# Nowcasting Belgium


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by David de Antonio Liedo

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## Abstract

This paper proposes a method that takes into account the calendar of European and Belgian intraquarterly data releases to automatically update GDP growth expectations or *nowcasts* in real-time. The role of surveys is well known in the nowcasting literature, but this is the first paper that has attempted to isolate *quality* from *timeliness* as independent properties that can be expressed in function of the model parameters. The modeling framework allows for the incorporation of different kinds of survey data directly in levels and features a parsimonious specification of the GDP revision process which does not impose strict assumptions regarding the rationality of the statistical agency. The results in the empirical section emphasize the quality of survey data, which allows the model to produce accurate real GDP growth nowcasts for Belgium three months prior to the publication of the official flash estimate.

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Keywords: news, dynamic factor models, EM algorithm.

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# 1 Introduction

The meteorological term *nowcasting* has become increasingly popular in economics over the last years after the success of statistical methods in formalizing the mixture of judgment and expert knowledge involved in the calculation of early estimates of economic activity. Unlike nowcasting users in meteorology, who base their decisions on the current weather along with forecasts for a period of zero to six hours ahead, institutions responsible for economic policy need to make important decisions without directly observing the current state of the economy. The so-called Flash estimate of Gross Domestic Product (GDP) is published by the National Accounts Institute (NAI) about 30 days after the end of the quarter, while Eurostat publishes the aggregate euro area Flash figure with an approximate delay of 45 days. This implies that not only the current quarterly growth of the economy is actually unknown, but also the one corresponding to the previous quarter is available with an important delay. Within each quarter, however, many other economic indicators and surveys become available.

In this paper, I propose a joint state-space model for the euro area and Belgian economies formalizing the role of the intraquarterly data flow as an input to construct early estimates of GDP growth and update them in real time. Those updates will be decomposed in terms of surprises embodied in each one of the macroeconomic releases. The first papers that formalize the so-called nowcasting process are due to Evans (2005) and Giannone et al. (2008). As defined by Giannone et al. (2008) or Banbura et al. (2011), *nowcasting* refers to the prediction of the most recent past, the present, and the nearest future[1].

[1] Although these papers use the general term *"nowcasting"* regardless of whether the aim is to anticipate the last, current or next quarter, some papers in the literature, e.g. Angelini et al. (2010), distinguish between backcasting, nowcasting and forecasting. This would imply that predictions for the first quarter based on the information set available on December 31st would be called forecasts, while predictions constructed one day later, on January 1st, would be nowcasts.

Like many of the existing tools available for nowcasting GDP growth in real time, the method presented here takes into account the presence of strong co-movements in macroeconomic data by incorporating restrictions inspired by the literature on dynamic factor models. Factor models are relatively restrictive representations allowing GDP growth to be expressed as the sum of two orthogonal components: one driven by pervasive factors that spread throughout the economy, and a measurement error component that is idiosyncratic. Such restrictions have also been successful in nowcasting US and euro area data, as shown by Giannone et al.(2008) or Camacho and Pérez-Quirós (2010), respectively.

Here, I focus on the accuracy of the forecasts for the real GDP growth rates in Belgium in a framework that allows for the co-existence of both Belgian specific and euro area wide shocks. The empirical results underline the importance of survey data such as the Business Sentiment Index constructed by the National Bank of Belgium, which is not necessarily a surprising feature given the popularity of the Belgian Business Survey, highlighted by the Wall Street Journal (1999) as a leading indicator of the euro area economy. I show that the release corresponding to the first month of each quarter plays a particularly big role in updating GDP growth expectations. Other indicators that have a large impact on growth forecasts are the Markit Economics PMI (Manufacturing) release for the euro area, $3-$month euribor and real house prices in Belgium, which turn out to contribute mainly at long-term horizons. This is consistent with my finding that three months prior to the publication of the Belgian Flash, the nowcast turns out to be as accurate as the flash release itself. Given the information available in real time, the flash release for Belgium does not enable the model to have a significant gain in estimation accuracy regarding the state of the economy. The paper goes further than the literature in understanding whether the importance of survey data can be accounted for by their timeliness or rather their quality. In a counterfactual exercise, I show that the weights associated to survey data do not deteriorate when all hard data is published with the same degree of timeliness. This result underlines the quality of survey data. The importance of survey data in Belgium is also discussed in detail by Piette and Langenus (2014).

The model is estimated with restricted maximum-likelihood using the EM algorithm following Banbura and Modugno (2010) in their treatement of arbitrary patterns of missing values. Thus, nowcasts are defined as forecasts conditional on the available information set, which may have gaps at the beginning, in the middle, and at the end of the sample, but which expands forward with every new data release. An important element of this approach is that it is possible to determine precisely how each one of the indicators contributes to updating the GDP forecasts. As shown by Banbura and Modugno (2010) and Banbura et al. (2011), any state-space model can help analyze the informative content provided by intraquarterly publication of “news”.

This paper is structured as follows. Section 2 defines the model and compares it to the state of the art. Section 3 presents the data and the particularities of GDP revisions. Section 4 studies the precise role of all data releases in the process of updating the real GDP growth rate. In addition I briefly discuss why such role depends crucially on timeliness and quality, which are desirable characteristics of macroeconomic data releases. Finally, section 5 presents out-of-sample forecasts that would have been obtained by the model at since the last quarter of 2007 using the information that was available in real-time. The last section concludes.

# 2 Modeling Framework

All monthly and quarterly variables are represented as a parametric dynamic factor model, which can be expressed in state-space form. Within this very specific framework, I outline the most common approach to link GDP, which is a quarterly variable, with the unobserved factors, which are specified at a monthly frequency.

## 2.1 A State-Space Representation

I describe here the particularities of the joint model for the Belgian economy and the aggregate euro area data. The following expression links the monthly growth rates of the variables to the vector of underlying monthly factors:

$$y_t = \bar{y} + \Lambda_y f_t + \Theta_y b_t + \psi_t \quad \textit{Measurement Belgium} \tag{1}$$

$$x_t = \bar{x} + \Lambda_x f_t + \chi_t \quad \textit{Measurement euro area} \tag{2}$$

Because the model has been designed for the conduct of short-term analysis, it makes sense to represent all these series, including GDP, in terms of monthly growth rates or monthly differences. Belgian time series will be denoted by $y_t$, while euro area series are represented by $x_t$. The factor $f_t$ represents the latent monthly growth rate of the area economy, which is also relevant for Belgium, and $b_t$ formalizes the monthly growth rate of the Belgian economy. The so-called Belgian specific factor, $b_t$, does not load contemporaneously on the euro area data, which makes the model more parsimonious (i.e. $\Theta_x$ would be equal to zero). The error terms $\chi_t$ and $\psi_t$ are assumed to be uncorrelated with the factors at all leads and lags. They are also assumed to be iid following a normal distribution: $\chi_t \sim N(0, R_\chi)$ and $\psi_t \sim N(0, R_\psi)$. Both covariance matrices are assumed to be diagonal, which implies that the factors will account for 100% of the comovements implicit in the model. As suggested by Doz et al. (2012), this assumption is not very restrictive. They show that Quasi-ML estimation of the factors is consistent even in the presence of weak cross-correlation patterns in the error term.

Because the monthly growth rates of official GDP figures are not published, equations 2 and 1 need to be modified. Thus, GDP growth rates published by the statistical agencies (i.e. $y_t^Q$ for Belgium and the $x_t^Q$ for the euro area) are linked to the quarterly growth rates of the underlying factors, which can be expressed as a moving average of their monthly growth rates:

$$\begin{aligned} y_t^Q &= \bar{y}^Q + \Lambda_y^Q f_t^Q + \Theta^Q b_t^Q + \chi_t^Q, \quad t = 3, 6, 9, \ldots \quad \textit{Belgian GDP} \qquad (3) \\ x_t^Q &= \bar{x}^Q + \Lambda_x^Q f_t^Q + \psi_t^Q, \quad t = 3, 6, 9, \ldots \quad \textit{euro area GDP} \qquad (4) \end{aligned}$$

where

$$\begin{aligned} f_t^Q &= \frac{1}{3} f_t + \frac{2}{3} f_{t-1} + f_{t-2} + \frac{2}{3} f_{t-3} + \frac{1}{3} f_{t-4} \\ b_t^Q &= \frac{1}{3} b_t + \frac{2}{3} b_{t-1} + b_{t-2} + \frac{2}{3} b_{t-3} + \frac{1}{3} b_{t-4} \end{aligned}$$

As mentioned above, $f_t$ and $b_t$ represent monthly growth rates of the latent factors. The last expressions for $f_t^Q$ and $b_t^Q$ are based on the technical assumption that the quarterly level of the factors can be represented by the geometric mean of the latent monthly levels[2]. This assumption makes it possible to obtain a simple expression for the quarterly growth rate of the factors as a moving average of the latent monthly growth rates. Because we apply the Mariano and Murasawa

[2]The approximation proposed by Mariano and Murasawa (2003) is applied to the factors. Let $F_t$ be the monthly *level* of the economy and let $f_t = lnF_t - lnF_{t-1}$ be its monthly growth rate. Now, define $F_t^Q$ as the geometric mean of the last three levels. This implies that $lnF_t^Q = \frac{1}{3}(lnF_t + lnF_{t-1} + lnF_{t-2})$. The resulting quarterly growth rate of the factors, which we denote as $f_t^Q$, can be expressed as $lnF_t^Q - lnF_{t-3}^Q$. By substituting both terms by the geometric mean approximation we obtain $f_t^Q = \frac{1}{3}(lnF_t + lnF_{t-3}) + \frac{1}{3}(lnF_{t-1} + lnF_{t-4}) + \frac{1}{3}(lnF_{t-2} + lnF_{t-5})$. Finally, a simple expression for the quarterly growth rate of the factors in terms of their monthly growth rates can be obtained as follows: $f_t^Q = \frac{1}{3}(f_t + f_{t-1} + f_{t-2}) + \frac{1}{3}(f_{t-1} + f_{t-2} + f_{t-3}) + \frac{1}{3}(f_{t-2} + f_{t-3} + f_{t-4})$. Rearranging terms yields the expression $f_t^Q = \frac{1}{3} f_t + \frac{2}{3} f_{t-1} + f_{t-2} + \frac{2}{3} f_{t-3} + \frac{1}{3} f_{t-4}$ presented above.

(2003) approximation to the factors alone, and not to the observables, the error terms $\chi_t^Q$ and $\psi_t^Q$ are assumed to be iid normally distributed and uncorrelated with all factors and measurement errors defined at all leads and lags.

So far, I have described the so-called measurement equation, which defines the link between the unobserved factors and the two types of observable time series: monthly variables and quarterly variables (e.g. GDP). Specifying the joint dynamics of all variables in both the euro area and Belgium requires a second equation representing the factors as a vector autoregressive (VAR) process with a non-diagonal covariance matrix for the error term. Thus, even if Belgian specific factors do not load contemporaneously on euro area data (see equation 2), they can be correlated to the euro area factors. To sum up, representation given by equations 5 and 6 conforms to the so-called state-space representation of this model and determines the joint dynamics of both the euro area and the Belgian business cycles:

$$\begin{pmatrix} x_t^Q - \bar{x}^Q \\ x_t - \bar{x} \\ \hline y_t^Q - \bar{y}^Q \\ y_t - \bar{y} \end{pmatrix} = \left(\begin{array}{ccccc|ccccc} \Lambda_x^Q & 2\Lambda_x^Q & 3\Lambda_x^Q & 2\Lambda_x^Q & \Lambda_x^Q & 0 & 0 & 0 & 0 & 0 \\ \Lambda_x & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \hline \Lambda_y^Q & 2\Lambda_y^Q & 3\Lambda_y^Q & 2\Lambda_y^Q & \Lambda_y^Q & \Theta_y^Q & 2\Theta_y^Q & 3\Theta_y^Q & 2\Theta_y^Q & \Theta_y^Q \\ \Lambda_y & 0 & 0 & 0 & 0 & \Theta_y & 0 & 0 & 0 & 0 \end{array}\right) \begin{pmatrix} f_t \\ f_{t-1} \\ f_{t-2} \\ f_{t-3} \\ f_{t-4} \\ \hline b_t \\ b_{t-1} \\ b_{t-2} \\ b_{t-3} \\ b_{t-4} \end{pmatrix} + \begin{pmatrix} \chi_t^Q \\ \chi_t \\ \hline \psi_t^Q \\ \psi_t \end{pmatrix} \tag{5}$$

$$\begin{pmatrix} f_t \\ f_{t-1} \\ f_{t-2} \\ f_{t-3} \\ f_{t-4} \\ \hline b_t \\ b_{t-1} \\ b_{t-2} \\ b_{t-3} \\ b_{t-4} \end{pmatrix} = \left(\begin{array}{ccccc|ccccc} A_{11} & 0 & 0 & 0 & 0 & A_{12} & 0 & 0 & 0 & 0 \\ I & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & I & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & I & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & I & 0 & 0 & 0 & 0 & 0 & 0 \\ \hline A_{21} & 0 & 0 & 0 & 0 & A_{22} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & I & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & I & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & I & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & I & 0 \end{array}\right) \begin{pmatrix} f_{t-1} \\ f_{t-2} \\ f_{t-3} \\ f_{t-4} \\ f_{t-5} \\ \hline b_{t-1} \\ b_{t-2} \\ b_{t-3} \\ b_{t-4} \\ b_{t-5} \end{pmatrix} + \begin{pmatrix} u_t^f \\ 0 \\ 0 \\ 0 \\ 0 \\ u_t^g \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} \tag{6}$$

where the innovations to the Belgian and external factors are allowed to be cross-correlated:

$$\begin{pmatrix} u_t^f \\ u_t^g \end{pmatrix} \sim \mathcal{N}\left(0, \begin{bmatrix} Q_1 & \Omega_{12} \\ \Omega_{12} & Q_2 \end{bmatrix}\right)$$

These error components are also uncorrelated with all measurement error terms, in line with the literature on factor models. For simplicity, and in contrast to the model built by Mariano and Murasawa (2003), I do not incorporate autocorrelation in the measurement errors. This helps to keep the size of the state vector as small as possible without restricting the extent to which the factors can account for the business cycle comovements.

## 2.2 Estimation in the Context of Missing Observations

Once the building blocks of the model have been described, we need to tackle the problem of estimation. The alternative versions of the model, which will be described in detail in the next section, could be misspecified if the innovations do not follow a normal distribution or if the covariance of the noise component is not diagonal. The Quasi-maximum likelihood procedure of Doz et al. (2012) is used here with the aim of achieving a consistent estimation even in the presence of weak correlation patterns in the measurement errors. Thus, the model is estimated under the restriction that the off-diagonal elements of the measurement error covariance matrix are equal to zero. This has the practical implication that one hundred percent of the cross-correlation patterns generated by the model will be fully accounted for by the factors.

The model is estimated at monthly frequency with maximum-likelihood even in the presence of missing observations. For example, survey data for the euro area is often not available prior to 2000, while some of the Belgian series date back to 1980. The presence of quarterly data also generates additional missing observations, since they are treated as indicators that are observed every third month of the quarter, i.e. $y_t^Q$ as a missing variable for $t \neq 3, 6, \ldots$. Finally, as in most macro-economic forecasting applications, the relevant information set is based on indicators that arrive gradually throughout the quarter and with important delays with respect to the period of time to which they refer. Thus, in practice, it is unavoidable to have missing values at the end of the sample. For a detailed overview of the estimation method used in this paper, the reader is referred to Banbura and Modugno (2012). Below, I summarize the most important concepts underlying the approach with special emphasis on the aspects that are particularly relevant in our nowcasting framework:

- **Maximum-likelihood**. In this application, the state-space model represented by equations 5 and 6 is estimated with the Expectation-Maximization (EM) algorithm. The Kalman (1960) filter and smoothing recursions, however, need to be slightly modified so that only the actual observations can be taken into account in the estimation of the factors and the evaluation of the likelihood. The EM algorithm was derived by Shumway and Stoffer (1982) only for the case where the factor loadings multiplying the factors in the measurement equation are known. Banbura and Modugno (2010) are the first ones to apply this algorithm to the current set-up, where the loadings need to be estimated in the context of missing observations. They show their method is consistent and computationally feasible even in the case where the number of variables is large. Alternatively, Camacho and Perez-Quiros (2010) propose the use of standard optimization routines to maximize the likelihood of a model of the same class, but based on a smaller number of variables[3].

[3]Numerical optimization of the likelihood, which is feasible for parsimonious models, has the advantage that it does not require the Kalman smoother. Moreover, the multithreading ability of most software packages is able to reduce the execution time by exploiting multiple processors.

