

**A TOOLKIT TO STRENGTHEN  
GOVERNMENT BUDGET  
SURVEILLANCE**

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Diego J. Pedregal, Javier J. Pérez  
and A. Jesús Sánchez-Fuentes

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# A TOOLKIT TO STRENGTHEN GOVERNMENT BUDGET SURVEILLANCE (\*)

Diego J. Pedregal

U. CASTILLA-LA-MANCHA

Javier J. Pérez

BANCO DE ESPAÑA

A. Jesús Sánchez-Fuentes

U. COMPLUTENSE DE MADRID

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## **Abstract**

In this paper we develop a comprehensive short-term fiscal forecasting system of use for the real-time monitoring of the Spanish government's borrowing requirement. Spain has been at the centre of the recent European sovereign debt crisis, not least because of sizeable failures in meeting public deficit targets. The system comprises a suite of models, with different levels of disaggregation (bottom-up vs top-down; general government vs sub-sectors), which are suitable for the automatic processing of the large amount of monthly/quarterly fiscal data currently published by the Spanish statistical authorities. Our tools are instrumental in the ex-ante detection of risks to official projections, and can thus help reduce the ex-post reputational costs of budgetary slippage. On the basis of our results, we discuss how official monitoring bodies could expand, on one hand, their toolkit to evaluate regular adherence to targets (moving beyond a legalistic approach) and, on the other, their communication policies as regards sources of risks to (ex-ante) compliance with budgetary targets.

**Keywords:** government accountability, transparency, fiscal Forecasting.

**JEL classification:** E62; E65; H6; C3; C82.

## **Resumen**

En este trabajo presentamos una herramienta para el seguimiento en tiempo real de la ejecución presupuestaria de las Administraciones Públicas en España. La herramienta incorpora un conjunto amplio de modelos estadísticos, con diferentes niveles de agregación entre partidas presupuestarias y subsectores de las Administraciones Públicas, que permiten procesar de manera eficiente la sustancial información mensual y trimestral publicada actualmente por las autoridades estadísticas en España. La principal utilidad de la herramienta es complementar el análisis habitualmente realizado para detectar de manera anticipada posibles riesgos de desviación con respecto a los objetivos fiscales oficiales.

**Palabras clave:** transparencia de las Administraciones Públicas, mecanismos de control presupuestario, previsiones presupuestarias.

**Códigos JEL:** E62; E65; H6; C3; C82.

# 1 Introduction

Government accountability is an essential principle of democracy through which elected and non-elected officials are obliged to explain to the parliament and the public in general their decisions, actions and the consequences of these decisions and actions (see e.g., IMF, 2012; Hameed, 2005; Leal et al., 2008). Most developed countries do have in place a framework of political, legal, and administrative mechanisms designed to control government bodies and officials. Typically, these controls focus on the adherence of the designed policies to the extant legal framework, and are not designed to influence the ex-ante design of policies nor the ex-post responsibility of policy-makers as regards the performance of their actions.

Planning errors can have enormous influence on the economy, in particular those related to budgetary policies. For example systematic and/or sizeable budgetary forecast errors may spur waves of lack of confidence on current governmental policies, and as a consequence affect the economy as a whole via e.g. by tightening the constraints on financing channels for firms. In addition, above-fundamentals financing of the public debt imposes a burden on future generations of taxpayers. Indeed, it can be claimed that the reputational costs associated to lack of adherence of budgetary outcomes to ex-ante budgetary targets were among the group of fundamental drivers behind the recent sovereign debt crisis in the particular case of Spain, within the broader euro-area crisis.

As a consequence, a significant change in the fiscal governance framework took place since the end of 2011 in Spain, whereby an enhanced framework of national budgetary surveillance entered into force as of mid-2012, enshrined in high-ranked legal documents (Constitution and Royal Organic Law), including a huge leap forward in the availability of fiscal statistics and the procedures governing all stages of budgetary planning, including the design and the implementation phases. By now the link between the quality of fiscal frameworks and budgetary discipline is a well-proven fact from an international perspective (see, e.g. von Hagen, 2010). In the case of Spain, though, the new budgetary surveillance framework still has to prove its usefulness to control the behavior of policy makers, as regards budgetary matters, in particular in the face of upcoming electoral periods. But even assuming that policy makers were to have the will to fully implement all the legal procedures in place and were to publish timely and non-controversial real-time fiscal data, two potential weaknesses remain.

First, more information does not necessarily mean better understanding and trust from users, including private and public analysts. On the contrary, it has become increasingly difficult for private and public analysts alike to follow and interpret the continuous flow of monthly fiscal data that is currently published by official statistical agencies in Spain. Indeed, just to quote one example, in March 2012 the only monthly publication about government's budgetary execution did refer to the central government, while since the beginning of 2013 the Spanish statistical authorities do disseminate monthly information following national accounts' definitions for the central, regional and social security sectors, including individual regional governments. This is a level of dissemination of data on public accounts that has no parallel nowadays in Europe. Nevertheless, at the same time, significant and not clearly explained revisions of headline, annual past fiscal data occurred in 2012 and 2013, spurring doubts in private investors and analysts. Just to quote one example, in a Reuters' press news published as recently as November 2013, one could read: "Spain's erratic reporting of fiscal figures, especially from its regional authorities, and repeated revisions to data have fuelled investor mistrust in the government's effort to reduce one of the euro zone's largest public deficits".<sup>1</sup>

Second, the budgetary control and monitoring procedures and institutions currently in place in Spain,<sup>2</sup> pose too much weight on the ex-post adherence of policy outcomes to certain legal and administrative clauses, more than to the ex-ante design and reporting of policy actions, and the real-time monitoring of budgetary execution. This is the standard approach in continental Europe, but it remains to be seen if this approach would be able to detect in a timely fashion fiscal slippage, and to send early-warning signals that could help develop timely corrective actions.

It is against this framework that in this paper we propose a broad set of models and tools suitable for real-time monitoring of fiscal plans, including the assessment of the probability of meeting fiscal targets, that allow for a quick and efficient processing of a vast amount of incoming monthly, quarterly and annual information pertaining to most revenue and expenditure categories, and for all sub-sectors of the General Government. The models are time-series, mixed-frequencies models along the lines of Harvey and Chung (2000), Moauro and Savio (2005), Proietti and Moauro (2006), and Pedregal and Pérez (2010).<sup>3</sup> These papers use a temporal aggregation method that

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<sup>1</sup>13 November 2013, Reuters on-line, "Spain sets up fiscal watchdog, doubts linger on independence".

<sup>2</sup>In particular the legal provisions on budgetary surveillance procedures included in the new Budgetary Stability Law (May 2012), and other comptroller institutions like the IGAE (State Accounts Comptroller) or the Court of Exchequer ("Tribunal de Cuentas"). At the end of 2013 the Spanish Government also created an "Independent Fiscal Authority" that should help in the monitoring process of budgetary plans.

<sup>3</sup>Other approaches for modeling data at different sampling intervals are the methods based on regression techniques



relies on the information contained on related indicators observed at the desired higher frequency. The statistical treatment of structural time series models is based on the state space form and the Kalman Filter. In our case this approach allows the estimation of monthly and quarterly models using annual, quarterly and monthly observations, and permit changes over time arising from an increase in sample size. The State Space framework used allows us to build constrained forecasts in order to evaluate how feasible a given annual target might result. By setting future values of the relevant variable to the actual future policy target, we force a given model to converge to that very target, regardless of how improbable such target might be. But the interesting part of this analysis is that the model replicates a path of indicators compatible with the targets and all the information available at each moment in time. In other words, the model shows a limiting monthly/quarterly path for the indicators, necessary to meet the policy targets. We also proceed one step further and adapt the approach of Gómez and Guerrero (2006) in order to test whether official targets are compatible with the natural unconditional true forecast of a given statistical model. Such a test would produce evidence on the chances of meeting the target.

It is important to stress upfront in the paper that we see the usefulness of our models as a benchmark for the interpretation of newly available data, and not as a substitute of the in-depth analysis normally carried out by fiscal experts in policy institutions. A detailed knowledge of institutional and special factors is a key ingredient for the short-term analysis of fiscal data, which could be further exploited in conjunction with the toolkit presented in this paper.<sup>4</sup> Nonetheless, being aware that budget planning and implementation is more an art than a science (as claimed, for example, by Leal et al., 2008), we are at the same time convinced that looking at short-term fiscal data (i.e. data on the actual implementation of fiscal plans) through the lens of the kind of tools and models we put forward in our paper could provide a neutral and transparent assessment of adherence of observed budgetary data against the monthly/quarterly path consistent with the achievement of annual fiscal targets. On the basis of our results, we discuss how official monitoring bodies could expand, on the one hand, their toolkit to evaluate regular adherence to targets (moving beyond a legalistic approach) and, on the other, their communication policies as regards sources of risks of (ex-ante) compliance with budgetary targets, and the convenience to launch, when needed, ex-ante corrective actions.

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(Chow and Lin, 1971, Guerrero, 2003), the MIDAS (MIxed DAta Sampling) approach (see Ghysels, Santa-Clara & Valkanov, 2004, Clements and Galvão, 2007), the state space approaches of Liu and Hall (2001) and Mariano and Murusawa (2003), or the ARMA model model with missing observations of Hyung and Granger (2008).

<sup>4</sup>Along the same lines see also the discussion of Leal, Pedregal and Pérez (2010).

The rest of the paper is organized as follows. In Section 2 we briefly review the related literature, stressing the contributions of the current paper. The system presented in our paper could serve as a side tool within the monitoring steps prescribed by current national fiscal rules in Spain. To make this clear, in Section 3 we describe a number of institutional issues, namely the territorial organization of Spain, one of the most fiscally decentralized countries in Europe, and the extant framework of national fiscal rules. We also provide a description of ex-ante targets set in real-time by Governments over the period 2008-2013, as well as its adherence to ex-post, published figures, to make explicit the need to incorporate further tools in the national surveillance process. Then, in Section 4 we turn to the description of the data available and the publication lags of official information, to move next in Section 5 to the discussion of the methodological vagaries of our models, and present formally their potential uses for actual policy-makers. Finally, in Section 6 we show some counterfactual, empirical results to somehow justify the validity of our approach, in particular by means of a truly real-time example on the case of the fiscal year 2011, a year in which the ex-post public deficit outcome turned out to exceed hugely ex-ante policy targets, taking by surprise not only international organizations but also private sector analysts. Finally, in Section 7 we provide the main conclusions of the paper.

