materials, excluding Fuels Millions CZK	CZ	M	International
Exports of Mineral Fuels, Lubricants, and Related Materials Millions CZK	CZ	M	International
Exports of Animal and Vegetable Oils, Fats, and Waxes Millions CZK	CZ	M	International
Exports of Chemicals and Related Products Millions CZK	CZ	M	International
Exports of Manufactured Goods Classified Chiefly by Material Millions CZK	CZ	M	International
Exports of Machinery and Transport Equipment Millions CZK	CZ	M	International
Exports of Miscellaneous Manufactured Articles Millions CZK	CZ	M	International
Exports of Commodities and Transactions Millions CZK	CZ	M	International
Imports of Food and Live Animals Millions CZK	CZ	M	International
Imports of Beverages and Tobacco Millions CZK	CZ	M	International
Imports of Crude Materials, excluding Fuels Millions CZK	CZ	M	International
Imports of Mineral Fuels, Lubricants, and Related Materials Millions CZK	CZ	M	International
Imports of Animal and Vegetable Oils, Fats, and Waxes Millions CZK	CZ	M	International
Imports of Chemicals and Related Products Millions CZK	CZ	M	International
Imports of Manufactured Goods Millions CZK	CZ	M	International
Imports of Machinery and Transport Equipment Millions CZK	CZ	M	International
Imports of Miscellaneous Manufactured Articles Millions CZK	CZ	M	International
Imports of Commodities and Transactions Millions CZK	CZ	M	International
Loans to Households (incl. Non-Profits) Millions of CZK Total End of Month	CZ	M	Finance
Loans to Firms Millions of CZK Total End of Month	CZ	M	Finance
Pribor 2 Weeks Interest Rate	CZ	M	Finance
Pribor 3 Months Interest Rate	CZ	M	Finance
Pribor 6 Months Interest Rate	CZ	M	Finance
Repo 2 Weeks Interest Rate	CZ	M	Finance
M1 Billions CZK	CZ	M	Finance
M2 Billions CZK	CZ	M	Finance
M1-M2 Billions CZK	CZ	M	Finance
Exchange Rate CZK/EUR Average Month	CZ	M	Finance
Nominal Effective Exchange Rate SITC 0-9	CZ	M	Finance

Continued on next page

Table 15 – continued from previous page

Variable	Country	Freq.	Category
Consumer Price Index (2005=100)	CZ	M	Prices
Industry Producer Price Index (2005=100)	CZ	M	Prices
Registered Unemployment Thousands (end of month)	CZ	M	Labor Market
Vacancies Thousands (end of month)	CZ	M	Labor Market
Newly Registered Unemployed Thousands (end of month)	CZ	M	Labor Market
Total Hours Worked	CZ	Q	Labor Market
Total Hours Worked Manufacturing	CZ	Q	Labor Market
Gross Domestic Product Expenditure Method Constant Prices, Billions of CZK Chained Reference Year 2000	CZ	Q	GDP
Household Expenditure Constant Prices, Billions of CZK Chained Reference Year 2000	CZ	Q	GDP
Government Expenditure Constant Prices, Billions of CZK Chained Reference Year 2000	CZ	Q	GDP
Gross Capital Formation Constant Prices, Billions of CZK Chained Reference Year 2000	CZ	Q	GDP
Gross Fixed Capital Formation Constant Prices, Billions of CZK Chained Reference Year 2000	CZ	Q	GDP
Change in Inventories Constant Prices, Billions of CZK Chained Reference Year 2000	CZ	Q	GDP
Exports Constant Prices, Billions of CZK Chained Reference Year 2000	CZ	Q	GDP
Exports of Goods Constant Prices, Billions of CZK Chained Reference Year 2000	CZ	Q	GDP
Exports of Services Constant Prices, Billions of CZK Chained Reference Year 2000	CZ	Q	GDP
Imports Constant Prices, Billions of CZK Chained Reference Year 2000	CZ	Q	GDP
Imports of Goods Constant Prices, Billions of CZK Chained Reference Year 2000	CZ	Q	GDP
Imports of Services Constant Prices, Billions of CZK Chained Reference Year 2000	CZ	Q	GDP
CES-Ifo Business Climate Trade and Industry (2000=100)	DE	M	Confidence Surveys
CES-Ifo Business Situation Trade and Industry (2000=100)	DE	M	Confidence Surveys
CES-Ifo Business Expectations Trade and Industry (2000=100)	DE	M	Confidence Surveys
Industry Production Index (2005=100) Mining and Quarrying, Manufacturing, Electricty, Gas, Steam, and Air Conditioning Supply Constant Prices	DE	M	Industry
Industry New Orders Index (2005=100) Manufacturing for New Orders	DE	M	Industry
Industry Turnover Index (2005=100) Mining and Quarrying, Manufacturing	DE	M	Industry
Industry Producer Prices Index (2005=100)	DE	M	Prices
HICP (2005=100)	DE	M	Prices
Retail Trade except for Motor Vehicles and Motorcycles (2005=100) Index of Deflated Turnover	DE	M	Services
Construction Production Index (average month of 2005=100) Constant Prices	DE	M	Construction
DAX Stock Price Index (End 1987 = 1000) Average Month	DE	M	Finance
Gross Domestic Product Expenditure Method Constant Prices, Millions of Euros, Chain Linked, Reference Year 2000	DE	Q	GDP
Final Consumption Expenditure of Households Constant Prices, Millions of Euros, Chain Linked, Reference Year 2000	DE	Q	GDP
Final Consumption Expenditure of General Government Constant Prices, Millions of Euros, Chain Linked, Reference Year 2000	DE	Q	GDP
Gross Capital Formation Constant Prices, Millions of Euros, Chain Linked, Reference Year 2000	DE	Q	GDP
Gross Fixed Capital Formation Constant Prices, Millions of Euros, Chain Linked, Reference Year 2000	DE	Q	GDP
Exports of Goods and Services Constant Prices, Millions of Euros, Chain Linked, Reference Year 2000	DE	Q	GDP