- **Identification of the factors** The strongest assumption, which is key for identification, is that the measurement errors $e_t$ are uncorrelated with the factor innovations $u_t$. This allows for a clear-cut separation of the measurement errors and the signal provided by the factors. In the absence of the restrictions I impose in the factor loadings, the model would be identified only up to an invertible linear transformation. That is, applying the following transformation, $g_t^M = Gf_t^M$, the transition equation $g_t^M = GA_1G^{-1}g_{t-1}^M + \ldots + GA_pG^{-1}g_{t-p}^M + Gu_t$ would be observationally equivalent to the one represented by equation 6. Nevertheless, Dempster, Laird and Rubien (1997) suggest that the EM algorithm is not affected by this lack of identification, which is well known in factor analysis and does not distort the results presented here. The forecasts are actually unaffected by the choice of $G$.

# 3 Data and Forecasting Models

## 3.1 Data Selection

The goal established in the data selection stage was to approximate the information set of professional forecasters and market analysts. Data selection algorithms such as the one proposed by Piette and Langenus (2014) for Belgian data are thereby ruled out in this paper even if they could potentially help to achieve further forecast accuracy gains. In addition, the use of real-time data for model validation enables me to simulate the actual environment of professional forecasters and, as suggested by Stark and Croushore (2002), avoid any misleading conclusion that may be obtained when the models are estimated and used on the basis of latest available data.

This paper also represents, together with work by Camacho and Pérez-Quirós (2010), one of the few attempts in Europe to reproduce the real-time data availability. The first dimension of real-time data is the presence of data revisions, which I consider GDP growth rates alone (see Figure 1). Fortunately, the variables that have the largest impact in my analysis, i.e. surveys, are not subject to revision. The second dimension of real-time data is the existence of a very specific publication schedule for each indicator. A visual representation of such calendar is provided in Table 1 . Since I consider the precise release calendar for all series, my analysis precisely reproduces the actual work environment of professional forecasters in real time.

In this section, I define the variables incorporated in the model's information set and the release calendar. The publication schedule for the Belgian National Accounts, which were published on a quarterly basis for the first time in 1998, has been gradually adapted to conform to changes in European recommendations, but continues to rely heavily on the yearly national accounts. The first part of Table 2 lists the most relevant releases for the euro area and Belgium. The

Table 1: The news flow


Note that financial variables are available at a daily basis and without delays. The remaining indicators, however, are typically released with some delay. As represented in the picture, survey data corresponding to a given month is published before the end of this month. By using colors to represent the months (or quarters) to which data refers, I am able to provide a precise description of the news flow from the timeliness viewpoint.

first real GDP growth estimate, i.e. the so-called flash release, is published only 30 days after the end of the quarter (two weeks earlier than the flash release for the euro area). This estimate is based on disaggregated data on industrial production and VAT returns for the first two months of the quarter. Given the incompleteness of such information set, the flash is subject to a first revision around 70 days after the end of the reference quarter. However, the revision process does not stop there, but continues indefinitely. Thus, the flash estimate is released together with revisions for previous quarters. The current revision schedule for the euro area is slightly more complex, since data needs to be sent from the national statistical agencies to Eurostat. Eurostat often releases the figures without having received the data from all countries. Figure 1 illustrates the different figures published for the growth rate of 2008Q3, which is the quarter where GDP starts reflecting the recession in Belgium. The main message from this figure is that the first scheduled revisions can be meaningless compared to the continuous revision process that keeps on revising the history year after year. Appendix B discusses in more detail some of the properties of data revisions.

The most relevant survey data for Belgium is described in the second part of Table 2. The first indicator is the so-called Business Confidence Index (BCI), which results from the overall NBB business confidence survey results. The second indicator corresponds to the results obtained by a subset of questions of the NBB survey, which aims to measure the forward-looking component of the manufacturing sector. The Consumer Confidence Index has been selected not only because it is published around 11 days before the end of each month, but also because consumption represents a significant fraction of total output in the Belgian economy. The last three survey indicators in Table 2 refer to the euro area. The flash release of the Purchasing Manager Indices (PMI) for both the manufacturing and services sectors in the euro area, which is published as promptly as the NBB survey are also incorporated in the analysis together with the Economic Sentiment Indicator (ESI). Following Piette and Langenus (2014), I have also considered the possibility of adding survey data for Germany, which is the main trading partner of Belgium, but the results did not not change. A more sophisticated model for the interaction with the main trading partners is a interesting avenue for future research. The current model's focus on euro area data offers the possibility of integrating this tool into coordinated forecasting exercises where the Belgian economy can be assessed given the ECB's views about the short-term evolution of the euro area as a whole.

The variables listed in Table 3 and Table 4 describe the remaining series introduced into the model. Most of the series in Table 3 are well known indicators, such as industrial production, sales, car registrations, employment, unemployment or the balance of trade. They are typically used to assess the short term evolution of the economy even if they are published with a significant delay. The fifth indicator in the table is the total turnover of Belgian firms according to the VAT declarations. It should be mentioned that, together with the industrial production data, this is a key indicator for in the construction of the GDP flash estimate at the NAI.

Table 4 incorporates a new set of variables that economists and policy makers have been closely monitoring since the beginning of the crisis even if they are not often incorporated in nowcasting applications for GDP growth. Those variables include stock prices and consumer prices indices for both the euro area and Belgium, housing market variables for Belgium, and several interest rates (3-months euribor, term spread, sovereign risk). To sum up, the indicators described represent relatively aggregate quantities and values that approximate the information set used by forecasters. Using more disaggregated data could be useful in order to mimic the information sets available to the statistical agency. Luciani (2014) shows that the so-called *non-pervasive* shocks, which affect a group of variables within a given sector without spreading towards the rest of the economy, do not significantly distort the estimation of the aggregate factors.

The state-space representation of the model displayed in Figure 2 assumes that GDP, $x_t^Q$, and the monthly indicators $x_t^S$ or $x_t$ are linked to unobserved factors. Those factors represent underlying monthly growth rates of real and nominal economic activity, which suggests the introduction of a $\Delta ln$ transformation in the data. Although this can be considered as the general rule, there are some remarkable exceptions. For example, surveys data will be specified in levels without any kind of adjustment. The surveys are often related to year-on-year growth rates, which implies in our framework that they should be linked to the cumulative sum of the factors for twelve months, i.e. year-on-year growth rate of the factor, as in Camacho and Pérez-Quirós (2010). The European Commission (2006) explicitly states that the guiding principle for the selection of questions in the different surveys is the aim to achieve as high as possible coincident correlation of the confidence indicator with year-on-year growth of the reference series. De Greef and Van Nieuwenhuyze (2009) also emphasize the coincident correlation of the NBB Business Survey with year-on-year GDP growth rates. Regarding GDP growth rates or PMI survey data, the most sensible approach is to link the variables to a linear combination of the factors that represents quarter-on-quarter growth rates, i.e. I use the Mariano-Murasawa linkage defined above. Although Markit Economics does not publish a detailed documentation about the construction of their index, they regularly compare their indices to the quarter-on-quarter growth rate of GDP. The coincident correlation between the PMI index and quarter-on-quarter GDP growth rate is also highlighted by Koenig (2002) for US data.

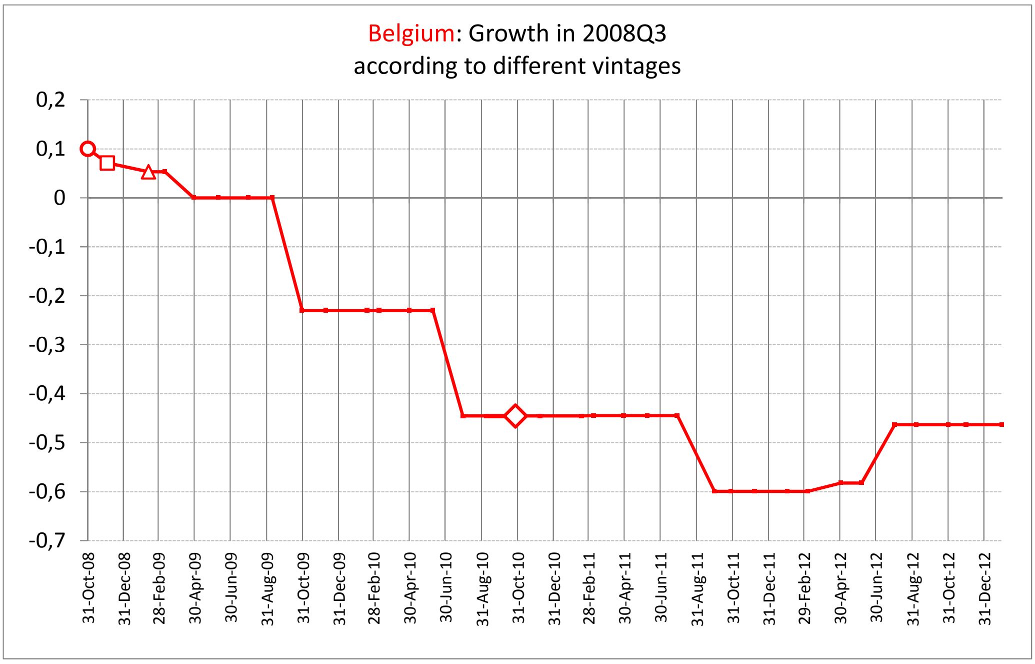
## 3.2 Forecasting Models

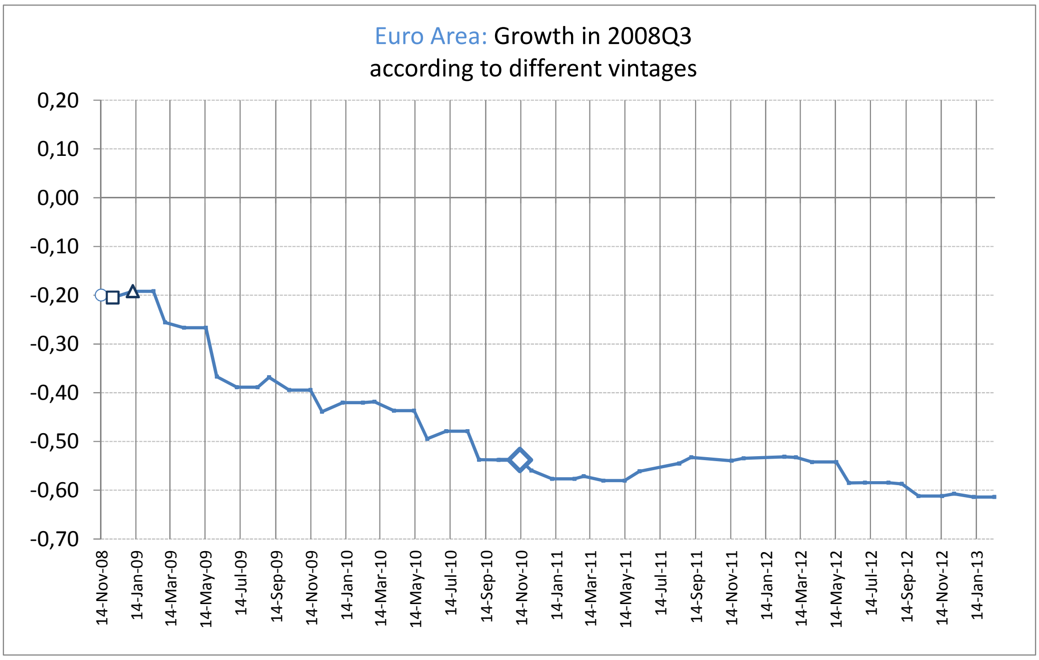
Two alternative models will be estimated to conduct the forecast evaluation exercise that will be described in Section 5:

1. The **Benchmark** model, represented in the measurement equation 5, will be estimated using the information set described in tables 2 and 3 in Section 3. As shown above, those factors represent underlying monthly growth rates of real and nominal economic activity. The surveys that are related with quarter-on-quarter growth rates will be more accurately represented by allowing them to load on a linear combination of the factors, as described in equations 3 and 4. In the same fashion, surveys related to year-on-year growth rates will be related to the cumulative sum over twelve months of factors representing the underlying monthly growth rate of the economy, as in Camacho and Pérez-Quirós (2010). The European Commission (2006) explicitly states that the guiding principle for the selection of questions in the different surveys is the aim to achieve as high as possible coincident correlation of the confidence indicator with year-on-year growth of the reference series. This implies that some variables in the Benchmark model load on twelve lags of the factors and not just five, as in the simplistic representation provided in equations 5 -6.

2. The **Financial** & **Housing** model, however, aims to also take into account the financial and housing market variables described in Table 4. This case study is particularly relevant, since accounting for specific developments in the Belgian housing market may help to better pinpoint the medium- and long-term growth in the Belgian economy. With this in mind, introducing a new block of factors, $\tau_t$, that loads on the housing market variables $h_t$ turns out to be a simple solution to make sure we capture housing market specific developments that are not accounted for by the remaining factors. As described in Figure 2, housing market variables in Belgium are assumed

Figure 1: The continuous revision process




The circle, the square and the triangle are used to mark the Flash, first, and second revision, respectively. The model will use the Belgian Flash (30 days), second revision (120 days) and the figures available two years after the reference quarter. For the euro area, given the small size of the scheduled revisions, only the Flash and the release available two years after the reference quarter will be considered in the model's information set.

Table 2: GDP and Surveys

| Real GDP time series | | source | unit | start | linked to | 100xlog | diff | average delay [days after the end of the quarter] | group (region) |
|---|---|---|---|---|---|---|---|---|---|
| **Real GDP at market prices; SA FLASH** | | NBB | volume | 2002Q1 | $f^Q(t)$ | 1 | 1 | 35 | GDP (BE) |
| **Real GDP at market prices; SA FIRST** | | NBB | volume | 2003Q4 | $f^Q(t)$ | 1 | 1 | 71 | |
| **Real GDP at market prices; SA SECOND** | | NBB | volume | 1999Q1 | $f^Q(t)$ | 1 | 1 | 124 | |
| **Real GDP at market prices; SA 2 years** | | NBB | volume | 1999Q1 | $f^Q(t)$ | 1 | 1 | 2 years | |
| **Real GDP at market prices; SA NBB history** | | NBB | volume | 1980Q1 | $f^Q(t)$ | 1 | 1 | - | |
| **Real GDP at market prices; SA FLASH** | **euro area** | eurostat | volume | 2001Q1 | $f^Q(t)$ | 1 | 1 | 45 | GDP (EA) |
| **Real GDP at market prices; SA FIRST** | **euro area** | eurostat | volume | 2001Q1 | $f^Q(t)$ | 1 | 1 | 78 | |
| **Real GDP at market prices; SA SECOND** | **euro area** | eurostat | volume | 2001Q1 | $f^Q(t)$ | 1 | 1 | 118 | |
| **Real GDP at market prices; SA 2 years** | **euro area** | eurostat | volume | 2001Q1 | $f^Q(t)$ | 1 | 1 | 2 years | |
| **Real GDP at market prices; SA AWM history** | **euro area** | ECB | volume | 1980Q1 | $f^Q(t)$ | 1 | 1 | - | |

| "Soft data" | | source | unit | start | linked to | 100xlog | diff | average delay [days after (+) /before (-) the end of the month] | group (region) |
|---|---|---|---|---|---|---|---|---|---|
| **NBB Business Confidence survey (overall);** | | Business Survey NBB | index | 1980M1 | $f^Y(t)$ | 0 | 0 | -7 | Survey (BE) |
| **NBB Demand expectations (manufacturing);** | | Business Survey NBB | index | 1980M1 | $f^Y(t)$ | 0 | 0 | -7 | Survey (BE) |
| **Consumer confidence indicator;** | | Consumer Survey NBB | index | 1980M1 | $f^Y(t)$ | 0 | 0 | -11 | Survey (BE) |
| **Purchasing manager index (flash)- Manufacturing;** | **euro area** | Markit Economics | Index | 1997M6 | $f^Q(t)$ | 0 | 0 | -6 | Survey (EA) |
| **Purchasing manager index (flash) - Services;** | **euro area** | Markit Economics | Index | 1999M1 | $f^Q(t)$ | 0 | 0 | -6 | Survey (EA) |
| **Economic Sentiment Indicator;** | **euro area** | eurostat Survey | Index | 2000M1 | $f^Y(t)$ | 0 | 0 | 2 | Survey (EA) |

Note that none of the surveys are transformed or filtered in any way. The column *linked to* defines how the variables are linked to the factors. Surveys from the European Commission or the National Bank of Belgium are linked to the cumulative sum of the factors over the last 12 months ($f_t^Y$), while the PMI indicators are linked to the factors through the Mariano-Murasawa filter ($f_t^Q$), in exactly the same way as GDP growth.