## 2 Related literature

Official annual fiscal targets and projections have been shown in the literature to display well-documented political biases and/or large forecast errors. See for example, Strauch et al. (2004), Moulin and Wiertz (2006), Annett (2006), Pina and Venes (2011), Jonung and Larch (2006), Leal et al. (2008), Merola and Pérez (2013), Frankel and Schreger (2013), and the references quoted therein. At the same time a recent strand of the literature has shown that intra-annual fiscal data, when modeled appropriately, contains extremely valuable and useful information for forecasting annual fiscal aggregates, enabling earlier detection of episodes of fiscal deterioration (or improvement) than traditional methods: for applications with euro area aggregate data and/or pools of euro area countries' data see Pérez (2007), Silvestrini et al. (2008), Onorante et al. (2009), Pedregal and Pérez (2010), Paredes et al. (2009), Asimakopoulos et al. (2013). Despite this fact, monitoring public finances in the very short-run by means of high-frequency fiscal data has not been an issue traditionally tackled in the literature, even though it is usually part of the routine of practitioners.<sup>5</sup>

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<sup>5</sup>The standard practice for factoring-in new intra-annual fiscal information on revised annual fiscal targets and projections is via informed, judgemental add-in factors (Leal et al, 2008). The fact that budgetary projections

For the case of Spain, some recent contributions to the latter literature are Fernández-Caballero, Pérez and Pedregal (2012), that look at sub-national governments' budgetary data,<sup>6</sup> Leal and Pérez (2009; 2005), that focus on the central government sector,<sup>7</sup> and Leal, Pérez and Pedregal (2010). The latter paper constructs multivariate, state-space mixed-frequencies models for the main components of the Spanish General Government sector made up of blocks for each one of its sub-sectors.

The contribution of the our paper can be seen, from the methodological point of view, as a step forward from Leal, Pérez and Pedregal (2010). In our paper we explore a much broader set of models, confronting their quite aggregated models with a number of single-variable models, thus enabling a clean comparison of bottom-up versus top-down approaches to the problem at hand: monitoring and forecasting general government borrowing requirements. A second contribution of our paper is that we cover the whole euro area period, 1999Q1 till 2012Q4, i.e. in particular we cover all crisis years up to the last fiscal year for which data is available as of the cut-off date of information for our paper. Thirdly, we integrate in our models the substantial amount of statistical data that has been made available by the Spanish statistical authorities since the end of 2010. Finally, and quite notably, our paper goes beyond previous only research-oriented academic contributions and provides, in addition to the research contribution, a fully-implementable toolbox usable for real-time monitoring of public finances. As regards the latter, a database of monthly and quarterly fiscal indicators fully updated every week is provided with the paper,<sup>8</sup> as well as a fully-documented MATLAB toolbox that uploads the data, runs all the models and provides

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are prepared in annual terms, given an annual budgetary cycle, and the discretionary nature of many government measures set up for the entire year, have traditionally limited the role of high-frequency fiscal data for monitoring annual budgetary targets in the course of the year.

<sup>6</sup>They make three main contributions. First, they compile a dataset on quarterly and monthly sub-national governments' spending variables, and indicators, by reviewing all available, scattered sources, and put together a database usable for economic analysis. Second, they exploit the compiled information by fitting time-series, mixed-frequencies models to the data, and show the forecasting and monitoring capabilities of the selected short-term spending indicators. Third, they show that official annual budgetary targets presented useful guidance as to the actual course of sub-national fiscal spending, in particular when combined with short-term indicators-based forecasts. Leal and Pérez (2005) assess adherence to announced budgetary targets of a set of fiscal revenue data for the Autonomous Community of Andalusia, by employing the methodology of Kanda (2002) to evaluate the likelihood of meeting annual fiscal revenue targets, given partial-year monthly data.

<sup>7</sup>They develop a temporal aggregation ARIMA model to monitor and forecast the annual Spanish central government

<sup>8</sup>See also de Castro et al. (2014) for details on the input database.

standardized output files, also available from the authors upon request. All in all, some 20 different models are run over a dataset including more than 200 fiscal variables, and this is done automatically in a few hours of computing time.

### **3 Some institutional and policy issues**

A number of institutional matters have to be discussed before jumping to the econometric methodology. This is so, because, first, Spain is a quite fiscally decentralized country, but has been so in successive waves of fiscal decentralization since the early 1980s. This devolution process is also reflected in the different coverage of available fiscal time series over time. Secondly, the Budgetary Stability Law that entered into force in May 2012 implied a substantial step forward in two respects quite relevant for the purposes of our paper. On the one hand, the law posed quite some emphasis on ex-ante and ex-post monitoring and control procedures. On the other hand, the Law has contributed fundamentally to the transparency of fiscal accounts, meaning that a huge additional amount of fiscal data has become public since May 2012.

#### **3.1 The territorial structure**

Spain is currently one of the most decentralized countries in the European Union. As an example, in 2010 close to 50% of general government expenditure was carried out by sub-national governments (see, e.g. Hernández de Cos and Pérez, 2013a). This is the result of a gradual transfer of responsibilities for the management of specific services from the Central Government to the Regional Governments since the beginning of the 1980s. The transfer of expenditure responsibilities from the Central Government to the regions has, however, neither come about at the same pace, nor have they been on the same scale for all of them. The main differences concern the time at which the various regions took over education and health competencies. In parallel to this process of devolution of expenditure responsibilities to the regions, a financing system for the sub-national governments was also progressively developed. Again, the process was not completely homogeneous across regions, and changed more or less every five years. In particular, the last reform of the financing agreements was approved at the end of 2009. The new system raised the amount of taxes transferred (to 50% in the case of the personal income tax and VAT; to 58% in the case of excise

duties on manufactured production of alcohol, tobacco and hydrocarbons)<sup>9</sup> and Regions received additional powers to modify their rates in some of these taxes.<sup>10</sup> In the case of local governments, the spending responsibilities assigned to them are regulated by the Local Government Act of 1985, which establishes a minimum list of services to be provided by them, the so-called compulsory services. This list of “compulsory services” increases with population size.<sup>11</sup> As a result, the financing system of local governments also changes with size.

The long process of devolution of spending and revenue capabilities to the regions has several implications for the purposes of our project. Firstly, the changes in the revenue system/spending responsibilities (substantial up to 2002 for spending, and up to 2009 for revenue) induced structural breaks in the time series of the sub-sectors of the general government, and make it difficult the evaluation of the performance of dedicated models on the basis of past data. Regional/local government data of sufficient quality and at the quarterly/monthly frequency has only been disseminated quite recently, and its usefulness in general-purpose models is still limited (see the discussion in Fernández-Caballero et al., 2010). Secondly, notwithstanding the previous comment, it is possible to set up models for the sub-sectors of the general government, but more from a forward-looking point of view, i.e. it is hard to validate them on the basis of standard, out-of-sample forecasting exercises, but looking forward this does not invalidate its potential use for current policy-making.

### **3.2 The budgetary surveillance framework**

In September 2011 it was decided to reinforce the prevailing framework of budgetary rules in Spain with the approval of a constitutional reform. The reform enshrines in the Constitution the obligation for all tiers of the general government sector to adjust their conduct to the principle of budgetary stability. Subsequently, on 27 April 2012, the Organic Law of Budgetary Stability and Financial Sustainability (BSL) implementing this constitutional reform was approved, replacing the stability laws in force. The BSL made significant amendments to the definitions of and the mechanisms for determining the deficit, debt and public spending limits applicable to the different

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<sup>9</sup>Regions keep the 100% collection of the hydrocarbon-oil retail sales, electricity tax, property and stamp duty tax, tax of registration of motor vehicles, taxes on gaming, wealth tax and inheritance and gift tax.

<sup>10</sup>In addition, the criteria for distributing the different tax revenues and transfers to the regions changed. See e.g. Hernandez de Cos and Pérez (2013a) for details on these issues.

<sup>11</sup>For additional details see, e.g. Solé-Ollé and Bosch (2007). On January 2014 a new “Local government reform act” entered into force, that incorporated a number of new elements to the definition of services provided by local governments.

levels of government, along with changes in correction procedures and mechanisms in the event of slippage (see, e.g. Hernández de Cos and Pérez, 2013b). The BSL establishes a very detailed procedure for the annual setting of budgetary objectives for the overall general government sector and its agents. Further, it details the mechanisms for the monitoring of the fulfilment of these objectives, it establishes significant improvements in terms of transparency of public finances and it provides for a set of instruments to prevent slippage or to redress it should it arise. In the one year and a half in which the BSL has been applied so far, quarterly reports have been issued on non-compliant regional governments, and even though this has been an improvement with respect to previous practice, they tend to adopt a backward-looking perspective, and no preemptive action has been asked, despite repeated occurrence of non-compliance with pre-set fiscal targets. Precisely, it is in these type of quarterly reports in which the use of additional tools of the kind discussed in our paper could be of help.

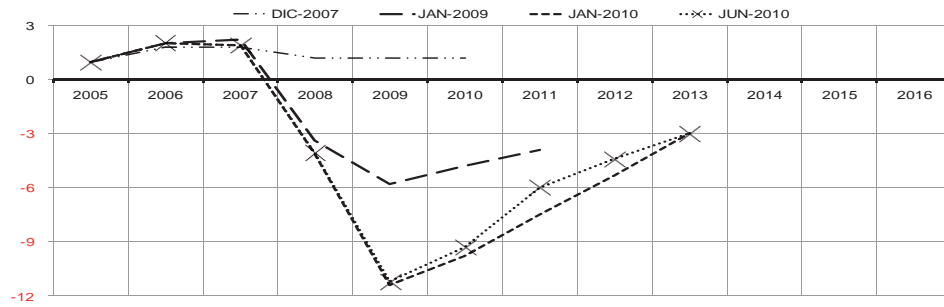
In addition to the BSL, the Spanish Parliament approved in November 2013 the creation of the so-called “Independent Fiscal Responsibility Authority” (AIReF), that became operational over the first half of 2014. According to the law that establishes this new figure, its aim is “to guarantee effective compliance by all public authorities with the principles of budgetary and financial stability”, principles that were introduced in Spanish legislation by the September 2011 constitutional reform and subsequently developed in the BSL in 2012. The AIReF is in charge of issuing reports on government’s macroeconomic forecasts and budgetary plans, and monitoring adherence of the different public administrations to budgetary targets.