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Table 15 – continued from previous page

Variable	Country	Freq.	Category
Imports of Goods and Services Constant Prices, Millions of Euros, Chain Linked, Reference Year 2000	DE	Q	GDP
Industry Production Index (2005=100) Mining and Quarrying, Manufacturing, Electricty, Gas, Steam, and Air Conditioning Supply Constant Prices	EA17	M	Industry
Industry New Orders Index (2005=100) Manufacturing for New Orders	EA17	M	Industry
Industry Turnover Index (2005=100) Mining and Quarrying, Manufacturing	EA17	M	Industry
Industry Producer Prices Index (2005=100)	EA17	M	Prices
Retail Trade except for Motor Vehicles and Motorcycles (2005=100) Index of Deflated Turnover	EA17	M	Services
Construction Production Index (average month of 2005=100) Constant Prices	EA17	M	Construction
Gross Domestic Product Expenditure Method Constant Prices, Millions of Euros, Chain Linked, Reference Year 2000	EA17	Q	GDP
Final Consumption Expenditure of General Government Constant Prices, Millions of Euros, Chain Linked, Reference Year 2000	EA17	Q	GDP
Gross Capital Formation Constant Prices, Millions of Euros, Chain Linked, Reference Year 2000	EA17	Q	GDP
Gross Fixed Capital Formation Constant Prices, Millions of Euros, Chain Linked, Reference Year 2000	EA17	Q	GDP
Exports of Goods and Services Constant Prices, Millions of Euros, Chain Linked, Reference Year 2000	EA17	Q	GDP
Imports of Goods and Services Constant Prices, Millions of Euros, Chain Linked, Reference Year 2000	EA17	Q	GDP