Table 3: Activity indicators

| "Hard data" | source | unit | start | linked to | 100xlog | diff | average delay | group (region) |
|---|---|---|---|---|---|---|---|---|
| **Trade balance in goods based on the national concept** | INA | millions of euros | 1995M1 | f(t) | 0 | 0 | 52 | External (BE) |
| **Industrial production, excluding construction** | FPS Economy | volume index (2005 = 100) | 2000M1 | f(t) | 1 | 1 | 54 | IPI (BE) |
| **Industrial production, excluding construction; euro area** | FPS Economy | volume index (2005 = 100) | 2000M1 | f(t) | 1 | 1 | 54 | IPI (EA) |
| **Registration of new private cars ( transit not included)** | FEBIAC | number of units | 1980M1 | f(t) | 1 | 1 | 1 | cars (BE) |
| **Total turnover** | FPS Economy and INA | Millions of euro | 1980M1 | f(t) | 1 | 1 | 51 | sales (BE) |
| **Total receipts** | NBB | Millions of euro | 1980M2 | f(t) | 1 | 1 | 51 | sales (BE) |
| **Retail Sales (deflated turnover in the retail trade, excluding motor vehicles), euro area** | eurostat | volume index (2005 = 100) | 1995M1 | f(t) | 1 | 1 | 35 | sales (EA) |
| **Adjusted harmonised unemployment rate (Eurostat definition)** | NEO | Percentages of the active population | 1983M1 | f(t) | 0 | 1 | 21 | labour (BE) |
| **Work volume of temporary workers** | Federgon | Thousands of hours | 1992M1 | f(t) | 1 | 1 | 24 | labour (BE) |

The column *linked to* defines how the variables are linked to the factors, which represent the underlying monthly growth rates of the economy. As opposed to surveys, all those indicators are directly linked to the factors.

Table 4: Extending the information set

| Robustness: financial & housing market | source | unit | start | linked to | 100xlog | diff | average delay | group (region) |
|---|---|---|---|---|---|---|---|---|
| **National CPI** | FPS ECO | Price index, 1996 = 100 | 1996M1 | f(t) | 0 | 1 | -2 | Prices (BE) |
| **HICP; euro area** | eurostat | Price index, 1996 = 100 | 1996M1 | f(t) | 0 | 1 | 17 | Prices (EA) |
| **euronext100; euro area** | Thomson Reuters Datastream | Price index in euros (monthly average) | 31-Dec-99 | f(t) | 1 | 1 | 0 | financial (EA) |
| **Brussels all Shares** | Thomson Reuters Datastream | Price index in euros (monthly average) | 1-Jan-80 | f(t) | 1 | 1 | 0 | financial (BE) |
| **Spreads on Belgian ten-year government bonds relative to the German Bund** | ECB | Basis points (monthly average) | 5-Jun-89 | f(t) | 0 | 1 | 0 | financial (BE, DE) |
| **3-month Euribor; euro area** | ECB | Percentage points (monthly average) | 30-Dec-98 | f(t) | 0 | 1 | 0 | financial (EA) |
| **German Ten-year government bond yield minus 3m euribor** | ECB | Percentage points (monthly average) | 1-Jan-80 | f(t) | 0 | 1 | 0 | financial (EA,DE) |
| **Permits for new residential buildings, SA** | FPS Economy | Volume in cubic metre | 1990M1 | f(t) | 1 | 1 | 105 | housing (BE) |
| **New residential building starts, SA** | FPS Economy | Volume in cubic metre | 1980M1 | f(t) | 0 | 0 | 135 | housing (BE) |
| **Real House Prices, SA** | NBB | Index | 1980Q1 | $f^Q(t)$ | 1 | 1 | 80 | housing (BE) |

The column *linked to* defines how the variables are linked to the factors, which represent the underlying monthly growth rates of the economy. As opposed to surveys, most of those indicators are directly linked to the factors. Note that financial variables are available at daily or even higher frequency. Incorporating them at the highest frequency simply requires the factors to defined accordingly. See Banbura, Giannone, Modugno and Reichlin (2012) for a detailed discussion.

to be driven not only by the so-called external ($f_t$) and specifically Belgian ($b_t$) factors, but also by the housing factor ($\tau_t$). Since the transition equation specifies a vector autoregressive structure for all latent factors, unexpected movements in housing market factors can also affect the forecast for the other two factors[4], and thereby for all variables in the system, which are linked to the factors through the measurement equation.

### 3.3 Model Specification

Figure 2 displays the state-space representation of the *Financial* & *Housing* model, which is based on three blocks of unobserved factors ($f_t, b_t, \tau_t$) and their lags. Such representation, however, remains at a highly abstract level. First of all, note that the variables with upper index $Q$ incorporate real GDP growth rates of alternative indicator variables: Flash release, the so-called second release, the figures available two years after the end of each quarter, and the historical series, which dates back to 1980. By allowing the factor loadings to be different for all releases, I acknowledge the possibility of them all referring to different concepts and that the methodology used in their construction can be different. Alternatively, Camacho and Pérez-Quirós (2010) or Evans (2005) assume that revisions can be formalized in terms of pure noise (see Mankiw and Shapiro, 1986). In such case, the difference between the GDP flash release and the subsequent revision is assumed to be uncorrelated with the underlying measure of economic activity. However, this specification has the counterfactual implication that the variance of the flash is larger than the variance of the subsequent revisions. As shown in the appendix, the noise hypothesis is overwhelmingly rejected within our sample period for both Belgium and the euro area.

[4]Because the focus of this paper is on forecasting accuracy, I am not discussing the options for conducting structural analysis for the purpose of identifying the shocks, as typically done in the literature on vector autoregressive modeling.

A key issue that needs to be clarified is the total number of factors and the number of lags in the VAR representation. Although the transition equation of Figure 2 is a VAR(1), all the empirical results presented in the paper have been obtained with a VAR(4) representation. This choice, which was meant to capture some of the complex interactions between the business cycle and the housing market, does not affect the precision of GDP forecast over out evaluation sample even if the number of parameters increases[5]. In order to render the model as parsimonious as possible, I decided to introduce only one factor in each of the three blocks represented in the figure. Thus, you can think of $f_t, b_t$ and $\tau_t$ as three factors and not as three blocks of factors as suggested above. This implies that the number of factor loadings to estimate remains as small as possible.

[5]It is common wisdom in macroeconomic forecasting applications that parsimonious models do better at forecasting.

Figure 2: State-Space representation of Financial & Housing Model

$$
\begin{pmatrix} x_t^Q-\bar{x}^Q \\ x_t^S-\bar{x}^S \\ x_t-\bar{x} \\ \hline y_t^Q-\bar{y}^Q \\ y_t^S-\bar{y}^S \\ y_t-\bar{y} \\ \hline h_t-\bar{h} \end{pmatrix}
=
\left(\begin{array}{cccccccccccc|cccccccccccc|c}
\Lambda_x^Q & 2\Lambda_x^Q & 3\Lambda_x^Q & 2\Lambda_x^Q & \Lambda_x^Q & 0&0&0&0&0&0&0 & 0&0&0&0&0&0&0&0&0&0&0&0 & 0 \\
\Lambda_x^S & \Lambda_x^S & \Lambda_x^S & \Lambda_x^S & \Lambda_x^S & \Lambda_x^S & \Lambda_x^S & \Lambda_x^S & \Lambda_x^S & \Lambda_x^S & \Lambda_x^S & \Lambda_x^S & 0&0&0&0&0&0&0&0&0&0&0&0 & 0 \\
\Lambda_x & 0&0&0&0&0&0&0&0&0&0&0 & 0&0&0&0&0&0&0&0&0&0&0&0 & 0 \\ \hline
\Lambda_y^Q & 2\Lambda_y^Q & 3\Lambda_y^Q & 2\Lambda_y^Q & \Lambda_y^Q & 0&0&0&0&0&0&0 & \Theta_y^Q & 2\Theta_y^Q & 3\Theta_y^Q & 2\Theta_y^Q & \Theta_y^Q & 0&0&0&0&0&0&0 & 0 \\
\Lambda_y^S & \Lambda_y^S & \Lambda_y^S & \Lambda_y^S & \Lambda_y^S & \Lambda_y^S & \Lambda_y^S & \Lambda_y^S & \Lambda_y^S & \Lambda_y^S & \Lambda_y^S & \Lambda_y^S & \Theta_y^S & \Theta_y^S & \Theta_y^S & \Theta_y^S & \Theta_y^S & \Theta_y^S & \Theta_y^S & \Theta_y^S & \Theta_y^S & \Theta_y^S & \Theta_y^S & \Theta_y^S & 0 \\
\Lambda_y & 0&0&0&0&0&0&0&0&0&0&0 & \Theta_y & 0&0&0&0&0&0&0&0&0&0&0 & 0 \\ \hline
\Lambda_h & 0&0&0&0&0&0&0&0&0&0&0 & \Theta_h & 0&0&0&0&0&0&0&0&0&0&0 & \Gamma_h
\end{array}\right)
\begin{pmatrix} f_t \\ f_{t-1} \\ f_{t-2} \\ f_{t-3} \\ f_{t-4} \\ f_{t-5} \\ f_{t-6} \\ f_{t-7} \\ f_{t-8} \\ f_{t-8} \\ f_{t-10} \\ f_{t-11} \\ \hline b_t \\ b_{t-1} \\ b_{t-2} \\ b_{t-3} \\ b_{t-4} \\ b_{t-5} \\ b_{t-6} \\ b_{t-7} \\ b_{t-8} \\ b_{t-9} \\ b_{t-10} \\ b_{t-11} \\ \hline \tau_t \end{pmatrix}
+
\begin{pmatrix} \chi_t^Q \\ \chi_t \\ \chi_t^\pi \\ \hline \psi_t^Q \\ \psi_t \\ \psi_t^\pi \\ \hline \eta_t \end{pmatrix}
$$

$$
\begin{pmatrix} f_t \\ f_{t-1} \\ f_{t-2} \\ f_{t-3} \\ f_{t-4} \\ f_{t-5} \\ f_{t-6} \\ f_{t-7} \\ f_{t-8} \\ f_{t-8} \\ f_{t-10} \\ f_{t-11} \\ \hline b_t \\ b_{t-1} \\ b_{t-2} \\ b_{t-3} \\ b_{t-4} \\ b_{t-5} \\ b_{t-6} \\ b_{t-7} \\ b_{t-8} \\ b_{t-9} \\ b_{t-10} \\ b_{t-11} \\ \hline \tau_t \end{pmatrix}
=
\left(\begin{array}{cccccccccccc|cccccccccccc|c}
A_{11} & 0&0&0&0&0&0&0&0&0&0&0 & A_{12} & 0&0&0&0&0&0&0&0&0&0&0 & A_{13} \\
I&0&0&0&0&0&0&0&0&0&0&0 & 0&0&0&0&0&0&0&0&0&0&0&0 & 0 \\
0&I&0&0&0&0&0&0&0&0&0&0 & 0&0&0&0&0&0&0&0&0&0&0&0 & 0 \\
0&0&I&0&0&0&0&0&0&0&0&0 & 0&0&0&0&0&0&0&0&0&0&0&0 & 0 \\
0&0&0&I&0&0&0&0&0&0&0&0 & 0&0&0&0&0&0&0&0&0&0&0&0 & 0 \\
0&0&0&0&I&0&0&0&0&0&0&0 & 0&0&0&0&0&0&0&0&0&0&0&0 & 0 \\
0&0&0&0&0&I&0&0&0&0&0&0 & 0&0&0&0&0&0&0&0&0&0&0&0 & 0 \\
0&0&0&0&0&0&I&0&0&0&0&0 & 0&0&0&0&0&0&0&0&0&0&0&0 & 0 \\
0&0&0&0&0&0&0&I&0&0&0&0 & 0&0&0&0&0&0&0&0&0&0&0&0 & 0 \\
0&0&0&0&0&0&0&0&I&0&0&0 & 0&0&0&0&0&0&0&0&0&0&0&0 & 0 \\
0&0&0&0&0&0&0&0&0&I&0&0 & 0&0&0&0&0&0&0&0&0&0&0&0 & 0 \\
0&0&0&0&0&0&0&0&0&0&I&0 & 0&0&0&0&0&0&0&0&0&0&0&0 & 0 \\ \hline
A_{21} & 0&0&0&0&0&0&0&0&0&0&0 & A_{22} & 0&0&0&0&0&0&0&0&0&0&0 & A_{23} \\
0&0&0&0&0&0&0&0&0&0&0&0 & I&0&0&0&0&0&0&0&0&0&0&0 & 0 \\
0&0&0&0&0&0&0&0&0&0&0&0 & 0&I&0&0&0&0&0&0&0&0&0&0 & 0 \\
0&0&0&0&0&0&0&0&0&0&0&0 & 0&0&I&0&0&0&0&0&0&0&0&0 & 0 \\
0&0&0&0&0&0&0&0&0&0&0&0 & 0&0&0&I&0&0&0&0&0&0&0&0 & 0 \\
0&0&0&0&0&0&0&0&0&0&0&0 & 0&0&0&0&I&0&0&0&0&0&0&0 & 0 \\
0&0&0&0&0&0&0&0&0&0&0&0 & 0&0&0&0&0&I&0&0&0&0&0&0 & 0 \\
0&0&0&0&0&0&0&0&0&0&0&0 & 0&0&0&0&0&0&I&0&0&0&0&0 & 0 \\
0&0&0&0&0&0&0&0&0&0&0&0 & 0&0&0&0&0&0&0&I&0&0&0&0 & 0 \\
0&0&0&0&0&0&0&0&0&0&0&0 & 0&0&0&0&0&0&0&0&I&0&0&0 & 0 \\
0&0&0&0&0&0&0&0&0&0&0&0 & 0&0&0&0&0&0&0&0&0&I&0&0 & 0 \\
0&0&0&0&0&0&0&0&0&0&0&0 & 0&0&0&0&0&0&0&0&0&0&I&0 & 0 \\ \hline
A_{31} & 0&0&0&0&0&0&0&0&0&0&0 & A_{32} & 0&0&0&0&0&0&0&0&0&0&0 & A_{33}
\end{array}\right)
\begin{pmatrix} f_{t-1} \\ f_{t-2} \\ f_{t-3} \\ f_{t-4} \\ f_{t-5} \\ f_{t-6} \\ f_{t-7} \\ f_{t-8} \\ f_{t-8} \\ f_{t-10} \\ f_{t-11} \\ f_{t-12} \\ \hline b_{t-1} \\ b_{t-2} \\ b_{t-3} \\ b_{t-4} \\ b_{t-5} \\ b_{t-6} \\ b_{t-7} \\ b_{t-8} \\ b_{t-9} \\ b_{t-10} \\ b_{t-11} \\ b_{t-12} \\ \hline \tau_{t-1} \end{pmatrix}
+
\begin{pmatrix} u_t^f \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ \hline u_t^g \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ \hline u_t^b \end{pmatrix}
$$

with $\begin{pmatrix} u_t^f \\ u_t^g \\ u_t^b \end{pmatrix} \sim \mathcal{N}\left(0, \begin{bmatrix} Q_1 & \Omega_{12} & \Omega_{13} \\ \Omega_{12} & Q_2 & \Omega_{23} \\ \Omega_{13} & \Omega_{13} & Q_3 \end{bmatrix}\right)$ *uncorrelated with the idiosyncratic measurement errors.*

The superscript $Q$ refers to the quarterly variables. The EC and the NBB surveys, which have the "S" upperscript, will be directly linked to the cumulative sum of the factors over the past 12 months. The filter applied to the the PMI indicators is the same one as for the quarterly variables even if not explicitly mentioned here.

# 4 Analysis of News

The *news* associated with a given release is represented by the discrepancy of the published figure with respect to the forecast of the model. Thus, I will use the word *news*, *innovations* or *forecast errors* interchangeably (see Durbin and Koopman, 2001, section 4.8). Once the concept of news is clearly defined, I will show how the so-called *Kalman gain* induces the model to update the forecast path for GDP or any other variable of interest after a given piece of news becomes available. The role played by the news that gradually enters the forecaster's information set is given not only by their quality, but also by their timeliness, which crucially depends on the release calendar. The last part of this section quantifies the precise role of all data releases at forecasting Belgian GDP growth rates.

Let's consider a generic recursive representation, which encompasses any of the model specifications discussed before for the observable indicators:

$$\mathrm{y_t} = \Lambda \mathrm{f_t} + \mathrm{e_t} \tag{7}$$

$$\mathrm{f_{t+1}} = A\mathrm{f_t} + \eta_t \tag{8}$$

with normally distributed measurement errors and shocks to the factors: $e_t \sim N(0, R_t)$, $\eta_t \sim N(0, Q_t)$.

**Defining the information sets**

The concept of news can be formalized by specifying information sets that enter the model:

$\mathcal{F}^{old}$ contains all time series available right before the publication of the news. Consider for the sake of simplicity that all observations are available until time $t$.

$\mathcal{F}^{new}$ includes the previous information set, $\mathcal{F}^{old}$, plus new data corresponding to a given macroeconomic release. Again for the sake of simplicity, one can assume that the release extends by one month, $(t+1)$, two of the indicators, i.e. the PMI release for services ($\mathrm{y}_{\mathrm{t+1}}^{\mathrm{PMI_s}}$) and for manufactures ($\mathrm{y}_{\mathrm{t+1}}^{\mathrm{PMI_m}}$).

