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A short-term forecasting model for GDP and its demand components

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This article summarises the key aspects of the extended and revised version of Spain-STING (Spain, Short-Term INdicator of Growth), which is a tool used by the Banco de España for short-term forecasting of the Spanish economy's GDP and its demand components. Drawing on a broad set of indicators, several models are estimated that enable GDP, private consumption, public expenditure, investment in capital goods, construction investment, exports and imports to be forecast. The assessment of the new model's predictive power for the period spanning June 2005-September 2016 shows a slight improvement on the previous version of Spain-STING.

A SHORT-TERM FORECASTING MODEL FOR GDP AND ITS DEMAND COMPONENTS

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Introduction

The analysis and characterisation of the economy's conjunctural situation, and the projection of its future course, are fundamental tasks of central banks and national and international institutions in the economic sphere. The monitoring of the economic cycle and the conducting of short and medium-term macroeconomic projection exercises require work that involves drawing together the latest conjunctural indicators. The Spain-STING (Spain, Short-Term INdicator of Growth) model is a short-term forecasting tool (e.g. one or two quarters ahead) for the quarterly growth rate of the Spanish economy's GDP [see Camacho and Pérez Quirós (2009 and 2011)] in real time (i.e. as fresh information on the explanatory variables becomes known). The indicator is made up of GDP, in a quarterly frequency, and ten monthly indicators that offer information on conjunctural developments.

Spain-STING jointly models the dynamics of each of its eleven variables and distinguishes between a common part (that captured by the factor) and an idiosyncratic part associated with each of these variables. This tool enables forecasts to be made on the variables included in the model, taking into consideration both the predictive power of each variable and the availability of information. The model has been used as an internal short-term forecasting tool at the Banco de España since late 2009.[1]

This article presents an extended and revised version of the Spain-STING model, designed expressly to incorporate forecasts of all the demand components of the Spanish economy's macroeconomic aggregates: private consumption, public expenditure, investment in capital goods, construction investment, exports and imports. The estimation of all the macroeconomic aggregates allows us not only to forecast real-time GDP but also to incorporate information on the components that explain the forecast, making it possible to deepen the analysis of the causes behind changes in GDP forecasts.[2]

Following this introduction, the article is structured as follows. The second section briefly describes the econometric methodology and the characteristics of the set of indicators that are part of the database used to forecast GDP. Subsequently, the models for the different demand components and the aggregation method used so as to have a consistent overall forecast are presented. The final section then analyses the new model's forecasting quality, which is compared with that of the previous model.

Econometric methodology

Spain-STING, based on Camacho and Pérez-Quirós (2009 and 2011), is a small-scale dynamic factor model made up of GDP, whose publication is quarterly, and ten monthly indicators, eight of which relate to real activity (the non-energy industrial production index, General Social Security Regime registrations, real sales by large non-financial

1 There is also a similar model for economic forecasting in the euro area. See Camacho and Pérez-Quirós (2010) and Burriel and García-Belmonte (2013).

2 Very few central banks have tools of this type. The recent advances made by the Federal Reserve Bank of Atlanta with its GDPNow project and the Federal Reserve Bank of New York's Nowcast project merit a mention. In the case of the Spanish economy, solely AIReF with its MIPRED model has a similar project [see Cuevas et al. (2015)].

corporations, electricity consumption in industry, apparent consumption of cement and real goods exports and imports), and two to survey-based data [PMI and ESI (Economic Sentiment Indicator)].[3]

The characteristics of this model enable a response to be given to various problems of forecasting GDP in real time. Specifically, Spain-STING is constructed with: (i) information that is not balanced out at the end of the sample (i.e. combining indicators released with a lag with others which, by their nature, are available sooner); (ii) a mix of frequencies (i.e. with monthly indicators to bring forward the quarterly GDP growth rate); (iii) different types of data (survey-based and real activity indicators); (iv) information relating to different periods of activity (annual, quarterly and monthly); and (v) data that are not always available for the whole sample analysed.