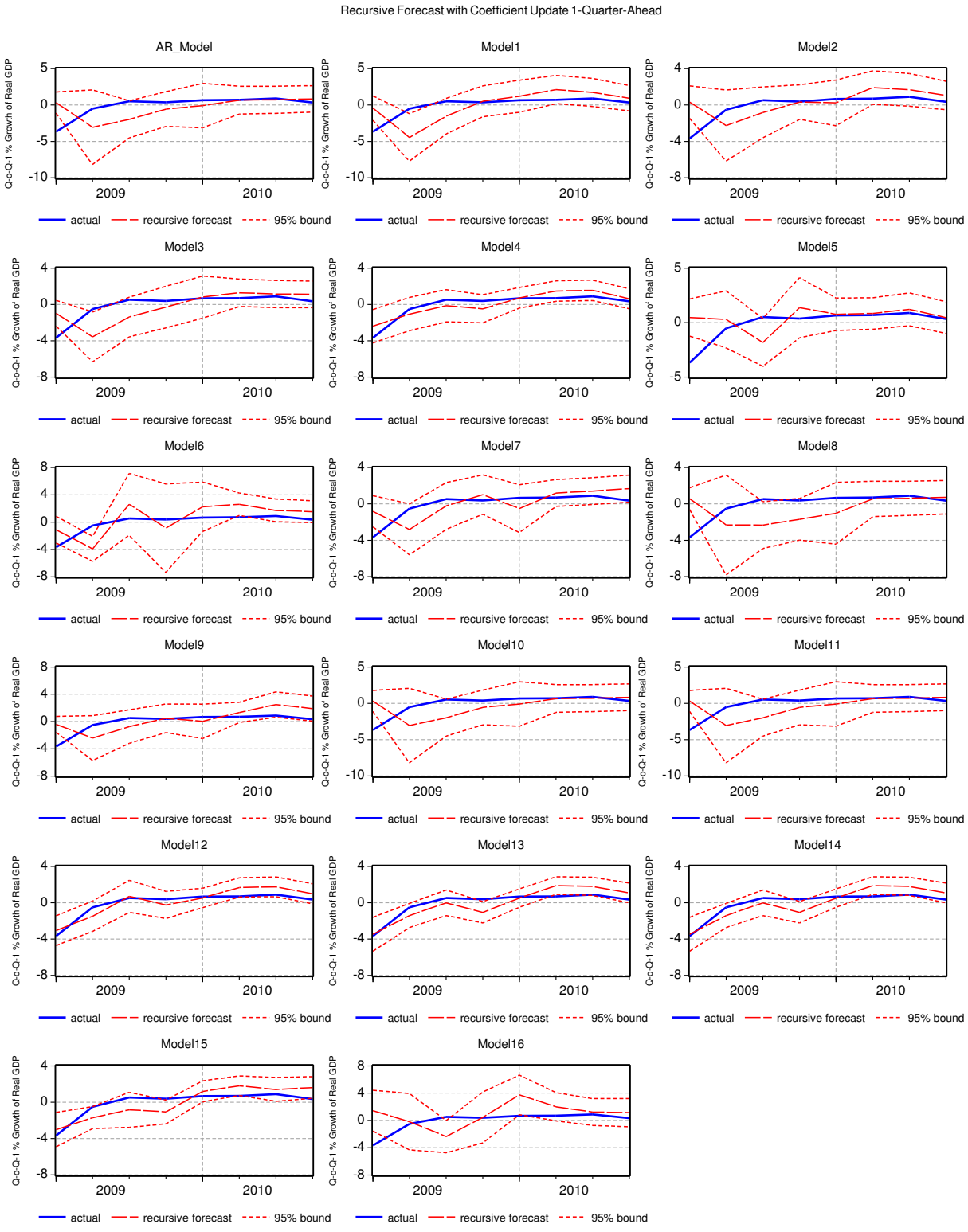

Figure 7: Single Equation Model: 1-Quarter Ahead Forecasting Performance

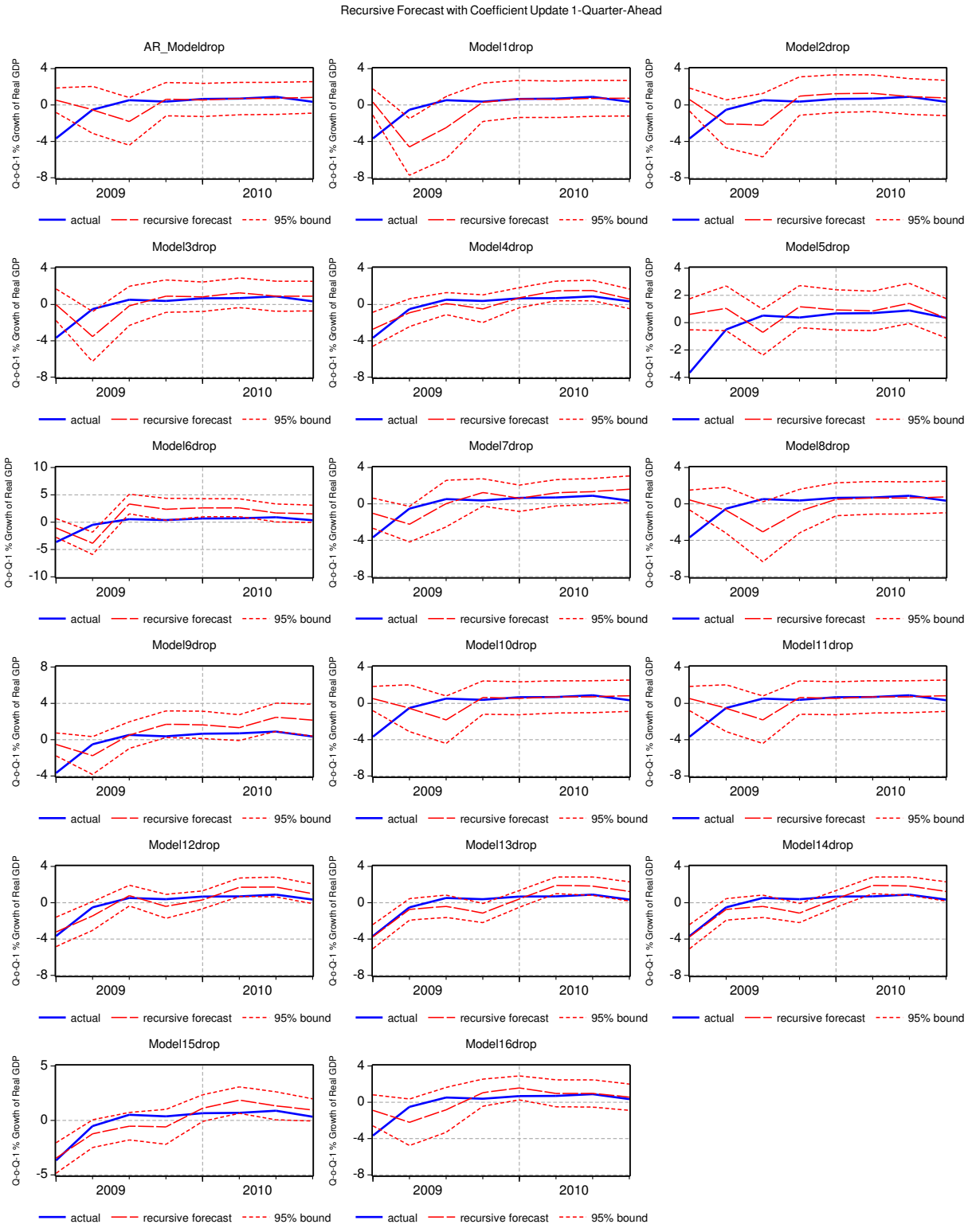