The forecast for the whole vector of variables $y_{t+h}$ is formulated in our framework in terms of model consistent conditional expectations:

$$E_\theta[y_{t+h}|\mathcal{F}^{new}] = E_\theta[y_{t+h}|\mathcal{F}^{old}, \{V_{t+1}\}] \tag{9}$$

where the expression on the right-hand side decomposes the new conditioning information set in two orthogonal parts. In this particular example, $V_{t+1} \equiv \mathcal{F}^{new} - \mathcal{F}^{old} = [\mathrm{v}_{\mathrm{t+1}}^{\mathrm{m}} \quad \mathrm{v}_{\mathrm{t+1}}^{\mathrm{s}}]'$ incorporates two innovations or news, which are defined as the difference between the released figures and the model's forecasts:

$$\mathrm{v}_{\mathrm{t+1}}^{\mathrm{m}} = \mathrm{y}_{\mathrm{t+1}}^{\mathrm{PMI_m}} - E_\theta[\mathrm{y}_{\mathrm{t+1}}^{\mathrm{PMI_m}}|\mathcal{F}^{old}]$$

$$\mathrm{v}_{\mathrm{t+1}}^{\mathrm{s}} = \mathrm{y}_{\mathrm{t+1}}^{\mathrm{PMI_s}} - E_\theta[\mathrm{y}_{\mathrm{t+1}}^{\mathrm{PMI_s}}|\mathcal{F}^{old}]$$

Thus, one could state that, even if the released figures have declined with respect to the recent past, the model could interpret them as good news as long as they are above the values that the model was expecting.

**The Kalman filter gain**

This news is exploited by the Kalman filter *gain* in order to update GDP forecasts together with the remaining variables. If we could observe $\mathrm{f_{t+h}}$, obtaining the forecast would be straightforward: $E_\theta[y_{t+h}|\mathcal{F}^{new}] = \Lambda A^{h-1} f_{t+1}$. But unfortunately, the factor $\mathrm{f_{t+1}}$ cannot be observed because only two data releases for $t+1$ are available and they are assumed to contain measurement errors. Thus, the conditional expectation in expression 9 must be developed further:

$$\begin{aligned} E_\theta[y_{t+h}|\left\{\mathcal{F}^{old}, V_{t+1}\right\}] &= \Lambda A^{h-1} E_\theta[\mathrm{f_{t+1}}|\left\{\mathcal{F}^{old}, V_{t+1}\right\}] \\ &= \underbrace{\Lambda A^{h-1} E_\theta[\mathrm{f_{t+1}}|\mathcal{F}^{old}]}_{old\,forecast} \\ &+ \Lambda A^{h-1} \underbrace{E_\theta[\mathrm{f_{t+1}} V_{t+1}'] E_\theta[V_{t+1} V_{t+1}']^{-1}}_{Gain\,(quality,\,timeliness)} \underbrace{V_{t+1}}_{news} \end{aligned} \tag{10}$$

Interestingly, the product of expectations shown in the expression above defines how the *news* induces an update[6] of the state of the economy, which is represented by $\mathrm{f}_{t+1}$. The precise weight of each one of the innovations at updating the expectations about the state of the economy depends on the quality and the timeliness of the indicators, as will be shown in detail in the appendix.

**Defining the standard impact of news**

In this simple example with only two data releases and one factor, the last term of expression 10 can be written in terms of parameters $\sigma_m^2 = var_\theta(v_{t+1}^m)$, $\sigma_s^2 = var_\theta(v_{t+1}^s)$, $\sigma_{ms}^2 = cov_\theta[v_{t+1}^m, v_{t+1}^s]$, $\beta_m = cov_\theta[\mathrm{f}_{t+1}, v_{t+1}^m]$, $\beta_s = cov_\theta[\mathrm{f}_{t+1}, v_{t+1}^s]$ (see Appendix). Thus:

$$E_\theta[y_{t+h}| \left\{\mathcal{F}^{old}, V_{t+1}\right\}] - E_\theta[y_{t+h}| \left\{\mathcal{F}^{old}\right\}] = \underbrace{\Lambda A^{h-1} \frac{\beta_m \sigma_s^2 - \beta_s \sigma_{ms}^2}{\sigma_m^2 \sigma_s^2 - \sigma_{ms}^2 \sigma_{ms}^2}}_{impact\ of\ PMI\ manufacturing} v_{t+1}^m + \underbrace{\Lambda A^{h-1} \frac{\beta_s \sigma_m^2 - \beta_m \sigma_{ms}^2}{\sigma_m^2 \sigma_s^2 - \sigma_{ms}^2 \sigma_{ms}^2}}_{impact\ of\ PMI\ services} v_{t+1}^s \quad (11)$$

This illustration has served as a vehicle to underline that the whole set of news, i.e. the vector of innovations $V_{t+1}$, induce an update of the path for all variables in $y_t$. The extent to which all the individual pieces of news induce change expectations for GDP growth rates in Belgium depends on all the different factors and on the particularities of the calendar of data releases. Quantifying the precise role of all the news is the goal of the next subsection. By multiplying the impacts defined in the equations above by the standard deviation of the news associated with each data release, we obtain a measure that allows us to compare the average informative content of the different indicators. Such a measure will be referred

[6] This update takes the form of a simple OLS regression of the factors on the innovations. Note that the size of the news vector $V_{t+1}$ may be large in practical applications. For example when many variables can be released at the same time, or many observations for the same variable are made available simultaneously.

to as the *standard impact* of a release, e.g. PMI, on a given variable of interest, e.g. GDP growth .

## 4.1 The "Standard Impact" of Macroeconomic Releases

I have defined the *standard impacts* associated with each one of the news releases as the product of the impact coefficients defined in equation 11 and the standard deviation of the respective innovations, i.e. the RMSE associated with the release of each series. The flow of information within the quarter can be represented by Table 1 in section 3. As discussed above, timely releases will tend to have a higher weight, so it is important to take into account the exact release calendar. Given that the calendar is relatively stable over the last seven years, the results from an exercise taking the 2008 calendar as a reference can be considered to be representative enough.

The resulting standard impacts for all data releases are displayed in descending order in Table 5. The element in the first row and third column of the table can be read as follows: *Purchasing Manager Index* releases corresponding to the last month of each quarter, which have a standard deviation of 1.3 units with respect to the model forecast (see the last column), will *typically* induce revisions in GDP growth forecasts of plus or minus 0.2 percentage points. While GDP growth in a given quarter is actually affected by the PMI releases corresponding to all months in the previous quarter, the impact of the Business Confidence Index published by the National Bank of Belgium (BCI) concentrates in the publications referring to the first month of the current quarter and the last month of the previous quarter. It is remarkable that the 3−month euribor is the third most important variable for this model, even if we are only taking it into account at the end of each month[7].

[7]Banbura et al. (2010) propose a state-space model with daily factors that allows for the treatment of daily data

The second block of Table 5 displays the impact of quarterly releases on the real GDP growth rate in Belgium. The most remarkable facts are the relatively large impact of house prices, which contribute to updating GDP growth forecasts several quarters ahead and the economically insignificant impact of the Flash releases. As formalized in Appendix $B.1$, the latter result implies that the Flash release does not help the model to significantly update the state of the economy.

The most puzzling result in Table 5 is the relatively small impact of hard data. This fact is also visible when we plot the standard impacts of news for more distant forecast horizons (see Figure 3). Although the figure analyzes the standard impact of data releases on the last quarter of 2008, the results for other years and quarters would remain unchanged if the publication schedule for all indicators does not change. Again, the releases corresponding to the last six months of the year for both the BCI and the PMI releases stand out as the most relevant pieces of information at forecasting growth. In addition to them, innovations in the $3-$month euribor and on the quarterly releases of real house prices, which can have an impact on the forecasts of Belgian growth about more than two years ahead, also have a significant impact.

## 4.2 Counterfactual Analysis of Timeliness

We have seen that hard data releases, notably the industrial production index or total turnover, do not seem to have a large impact. This is surprising because those series are used in the construction of the official GDP growth releases. Table 1 could solve the puzzle, since it shows that hard data are published with a significant delay, which could be the reason why their impact is so low relative to surveys.

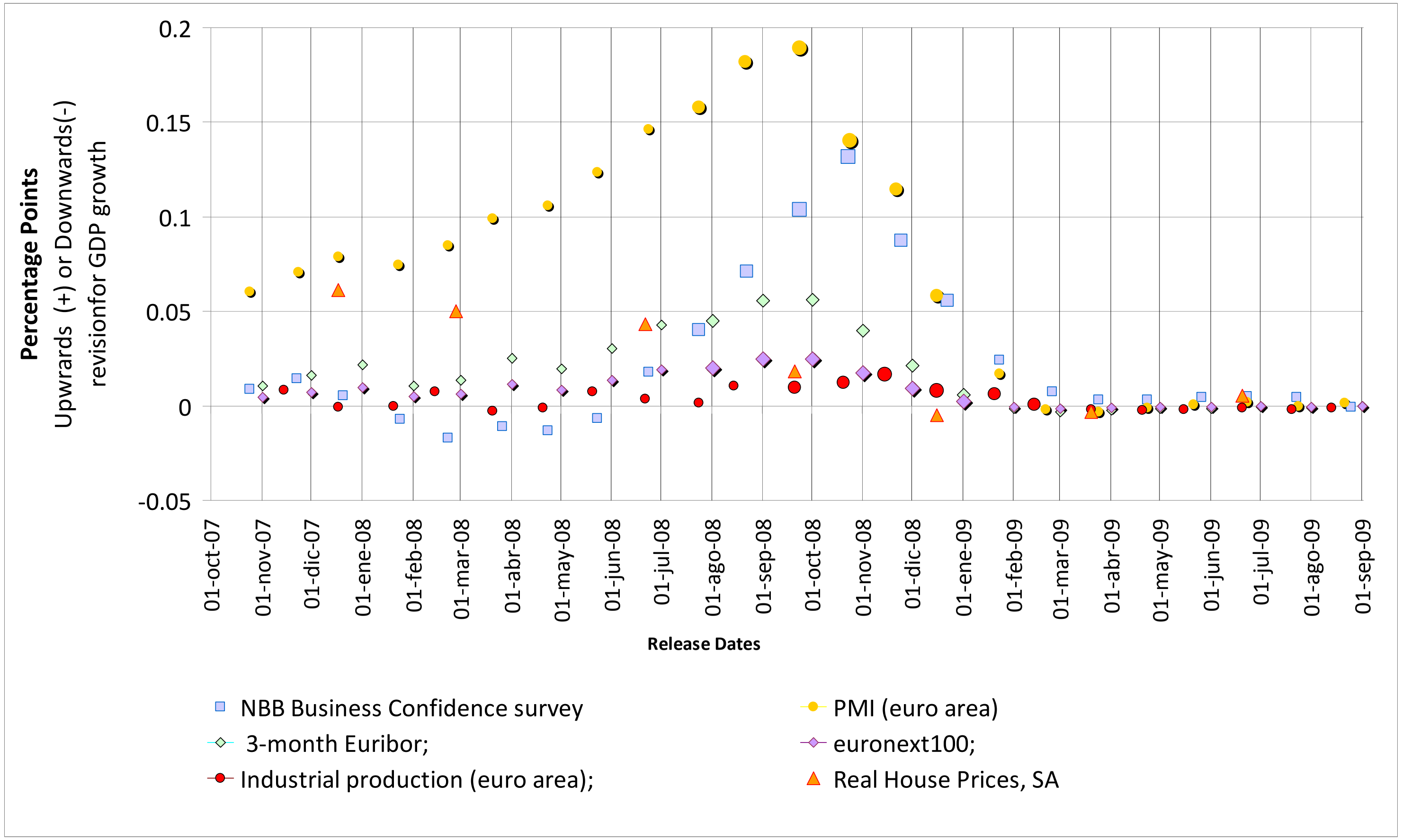
In order to understand whether publication lags of hard data, e.g. industrial production, total returns or temporary employment, determine their low impact on GDP forecast revisions, I will compute their impact under the counterfactual

Table 5: Standard Impact of News in Belgian GDP growth

| | | standard impact = weight x stdev | | | | | | stdev |
|---|---|---|---|---|---|---|---|---|
| | | previous quarter | | | current quarter | | | |
| | | month 1 | month 2 | month 3 | month 1 | month 2 | month 3 | |
| Purchasing manager index (flash)- Manufacturing; | euro area | 0.158 | 0.182 | 0.189 | 0.140 | 0.114 | 0.058 | 1.288 |
| NBB Business Confidence survey (overall); | | 0.040 | 0.071 | 0.104 | 0.132 | 0.087 | 0.056 | 2.000 |
| 3-month Euribor; | euro area | 0.045 | 0.056 | 0.056 | 0.040 | 0.021 | 0.006 | 0.154 |
| Consumer confidence indicator; | | 0.017 | 0.023 | 0.027 | 0.013 | 0.019 | 0.008 | 4.544 |
| Purchasing manager index (flash) - Services; | euro area | 0.019 | 0.023 | 0.024 | 0.017 | 0.015 | 0.008 | 1.672 |
| euronext100; | euro area | 0.020 | 0.025 | 0.025 | 0.018 | 0.009 | 0.003 | 4.650 |
| NBB Demand expectations (manufacturing); | | 0.005 | 0.012 | 0.021 | 0.024 | 0.020 | 0.013 | 4.323 |
| Economic Sentiment Indicator; | euro area | 0.018 | 0.021 | 0.022 | 0.017 | 0.011 | 0.004 | 3.323 |
| HICP; | euro area | 0.016 | 0.022 | 0.020 | 0.016 | 0.007 | 0.002 | 0.181 |
| German 10Y gov. bond yield minus 3m euribor; | euro area | -0.015 | -0.019 | -0.019 | -0.013 | -0.007 | -0.002 | 0.222 |
| Industrial production, excluding construction; | euro area | 0.010 | 0.012 | 0.017 | 0.008 | 0.006 | 0.001 | 0.949 |
| Brussels all Shares | | 0.004 | 0.009 | 0.013 | 0.014 | 0.009 | 0.003 | 4.601 |
| Work volume of temporary workers | | 0.007 | 0.009 | 0.023 | 0.007 | 0.003 | 0.000 | 9.934 |
| National CPI | | 0.008 | 0.011 | 0.010 | 0.008 | 0.004 | 0.001 | 0.263 |
| Industrial production, excluding construction | | 0.000 | 0.000 | 0.007 | 0.010 | 0.008 | 0.002 | 1.573 |
| Adjusted harmonised unemployment rate | | -0.011 | -0.009 | -0.005 | 0.000 | 0.005 | 0.001 | 0.002 |
| Total turnover ("chiffre d'affaires") | | 0.001 | 0.002 | 0.005 | 0.005 | 0.003 | 0.001 | 2.428 |
| Retail Sales (deflated turnover in the retail trade); | euro area | 0.002 | 0.003 | 0.004 | 0.002 | 0.002 | 0.000 | 0.703 |
| Permits for new residential buildings, SA | | 0.002 | 0.000 | 0.001 | 0.001 | 0.002 | 0.001 | 8.861 |
| New residential building starts, SA | | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 | 0.000 | 6.346 |
| Registration of new private cars | | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 7.835 |
| Trade balance in goods | | -0.002 | -0.001 | -0.001 | 0.001 | 0.001 | 0.001 | 916.786 |
| Spreads on Belgian ten-year government bonds | | 0.005 | 0.004 | 0.000 | -0.002 | -0.004 | -0.004 | 53.967 |
| Total receipts ("recettes") | | -0.001 | -0.001 | 0.000 | 0.000 | 0.001 | 0.001 | 4.700 |

| | standard impact = weight x stdev | | | | | | | | | | stdev |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Q-9 | Q-8 | Q-7 | Q-6 | Q-5 | Q-4 | Q-3 | Q-2 | Q-1 | current Q | |
| Real House Prices, SA | **0.063** | **0.067** | **0.062** | **0.060** | **0.061** | **0.050** | **0.043** | **0.018** | -0.005 | -0.003 | 0.930 |
| Flash Real GDP growth | 0.000 | 0.000 | 0.000 | -0.001 | -0.001 | 0.000 | -0.003 | -0.007 | -0.003 | **0.011** | 0.210 |
| Flash Real GDP growth; euro area | 0.000 | 0.000 | 0.000 | -0.001 | -0.001 | 0.000 | -0.002 | -0.007 | -0.002 | **0.012** | 0.300 |

Figure 3: Standard Impact of News on Belgian growth for 2008$Q4$




This figure represents the impact of a better than expected release of the *standard size* for several indicators at different points in time. The releases corresponding to the last six month of the year are highlighted with a thicker marker. The survey released by the NBB corresponding to the month of October is expected to have a larger impact than any other release for this indicator on the forecast for the last quarter of the year. Given that the calendar is relatively stable, the same conclusion could be made about any other quarter of the year. The patter for the PMI releases by Markit Economics is slightly different. Their release corresponding to the month of September has the largest impact. Finally, quarterly releases of real house prices start to have a relatively large impact on Belgian growth forecasts about one year ahead.

