

































### 3.4 Budgetary targets during the crisis

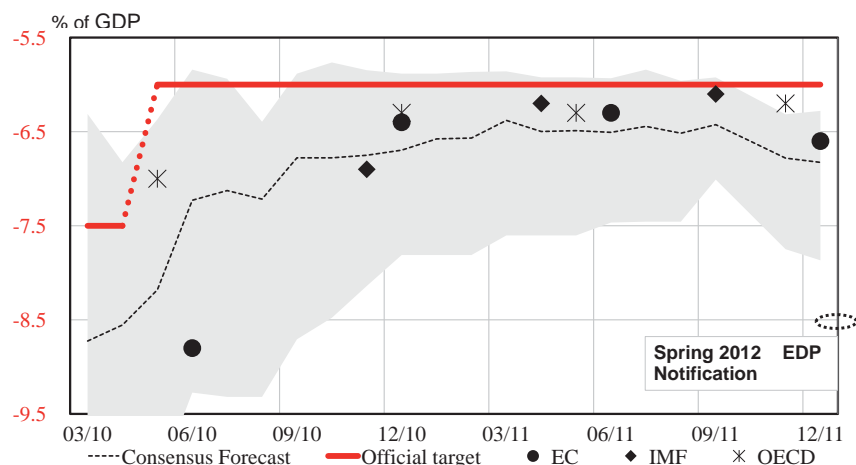
Since the burst of the economic and financial crisis in 2008, the adherence of realized government policies to budgetary targets has been a story of defeats, in most European countries. Certainly, it has been the case in Spain. The difficulties in forecasting government borrowing needs are well documented 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

---

<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						