### **3.3 The European budgetary surveillance framework**

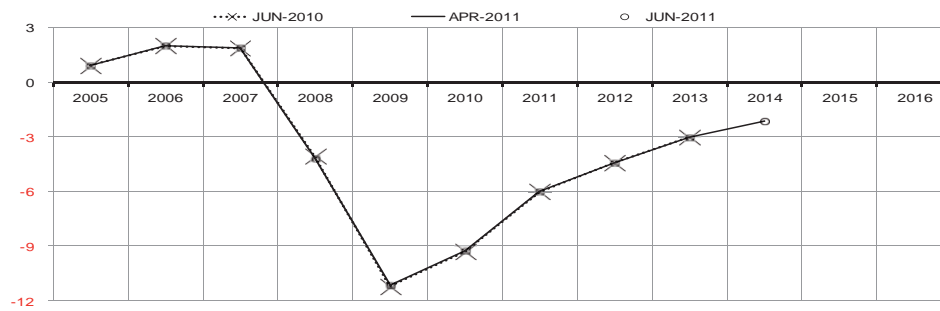
Beyond national fiscal rules, EU countries are subject to the scrutiny of the European Commission, on the one hand, and the multilateral surveillance of the peer EU countries, following procedures defined within the confines of the so-called Stability and Growth Pact (SGP). Moreover, as a response to the 2010-2011 European sovereign debt crisis, and extensive reform of the SGP and the broader economic governance framework was adopted in 2011 (see European Commission, 2013). Six pieces of legislation (the “Six pack”) reformed both the preventive and corrective arms of the SGP. The latter reform followed the introduction of the so-called “European Semester”, a substantially improved surveillance system, covering not only fiscal monitoring but also more general macroeconomic issues.

Figure 1: Multi-annual budgetary targets and outcomes over the crisis: 2008-2013. General government balance targets as percentage of GDP.<sup>a</sup>

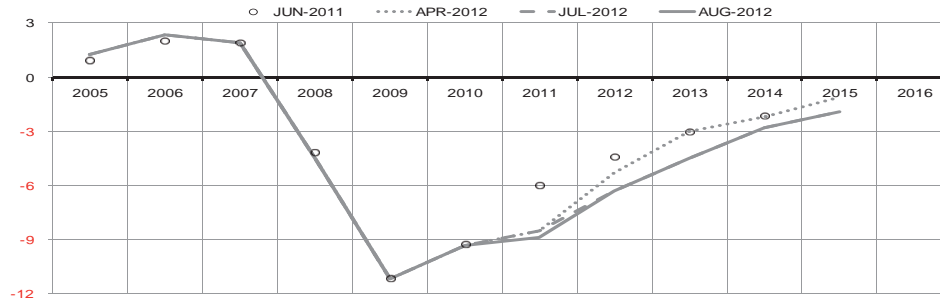
Panel A. From the burst of the economic crisis to the first consolidation package



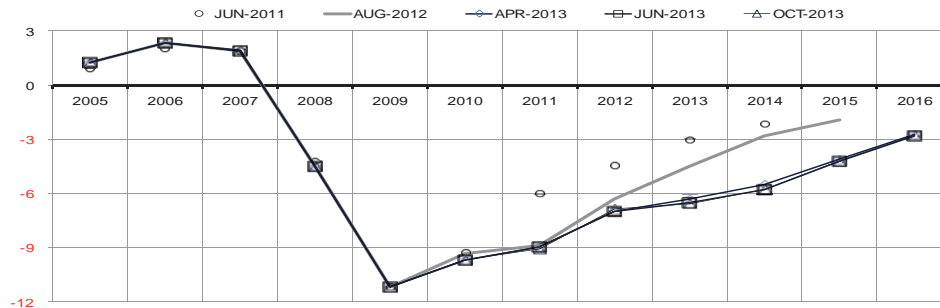
Panel B. The pre-sovereign crisis period – the 2010 target is met



Panel C. The 2011 fiscal slippage



Panel D. The 2012 fiscal adjustment and the relaxation of the consolidation path



<sup>a</sup> SOURCE: Stability and Convergence Programmes (including mid- and/or end-year updates). The government balance excludes the one-off impact of financial assistance to the banking sector in 2011, 2012 and 2013.

### 3.4 Budgetary targets during the crisis

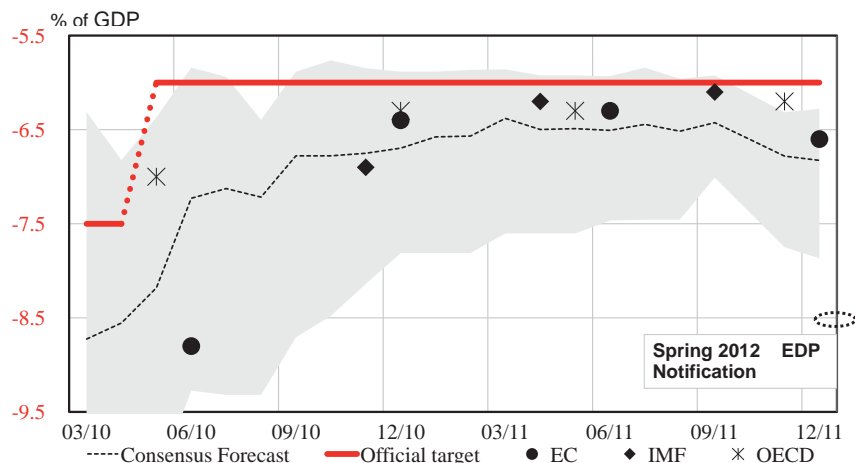
Since the burst of the economic and financial crisis in 2008, the adherence of realized government policies to budgetary targets has been a story of defeats, in most European countries. Certainly, it has been the case in Spain. The difficulties in forecasting government borrowing needs are well documented in the literature, not only by governments, but also by other fiscal forecasters – see, e.g. Hannon (2014). An unanticipated revision of the estimated deficit by the government can be unpredictable (due to unforeseen adverse economic shocks and their impact via automatic stabilizers) or predictable if some type of strategic/electoral behaviour is considered, as the literature on politically-motivated fiscal forecasts would suggest. Without entering into any type of positive analysis, in this sub-section we describe the target public deficit paths defined by the Spanish and European authorities for the Spanish General Government sector over the period 2008-2013. This is done in Figure 1.

According to the Spring 2009 EDP notification, the Spanish general government recorded a deficit of 3.8% of GDP in the fiscal year 2008. By June 2008 most national and international institutions still projected a budgetary surplus for 2008, and only some institutions timidly turned their estimates to small deficits for the whole year after the summer. Nevertheless, as late as October 2008 the government still estimated a deficit of 1.5% of GDP, slightly above the 1.6% deficit projected by the European Commission around the same date (see EC, 2008). The same estimate for 2008 was kept as a reference by the government in the budget law for 2009 that passed parliamentary approval at the end of December. At the beginning of January, though, in the framework of the updated Stability Programme for 2008-2012 (line “JAN-2009” in Panel A of Figure 1), the government provided an estimated deficit for 2008 of 3.4% of GDP, close to the final figure. At the same time, the whole medium-term deficit target path was revised downwards, and the objective for 2009 was set at close to 6% of GDP.

Nevertheless, the deepening of the crisis and, mainly, the fiscal stimulus packages enacted at the end of 2009 led the general government deficit well beyond 11% of GDP. Also in the summer of 2009 Spain was put under an “Excessive Deficit Procedure” (EDP), whereby the “Excessive deficit” had to be corrected by 2013 (i.e. in 2013 the overall government deficit had to be at or below 3%). The significant deterioration of public finances led to the May 2010 public debt crisis, that forced the government to launch a sizeable fiscal consolidation package, including across-the-board spending cuts that hinged particularly on the wage bill. The medium-term target of a deficit of 3% of GDP



Figure 2: *The 2011 fiscal targets (red, horizontal lines): forecast prepared by different private and public institutions for the general government balance in 2011, from different forecast origins.<sup>a</sup>*



<sup>a</sup> SOURCE: Stability and Convergence Programmes, Consensus Forecast, OECD, IMF and EC Spring and Autumn reports, several years. The grey area represents the distance between the max and min forecast within the Consensus Forecast pool of forecasters.

in 2013 was maintained, but part of the assumed fiscal consolidation effort was front-loaded to 2011 (difference between lines “JUN-2010” and “JAN-2010” in Panel A).

The May 2010 fiscal adjustment plan was perceived by markets and international organizations as broadly credible, given that the 2010 revised fiscal target was met. The successive medium-term plan/objectives (April 2011, June 2010) kept the same targets, also in line with the EDP requirements. This is clear from Panel B of Figure 1. The government insisted until the very end of 2011 that the objective of a 6% of GDP deficit in 2011 was reachable. But the April 2012 publication of the 2011 budgetary outcome showed a public deficit outcome well-above 8.5%. Nevertheless, as shown in Figure 2, the government managed to anchor the expectations of private forecasters (summarized by the mean of the “Consensus Forecast” panel) and independent public analysts (European Commission, OECD and IMF). The anticipated budgetary deviation was on average less than 1% of GDP, and even the most extreme forecaster fell short of the deficit figure published in Spring 2012 (a deficit of 8.5% of GDP in 2011), that was even revised upwards in subsequent revisions.

The fiscal slippage of 2011 brought about a substantial reaction by the markets, and the European Council, also in view of adverse macroeconomic projections, decided to loosen the adjustment

path toward the EDP, that was postponed by one year to 2014 (Panel C of Figure 1). In the year 2012 the fiscal adjustment was quite sizeable, also in view of adverse economic conditions, and the deficit was significantly reduced (in particular in structural terms), even though the target deficit-to-GDP ratio was missed by some half percent of GDP. In view of the effective action taken by the Spanish government in 2012, the path of adjustment towards the 3% was relaxed again in June 2013, in such a way that the end to the EDP procedure was postponed till 2016.

The previous discussion has been kept on purpose at a descriptive level. There are no published studies on the economic and political-economy determinants of budgetary deviations for the general government in Spain. Nevertheless, some papers have documented for the central government sector (*Estado*) the existence of systematic biases in budget estimates when compared to realized outcomes, for the pre-crisis period (from the 1980s till 2009). In this respect see Leal and Pérez (2009) and Pons and Solé (2001) that analyze these issues in empirical frameworks in which economic, institutional and political-economy controls are included. See also the more descriptive approach of Edo (2012). On the determinants of the budgetary deviations of regional governments see Leal and López-Laborda (2014) and Argimón and Martí (2006).