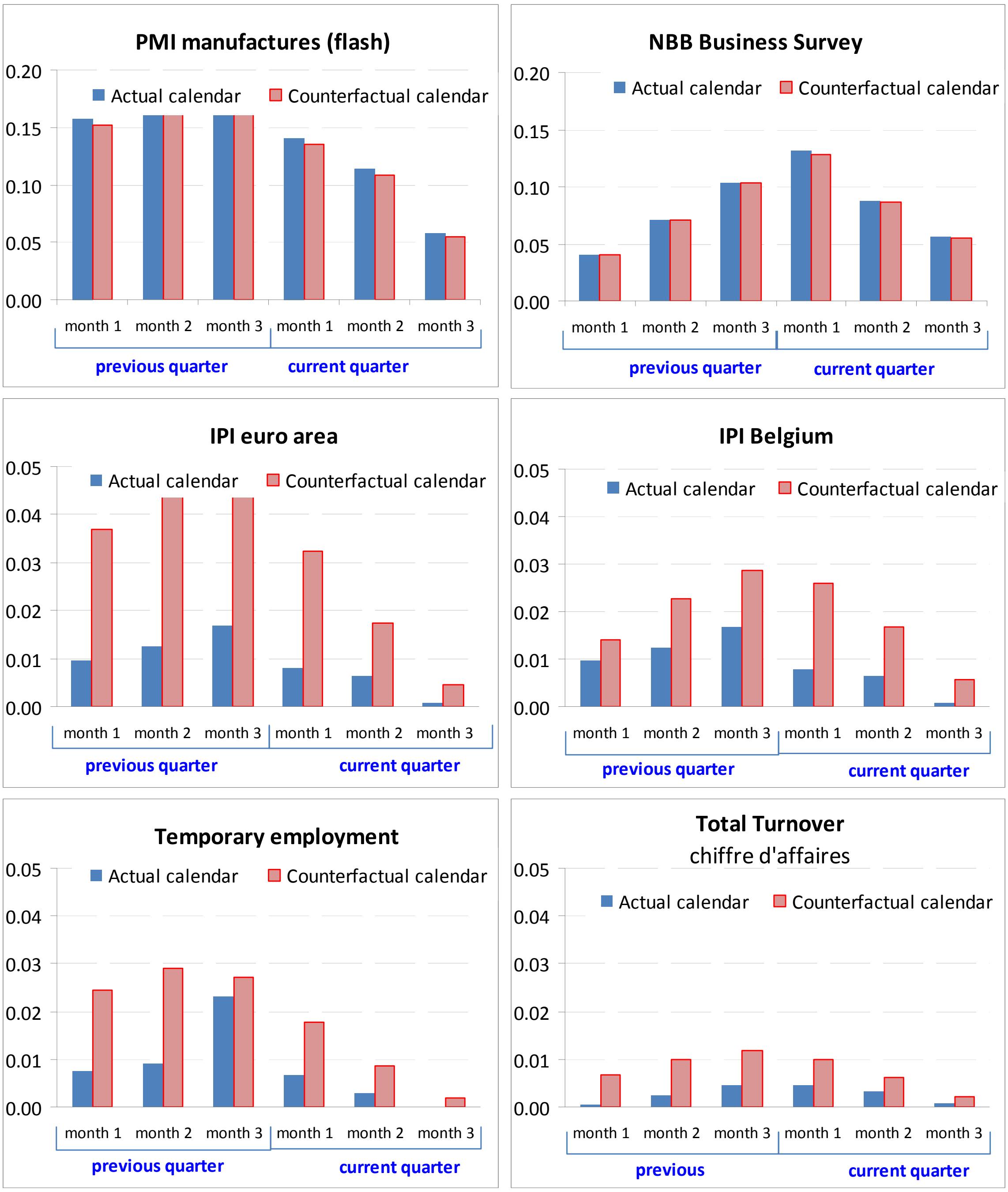
assumption that the figures corresponding to a given month are published at the end of each month without any delay. This experiment will enable us to assess whether news associated with the most relevant hard data releases are sufficiently correlated with the factors of the model.

The results displayed in Figure 4 reveal that two survey releases with the largest impact, PMI and BCI, continue to have a very large impact at updating growth expectations in Belgium when they have to compete with hard data releases. Interestingly, the standard impact of industrial production innovations in the euro area is about four times larger in the counterfactual absence of publication lags. The Figure also exhibits an increase in the standard impacts of industrial production, total turnover and temporary employment in Belgium, but the role of those variables remains very small relative to the surveys.

To conclude, even if *timeliness* remains an important property of survey data, it is rather quality that seems to help in the current set-up. The role of surveys is well known in the nowcasting literature since Giannone, Reichlin and Small (2008), but this is the first paper that attempts to isolate the role of quality from timeliness. The work by Camacho and Pérez-Quirós (2010) for the euro area is particularly relevant for our current application, since they place a particular emphasis on the timeliness of the BCI published by the National Bank of Belgium, which receives 100% of the weight when it is published[8]. However, they do not clarify the precise role of quality.

[8]Rather than focusing on the contribution of the news in updating the forecast, they calculate the weight of the variables on the factor driving GDP. The problem with this approach, which has also been proposed by Banbura and Runstler (2011), is that the contribution of an indicator can increase at the release date even if it does not incorporate any news, i.e. the released figure is in line with expectations. As shown by Banbura and Modugno (2010), by focusing on the news one can obtain a more refined analysis of the sources of forecast revisions.

Figure 4: Counterfactual "Standard Impact" of News on Belgian growth for 2008$Q4$



# 5 Results

In this section, I describe the major implications of the *Financial* & *Housing* model described in Section 2.2. The model is compared with the *Benchmark* specification, which does not take into account financial and housing market variables. As explained above, the Benchmark model uses the information set described in tables 2 and 3 alone and incorporates only two factors: one that loads on all variables and one specific for the Belgian variables, with a transition equation for the factors that follows an unrestricted VAR, as described in section 2. We will show that the forecasts of the Financial & Housing model, which incorporates the extra information described in Table 4 together with the assumption that only housing market variables are allowed to load on an additional factor, are not very different from those of the Benchmark model at short term horizons.

## 5.1 Out-of-Sample Evaluation

A bird's eye view on the most recent real-time forecasting performance of the models is given in figures 5 and 6. In this evaluation setting, the models produced GDP growth forecasts for a given quarter using all the information available at three different points in time:

1. 90 days before the end of the quarter.

2. 30 days before the end of the quarter.

3. 15 days after the end of the quarter, which roughly corresponds to 15 days before the GDP flash estimate is released in Belgium.

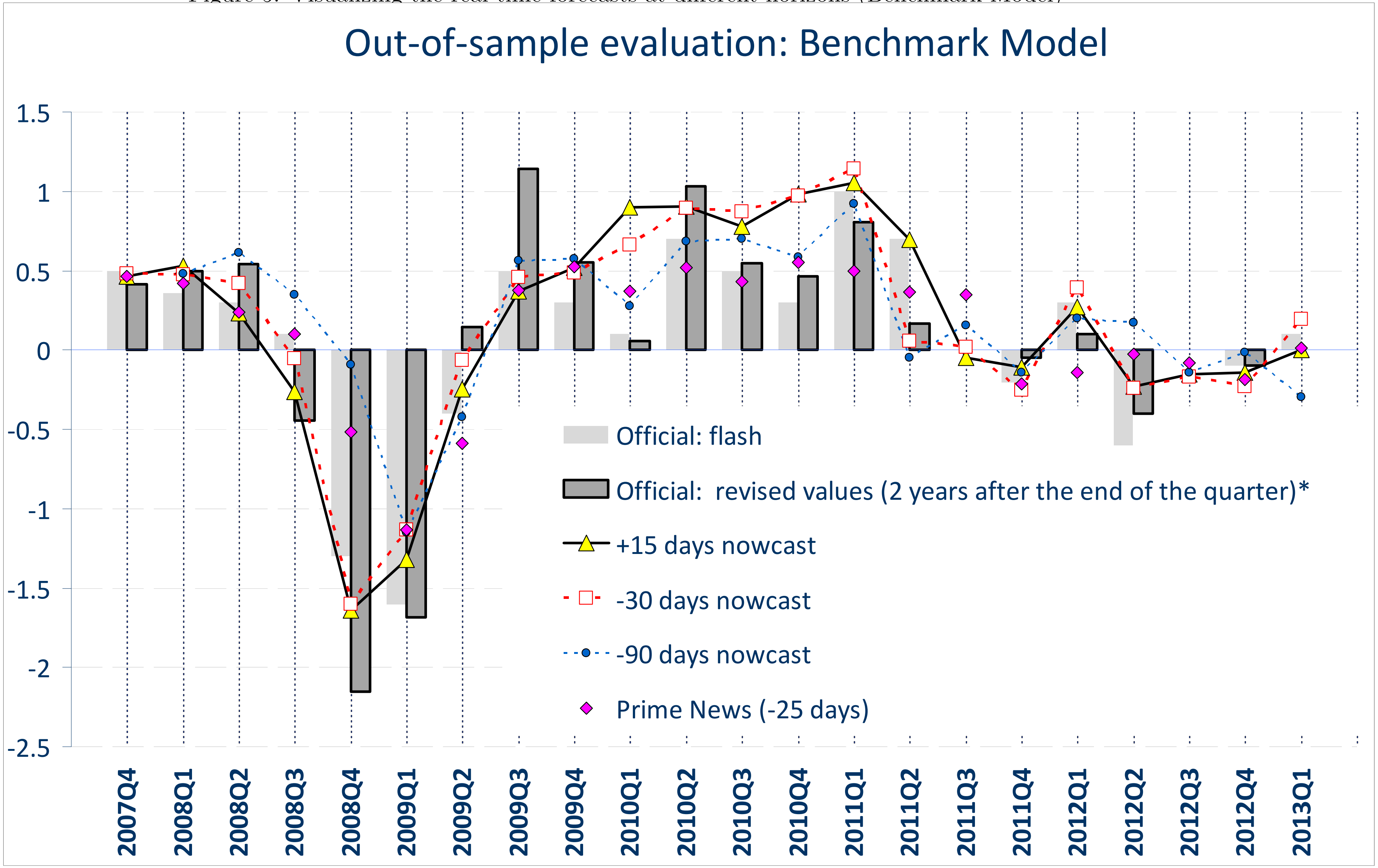
The model parameters are estimated exploiting all information available at the first forecasting round and it is not re-estimated again until next quarter. In practice, one could follow the strategy of re-estimating the model only once a year. The nowcasts produced by the models are based on the concept of revised GDP growth rate, which is available only two years after the end of the quarter, and can be compared to both the official flash release and the subsequently revised values. The bars in figures 5 and 6 visualize both GDP growth concepts and show that the third quarter of 2008, when real GDP in Belgium declined for the first time since the onset of the Great Recession, could be anticipated by both models prior to the official releases.

The performance of the model is often evaluated in terms of the (squared) root of the average mean squared out-of-sample forecast errors (RMSE) over a given evaluation sample period, and compared to competing forecasts. The error is defined here as the difference between the nowcast and the GDP figures available two years after the initial flash release.

Given the real-time nature of this forecasting exercise, I need to make such a comparison at different points in time. The graphs in Figure 7 represent the decreasing pattern of the RMSE as more and more information is incorporated into the models' information sets. Both models perform significantly[9] better than the Belgian Prime News forecast, which is distributed among the participants almost 30 days before the end of each quarter together with expectations for the annual growth rate. More strikingly, both models' nowcasts are as precise as the flash estimate itself, even when the former are obtained two months before the end of the quarter. It should be recalled from the news analysis that surveys released during the first month of the quarter have a very strong influence on the forecasts. The current RMSE analysis shows that such information seems to be enough to produce a reliable estimate of growth for the quarter. The second test

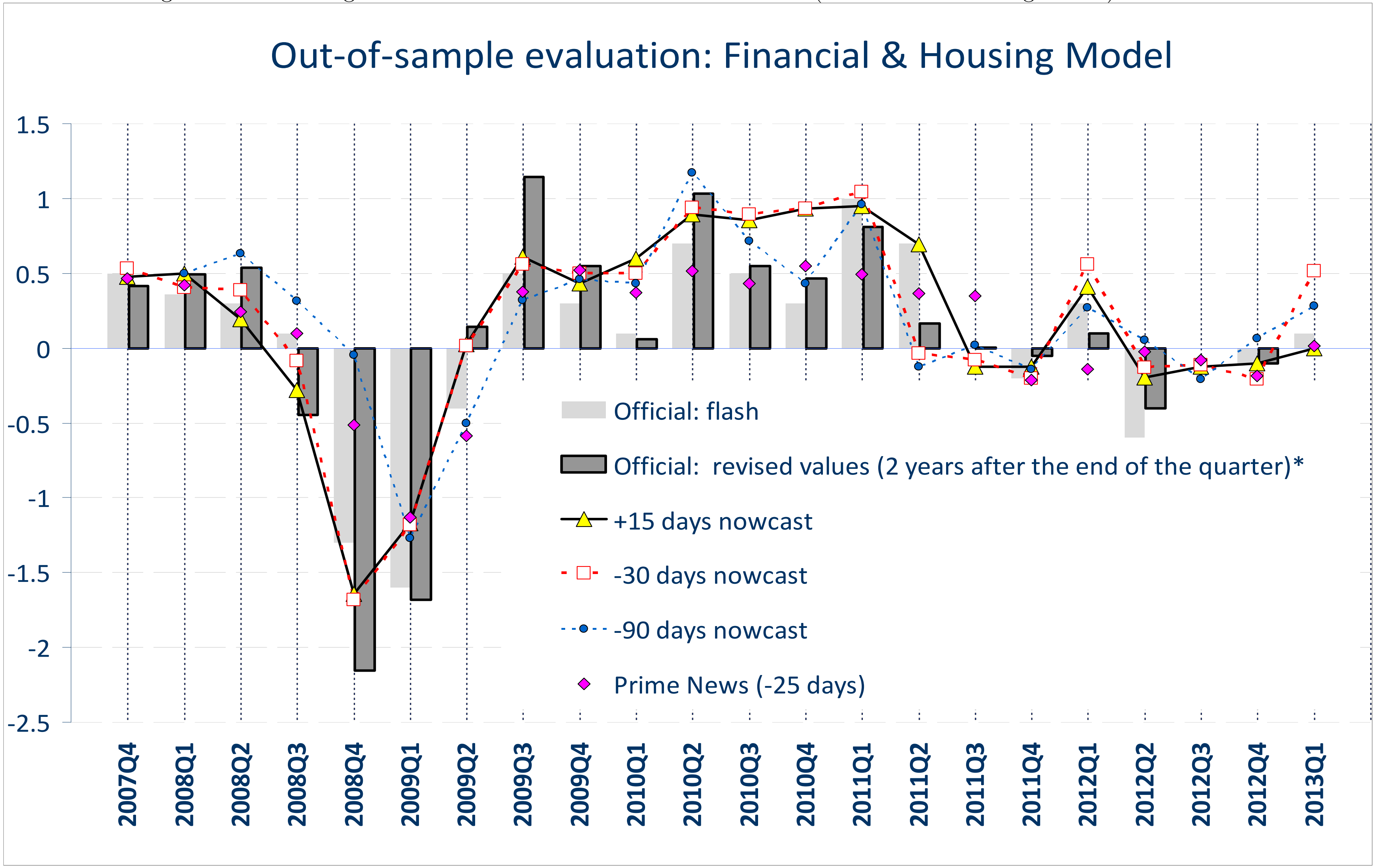
[9] Diebold-Mariano (1995) test rejects the equal forecast accuracy hypothesis with a 80% confidence level. Defining the time-t loss differential between two given forecasts 1 and 2 as $L_t^{12} = e_{1,t}^2 - e_{2,t}^2$, the Null hypothesis of equal forecast accuracy can be expressed as $h0 : E[L_t^{12}] = 0$. Under this assumption, the Diebold-Mariano test statistic, $DM^{12} = \frac{\bar{L}^{12}}{\hat{\sigma}_{\bar{L}^{12}}}$, follows a standard normal distribution. The sample mean loss differential is defined as $\bar{L}^{12} = \frac{1}{T}\sum_{t=1}^{T} L_t^{12}$ and $\hat{\sigma}_{\bar{L}^{12}}$ is a consistent estimate of its standard deviation.

Figure 5: Visualizing the real-time forecasts at different horizons (Benchmark Model)




* From 2011Q1 onwards, I take the last available vintage.

Figure 6: Visualizing the real-time forecasts at different horizons (Financial & Housing Model)




* From 2011Q1 onwards, I take the last available vintage.