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

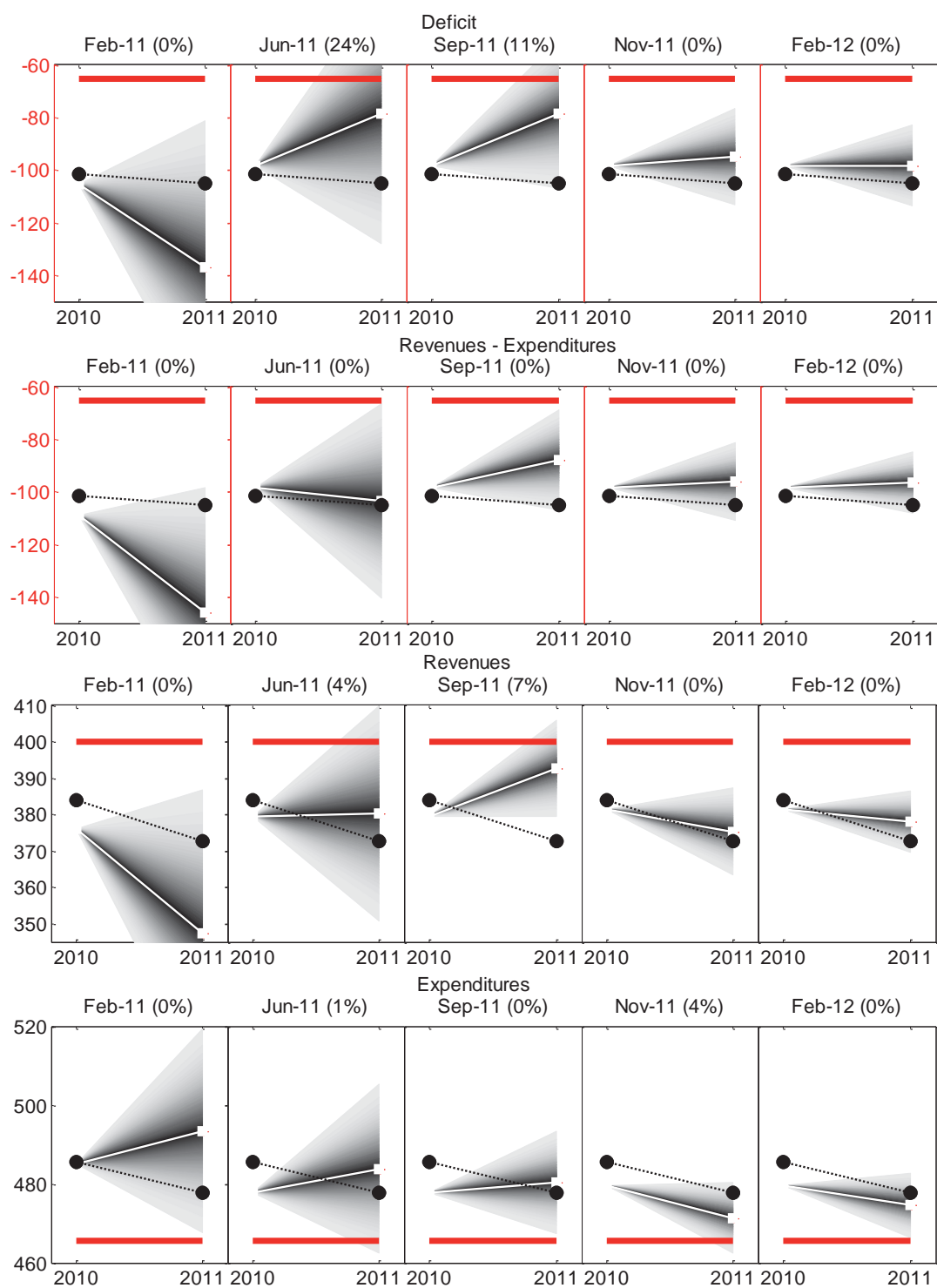
probability assigned to meeting the government revenue target, though, was not null, but was as small as 5%. The publication of the general government figures for Q1 and of short-term indicators up to July (September 2011 forecast origin) improved marginally the revenue projection, while in the case 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)  $\mathbf{z} = \{\text{TOR}, \text{TOE}\}$ .