## 4 Description of the data and publication lags

### 4.1 The data

As mentioned above, the excellent coverage of central government budgetary execution accounts at the monthly frequency, kept on loosing relevance as the devolution process to regional governments continued over the 1990s and, specially, the 2000s. The BSL posed a great deal of emphasis on the transparency of budget plans and the production of new budgetary execution statistics. As regards the former, the BSL states that the budgets of all general government tiers should include exact information so as to relate the balance of revenue and spending in the budget to net lending or net borrowing according to the European System of Accounts (ESA). As regards the latter, the BSL establishes some minimum reporting requirements for regions and municipalities, including most notably monthly outturns of regional governments' revenue and spending, and quarterly outturns in the case of local governments, along with all the information needed to calculate the budgetary outturn in terms of national accounts.<sup>12</sup> Thus, from June 2012, the IGAE began to

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<sup>12</sup>Ministerial Order HAP/2105/2012 of 1 October 2012 implementing the reporting obligations envisaged in the BSL.

regularly publish quarterly accounts of all general government sub-sectors in terms of ESA95. Also, since October 2012, the statistical agencies have been publishing regularly monthly regional governments' accounts in terms of budgetary accounts and, since March 2013, regional and Social Security monthly accounts in terms of national accounts.

From the point of view of fitting empirical models, the newly published time series, that cover at most one year and a half, are of limited use. Nevertheless, they will become the series of references in the future, and have to be somehow connected to the rest of the information on which a wealth of historical information is available. Table 1 shows a summary of the main variables included in the dataset employed in the paper. It comprises a total amount of some 200 time series, taken from different official providers of statistics (IGAE, INE, BDSICE, Bank of Spain), and covers the period 1985-2013. The data covers the General Government sector and its subsectors. Part of the dataset is in line with ESA95 standards, while another part follows public accounts (cash) accounting rules.

## 4.2 Publication lags and timing convention

Annual fiscal outturns for a given year  $t$  are published at the very end of March of year  $t + 1$ . Quarterly non-financial accounts for the General government and all its sub-sectors are published regularly with a delay of 90 days. Monthly data for the State sector (“Estado”) are published with a lag of one month. Also with a lag of one month are published the data on shared taxes' collection, and social security system outturns, in both cases in cash terms. As regards the newly available information, monthly national accounts data for the Central Government, the regions and the Social Security, are published with a delay of broadly two months.

For the counterfactual, forecasting exercises that will follow in a subsequent section of the paper, following the information provided in the previous paragraph we replicate the real-time constraints faced by real-time fiscal policy analysts, and thus we adopt the timing rules displayed in Table 2, following the standard dates of dissemination of data at the different frequencies. We deem this convention as a fair heuristic representation of reality, on average.

Nevertheless, it is worth mentioning that in a first exercise we will not use real-time data, but revised data as available in October 2013. Of course, the empirical exercises that follow would have some counter-factual features in that data revisions might have affected the lessons drawn from the application of the toolbox in relation to a today's re-creation. Given the absence of historical data records, it is not possible to fully re-create the real-time nominal fiscal series that would have been available at each point in time. Nevertheless, we illustrate the specific case of the year 2011

Table 1: Summary of the data used in the fiscal surveillance system.

Non-financial series	ESA95 coverage*	Periodicity	Sample period	Basis	Source**	Units
General government total revenue	S.13 GG	Annual, quarterly	1985-2012  GG: 2000Q1-2012Q4  Rest: 2004Q1-2013Q3	ESA95	INE (BADESPE database), IGAE	Mrd EUR
General government total expenditure	S.1311 CG					
Central government total revenue	S.1311 RG					
Central government total expenditure	S.1311 RG					
Regional government total revenue	S.1311 RG					
Regional government total expend.	S.1311 RG					
Social Security total revenue	S.1314 SS					
Social Security total expenditure	S.1314 SS					
Labour force survey: GG employment		Monthly, Quarterly	1995-2012		IGAE, INE, Eurostat, other	
Monthly affiliates to SS in non-market						
Investment of Estado						
Public work tenders						
AEAT public wages indicators						
Direct taxes	S.13 GG	Monthly, or Quarterly	1985-2012	ESA95  Cash	IGAE and INE	
Indirect taxes						
VAT taxes						
Social security contributions						
Other revenues						
Real government consumption						
Nominal Government consumption						
Public investment						
Other capital expenditure						
Interest payments						
Social payments						
Subsidies						
Other expenditures						
PUBLIC DEBT						
Total cash non-financial receipts	S.1314 subsector (Social Security System)			Cash	Min. of Economics / Ministry of Social Security	
Total contributory social benefits	S.1314 subsector (Public State Employment Service)				Min. of Economics / Ministry of Social Security	
Pensions					Public State Emp. Service	
Unemployment benefits						
Total expenditure						
Ceded (own) taxes of regional governments	Regional governments	Monthly	1984-2012	Cash	BDSICE database	
Shared taxes	Central + regional + local governments	Monthly	1995-2012	Cash	BDSICE database	
Personal income tax						
Corporate Taxes						
VAT						
Excise duties						

(\*) ESA European System Account; GG General Government; CG Central Government; LG Regional and Local Governments' aggregate; SS Social Security.

(\*\*) INE Spanish National Institute; IGAE General Comptroller of the State Administration

Table 2: Assumptions about availability of data for the counterfactual, pseudo-real-time, forecasting exercises.

	First quarter (March)	Second quarter (June)	Third quarter (September)	Fourth quarter (December)
Annual data up to	Year $t - 2$	Year $t - 1$ (April)	Year $t - 1$	Year $t - 1$
Quarterly data up to	Third quarter $t - 1$	Fourth quarter $t - 1$ (April)	First quarter $t$	Second quarter $t$
Monthly data up to	January $t$	April $t$	July $t$	October $t$

Table 3: Forecasting the 2011 fiscal year in real time: information available in February 2011, June 2011 September 2011, November 2011 and February 2012.

	February 2011	June 2011	September 2011	November 2011	February 2012
Annual data up to	Year 2009	Year 2010	Year 2010	Year 2010	Year 2010
Quarterly data up to	Third quarter 2010	Fourth quarter 2010	First quarter 2011	Second quarter 2011	Second quarter 2011
Monthly data up to	December 2010	March 2011	July 2011	September 2011	November 2011

for which we have compiled a truly real-time database. In Table 3 we show the exact information available at each specific date of reference.

## 5 Main features of the toolkit

### 5.1 A suite of models

Given the different sampling frequencies of the time series included in our dataset, we estimate multivariate, mixed-frequencies models, of the unobserved components type (along the lines of Harvey and Chun, 2000). These type of models have been used with success in the field of fiscal forecasting. Their flexibility allows us to accommodate a number of policy-relevant exercises. We develop a number of models that look at the data from different, complementary approaches. In particular:

- Model 1 (“Joint model”): this is an aggregated model for total revenues and expenditures of the general government sector in national accounts. Three “indicators” (public accounts series pertaining to the central government and the social security system) are used for each general government aggregate, but the model is estimated jointly so that the dynamics of revenues and expenditures are jointly determined. This is in line with the literature, that predicts a tight linkage between revenues and expenditures (in the form of bi-directional causality relationships). The model is set up and estimated at the monthly frequency.
- Model 2 (“Direct model”): this is an aggregated model for the general government sector balance in national accounts terms. Short-term indicators are the monthly balances of the sub-sectors of the general government, in public accounts’ terms. The model is set up and estimated at the monthly frequency.
- Model 3 (“Disaggregated model, components of total revenues and total expenditures”): single models for each one of the sub-components of total general government revenues and expenditures are produced independently, and forecasts for the general government borrowing requirements are produced by bottom-up aggregation. The models are set up and estimated at the quarterly frequency.
- Model 4 (“Disaggregated model, total revenues and total expenditures”): single models for total general government revenues and expenditures are produced independently, and forecasts for the general government borrowing requirements are produced by subtraction. The models are set up and estimated at the quarterly frequency.
- Model 5 (“Joint, sectoral models”): models by each one of the sub-sectors of the General Government (Central, Regions, Social Security) along the lines of Model 1. Forecasts for the general government borrowing requirements are produced by aggregation.
- Model 6 (“Direct, sectoral models”): models by each one of the sub-sectors of the general government (Central, Regions, Social Security) along the lines of Model 2. Forecasts for the general government borrowing requirements are produced by aggregation.

The classes of models considered allow in particular to address the questions of interest, while at the same time providing information on the “bottom-up versus top-down” dichotomy and the “aggregate general government approach versus approach by sub-sectors” dichotomy. All the models can be written in a common general form as described in Appendix A. Our approach is closely

related to Harvey and Chung (2000), Moauro and Savio (2005), and Proietti and Moauro (2006). These papers use a temporal aggregation method that relies on the information contained on related indicators observed at the desired higher frequency. The statistical treatment of structural time series models is based on the state space form and the Kalman Filter (see Harvey, 1989). In our case this approach allows the estimation of a monthly model using annual, quarterly and monthly observations, and permit changes over time arising from an increase in sample size.

## 5.2 Evaluating the probability of meeting the budgetary target

The methodology used, i.e. the State Space framework, allows for some easy and relevant exercises. It is straightforward to build constrained forecasts in order to evaluate how feasible a given target might result. By setting future values of the indicated variables to the actual future targets of a given public agency, we force the model to converge to that target (due to the built-in time constraints in the model), regardless of how absurd or improbable such targets might be. But the interesting part of this analysis is that the model replicates a path of indicators compatible with the targets and all the information available at each moment in time. In other words, the model shows a limiting monthly path for the indicators necessary to meet the future annual targets issued by the agency.

We can proceed one step further still in a more formal way, by testing whether a given government target, or a given forecast provided by any public or private agency, is compatible with the natural unconditional true forecasts of the model. Such a test would produce evidence in favor or against the chances of meeting that very target. Following an adaptation of e.g. Gómez and Guerrero (2006) for a general State-Space model, let's assume all noises in the model are Gaussian,  $R$  is a vector of  $m$  future targets supplied by an independent agency and  $Y_F$  are the forecasts of the model, with covariance matrix  $\Sigma_y$ . Meeting the constraints imply that  $R = Y_F + u$ , with  $u \sim N(0, \Sigma_u)$ , a noise that is assumed independent of any other noises in the model. Then, the formal compatibility test consists of evaluating the distance  $d = R - Y_F$ , which distribution is  $N(0, \Sigma_y + \Sigma_u)$ . For the estimated values in a particular model the compatibility test is based on the statistic

$$K = d' (\Sigma_u + \Sigma_y)^{-1} d/m \sim F_{m,r} \quad (1)$$

where  $r$  is the length of the series minus the number of parameters involved in the model. Two cases may be distinguished: (i) The targets are considered as binding constraints, i.e. the constraints ought to be met exactly. This is equivalent to saying that  $u = 0$ ; (ii) The targets are unbinding

constraints, i.e. the constraints are met “statistically”, not exactly with  $u \neq 0$ . Here feasible estimation of  $\Sigma_u$  is necessary in order to carry out the test. It is not clear how a reliable estimation of this covariance may be obtained in general, being the most obvious (though not free from problems) to rely on a sufficient long chain of previous forecast errors.