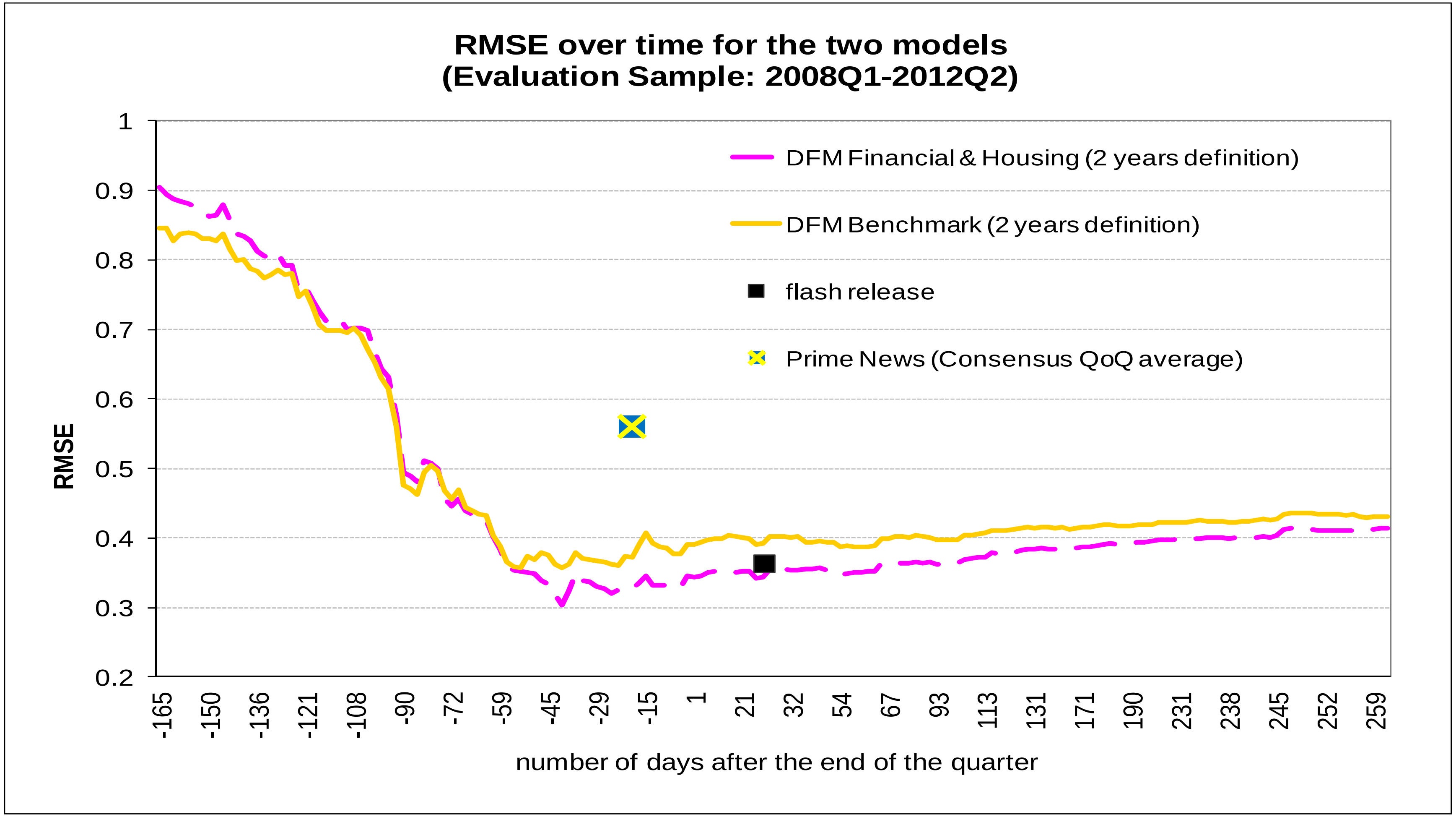
Table 6: Diebold-Mariano(West) test

| | RMSE | DM test 1 (Prime N) | DM test 2 (Flash) | DM test 3 (Pairwise) |
|---|---|---|---|---|
| Benchmark (-165 days) | 0.96 | 1.96*** | 1.93** | -1.71** |
| Financial & Housing (-165 days) | 1.01 | 2.21*** | 2.15*** | |
| Benchmark ( -90 days) | 0.62 | 0.61 | 1.19 | -0.74 |
| Financial & Housing (-90 days) | 0.64 | 0.75 | 1.23 | |
| Benchmark ( -30 days) | 0.37 | -1.33* | -0.06 | 1.53* |
| Financial & Housing (-30 days) | 0.33 | -1.47* | -0.57 | |
| Benchmark (+15 days) | 0.40 | -1.09 | 0.39 | 1.29* |
| Financial & Housing (+15 days) | 0.35 | -1.4* | -0.37 | |
| Prime News (-25 days) | | 0.57 | | |
| Flash (+30 days) | | | 0.37 | |

The DM(W) test statistic rejects the null hypothesis of equal forecast accuracy at significance levels of 95% ($***$), 90% ($**$) and 80% ($*$). The RMSE of the different models is displayed in the first column of the Table. The second column contains the DM(W) test comparing the models with the Prime News forecasts, while the third column compares the models' forecasts errors with the ones obtained when the Flash is interpreted as a nowcast. Finally, the last column implements pairwise comparisons between the Benchmark and the Financial & Housing models at given horizons.

displayed in Table 6 actually shows that the hypothesis that the nowcasts are as accurate as the flash cannot be rejected. Finally the third test displayed in the last column of the Figure suggests that the Housing & Financial specification is more accurate than the Benchmark, but only at very short-term horizons.

Figure 7: Real Time Evaluation



## 5.2 Evaluation of fixed events

Here, I show that any of the two models can be used to update the forecasts as an increasing amount of information becomes available. We have seen that both the Benchmark and the Financial&Housing models turn out to offer a very similar performance (on average). However, the presence of real house prices and 3−month euribor in the second model induces a higher sensitivity to news at the cost of more volatile forecasts for 2012Q2, as depicted in Figure (8) . The same feature can be observed in Figure 13 (see Appendix C), which displays real-time updates of yearly growth forecasts for 2010, 2011 and 2012. In particular, the forecasts for 2010 seem to be in line with market expectations, i.e. Consensus forecasts, which turned out to be too pessimistic.

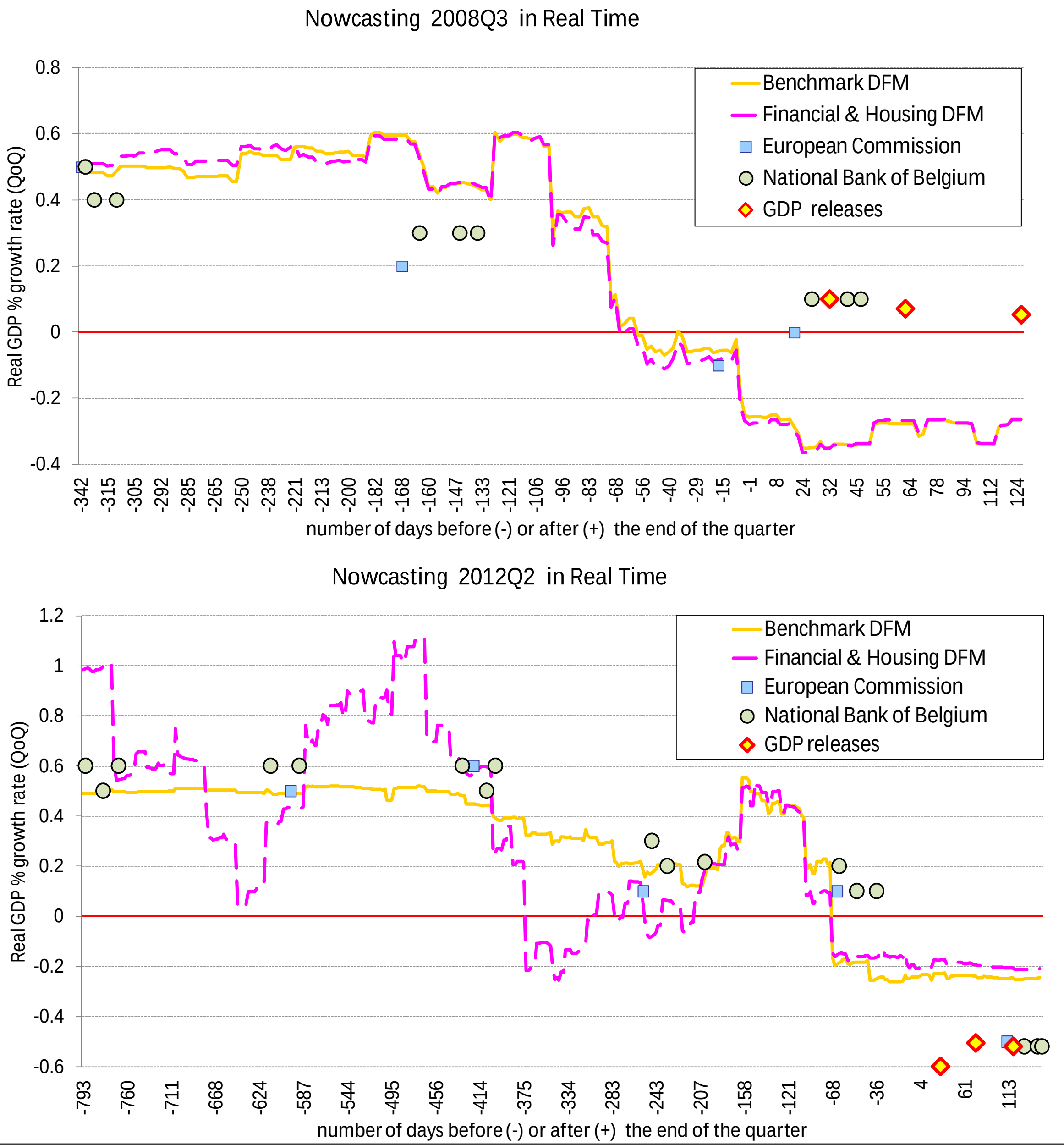
Because fluctuations in house prices have an effect only on medium term growth expectations[10], both models can offer very similar forecasts at short term horizons. Figure 8 illustrates the relative performance of both models at forecasting 2008Q3, which eventually turned out to be the first quarter of negative growth rate, and 2012Q2, which was a negative surprise both for the National Bank of Belgium and for the European Commission.

## 5.3 Nowcasting in Practice

Given the supremacy of survey data documented in the previous section, we could consider one of the simplest possible uses of the model: running it only after the most relevant surveys have been released. This subsection illustrates how the Financial & Housing model works at updating the forecasts by the end of each month, when the most relevant survey data is released. The model, which is re-estimated only once a year, reads the information set available each month and updates the forecasts for growth in Belgium. The target variable is the real GDP growth release that will be made available after two years and not the flash

[10]see standard impacts in Table 5.

Figure 8: Comparing the two models




Note that the x-axis represents the actual date when the forecast was made. The NBB forecasts are always constructed in three rounds, which are not publicly available in terms of quarter-on-quarter growth rates. The EC forecasts are reported on the European Commission's website.

release. As we have shown in Appendix B.2, the two-year revision is more reactive to news and therefore more suitable for identifying potential turning points in economic activity.

The first graph shows that the information available on March 22 is read as bad news with respect to the information set available one month ago. Given the large impact of surveys, which I have documented in the previous section, it is not surprising to have such a significant revision in the forecast. By looking at the four panels of Figure 9, we can see the news interpretation provided by the model month by month.

The underlying news that we obtained in real time over the most recent months, which have been defined in Section 5 as the difference between the released figures and the values expected by the model, i.e. forecast errors, can actually be compared to the errors produced by Bloomberg analysts. According to Figure 10, most of the times that Bloomberg reads good news, the model will provide the same interpretation. There are, however, some important exceptions. The BCI released by the National Bank of Belgium for March and April 2012 was interpreted by Bloomberg as a negative surprise of 3 units, while the factor model was interpreting it as neutral or no news.

Figure 9: Anticipating the GDP growth for 2013Q2

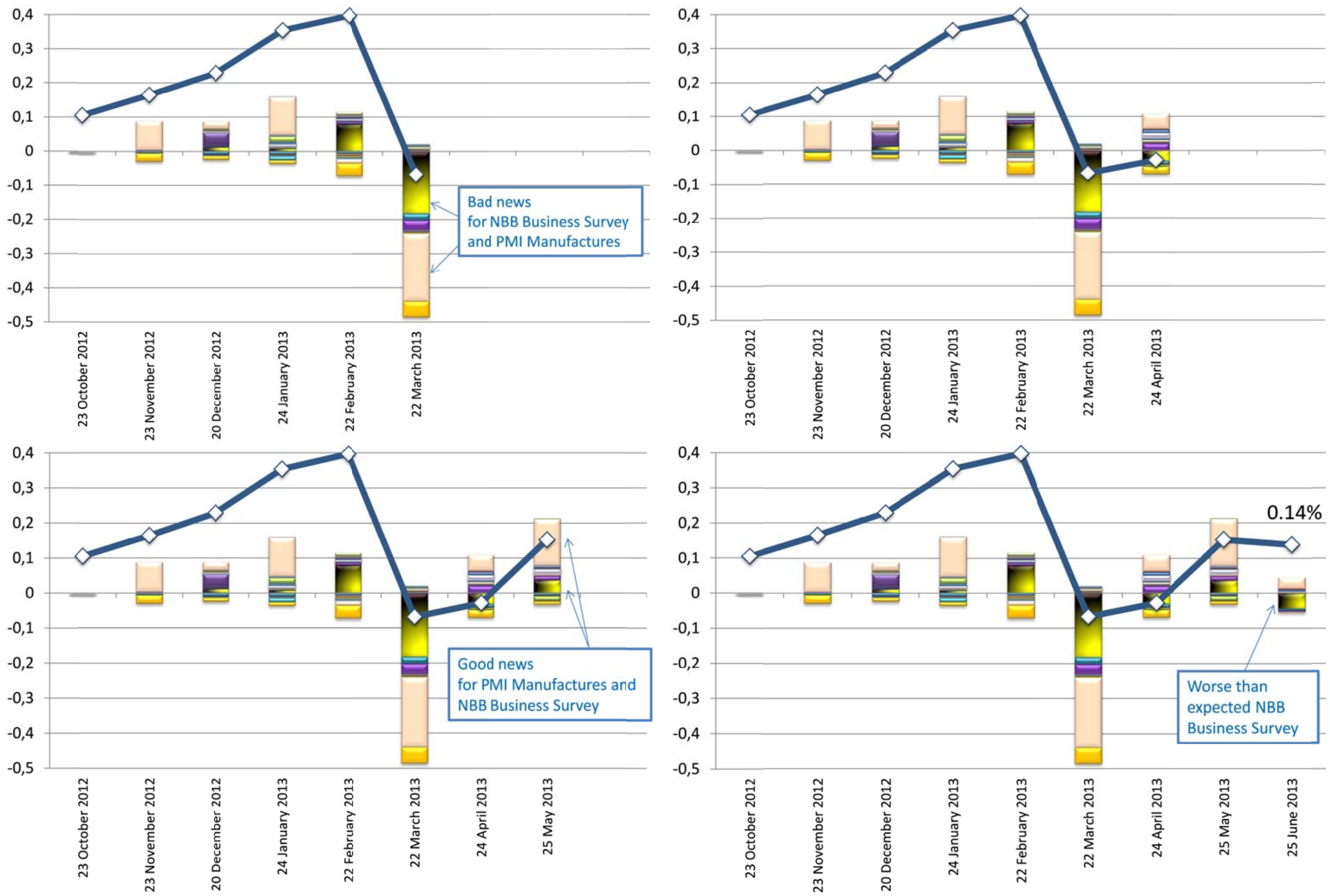
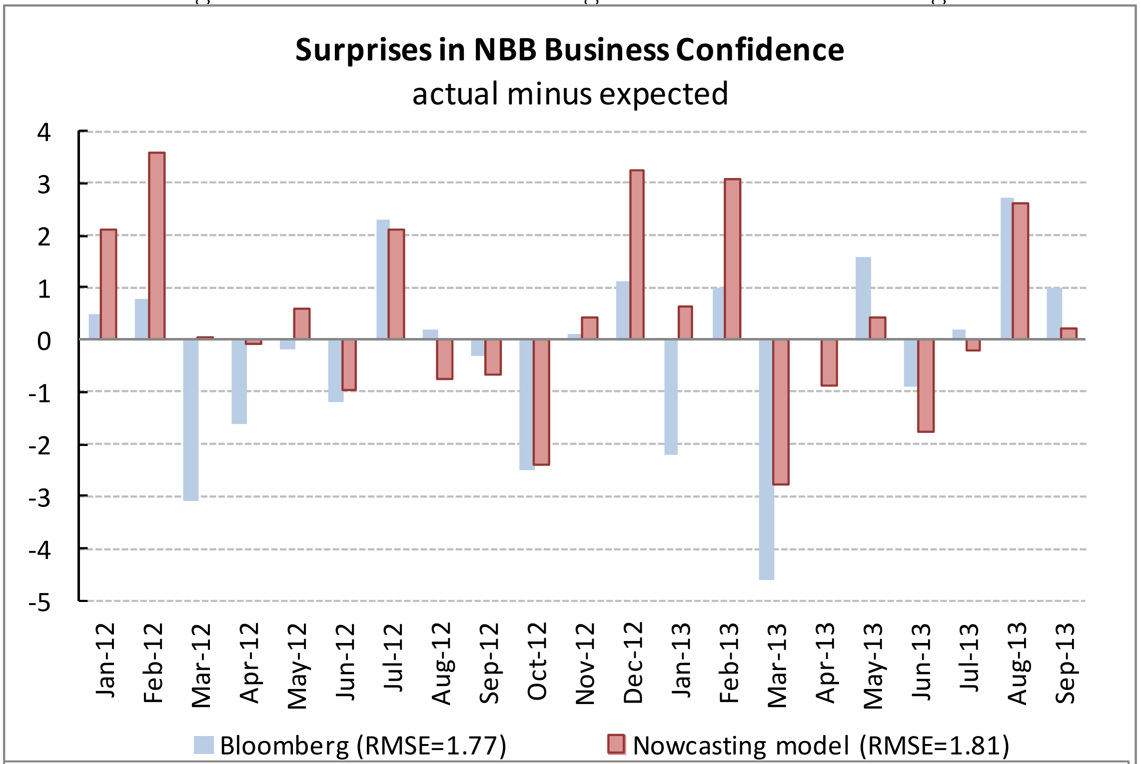
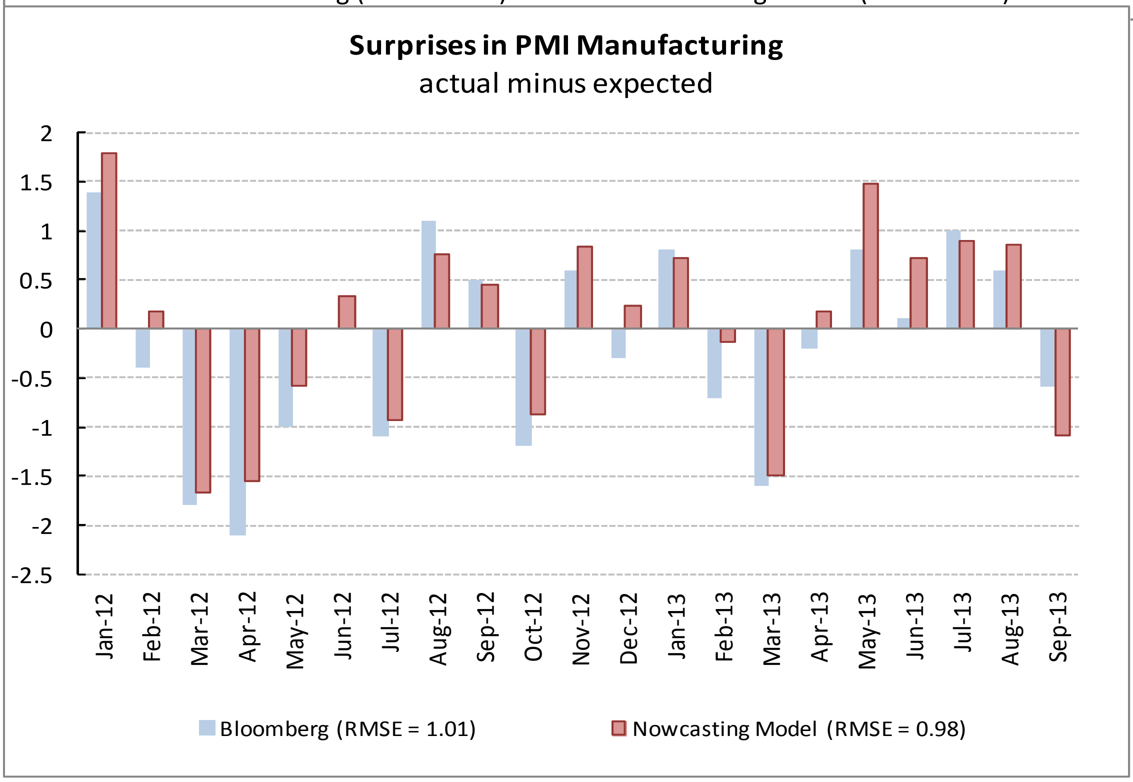