Figure 8: Single Equation Model: 1-Quarter Ahead Forecasting Performance

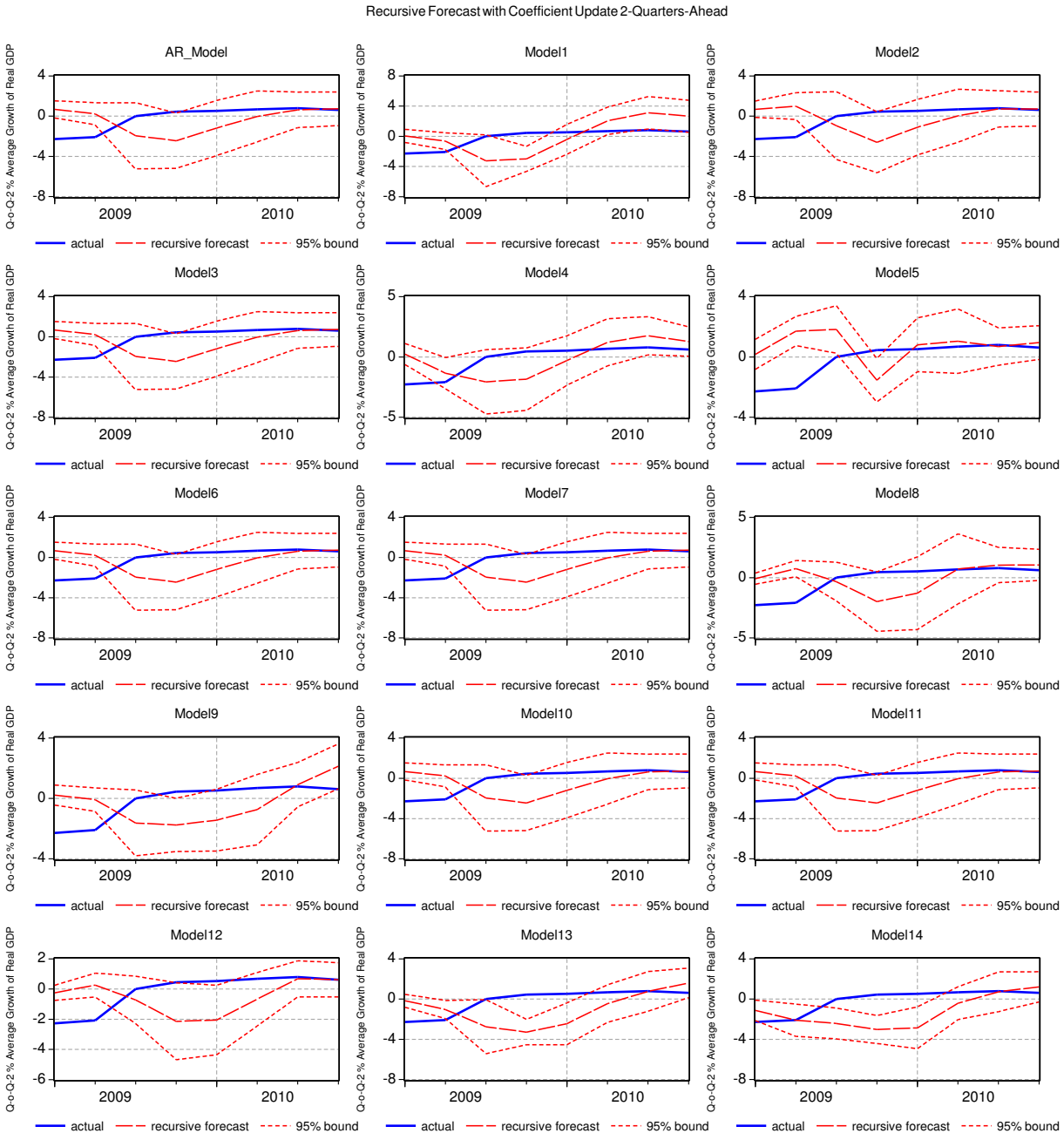