One way of avoiding the not obvious problem of  $\Sigma_u$  estimation and still more informative is to use the distribution of the statistic above to calculate probabilities of meeting the targets. This is the approach followed in our paper. In this regard, a distinction between public deficit and revenues on the one hand, and public expenditures on the other, has to be taken into account. Certainly, meeting a deficit or revenue target means in practice achieving a value greater or equal to the target, as a matter of fact, the further is the unconditional forecast above the target implies a greater probability of meeting such a target. Formally, the probability of meeting the target would translate into  $P(Y_F \geq R)$ . If the unconditional forecast hits exactly the target, then the probability of meeting the target is 0.5. On the other hand, for expenditures further unconditional forecasts below the target is evidence of a high probability of meeting the target, formally we ought to calculate  $P(Y_F \leq R)$ .

## 6 Empirical illustrations

### 6.1 Some general remarks

We perform a rolling forecasting exercise in which the selection of the forecast origin and the information set available at each date are carefully controlled for. In particular we evaluate the forecasts generated from four forecast origins per year from March 1999 to December 2012, which makes up to  $14 \times 4$  projections at each forecast horizon. The first forecast origin is March 1999, and following the timing convention outlined before (see Table 2) the annual information available covers up to the year 1997, the quarterly information up to 1998:Q3, and the monthly information up to January 1999. The second forecast origin is June 1999, with annual information up to 1998, quarterly up to 1998:Q4 and monthly up to January-April 1999. Then we move the forecast origin to September 1999 and so on and so forth until December 1999. We focus on the forecast performance for annual projections, i.e. forecasts generated from each forecast origin for the end of the current year, as this is the main horizon of use for mechanical, time-series based forecast. From the point of view of a practitioner, forecasts of fiscal variables for a horizon longer than the current year is of less importance. Our tools are developed to monitor the budget, and the latter, in the case of Spain, follows an annual cycle.



For the nominal public balance, the forecast error committed for year  $t$  by model  $J$  from forecast origin  $Q$  is defined as

$$\varepsilon_{t,Q}^{BAL,J} \equiv (BAL_t - BAL_{t-1}) - \left( E_{\Omega,Q}^J [BAL_t] - E_{\Omega,Q}^J [BAL_{t-1}] \right) \quad (2)$$

where  $\Omega$  makes reference to the information set available at the time of generating a given forecast, as described in Table 2. For revenue and expenditure items, the error committed in year  $t$  for item  $I$  by model  $J$  from forecast origin  $Q$  is defined as

$$\varepsilon_{t,Q}^{I,J} \equiv \left( \frac{I_t}{I_{t-1}} - 1 \right) * 100 - \left( \frac{E_{\Omega,Q}^J [I_t]}{E_{\Omega,Q}^J [I_{t-1}]} - 1 \right) * 100 \quad (3)$$

We compute two standard quantitative measures of forecasting performance for a number of pseudo-real-time forecasting exercises. On the one hand, the ratio of the Root Mean Squared Errors (RMSE) of the different alternative models with respect to an annual random walk (i.e. no-change) alternative. On the other hand, we also look at a qualitative measure of forecast performance, namely, whether the predicted change coincided or not with the actual change observed in the variable of interest. We also present, as discussed in a previous Section, a truly real-time exercise, focused on the 2011 fiscal year, given the relevance of the budgetary deviation observed that year.

## 6.2 Bottom-up vs top-down models

The results of a first exercise are presented in Table 4. In that table we show the relative root mean squared error of our models compared to the annual random walk extrapolation for a number of cases: (i) aggregate of the forecast errors generated for the whole year from all forecasts origins (baseline); (ii) forecasts errors computed on the basis of forecasts computed taking as forecasts origin the first quarter (Q1), the second (Q2), the third (Q3) and the fourth (Q4); (iii) these exercises are presented for the whole sample used for the rolling forecasting exercise (“Full sample”, 1999-2012), and for the crisis sample (2008-2012). The following messages can be highlighted from Table 4 for a subset of the results obtained, namely the aggregated results for the general government balance, revenues and expenditures.

First, when looking at the full sample, and pooling all forecast errors (resulting from forecast origins Q1 to Q4), the most aggregated models (i.e. those that model directly the budget deficit), models 1 (general government) and model 6 (sub-sectors), are the best. All other models are close to these ones, with the exception of model 4. This relative ranking of models is broadly kept when

Table 4: *Quantitative forecasting performance of alternative models: summary of results for the general government balance, revenue and expenditure.*<sup>‡</sup>

	General Government balance						Total revenues				Total expenditures			
	M1	M2	M3	M4	M5	M6	M1	M3	M4	M5	M1	M3	M4	M5
<b>Full Sample</b>	0.88	0.91	0.96	1.19	1.01	0.90	1.04	1.01	1.15	1.00	0.95	0.93	0.86	1.31
Q1	0.95	0.99	1.05	1.20	1.18	0.99	1.15	1.18	1.17	1.03	0.98	0.89	0.78	1.23
Q2	1.12	1.17	1.16	1.43	1.21	1.09	1.38	1.10	1.33	1.14	1.17	1.28	1.04	1.68
Q3	0.70	0.75	0.84	1.19	0.77	0.73	0.87	0.85	1.15	0.96	0.80	0.80	0.91	1.21
Q4	0.55	0.47	0.62	0.88	0.58	0.66	0.50	0.71	0.92	0.84	0.74	0.72	0.78	1.15
<b>Crisis</b>	0.84	0.87	0.95	1.20	1.00	0.90	0.87	1.00	1.15	0.96	0.67	0.56	0.86	1.25
Q1	0.91	0.97	1.05	1.20	1.18	0.99	1.04	1.18	1.16	1.03	0.61	0.61	0.76	1.11
Q2	1.10	1.11	1.13	1.43	1.19	1.09	1.05	1.11	1.34	1.11	0.96	0.68	1.13	1.70
Q3	0.68	0.72	0.84	1.20	0.75	0.72	0.72	0.82	1.16	0.93	0.68	0.45	0.94	1.23
Q4	0.48	0.42	0.62	0.89	0.55	0.63	0.42	0.66	0.91	0.68	0.40	0.29	0.70	1.18

<sup>‡</sup> The numbers in the table are the ratios of Root Mean Squared Errors of the errors obtained with each model (labeled models 1 to 6) with respect to an annual random walk approach (no-change baseline). Forecast errors are computed as follows. For the nominal balance, the error committed for year  $t$  by model  $J$  from forecast origin  $Q$  is defined as  $\varepsilon_{t,Q}^{BAL,J} \equiv (BAL_t - BAL_{t-1}) - (E_{\Omega,Q}^J[BAL_t] - E_{\Omega,Q}^J[BAL_{t-1}])$ . For revenue and expenditure items, the error committed in year  $t$  for item  $I$  by model  $J$  from forecast origin  $Q$  is defined as  $\varepsilon_{t,Q}^{I,J} \equiv \left( \frac{I_t}{I_{t-1}} - 1 \right) * 100 - \left( \frac{E_{\Omega,Q}^J[I_t]}{E_{\Omega,Q}^J[I_{t-1}]} - 1 \right) * 100$ .  $\Omega$  makes reference to the information set available at the time of generating a given forecast, as described in Table 2.

looking into forecasts from each origin (Q1 to Q4, taken individually). Thus, with the exception of models 3 versus 4, in the other two cases more aggregate models outperform more disaggregated models. This can be taken as evidence that bottom-up approaches are not necessarily better than top-down ones, at least as regards forecast accuracy. Of course, in real-time, bottom-up approaches provide the advantage of giving a more comprehensive view, which can be an asset in cases like the current one in which overall performance across models is not overwhelmingly different. The main results on bottom-up versus top-down holds when looking into sub-samples.

Second, in general, the forecast accuracy of all models is better in the crisis sample than in the “expansion” one. This may reflect the fact that the models can do a fair job in periods of significant changes, while in a period with no fiscal stress and persistent economic growth, it is more difficult to beat a simple extrapolation of the past.

Third, across quarters, the forecasting performance of all models improves when more information about revenue collection and the implementation of spending plans kicks-in. This is quite clear in the second half of the year compared to forecasts prepared in the first half. In particular, in Q3 a fair amount of information for the first half of the year is assumed to be available, but only the first quarter of the general government accounts, while in Q4 the first half of the year is fully known. For projections prepared from forecast origin Q2 things are quite different. In our timing convention this is the quarter in which the annual figure of year  $t - 1$  is known. This seems to create a discontinuity in how models process incoming information, as forecast accuracy is worse than Q1-based forecasts, a fact that may be linked to the realization of past data revisions, including the appearance of “hidden spending” not reflected in monthly/quarterly indicators.

Fourth, when looking at revenue and expenditure errors, the same general results as regards full-sample versus crisis-sample forecasts, and as regards first semester versus second semester forecasts, hold. Interestingly, models add more information compared to the simple random walk baseline in the case of expenditures than in the case of revenues, i.e. in general relative RMSEs tend to be lower across models, though not in all cases. This provides some evidence on the ability of models to accommodate purely within-the-year discretionary policy changes.

Some interesting results can be highlighted from the particular set of revenue/expenditure projections. In the case of total revenues: (i) the aggregated, joint revenue-expenditures model (model 1, “M1”) tends to be the best performer, in particular in the case of the crisis period; this is the case versus the bottom-up approach, M3, and model M4 that does not exploit the link between revenues and expenditures; (ii) as regards the other models, M3 seems to be the best in general,

even though it is not clear-cut along all the dimensions considered (full-sample/pre-crisis, across quarters). As regards total expenditures: (i) bottom-up approaches seem to provide (marginal) better results, being clear from the comparison of M3 versus M1, which makes sense given that, in particular, fiscal consolidations tend to have a differentiated profile for the different spending components; while social payments tend to increase in crisis times (unemployment benefits) or to stay, at most, stable (pensions), other components like public investment, or the wage bill, tend to move in the opposite direction in fiscal adjustment periods - this is a differentiated element when compared to government revenues, that are subject to similar macroeconomic shocks, even though tax hikes can be uneven across revenue aggregates; (ii) the aggregation of sectoral models (M5) performs quite badly in the case of TOE, which is not surprising given the fact that central government transfers to the rest of the sectors, in particular to the social security, tend to occur during the year, distorting, thus, the genuine signals of sectoral data.