Figure 10: Financial & Housing Model versus Bloomberg



# 6 Conclusion

In this paper, I propose a joint state-space model for the euro area and Belgian economies formalizing the role of the intraquarterly data flow as an input to construct early estimates of GDP growth and update them in real-time. Those updates are given by the unexpected component included in each one of the macroeconomic releases. The impact that those surprises have on the forecasts is precisely determined by important properties of the statistical releases, such as timeliness and quality, which can be explicitly expressed as a function of the model parameters. Those objective weights that the model gives to each data release insures the analysts against the human tendency to favour information that confirms their beliefs or hypotheses.

The empirical results underline the importance of survey data such as the Business Sentiment Index constructed by the National Bank of Belgium, the Markit Economics PMI (Manufactures) release for the euro area, 3−month euribor and real house prices in Belgium, which turn out to contribute mainly at long-term horizons. The large impact of the survey releases that refer to the first month of a given quarter is consistent with the empirical finding that three months prior to the publication of the Belgian Flash, the nowcast turns out to be as accurate as the flash release itself. The paper goes further than the literature in understanding whether the importance of survey data can be accounted for by their relative timeliness or rather their quality. In a counterfactual exercise, I show that the weights associated with survey data do not deteriorate when all hard data is artificially published with the same degree of timeliness. This result underlines quality as a relevant property of survey data.

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# A The Role of Quality and Timeliness

The process of updating the forecasts in response to news is formalized by equation 10 above. In state-space modeling terminology, the innovations are weighted by the so-called *gain* of the Kalman filter in order to have an update of the state vector, i.e. the unobserved factors. In addition to this, the factor loadings $\Lambda$ and the matrix accounting for the transition of the factors $A$ play an important role in determining the sign, the impact, and the smoothness in the propagation of macroeconomic news into the forecast.

The focus of this subsection is on the *gain*, since it enables the forecast updates to be expressed in terms of the different types of news. In line with the nowcasting practice, this framework allows data releases with high quality and timeliness to have a large weight in the forecast revisions. To understand why, I will express the *gain* in equation 10 as a function of parameters implicit in the definition of the generic state-space representation given by equations 7 and 8:

$$E_\theta[\mathrm{f}_{t+1}V'_{t+1}]E_\theta[V_{t+1}V'_{t+1}]^{-1}V_{t+1} = \begin{pmatrix} cov_\theta[\mathrm{f}_{t+1}, v^m_{t+1}] & cov_\theta[\mathrm{f}_{t+1}, v^s_{t+1}] \end{pmatrix} \times \begin{pmatrix} var_\theta[v^m_{t+1}] & cov_\theta[v^m_{t+1}, v^s_{t+1}] \\ cov_\theta[v^m_{t+1}, v^s_{t+1}] & var_\theta[v^s_{t+1}] \end{pmatrix}^{-1} \begin{pmatrix} \mathrm{v}^{\mathrm{m}}_{\mathrm{t+1}} \\ \mathrm{v}^{\mathrm{s}}_{\mathrm{t+1}} \end{pmatrix} \quad (12)$$

One can develop this expression further under the simplifying assumption that there is only one factor. As a result, a very simple formula for the weights associated with the two pieces of news can be obtained. It is worth simplifying the notation: $\sigma^2_m = var_\theta(v^m_{t+1})$, $\sigma^2_s = var_\theta(v^s_{t+1})$, $\sigma^2_{ms} = cov_\theta[v^m_{t+1}, v^s_{t+1}]$, $\beta_m = cov_\theta[\mathrm{f}_{t+1}, v^m_{t+1}]$, $\beta_s = cov_\theta[\mathrm{f}_{t+1}, v^s_{t+1}]$. The resulting expression has a very simple form:

$$\begin{aligned} E_\theta[\mathrm{f}_{t+1}V'_{t+1}]E_\theta[V_{t+1}V'_{t+1}]^{-1}V_{t+1} &= \\ &= \frac{\beta_m\sigma^2_s - \beta_s\sigma^2_{ms}}{|cov_\theta[V]|} v^m_{t+1} + \frac{\beta_s\sigma^2_m - \beta_m\sigma^2_{ms}}{|cov_\theta[V]|} v^s_{t+1} \\ &= \underbrace{\frac{\beta_m\sigma^2_s - \beta_s\sigma^2_{ms}}{\sigma^2_m\sigma^2_s - \sigma^2_{ms}\sigma^2_{ms}}}_{w_1} v^m_{t+1} + \underbrace{\frac{\beta_s\sigma^2_m - \beta_m\sigma^2_{ms}}{\sigma^2_m\sigma^2_s - \sigma^2_{ms}\sigma^2_{ms}}}_{w_2} v^s_{t+1} \end{aligned} \quad (13)$$

I will now describe how those weights are associated with both the quality and timeliness of the indicators. Note that in the event that the two innovations are perfectly correlated ($\frac{\sigma_{ms}^2}{\sigma_m \sigma_s} = 1$), the determinant $|cov_\theta[V]|$ is equal to zero. This has the practical implication that the weights defining the Kalman gain are not uniquely identified, i.e. giving all the weight to one indicator to the detriment of the alternative yields the same forecasts as giving the same weight to both indicators.

## QUALITY

Consider the possibility that the manufacturing index, $\mathrm{y}_{\mathrm{t+1}}^{\mathrm{PMI_m}}$, and the services index, $\mathrm{y}_{\mathrm{t+1}}^{\mathrm{PMI_s}}$, are published simultaneously. In order to better understand the importance of relative quality, let us rewrite expression 13 by writing the two pieces of news in terms of their driving forces, i.e. the factor innovations and the measurement errors:

$$v_{t+1}^m = \beta_m(f_{t+1} - E_\theta[f_{t+1}|\mathcal{F}^{old}]) + \sigma_{\epsilon^m}\epsilon_{t+1}^m \quad (14)$$

$$v_{t+1}^s = \beta_s(f_{t+1} - E_\theta[f_{t+1}|\mathcal{F}^{old}]) + \sigma_{\epsilon^s}\epsilon_{t+1}^s \quad (15)$$

where $f_t$, $\epsilon_t^s$ and $\epsilon_t^m$ are uncorrelated to each other and their variance is normalized to one. Thus, $\sigma_{\epsilon^m}$ and $\sigma_{\epsilon^s}$ define the standard deviations of the measurement errors present in the two series. The weights that expression 13 would yield have a very simple form in this case:

$$w_1 = \frac{\beta_m \sigma_{\epsilon^s}^2}{\beta_m^2 \sigma_{\epsilon^s}^2 + \beta_s^2 \sigma_{\epsilon^m}^2 + \sigma_{\epsilon^m}^2 \sigma_{\epsilon^s}^2} \quad (16)$$

$$w_2 = \frac{\beta_s \sigma_{\epsilon^m}^2}{\beta_m^2 \sigma_{\epsilon^s}^2 + \beta_s^2 \sigma_{\epsilon^m}^2 + \sigma_{\epsilon^m}^2 \sigma_{\epsilon^s}^2} \quad (17)$$

This parameterization enables us to observe, more clearly than in expression 13, that the weight associated with one indicator not only depends on its quality, but also on the quality of the competing data releases. Thus, the weight ($w_1$) associated with the innovation in the manufacturing sector increases with the size of the measurement errors in the services sector ($\sigma_{\epsilon^s}$).

In order to understand the role played by quality, we can consider two extreme cases:

**Case 1:** The manufacturing release does not contain measurement errors, i.e. $\sigma^2_{\epsilon^m} = 0$. This implies that the corresponding innovation is perfectly correlated with the factor. In this case all the weight is attached to the news in the manufacturing sector, leaving the services release with zero weight:

$$\begin{aligned} w_1 &= \frac{1}{\beta_m} \\ w_2 &= 0 \end{aligned}$$

The weight associated with the manufacturing release is equal to one divided by the standard deviation of the news.

**Case 2:** The variance of the measurement errors for the manufacturing and the services releases tends to zero, which implies that both innovations tend to be perfectly correlated with the factor. This is a slightly more complex case because, in the limit, the covariance matrix of the innovations is not invertible, which implies that the weights in expression 13 cannot be obtained. The limit of the weights when both $\sigma^2_{\epsilon^m}$ and $\sigma^2_{\epsilon^s}$ tend to zero can easily be derived as follows:

$$\begin{aligned} \lim_{\sigma^2_{\epsilon^m},\sigma^2_{\epsilon^s}\to 0} w_1 &= \left[\frac{1}{\lim_{\sigma^2_{\epsilon^m},\sigma^2_{\epsilon^s}\to 0} w_1}\right]^{-1} = \frac{\beta_m}{\beta_m^2+\beta_s^2} \\ \lim_{\sigma^2_{\epsilon^m},\sigma^2_{\epsilon^s}\to 0} w_2 &= \left[\frac{1}{\lim_{\sigma^2_{\epsilon^m},\sigma^2_{\epsilon^s}\to 0} w_2}\right]^{-1} = \frac{\beta_s}{\beta_m^2+\beta_s^2} \end{aligned} \tag{18}$$

The results derived from our simple parameterization of the model suggest that the weights associated with the two innovations are determined by their covariance with the factor, i.e. $\beta_m$ and $\beta_s$, respectively.

## TIMELINESS

The impact of $\mathrm{y}_{\mathrm{t+1}}^{\mathrm{PMI_m}}$ would be very different if it was published *one day earlier* than the services index. This implies that only the news component $v^m_{t+1}$ will be incorporated in $\mathcal{F}^{new}$

$$E_\theta[y_{t+h}|\mathcal{F}^{new}] = E_\theta[y_{t+h}|\mathcal{F}^{old}, v^m_{t+1}] \tag{19}$$

Applying equation 10 to the case where $v^m_{t+1}$ alone enters the new information set defines a slightly simpler Kalman gain than the one shown in expression 12:

$$\begin{aligned} E_\theta[y_{t+h}|\mathcal{F}^{new}] &= E_\theta[y_{t+h}|\mathcal{F}^{old}, v_{\substack{m\\t+1}}] \\ &= \underbrace{\Lambda A^{h-1} E_\theta[\mathrm{f}_{t+1}|\mathcal{F}^{old}]}_{old\,forecast} + \Lambda A^{h-1} \underbrace{E_\theta[\mathrm{f}_{t+1} v^m_{t+1}{}'] E_\theta[v^m_{t+1} v^m_{t+1}{}']^{-1}}_{Gain\,(quality,\,timeliness)} \underbrace{v^m_{t+1}}_{news} \\ &= \Lambda A^{h-1} E_\theta[\mathrm{f}_{t+1}|\mathcal{F}^{old}] + \Lambda A^{h-1} \underbrace{\frac{\beta_m}{\sigma^2_m}}_{w^*_1} v^m_{t+1} \end{aligned} \tag{20}$$

As before, the natural parameterization of the innovations represented in expressions 14 and 15 yields to a simple expression for the weight associated to the *manufacturing* news release:

$$w^*_1 = \frac{\beta_m}{\beta^2_m + \sigma^2_{\epsilon^m}} \tag{21}$$

My previous focus on quality suggests the size of the measurement errors is an important determinant of weight associated to the news. Now, I emphasize the importance of timeliness. By computing expressions 21 and 16 for the case where both releases have the same quality $\beta_m = \beta_s = \beta$ and $\sigma^2_{\epsilon^m} = \sigma^2_{\epsilon^s} = \sigma^2$, i.e. both the measurement errors associated to the two releases and the covariance of the factor with both innovations are identical, we obtain:

$$\begin{aligned} w_1 &= \frac{\beta\sigma^2_\epsilon}{2\beta^2\sigma^2_\epsilon + \sigma^2_\epsilon\sigma^2_\epsilon} \\ w^*_1 &= \frac{\beta}{\beta^2 + \sigma^2_\epsilon} = \frac{\beta\sigma^2_\epsilon}{\beta^2\sigma^2_\epsilon + \sigma^2_\epsilon\sigma^2_\epsilon} \end{aligned}$$

The denominator of the first expression is always larger, which implies the weight associated with the *manufacturing* index is smaller when the *services* index release occurs simultaneously. The intuition is that when the news in manufacturing does not have to *compete* with the services release, they receive more attention. By comparing expressions 16 and 21, it can easily be show that in the case where there is no measurement error in the manufactures data, i.e. $\sigma^2_{\epsilon^m} = 0$, timeliness does not matter, i.e. $w_1 = w_1^*$ .

While timeliness and quality can be defined as independent properties of the data releases, the interaction of those two properties is an essential determinant of their *relevance*, which I represent here by the weights derived from the Kalman gain.

# B The *Flash* Release and Subsequent GDP revisions

The *Flash* release for GDP is considered by the model as an individual time series, together with both the so-called second release and the figures available two years after the end of each quarter. By allowing the factor loadings to be different for all releases, I acknowledge the possibility that they all refer to different concepts and that the methodology used in their construction can be different.