Figure 9: Single Equation Model: 2-Quarters Ahead Forecasting Performance

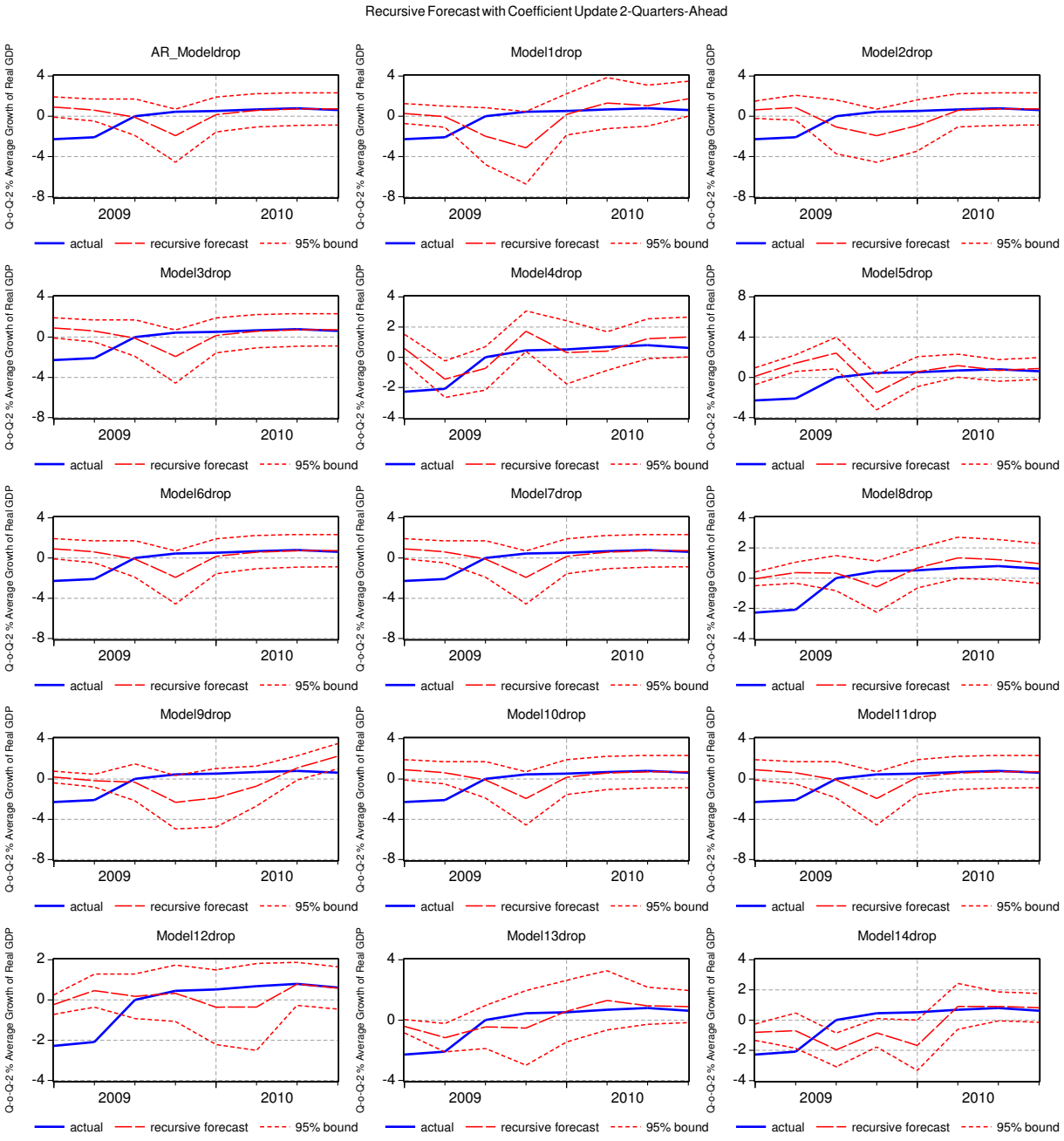

Figure 10: Single Equation Model: 2-Quarters Ahead