Beyond the comparison of alternative models across several dimensions of this subsection, it is by now a proven fact in the literature that the combination of alternative models tends to outperform individual models. In the next subsection of the paper we exploit that dimension of our models.

### **6.3 The usefulness of the combination of models**

In tables 5 and 6 we compare the performance of the combination of models' forecasts with the forecasts of the European Commission (EC henceforth). As shown in Artis and Marcellino (2001) and Keereman (1999), the forecast record of the EC is among the best of the international organizations producing regular forecasts for European countries, and in particular Spain (others include the International Monetary Fund and the OECD). EC forecasts tend to make use of all of the information available at the time the forecasts are done, not only observed data, but also all available, forward-looking information on budgetary plans, including additional corrective packages enacted by the governments in the course of the year. EC forecasts are based on a bottom-up approach. In addition, EC fiscal forecasts use both macroeconomic models and expert judgement. That is why checking the performance of the models (specifically, a combination of them) against EC forecasts should be quite a demanding criterion. Even bearing in mind that we are comparing against a difficult-to-beat benchmark, our objective with this exercise is to check the usefulness of the models to complement an approach that takes into account backward- and forward-looking information alike, as in the case of the EC forecast.

Table 5: *Quantitative forecasting performance<sup>a</sup>: combination of models' forecasts<sup>b</sup> (mean and median) versus European Commission forecasts<sup>c</sup>*

	Government Balance			Government revenues			Government expenditures		
	Mean	Median	EC	Mean	Median	EC	Mean	Median	EC
<b>Full Sample</b>	0.87	0.91	0.82	0.90	0.88	1.47	0.85	0.81	0.68
Q1	0.98	1.04	0.85	1.01	1.00	1.13	0.86	0.75	0.51
Q2	1.06	1.07	0.88	1.03	1.04	1.65	1.06	1.00	0.82
Q3	0.74	0.80	0.88	0.83	0.81	1.65	0.73	0.82	0.82
Q4	0.49	0.49	0.64	0.58	0.51	1.55	0.67	0.71	0.72
<b>Crisis</b>	0.87	0.91	0.81	0.87	0.86	1.49	0.72	0.68	0.59
Q1	0.98	1.04	0.84	1.01	1.00	1.13	0.70	0.64	0.44
Q2	1.05	1.06	0.86	0.99	1.01	1.68	0.96	0.89	0.73
Q3	0.74	0.79	0.86	0.81	0.78	1.68	0.67	0.70	0.73
Q4	0.49	0.48	0.64	0.51	0.44	1.56	0.51	0.46	0.66

<sup>a</sup> The numbers in the table are the ratios of Root Mean Squared Errors of the errors obtained with each alternative with respect to an annual random walk approach (no-change baseline).

<sup>b</sup> For the nominal balance, the error committed for year  $t$  by model  $J$  from forecast origin  $Q$  is defined as  $\varepsilon_{t,Q}^{BAL,J} \equiv (BAL_t - BAL_{t-1}) - (E_{\Omega,Q}^J [BAL_t] - E_{\Omega,Q}^J [BAL_{t-1}])$ . For revenue and expenditure items, the error committed in year  $t$  for item  $I$  by model  $J$  from forecast origin  $Q$  is defined as  $\varepsilon_{t,Q}^{I,J} \equiv \left( \frac{I_t}{I_{t-1}} - 1 \right) * 100 - \left( \frac{E_{\Omega,Q}^J [I_t]}{E_{\Omega,Q}^J [I_{t-1}]} - 1 \right) * 100$ .  $\Omega$  makes reference to the information set available at the time of generating a given forecast, as described in Table 2.

<sup>c</sup> European Commission forecasts are taken from AMECO real-time vintages. For the nominal balance, the error committed for year  $t$  from forecast origin  $Q$  is defined as  $\varepsilon_{t,Q}^{BAL,EC} \equiv (BAL_t - BAL_{t-1}) - (E_Q^{EC} [BAL_t] - E_Q^{EC} [BAL_{t-1}])$ . For total revenues and expenditures, the error committed in year  $t$  for item  $I$  is defined as  $\varepsilon_{t,Q}^{I,EC} \equiv \left( \frac{I_t}{I_{t-1}} - 1 \right) \times 100 - \left( \frac{E_Q^{EC} [I_t]}{E_Q^{EC} [I_{t-1}]} - 1 \right) \times 100$ .

In Table 5 we show the relative RMSE of each alternative with respect to the random walk approach. Overall, for the full sample and when all the errors from all forecast horizons are pooled, EC government balance forecast errors are lower than the mean and the median of the alternative models. This is also the case as regards full sample government expenditure errors, while in the case of public revenue the opposite happens. This full-sample picture also holds when looking at the crisis sample. Quite interestingly, though, Q3- and Q4-based forecast errors are systematically lower for the combination of models versus EC forecast, both for the whole sample and the crisis sample. This means that as soon as a sufficient amount of data is available on the implementation of spending plans and/or the behavior of revenue collection (under our quite restrictive timing convention in Q3 only the first quarter of the headline general government variable, and half-year in the case of indicators are available) the models are able to process and extrapolate these data in a quite informative way. By this we mean, in a way that even tends to outperform a full-information approach that incorporates in an explicit manner forward-looking elements (policy measures affecting future quarters). In particular, in Q4 the mean and the median of models displays a remarkable forecast accuracy. Turning to government revenues, it is surprising the relative bad forecast accuracy of EC forecasts for government revenue growth projections, a result that is dominated by the significant forecast errors around GDP turning points, related to the double-dip crisis.

Turning now to Table 6, the qualitative results shown display similar messages as in the quantitative case. Specifically, in the table we present the percentage of correctly predicted changes in the case of government balance, and the percentage of correctly predicted signs of the growth rate in the case of government revenues and expenditures.

#### **6.4 Real-time forecasting exercise for the 2011 year**

In this subsection we present an additional exercise, this time a truly real-time one, i.e. based on the exact dataset available at each point in time, is shown in Figure 3. We focus on the fiscal year 2011, a difficult year as discussed in the descriptive Section above.

As discussed, from each forecast origin, and conditional on the short-term information available, we can compute unconditional forecasts (as the ones shown in the previous examples) but also the consistency of government targets with these forecasts. In particular in Figure 3 we present in each single box how the unconditional forecasts (in white color) are updated to the new available information, in relation to the actual final data (dots), the targets (thick line red) and the uncertainty in each case (fan chart up to 99% confidence). The two top rows of charts in Figure 3 shows the

Table 6: *Qualitative forecasting performance<sup>a</sup>: combination of models' forecasts<sup>b</sup> (mean and median) versus European Commission forecasts<sup>b</sup>*

	Government Balance			Government revenues			Government expenditures		
	Mean	Median	EC	Mean	Median	EC	Mean	Median	EC
<b>Full Sample</b>	45.8	43.8	58.3	68.8	68.8	39.6	41.7	47.9	62.5
Q1	25.0	25.0	58.3	50.0	50.0	50.0	41.7	41.7	75.0
Q2	33.3	33.3	58.3	66.7	75.0	33.3	16.7	50.0	50.0
Q3	58.3	41.7	58.3	83.3	75.0	33.3	58.3	50.0	50.0
Q4	66.7	75.0	58.3	75.0	75.0	41.7	50.0	50.0	75.0
<b>Crisis</b>	50.0	40.0	35.0	75.0	75.0	40.0	50.0	55.0	70.0
Q1	20.0	20.0	20.0	40.0	40.0	40.0	40.0	40.0	80.0
Q2	40.0	40.0	40.0	80.0	60.0	40.0	40.0	60.0	60.0
Q3	60.0	40.0	40.0	80.0	100.0	40.0	60.0	60.0	60.0
Q4	80.0	60.0	40.0	100.0	100.0	40.0	60.0	60.0	80.0

<sup>a</sup> The numbers in the table are the percentage of correctly predicted changes in the case of the government balance, and the percentage of correctly predicted signs of the growth rate in the case of government revenues and expenditures.

<sup>b</sup> See footnotes to Table 5.

results for deficits obtained with models 1 and 2, and the third and fourth rows show total revenues and expenditures with model 1. Numbers in parentheses in each title shows the probability of meeting the target, i.e.  $P(Y_F \geq R)$  for deficits and revenues, and  $P(Y_F \leq R)$  for expenditures, as was stated in the previous section.

The two left-upper panels show government balance projections for 2011 from forecast origin in February 2011. The information available was quite scarce at that point in time: the annual figure for 2009, quarterly information up to the third quarter of 2010 and monthly indicators for the month of December in some cases. Thus, it is not surprising to see that confidence bands generated with both models were quite broad, reflecting a extremely high uncertainty surrounding the projections (white lines), and a central scenario of further deterioration of the budget balance. In June 2011, the information available increased substantially: the first estimate for the year 2010 was published and short-term indicators covered up to March 2011. Model 1 (first line of charts) indicated at that moment an improvement in the budget balance in 2011 compared to 2010, but still the probability associated with meeting the target was 24% percent, while in the case of Model 2 (joint model of revenues and expenditures) the probability assigned to meeting the target was zero, i.e. the target was out of the confidence bands of the model forecast. In the latter case, the