## B.1 Improving the Signal about the State of the Economy

An important advantage of incorporating the flash release as a variable in the model is that one can easily quantify how much value is added to the information set previously available, $\mathcal{F}^{old}$, which does not contain the Flash. Let us define $V_t = y_t^{flash} - E_\theta[y_t^{flash}|\mathcal{F}^{old}]$ as the innovation associated with the Flash release or the difference between the GDP growth expected just before the Flash release and its realized value.

Following the usual decomposition of information, the relevance of the official Flash release in updating the estimate of growth will depend on the gain and on the magnitude of the innovation $V_t$:

$$\begin{aligned} y_t^{flash} &= \lambda E_\theta[\mathrm{f_t}|\left\{\mathcal{F}^{old}, V_t\right\}] + E_\theta[e_t^{flash}|\left\{\mathcal{F}^{old}, V_t\right\}] \\ &= \underbrace{\lambda E_\theta[\mathrm{f_t}|\mathcal{F}^{old}]}_{expected\,flash} + \underbrace{\lambda E_\theta[\mathrm{f_t}V_t']E_\theta[V_tV_t']^{-1}V_t}_{improvement\,of\,the\,signal} + \underbrace{E_\theta[e_t^{flash}V_t']E_\theta[V_tV_t']^{-1}V_t}_{estimated\,noise\,in\,flash\,release} \end{aligned} \tag{22}$$

where $\mathrm{f_t}$ here stands without loss of generality for the whole vector of factors associated with the *Flash* release and their lags (see measurement equation 5) and $\lambda$ are the factor loadings. This expression suggests that both the underlying factors and the measurement error can account for the discrepancy between the flash release and what the model expected. The first component improves the signal about the state of the economy thanks to the so-called Kalman gain, which *interprets* the Flash release. The empirical results for Belgium suggest that the Kalman gain associated with the Flash release is negligible for this particular model. Table bottom of Table 5 shows that this result also holds for the euro area. In other words, forecast errors for the Flash release do not induce updates of the state with respect to the expectations given by $\mathcal{F}^{old}$. Section 4 provided the framework to formalize this important idea in terms of the impact that a given release has in the updating process of a given series.

## B.2 *News* versus *Noise* hypothesis

GDP releases revising the Flash estimate define a more accurate and comprehensive picture of growth. On the one hand, they exploit a larger information set that was not available when the Flash had to be published. Second, measurement errors may be removed. These two sources of data revisions were coined by Mankiw and Shapiro (1986) as *news* and *noise* respectively. This strict taxonomy for data revisions has implications for the model. If the Flash release was a noisy estimate or a rational nowcast of the subsequently revised values, I would have to incorporate the assumption that the subsequently revised value is uncorrelated with the revision itself, e.g. Camacho and Pérez-Quirós (2010). I will argue that the first hypothesis can be rejected for real GDP growth in both the euro area and Belgium:

- **The Noise Hypothesis**. Consider the Flash estimate of real GDP growth, $y_t^Q$ and its revised value after two years, $y_t^{Q*}$. Assuming that the revision error $r_t$ is independent from the $y_t^{Q*}$ has implications for the relative variance of the two estimates.

$$y_t^Q = y_t^{Q*} + r_t \tag{23}$$

$$E[y_t^{Q*} r_t] = 0 \Rightarrow var(y_t^Q) = var(y_t^{Q*}) + var(r_t) \tag{24}$$

Thus, the extra variance added to the Flash does not incorporate information about the values that will be obtained after two years. This hypothesis can actually be tested with the simple regression approach suggested by Mankiw and Shapiro (1986).

$$y_t^Q = c + \beta y_t^{Q*} + r_t^{noise} \tag{25}$$

$$H0 : c = 0, \beta = 1$$

$$H1 : c \neq 0, \beta \neq 1$$

- **The News Hypothesis**. Here, the revision error $r_t$ is correlated with the revised data $y_t^{Q*}$, but independent from the Flash.

$$y_t^{Q*} = y_t^Q - r_t \tag{26}$$

$$E[y_t^Q r_t] = 0 \Rightarrow var(y_t^{Q*}) = var(y_t^Q) + var(r_t) \tag{27}$$

This implies that the revision is actually adding information instead of removing noise. This hypothesis assumption conforms the rational expectations hypothesis. However, the empirical evidence seems to be against it, as suggested by the analysis conducted by Arouba (2008) with US data.

$$y_t^{Q*} = c + \beta y_t^Q + r_t^{news} \tag{28}$$
$$H0 : c = 0, \beta = 1$$
$$H1 : c \neq 0, \beta \neq 1$$

In our case, the results do not leave much room for discussion, since the noise hypothesis is clearly rejected both in Belgium and in the euro area.

Table 11 summarizes the main findings resulting from the estimation of the noise regression (equation 25) and the news regression (equation 28) over the sample period $2002Q1 - 2010Q3$. The test suggest that the null hypothesis of noise is clearly rejected for both Belgian and aggregate euro area GDP growth rates. Thus, I argue that the extreme assumption that data revisions are uncorrelated to the final release should not be used in my current application.

Here, I can illustrate the differences in the forecasts for the GDP Flash estimate and those of the revised figures, which enter the model with different factor loadings, as mentioned above. The real-time updates of GDP growth (Flash) are represented in the first graph, together with a forecasting interval that only represents uncertainty regarding future releases. The graph at the bottom suggests that the same pieces of news that revise our expectations for the *Flash* seem to have a larger impact in revising our nowcasts for the subsequently revised growth figure. As clearly shown in figure 12, the forecast updates for the Flash are less sensitive to news than the forecast for the revised values[11].

Understanding the complex patterns of data revisions would require us to extend the modeling framework along the lines of Jacobs and van Norden (2001). However, a detailed model for the regularities of the data revisions in Belgium

[11]This graph has been produced with the Financial&Housing model specification

Figure 11: Noise versus News regression analysis

## NEWS HYPOTHESIS — BELGIUM

| **News regression for Belgium** | Coef | Std. E | t-Stat | p-value |
|---|---|---|---|---|
| c | -0.01 | 0.06 | -0.12 | 0.91 |
| β | 1.15 | 0.10 | 11.34 | 0.00 |

| | | |
|---|---|---|
| R-squared | 0.80 | **Wald Test** |
| Mean dependent var | 0.35 | H0: c=0, β=1 |
| S.D. dependent var | 0.67 | $X_2$=2.69 (p-value=0.26) |

## NOISE HYPOTHESIS — BELGIUM

| **Noise regression for Belgium** | Coef | Std. E | t-Stat | p-value |
|---|---|---|---|---|
| c | 0.07 | 0.05 | 1.50 | 0.14 |
| β | 0.69 | 0.06 | 11.34 | 0.00 |

| | | |
|---|---|---|
| R-squared | 0.80 | **Wald Test** |
| Mean dependent var | 0.31 | H0: c=0, β=1 |
| S.D. dependent var | 0.52 | $X_2$=26.07 (p-value=0.00) |

## NEWS HYPOTHESIS — EURO AREA

| **News regression for the euro area** | Coef | Std. E | t-Stat | p-value |
|---|---|---|---|---|
| c | 0.00 | 0.03 | 0.06 | 0.95 |
| β | 1.05 | 0.04 | 26.50 | 0.00 |

| | | |
|---|---|---|
| R-squared | 0.96 | **Wald Test** |
| Mean dependent var | 0.24 | H0: c=0, β=1 |
| S.D. dependent var | 0.69 | $X_2$=1.84 (p-value=0.40) |

## NOISE HYPOTHESIS — EURO AREA

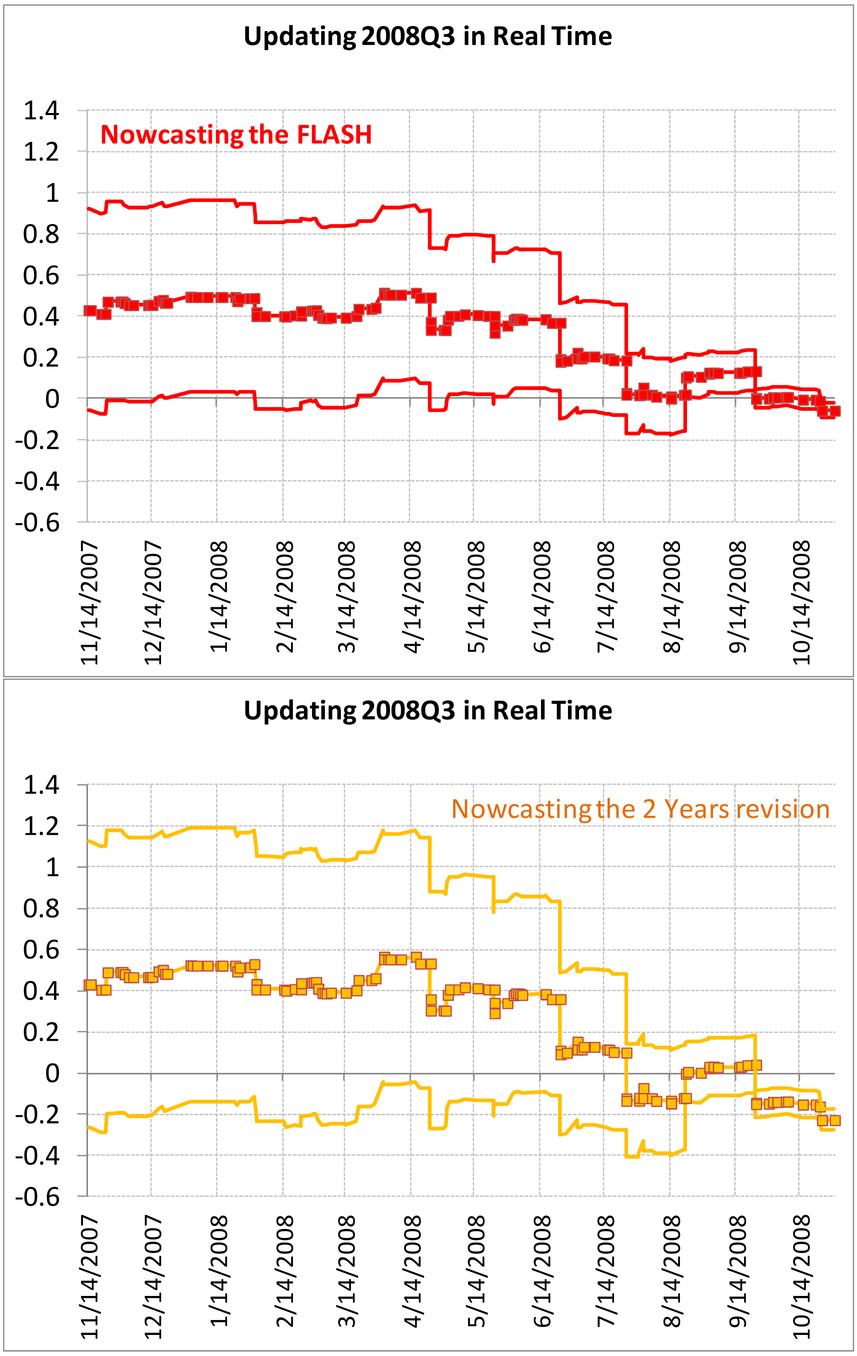
| **Noise regression for the euro area** | Coef | Std. E | t-Stat | p-value |
|---|---|---|---|---|
| c | 0.01 | 0.02 | 0.35 | 0.73 |
| β | 0.91 | 0.03 | 26.50 | 0.00 |

| | | |
|---|---|---|
| R-squared | 0.96 | **Wald Test** |
| Mean dependent var | 0.23 | H0: c=0, β=1 |
| S.D. dependent var | 0.64 | $X_2$=7.19 (p-value=0.03) |

Under the null hypothesis, the Wald statistic has an asymptotic $\chi_n$ distribution, where $n$ is the number of restrictions consistent with such null hypothesis. The p-values associated with the noise hypothesis suggest that such null hypothesis is overwhelmingly rejected, with significance levels of 0% and 3% in Belgium and in the euro area respectively. The test has been conducted over the same sample period $2002Q1 - 2010Q3$ for both countries. In the light of those results, assuming data revisions are uncorrelated to the final release is at least questionable.

NOISEvsNEWS_WALD

Figure 12: Anticipating GDP growth for 2008Q3




The first graph displays the real-time updates of GDP growth (Flash) together with a forecasting interval that only represents uncertainty regarding future releases. The graph at the bottom suggests that the same pieces of news that revise our expectations for the Flash seem to have a larger impact at revising our nowcasts for the subsequently revised growth figure. This higher sensitivity of the revised growth figures is given by the fact that the variance of the revised series is larger than that of the Flash estimates.

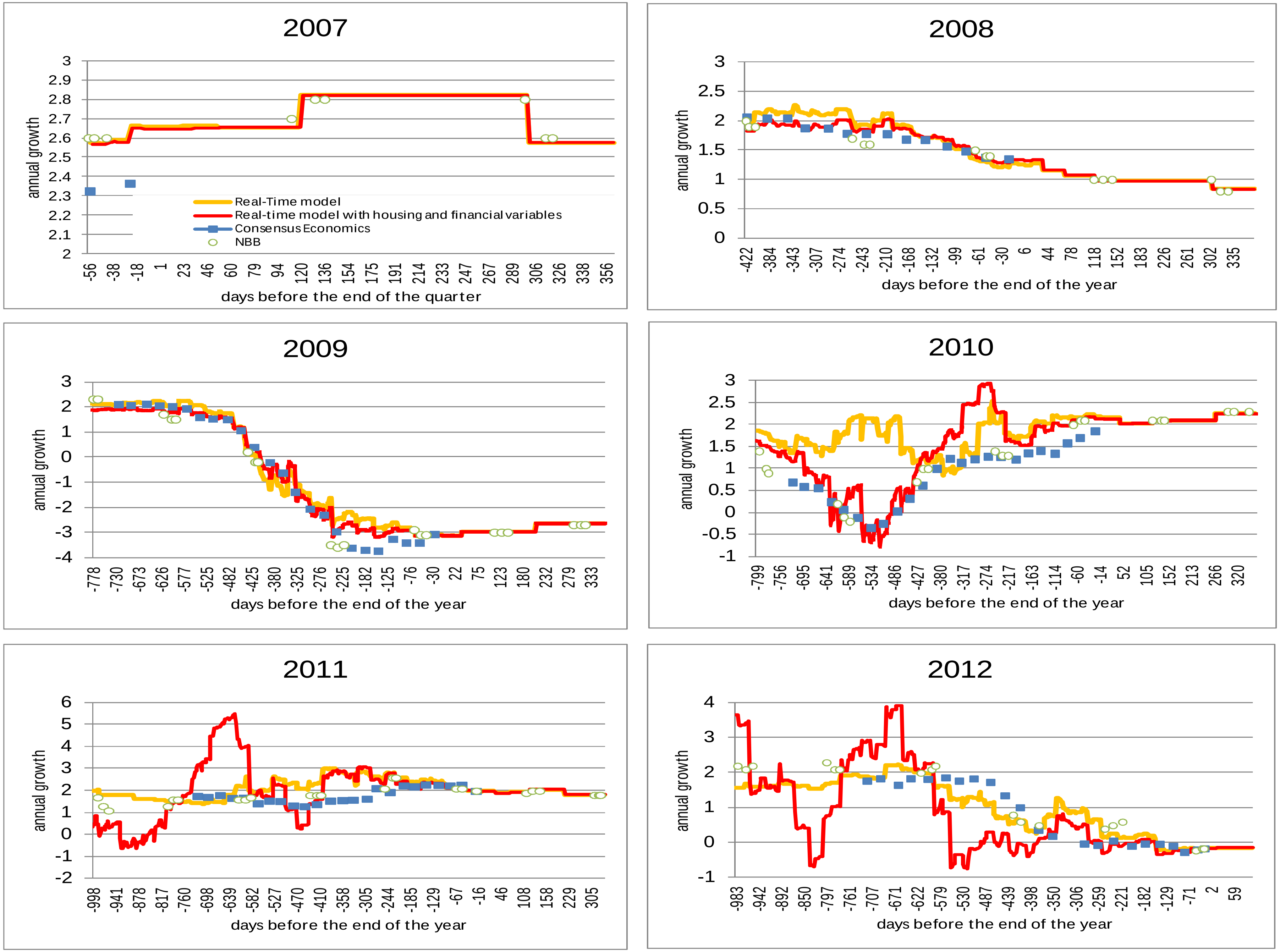
would be very challenging given that the revision calendar has suffered important modifications over time.

# C Forecasting Annual Growth Rates

Although this class of model is typically used in short-term forecasting applications, it is important to understand the long-run properties of the model. Appart from the detailed news analysis provided in Section 5, it is worth comparing the implicit annual forecasts of the models with those published by Consensus Economics.

The National Bank of Belgium's forecasts are not produced on a monthly basis, but only twice a year. It is interesting to include those forecasts in the analysis, since they incorporate a detailed macroeconomic assessment in close coordination with the ECB, and several discussion rounds are required. Although all the forecasts follow a similar updating pattern, model based forecasts are generally more sensitive to the news.

Figure 13: Annual Forecasts



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