Forecasting Performance

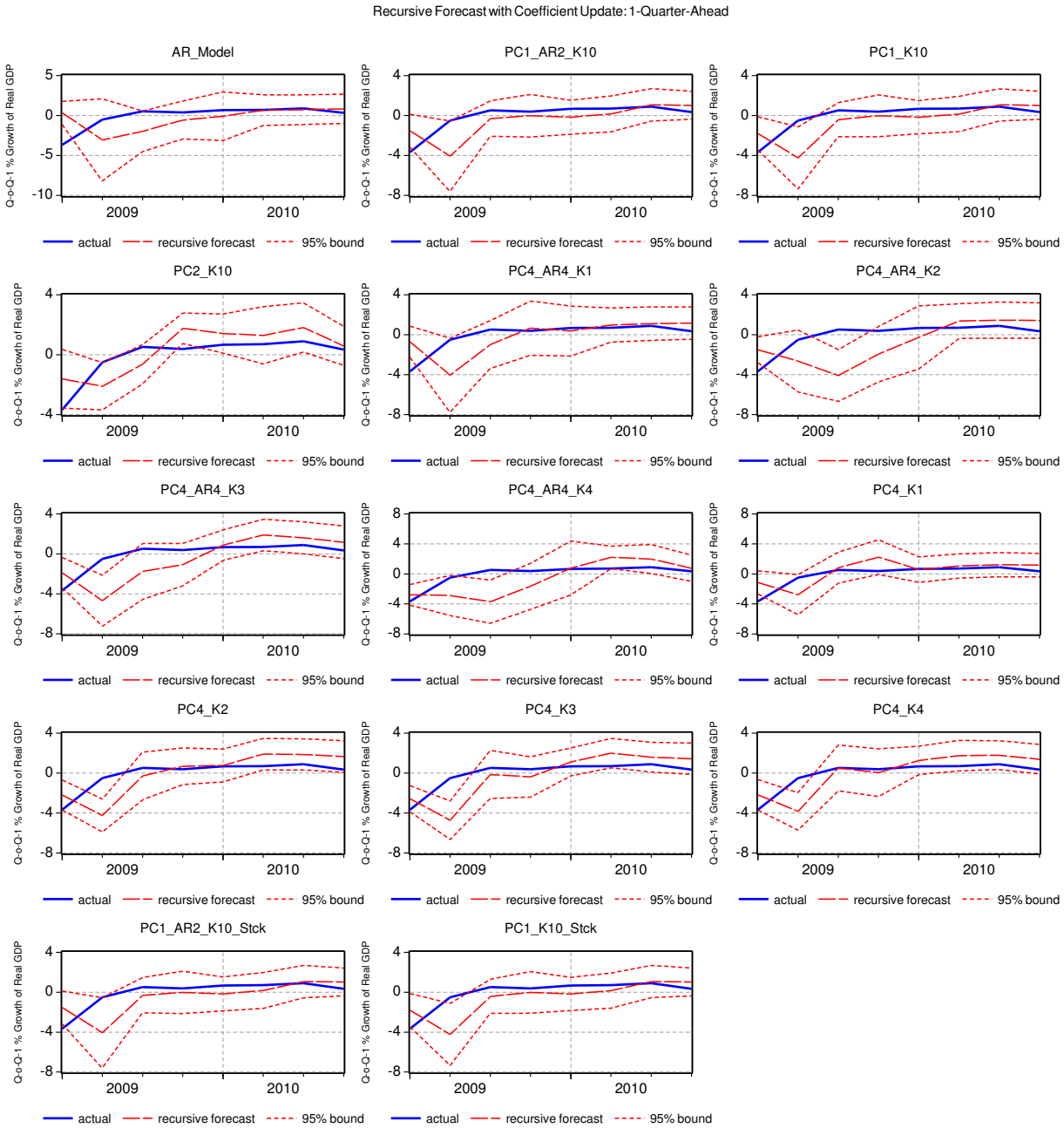

Figure 11: PC Model: 1-Quarter Ahead Forecasting Performance