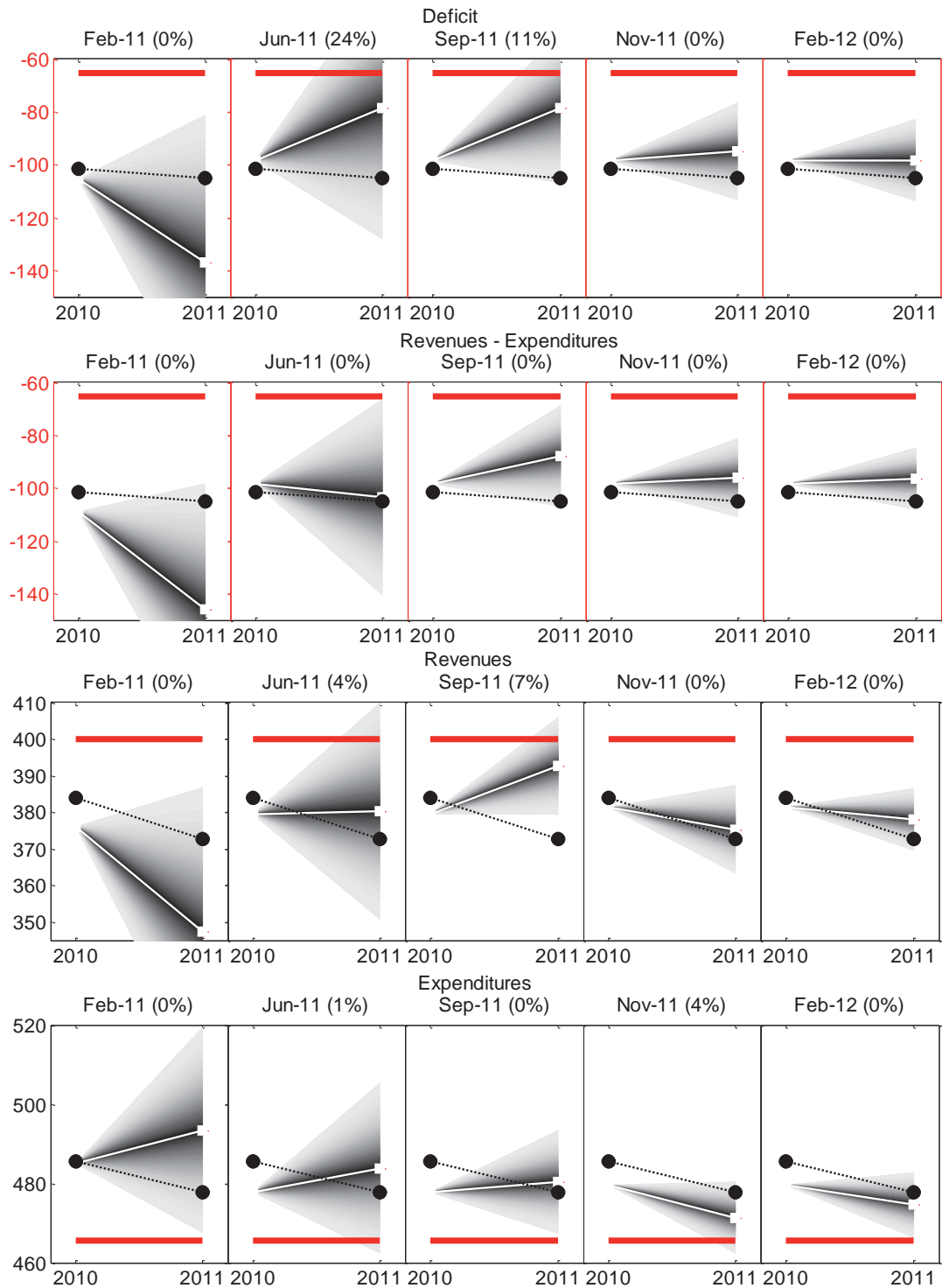
probability assigned to meeting the government revenue target, though, was not null, but was as small as 5%. The publication of the general government figures for Q1 and of short-term indicators up to July (September 2011 forecast origin) improved marginally the revenue projection, while in the case of the direct-deficit-model (model 1) the probability assigned to meeting the target was around 10%, but still, in qualitative terms the forecast signalled an improvement in the government balance, a direction consistent with the objective of the government.

In November 2011 (information set: second quarter of general government variables, short-term indicators up to September), though, the situation change considerably. Both models were assigning a zero probability to the event “the target is met”, and at the same time, both models signalled to basically no improvement in the budget balance compared to the one observed in 2010. In the case of model 2, estimated government revenues for 2011 were for a significant drop compared to the previous year, and the balance was estimated at more or less the same nominal amount as in 2010 due to the projected expenditure restraint, as in the official plans (red thick line). It is worth mentioning that in the last quarter of 2011 the double-dip in real GDP growth was starting to be evident, a fact that was visible in government revenue aggregates. Compared to the actual realization of deficits, revenues and expenditures, the estimates computed by those models in real-time was indeed quite accurate. This is even more clear when looking at the forecast labeled “February 2012”, that incorporated data for general government, headline variables up to Q2 2011, and short-term indicators up to November 2011.

The real-time recreation of the use of two of our suggested models for the 2011 episode is quite illustrative about the potential uses of our system. The bold signals of the models were quite clear, in particular after the summer. Since November, the two selected models were signalling clearly to a around 2% of GDP deviation with respect to the official, government target. In the case of the revenue/spending model, in addition, the slippage was almost fully related to revenue shortages, while expenditures, even being forecast to be above the target, were relatively close in quantitative terms. These results contrast with the “herding behavior” observed in Figure 2, and indicates that the data on the implementation of revenue targets were already hinting towards a sizeable slippage, despite corrective measures adopted at the end of the summer. Indeed, in August a broadening of corporate tax bases was approved, and entered into force in Q4, but as not able to compensate the strong, downward trend in tax collection that was visible at least since November 2011 (with data available up to September at the maximum).



Figure 3: *Forecasts and fancharts with the limit of 99% confidence.*<sup>a b</sup>



<sup>a</sup> Dots: actual values; White: forecasts; Red wide: 2011 target.

<sup>b</sup> Figures in parenthesis are probabilities of meeting the annual targets at each date.

## 7 Conclusions and policy discussion

In this paper we present a comprehensive fiscal forecasting system, based on all short-term fiscal data available for the Spanish case. Our system is made of a suite of models, with different levels of disaggregation (bottom-up vs top-down; general government vs sub-sectors) suitable for the automatic processing of the large amount of monthly/quarterly fiscal data published nowadays by Spanish statistical authorities.

Beyond presenting the tools as such, in this paper we show some example of its potential applications for real-time monitoring of public finances. In particular, we show how the combination of models provides extremely accurate signals when information pertaining to the first half of the year is available, both in quantitative and qualitative terms. Surprisingly enough, the models contain information that seemed not to have been factored into European Commission fiscal forecasts, that are among the best performers within the set of international organizations, and supposedly incorporate not only past data, but also forward-looking information on approved, but not yet implemented, policy measures. In addition, we provide a truly real-time application to the analysis of the huge budgetary deviation of the fiscal year 2011, showing the potential of the models in capturing in advance most of the ex-post observed deviation. Thus, we claim that our tools might potentially be instrumental for ex-ante detection of risks to official projections, and thus can help in reducing the ex-post reputational costs of budgetary deviations.

From a policy-making point of view, we also claim that official monitoring bodies could incorporate in their toolkit to evaluate regular adherence to targets more formal elements, of the kind presented in our paper, in order to move the standard evaluation procedure beyond the extant, more “legalistic” approach. In addition, presenting model-based results, or uncertainty tests around government targets, as the ones shown in our real-time exercise, may be helpful to convey to the public risks surrounding fiscal projections (on this subject see also Clark et al., 2013). Incorporating these type of elements may help in improving communication policies as regards sources of risks of (ex-ante) compliance with budgetary targets as well as reasons for (ex-post) budgetary deviations had them occurred.

## References

- Annett, A. (2006), “Enforcement and the Stability and Growth Pact: How Fiscal Policy Did and Did Not Change Under Europe’s Fiscal Framework”, IMF Working Paper 2006/116.

- Argimón, I. and F. Martí (2006), “Las finanzas públicas de las Comunidades Autónomas: presupuestos y liquidaciones”, *Boletín Económico del Banco de España*, December.
- Artis, M. and Marcellino, M. (2001), “Fiscal forecasting: the track record of the IMF, the OECD and the EC”, *The Econometrics Journal* 4, S20-S36.
- Asimakopoulos, S., J. Paredes and T. Warmedinger (2013), “Forecasting fiscal time series using mixed frequency data”, Working Paper Series of the European Central Bank 1550.
- Chow, G. C., and A. Lin (1971), “Best Linear Interpolation, distribution and extrapolation of time series by related series”, *Review of Economics and Statistics*, 53, 372-375.
- Clark, J., C. Gibbons, S. Morrissey, J. Pooley, E. Pye, R. Wilcox and L. Willard (2013), “Estimates of uncertainty around budget forecasts”, Australian Treasury Working Paper 2013–04.
- Clements, M.P., and A. B. Galvão (2007), “Macroeconomic forecasting with mixed frequency data: Forecasting US output growth”. Working Paper 616, Department of Economics, University of London.
- de Castro, F., F. Martí, A. Montesinos, J. J. Pérez and A. J. Sánchez (2014), “Fiscal policies in Spain: main stylized facts revisited”, Banco de España, mimeo submitted to BE Working Paper Series).
- Edo, V. (2012), “Los programas presupuestarios del Estado en España: metodología y análisis de las desviaciones presupuestarias 1990-2009”, *Revista Auditoría Pública*, 56.
- European Commission (2013), “Building a strengthened fiscal framework in the European Union: a guide to the Stability and Growth Pact”, *European Economy - Occasional Papers*, n. 150.
- Fernández-Caballero, L., D. J. Pedregal, D.J., and J. J. Pérez (2012), “Monitoring sub-central government spending in Spain”, *Hacienda Pública Española / Review of Public Economics*, 202, pp. 77-104.
- Frankel, J. A. and Schreger, J. (2013), “Over-optimistic official forecasts and fiscal rules in the Eurozone”, *Review of World Economics*, forthcoming.
- Ghysels, E., P. Santa-Clara, and R. Valkanov, R. (2004), “Predicting volatility: Getting the most out of return data sampled at different frequencies”, *Journal of Econometrics*.

- Gómez, N. and Guerrero, V.M. (2006), 'Restricted forecasting with VAR models: An analysis of a test for joint compatibility between restrictions and forecasts', *International Journal of Forecasting*, 22, 751-770.
- Gómez, V. and A. Maravall (1996), "Programs TRAMO (Time series Regression with Arima noise, Missing observations, and Outliers) and SEATS (Signal Extraction in Arima Time Series). Instructions for the User", Banco de España Working Paper No. 9628.
- Guerrero, V.M. (2003), "Monthly disaggregation of a quarterly time series and forecasts of its unobservable monthly values", *Journal of Official Statistics*, 19, 215-235.
- Hameed, F. (2005), "Fiscal transparency and economic outcomes", IMF Working Paper n. 05/225. Washington: International Monetary Fund.
- Hannon, P. (2014), "Difficulties in Forecasting Borrowing Requirements", *The Wall Street Journal*, 10 January 2014, available at: "[blogs.wsj.com/moneybeat/2014/01/10/difficulties-in-forecasting-borrowing-requirements/](http://blogs.wsj.com/moneybeat/2014/01/10/difficulties-in-forecasting-borrowing-requirements/)"
- Harvey, A. (1989), *Forecasting Structural Time Series Models and the Kalman Filter*. Cambridge University Press. UK.
- Harvey, A. and Chung, C. (2000), "Estimating the underlying change in unemployment in the UK", *Journal of the Royal Statistical Society, Series A*, 163, pp. 303-339.
- Hyung, N. and C. J. Granger (2008), "Linking series generated at different frequencies", *Journal of Forecasting*, 27, 95-108.
- Hernández de Cos, P. and J. J. Pérez (2013a), "Sub-national public debt in Spain: political economy issues and the role of fiscal rules and decentralization", pp. 188-216 in "Fiscal relations across government levels in times of crisis - making compatible fiscal decentralization and budgetary discipline", European Commission Economics Papers, 501. Brussels.
- Hernández de Cos, P. and J. J. Pérez (2013b), "The new budgetary stability law", *Economic Bulletin*, Bank of Spain, April.
- International Monetary Fund (2010), "Fiscal transparency, accountability and risk", *International Monetary Fund Policy Paper* 080712. Washington D.C.