## BANCO DE ESPAÑA PUBLICATIONS

### WORKING PAPERS

- 1220 ENRIQUE ALBEROLA, LUIS MOLINA and PEDRO DEL RÍO: Boom-bust cycles, imbalances and discipline in Europe.
- 1221 CARLOS GONZÁLEZ-AGUADO and ENRIQUE MORAL-BENITO: Determinants of corporate default: a BMA approach.
- 1222 GALO NUÑO and CARLOS THOMAS: Bank leverage cycles.
- 1223 YUNUS AKSOY and HENRIQUE S. BASSO: Liquidity, term spreads and monetary policy.
- 1224 FRANCISCO DE CASTRO and DANIEL GARROTE: The effects of fiscal shocks on the exchange rate in the EMU and differences with the US.
- 1225 STÉPHANE BONHOMME and LAURA HOSPIDO: The cycle of earnings inequality: evidence from Spanish social security data.
- 1226 CARMEN BROTO: The effectiveness of forex interventions in four Latin American countries.
- 1227 LORENZO RICCI and DAVID VEREDAS: TailCoR.
- 1228 YVES DOMINICY, SIEGFRIED HÖRMANN, HIROAKI OGATA and DAVID VEREDAS: Marginal quantiles for stationary processes.
- 1229 MATTEO BARIGOZZI, ROXANA HALBLEIB and DAVID VEREDAS: Which model to match?
- 1230 MATTEO LUCIANI and DAVID VEREDAS: A model for vast panels of volatilities.
- 1231 AITOR ERCE: Does the IMF's official support affect sovereign bond maturities?
- 1232 JAVIER MENCÍA and ENRIQUE SENTANA: Valuation of VIX derivatives.
- 1233 ROSSANA MEROLA and JAVIER J. PÉREZ: Fiscal forecast errors: governments vs independent agencies?
- 1234 MIGUEL GARCÍA-POSADA and JUAN S. MORA-SANGUINETTI: Why do Spanish firms rarely use the bankruptcy system? The role of the mortgage institution.
- 1235 MAXIMO CAMACHO, YULIYA LOVCHA and GABRIEL PEREZ-QUIROS: Can we use seasonally adjusted indicators in dynamic factor models?
- 1236 JENS HAGENDORFF, MARÍA J. NIETO and LARRY D. WALL: The safety and soundness effects of bank M&As in the EU: Does prudential regulation have any impact?
- 1237 SOFÍA GALÁN and SERGIO PUENTE: Minimum wages: do they really hurt young people?
- 1238 CRISTIANO CANTORE, FILIPPO FERRONI and MIGUEL A. LEÓN-LEDESMA: The dynamics of hours worked and technology.
- 1239 ALFREDO MARTÍN-OLIVER, SONIA RUANO and VICENTE SALAS-FUMÁS: Why did high productivity growth of banks precede the financial crisis?
- 1240 MARIA DOLORES GADEA RIVAS and GABRIEL PEREZ-QUIROS: The failure to predict the Great Recession. The failure of academic economics? A view focusing on the role of credit.
- 1241 MATTEO CICCARELLI, EVA ORTEGA and MARIA TERESA VALDERRAMA: Heterogeneity and cross-country spillovers in macroeconomic-financial linkages.
- 1242 GIANCARLO CORSETTI, LUCA DEDOLA and FRANCESCA VIANI: Traded and nontraded goods prices, and international risk sharing: an empirical investigation.
- 1243 ENRIQUE MORAL-BENITO: Growth empirics in panel data under model uncertainty and weak exogeneity.
- 1301 JAMES COSTAIN and ANTON NAKOV: Logit price dynamics.
- 1302 MIGUEL GARCÍA-POSADA: Insolvency institutions and efficiency: the Spanish case.
- 1303 MIGUEL GARCÍA-POSADA and JUAN S. MORA-SANGUINETTI: Firm size and judicial efficacy: evidence for the new civil procedures in Spain.
- 1304 MAXIMO CAMACHO and GABRIEL PEREZ-QUIROS: Commodity prices and the business cycle in Latin America: living and dying by commodities?
- 1305 CARLOS PÉREZ MONTES: Estimation of regulatory credit risk models.
- 1306 FERNANDO LÓPEZ VICENTE: The effect of foreclosure regulation: evidence for the US mortgage market at state level.
- 1307 ENRIQUE MORAL-BENITO and LUIS SERVEN: Testing weak exogeneity in cointegrated panels.
- 1308 EMMA BERENQUER, RICARDO GIMENO and JUAN M. NAVE: Term structure estimation, liquidity-induced heteroskedasticity and the price of liquidity risk.
- 1309 PABLO HERNÁNDEZ DE COS and ENRIQUE MORAL-BENITO: Fiscal multipliers in turbulent times: the case of Spain.