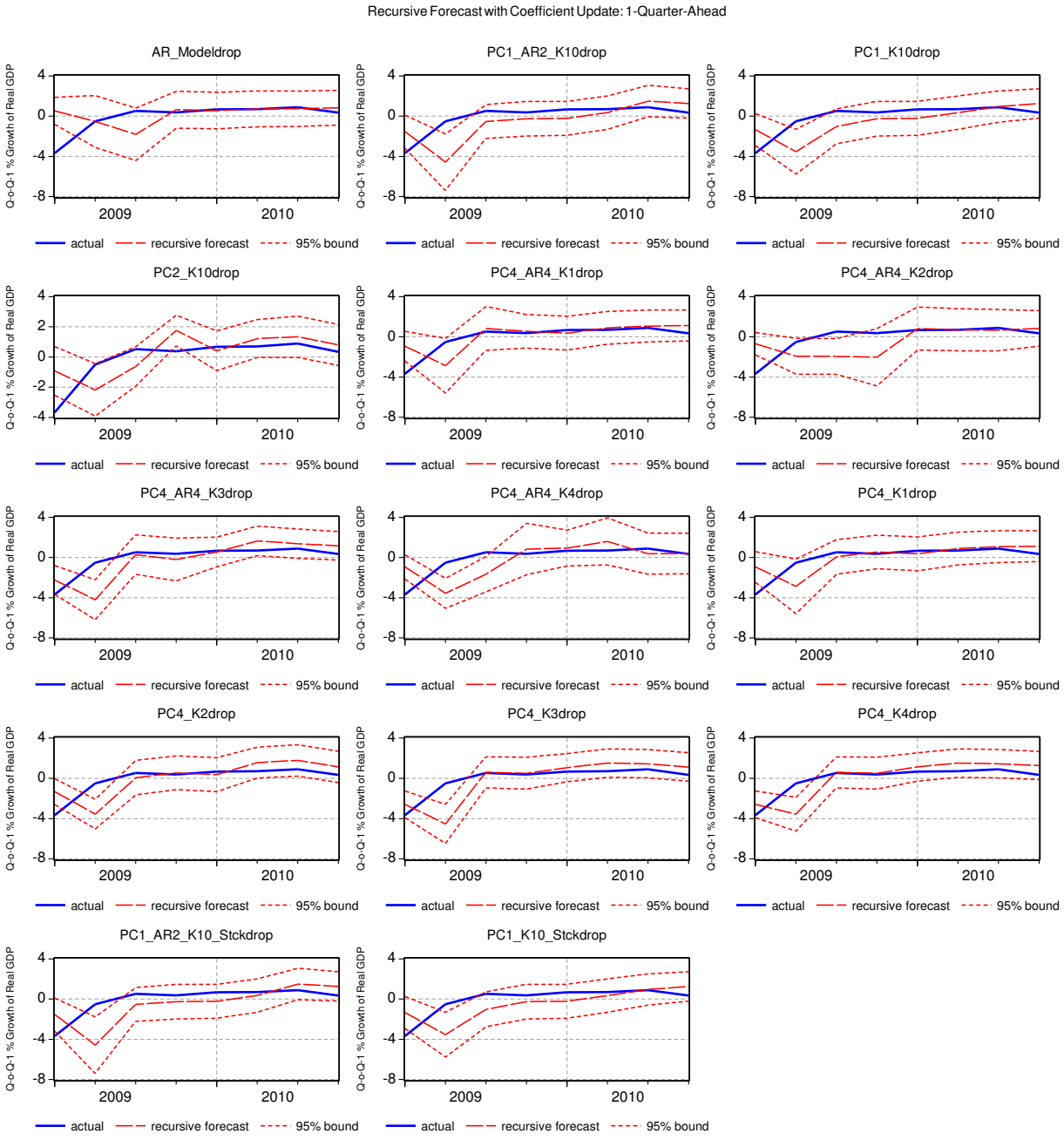

Figure 12: PC Model: 1-Quarter Ahead Forecasting Performance

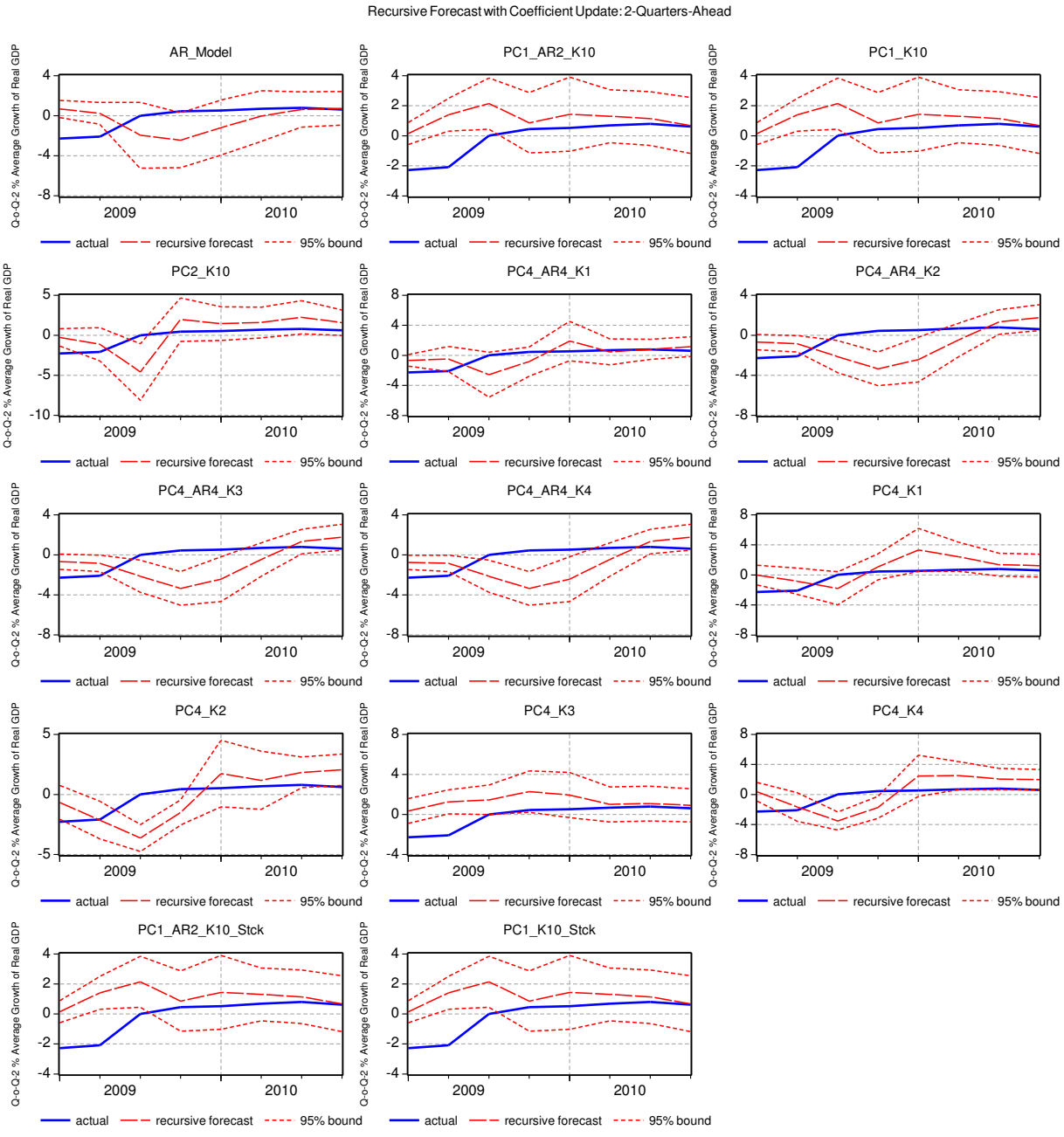