- Jonung, L., and Larch, M. (2006), “Fiscal policy in the EU: are official output forecasts biased?”, *Economic Policy*, July, 491-534.
- Kanda, D. (2002), “Assessing Monthly Progress Toward Annual Fiscal Revenue Targets”, IMF WP/02/116.
- Keereman, F. (1999), “The track record of Commission Forecasts”, European Commission Economic Papers, n. 137.
- Leal, T., J. J. Pérez, M. Tujula, and J.-P. Vidal (2008) “Fiscal forecasting: lessons from the literature and challenges”, *Fiscal Studies*, 29, 347-386.
- Leal, T. and Pérez, J. J. (2009), “Un sistema ARIMA con agregación temporal para la previsión y el seguimiento del déficit del Estado”, *Hacienda Pública Española / Review of Public Economics*, 190, 27-58.
- Leal, T. and Pérez, J. J. (2005), “Seguimiento de objetivos fiscales anuales: una aplicación con datos regionales”, *Investigaciones Regionales*, 7, pp. 53-67, November.
- Leal, T. and Pérez, J. J. (2011), “Análisis de las desviaciones presupuestarias aplicado al caso del presupuesto del Estado”, *Estudios de Economía Aplicada*, 29-3, pp. 1-14.
- Leal, T., D. J. Pedregal and Pérez, J. J. (2010), “Short-term monitoring of the Spanish government balance”, *SERIEs*.
- Liu, H. and S. G. Hall (2001), “Creating high-frequency national accounts with state space modelling: A Monte Carlo experiment”, *Journal of Forecasting*, 20, 441-449.
- Mariano, R.S. and Y. Murasawa (2003), “A new coincident index of business cycles based on monthly and quarterly series”. *Journal of Applied Econometrics*, 18, 427-443.
- Merola, R. and J. J. Pérez (2013), “Fiscal forecast errors: governments versus independent agencies?”, *European Journal of Political Economy*, 23, pp. 285-299.
- Moauo, F. and G. Savio (2005), “Temporal Disaggregation Using Multivariate Structural Time Series Models”, *Econometrics Journal*, 8, 214-234.
- Onorante, L., D. J. Pedregal, J. J. Pérez, and S. Signorini (2009), “The usefulness of infra-annual government cash budgetary data for fiscal forecasting in the euro area”, *Journal of Policy Modeling*, 32, pp. 98-119.

- Paredes, J., D.J. Pedregal, and J. J. Pérez (2009), “A quarterly fiscal database for the euro area based on intra-annual fiscal information”. Banco de España Working Paper, No. 0935.
- Pedregal, D. J. and J. J. Pérez (2010), “Should quarterly government finance statistics be used for fiscal surveillance in Europe?”, *International Journal of Forecasting*, 26, pp. 794-807.
- Pérez, J. J. (2007), “Leading Indicators for Euro Area Government Deficits”, *International Journal of Forecasting*, 23, 259-275.
- Pina, A. and Venes, N. (2011), “The political economy of EDP fiscal forecasts: an empirical assessment”, *European Journal of Political Economy*, 27, 534-546.
- Proietti T. and F. Moauro (2006), “Dynamic factor analysis with non-linear temporal aggregation constraints”. *Journal of the Royal Statistical Society Series C, Royal Statistical Society*, 55, pp. 281-300.
- Silvestrini A., M. Salto, L. Moulin, and D. Veredas (2008), “Monitoring and forecasting annual public finance deficit every month: the case of France”. *Empirical Economics*, 34, pp. 493-524.
- Strauch, R., M. Hallerberg and J. von Hagen (2004), “Budgetary Forecasts in Europe - The Track Record of Stability and Convergence Programmes”, European Central Bank WP 307.
- von Hagen, J. (2010), “Sticking to fiscal plans: the role of institutions”, *Public Choice*, 144, 487-503.

## A Appendix: econometric methodology

All the models developed in our paper fit with the following general discussion. The description follows quite closely Pedregal and Pérez (2010). The starting point of the modeling approach is to consider a multivariate Unobserved Components Model known as the Basic Structural Model (Harvey, 1989). A given time series is decomposed into unobserved components which are meaningful from an economic point of view (trend,  $T_t$ , seasonal,  $S_t$ , and irregular,  $e_t$ ). Equation (4) displays a general form, where  $t$  is a time sub-index measured in quarters,  $z_t$  denotes the variable in ESA95

terms expressed at an annual and quarterly sampling interval (depending on availability) for our objective time series, and  $u_t$  represents the vector of quarterly indicators.

$$\begin{bmatrix} \mathbf{z}_t \\ \mathbf{u}_t \end{bmatrix} = \mathbf{T}_t + \mathbf{S}_t + \mathbf{e}_t \quad (4)$$

The general consensus in this type of multivariate models in order to enable identifiability is to build SUTSE models (Seemingly Unrelated Structural Time Series). This means that components of the same type interact among them for different time series, but are independent of any of the components of different types. In addition, statistical relations are only allowed through the covariance structure of the vector noises, but never through the system matrices directly. This allows that, trends of different time series may relate to each other, but all of them are independent of both the seasonal and irregular components. The full model is a standard BSM that may be written in State-Space form as (see Harvey, 1989)

$$\mathbf{x}_t = \mathbf{\Phi}\mathbf{x}_{t-1} + \mathbf{E}\mathbf{w}_t \quad (5)$$

$$\begin{bmatrix} \mathbf{z}_t \\ \mathbf{u}_t \end{bmatrix} = \begin{bmatrix} \mathbf{H} \\ \mathbf{H}^u \end{bmatrix} \mathbf{x}_t + \begin{bmatrix} \epsilon_t \\ \mathbf{v}_t \end{bmatrix} \quad (6)$$

where  $\epsilon_t \sim N(0, \Sigma_\epsilon)$  and  $\mathbf{v}_t \sim N(0, \Sigma_{\mathbf{v}_t})$ . The system matrices  $\mathbf{\Phi}$ ,  $\mathbf{E}$ ,  $\mathbf{H}$  and  $\mathbf{H}^u$  in equations (5)-(6) include the particular definitions of the components and all the vector noises have the usual Gaussian properties with zero mean and constant covariance matrices ( $\epsilon_t$  and  $\mathbf{v}_t$  are correlated among them, but both are independent of  $\mathbf{w}_t$ ). The particular structure of the covariance matrices of the observed and transition noises defines the structures of correlations among the components across output variables. The mixture of frequencies, and the estimation of models at the quarterly frequency, implies combining variables that at the quarterly frequency can be considered as stocks with those being pure flows. This may be achieved by including the output variables in the state vector and defining an accumulator variable as defined in equation (7).

$$C_t = \begin{cases} 0, & t = \text{first quarter} \\ 1, & \text{otherwise} \end{cases} \quad (7)$$

In this way system (5)-(6) becomes (8)-(9). Beware that by setting  $C_t = 0$  we return actually to the previous system.

$$\begin{bmatrix} \mathbf{z}_t \\ \mathbf{x}_t \end{bmatrix} = \begin{bmatrix} C_t \otimes \mathbf{I} & \mathbf{H}\Phi \\ \mathbf{0} & \Phi \end{bmatrix} \begin{bmatrix} \mathbf{z}_{t-1} \\ \mathbf{x}_{t-1} \end{bmatrix} + \begin{bmatrix} 1 & \mathbf{H}\mathbf{E} \\ \mathbf{0} & \mathbf{E} \end{bmatrix} \begin{bmatrix} \epsilon_t \\ \mathbf{w}_t \end{bmatrix} \quad (8)$$

$$\begin{bmatrix} \mathbf{z}_t \\ \mathbf{u}_t \end{bmatrix} = \begin{bmatrix} \mathbf{I} & \mathbf{0} \\ \mathbf{0} & \mathbf{H}^u \end{bmatrix} \begin{bmatrix} \mathbf{z}_t \\ \mathbf{x}_t \end{bmatrix} + \begin{bmatrix} \mathbf{0} \\ \mathbf{I} \end{bmatrix} \mathbf{v}_t \quad (9)$$

Given the structure of the system and the information available, the Kalman Filter and Fixed Interval Smoother algorithms provide an optimal estimation of states. Maximum likelihood in the time domain provides optimal estimates of the unknown system matrices, which in the present context are just covariance matrices of all the vector noises involved in the model. The use of the models selected and the estimation procedures described in the previous paragraph, allows the estimation of models with unbalanced data sets, i.e. input variables with different sample lengths. This is a feature of relevance for the construction of the database at hand, given occasional differences in temporal coverage of indicators.

In our case, particular empirical specifications for each variable will be considered in the light of the available information (fiscal indicators). Let us provide some examples. For instance, for the case of the individual model for total government revenues,  $\mathbf{z}$  comprises total government revenues in National Accounts terms, a variable that is available at the annual frequency from 1986-1999 and at the quarterly frequency from 2000Q1-2012Q4, while  $\mathbf{u}$  is a matrix composed of three series (available at the quarterly frequency for the whole sample period): (i) a proxy to general government total revenues in public accounts (cash) terms; (ii) Central government total revenues and (iii) Social Security (SSS+SPEE) sector's total revenues. Models with more than one National Accounts variable also fit within the general formulation of this Section. In those cases,  $\mathbf{z}$  includes several variables and thus  $\mathbf{u}$  would have been a matrix with indicators by blocks for each component of  $\mathbf{z}$ . For example, in the case of the model that jointly estimates and forecasts total revenues (TOR) and total expenditures (TOE)  $\mathbf{z} = \{\text{TOR}, \text{TOE}\}$ .



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