- 1310 SAMUEL HURTADO: DSGE models and the Lucas critique.
- 1311 HENRIQUE S. BASSO and JAMES COSTAIN: Fiscal delegation in a monetary union with decentralized public spending.
- 1312 MAITE BLÁZQUEZ CUESTA and SANTIAGO BUDRÍA: Does income deprivation affect people's mental well-being?
- 1313 ENRIQUE ALBEROLA, ÁNGEL ESTRADA and DANIEL SANTABÁRBARA: Growth beyond imbalances. Sustainable growth rates and output gap reassessment.
- 1314 CARMEN BROTO and GABRIEL PEREZ-QUIROS: Disentangling contagion among sovereign CDS spreads during the European debt crisis.
- 1315 MIGUEL GARCÍA-POSADA and JUAN S. MORA-SANGUINETTI: Are there alternatives to bankruptcy? A study of small business distress in Spain.
- 1316 ROBERTO RAMOS and ENRIQUE MORAL-BENITO: Agglomeration matters for trade.
- 1317 LAURA HOSPIDO and GEMA ZAMARRO: Retirement patterns of couples in Europe.
- 1318 MAXIMO CAMACHO, GABRIEL PEREZ-QUIROS and PILAR PONCELA: Short-term forecasting for empirical economists. A survey of the recently proposed algorithms.
- 1319 CARLOS PÉREZ MONTES: The impact of interbank and public debt markets on the competition for bank deposits.
- 1320 OLYMPIA BOVER, JOSE MARIA CASADO, SONIA COSTA, PHILIP DU CAJU, YVONNE MCCARTHY, EVA SIERMINSKA, PANAGIOTA TZAMOURANI, ERNESTO VILLANUEVA and TIBOR ZAVADIL: The distribution of debt across euro area countries: the role of Individual characteristics, institutions and credit conditions.
- 1321 BRINDUSA ANGHEL, SARA DE LA RICA and AITOR LACUESTA: Employment polarisation in Spain over the course of the 1997-2012 cycle.
- 1322 RODOLFO G. CAMPOS and ILIANA REGGIO: Measurement error in imputation procedures.
- 1323 PABLO BURRIEL and MARÍA ISABEL GARCÍA-BELMONTE: Meeting our D€STINY. A Disaggregated €uro area Short Term Indicator model to forecast GDP (Y) growth.
- 1401 TERESA SASTRE and FRANCESCA VIANI: Countries' safety and competitiveness, and the estimation of current account misalignments.
- 1402 FERNANDO BRONER, ALBERTO MARTIN, AITOR ERCE and JAUME VENTURA: Sovereign debt markets in turbulent times: creditor discrimination and crowding-out effects.
- 1403 JAVIER J. PÉREZ and ROCÍO PRIETO: The structure of sub-national public debt: liquidity vs credit risks.
- 1404 BING XU, ADRIAN VAN RIXTEL and MICHIEL VAN LEUVENSTEIJN: Measuring bank competition in China: a comparison of new versus conventional approaches applied to loan markets.
- 1405 MIGUEL GARCÍA-POSADA and JUAN S. MORA-SANGUINETTI: Entrepreneurship and enforcement institutions: disaggregated evidence for Spain.
- 1406 MARIYA HAKE, FERNANDO LÓPEZ-VICENTE and LUIS MOLINA: Do the drivers of loan dollarisation differ between CESEE and Latin America? A meta-analysis.
- 1407 JOSÉ MANUEL MONTERO and ALBERTO URTASUN: Price-cost mark-ups in the Spanish economy: a microeconomic perspective.
- 1408 FRANCISCO DE CASTRO, FRANCISCO MARTÍ, ANTONIO MONTESINOS, JAVIER J. PÉREZ and A. JESÚS SÁNCHEZ-FUENTES: Fiscal policies in Spain: main stylised facts revisited.
- 1409 MARÍA J. NIETO: Third-country relations in the Directive establishing a framework for the recovery and resolution of credit institutions.
- 1410 ÓSCAR ARCE and SERGIO MAYORDOMO: Short-sale constraints and financial stability: evidence from the Spanish market.
- 1411 RODOLFO G. CAMPOS and ILIANA REGGIO: Consumption in the shadow of unemployment.
- 1412 PAUL EHLING and DAVID HAUSHALTER: When does cash matter? Evidence for private firms.
- 1413 PAUL EHLING and CHRISTIAN HEYERDAHL-LARSEN: Correlations.
- 1414 IRINA BALTEANU and AITOR ERCE: Banking crises and sovereign defaults in emerging markets: exploring the links.
- 1415 ÁNGEL ESTRADA, DANIEL GARROTE, EVA VALDEOLIVAS and JAVIER VALLÉS: Household debt and uncertainty: private consumption after the Great Recession.
- 1416 DIEGO J. PEDREGAL, JAVIER J. PÉREZ and A. JESÚS SÁNCHEZ-FUENTES: A toolkit to strengthen government budget surveillance.