Figure 13: PC Model: 2-Quarters Ahead Forecasting Performance

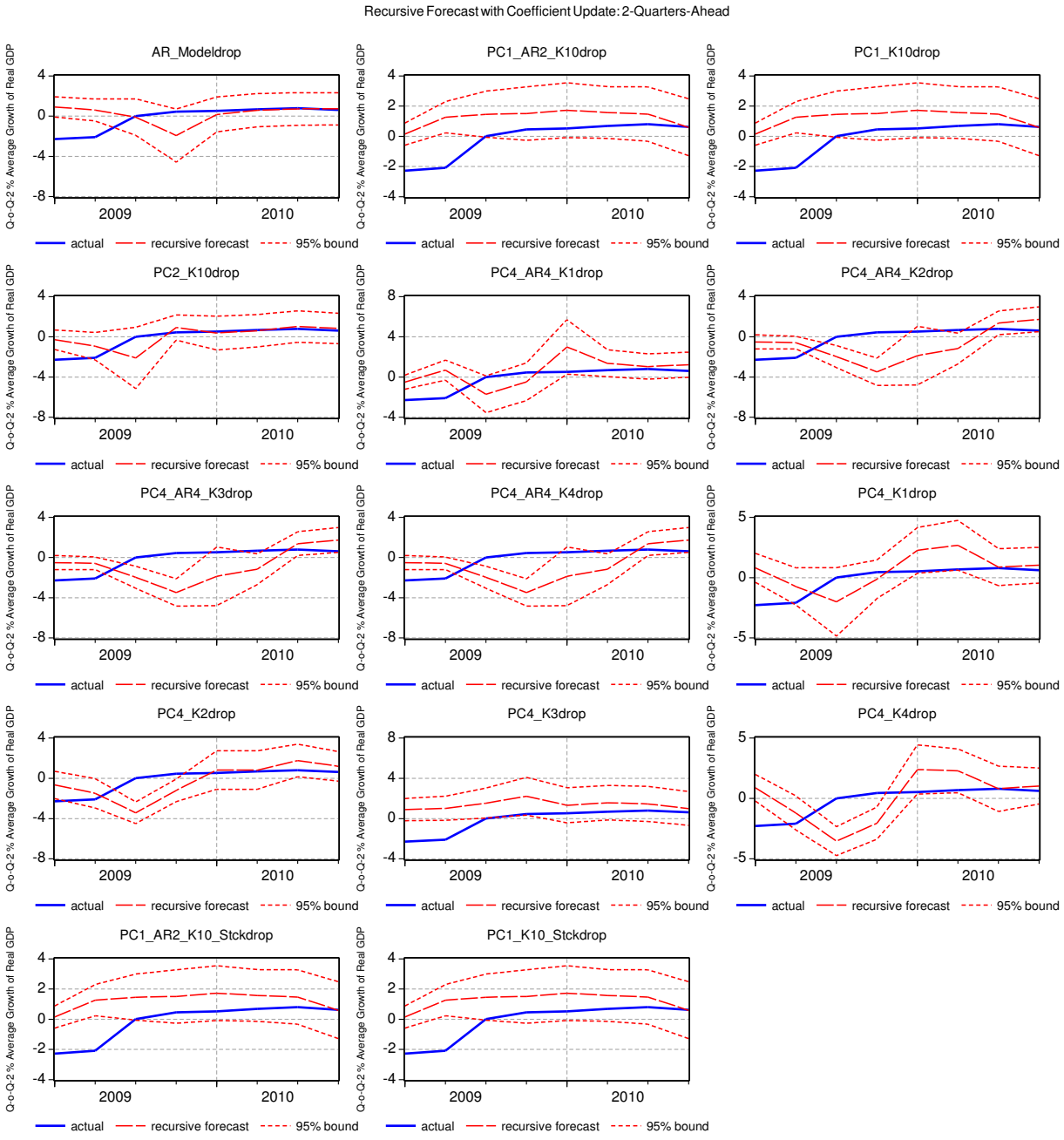

Figure 14: PC Model: 2-Quarters Ahead Forecasting Performance