Spain-STING captures the dynamics of each indicator (including those of GDP) and distinguishes between a common part, captured in the factor, and an idiosyncratic part, which determines the movements of each of the indicators not explained by the dynamics of that common factor. Under this system, the developments in each indicator help anticipate the trend of the common component and, therefore, that of GDP. As a result, the forecast is made taking into account the predictive power of each variable and the availability of information, which enables the relative significance of each indicator for the forecasting of GDP to be adjusted.

The original 2009 version of this Spain-STING model has scarcely changed, with some exceptions. First, the possibility of all indicators not being coincident (i.e. that despite being dated in a specific period “t” they refer to activity in a subsequent period) was introduced, meaning that leads on certain series were included, such as consumption of cement and the survey-based indicators, which in their original version were specified contemporaneously.[4] Second, practical experience showed that some of the indicators originally introduced into the model had no explanatory power, whereas others that were not initially included might marginally improve the performance of the model. Accordingly, credit to non-financial corporations was introduced, which enhanced the explanation of the last recessionary period. These two changes were made in 2013. In addition, in the latest extension of the model, which is presented in this article, the indicators are included as monthly rather than annual growth rates.[5]

In sum, the new model uses ten indicators that are representative of the Spanish economy, two of which are survey-based indicators (ESI and PMI) and are included in levels, and eight of which are activity indicators, introduced in terms of a monthly growth rate. Also, the ESI, the PMI and apparent consumption of cement are incorporated with a lead of three months.[6] The activity indicators have a monthly frequency and are introduced into the model contemporaneously, while the survey-based indicators, since they are correlated with annual economic activity, are introduced with twelve lags. The estimate for the selection of indicators comprises data for the period spanning January 1991-September 2016 (see Table 1).

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3 Specifically, the composite PMI and the ESI without the consumer component are used.

4 They were introduced with a lead of three months.

5 This entails a technical improvement: given that GDP is measured in quarterly terms, by considering the indicators as annual rates a structure of lags between the GDP ratio and each indicator was assumed.

6 The ESI and PMI questionnaires refer to the developments agents expect to see over a three-month time horizon, i.e. they reflect expectations and, therefore, are introduced with leads. Cement consumption, for its part, by its own idiosyncrasy, leads GDP. Indeed, the highest correlation with GDP is obtained with a lead of three periods.

INDICATORS SELECTED IN THE GDP FORECASTING MODEL — TABLE 1

	Periodicity/type of indicator	Sample	Lag in publication
GDP growth	Quarterly/Activity	1990.3-2016.6	+45 days
Economic Sentiment Indicator (ESI)	Monthly/Survey-based	1990.1-2016.8	0
Composite PMI	Monthly/Survey-based	1999.8-2016.8	+2 days
Non-energy Industrial Production Index	Monthly/Activity	1993.2-2016.7	+35 days
Sales of large firms	Monthly/Activity	1996.2-2016.8	+32 days
Apparent consumption of cement	Monthly/Activity	1990.1-2016.8	No set date
Social Security registrations	Monthly/Activity	1990.1-2016.8	0
Electricity consumption in industry	Monthly/Activity	1990.1-2016.8	+31 days
Credit to non-financial corporations	Monthly/Activity	1995.2-2016.7	+30 days
Goods exports	Monthly/Activity	1991.2-2016.7	+50 days
Goods imports	Monthly/Activity	1991.2-2016.7	+50 days

SOURCE: Banco de España.

Estimating a model such as that proposed has significant advantages. On one hand, a common factor representing the coincident indicator of developments in the Spanish economy, with a monthly frequency, is estimated; and on the other, the model produces forecasts in real time not only for the GDP growth rate but also for all the model variables. This is significant for two reasons. First, on publishing any indicator that appears in the model, the information is modified, updating all the forecasts. In that way each new observation can be broken down into an "expected" part and another part that can be interpreted as a "surprise". The model thus enables measurement of the contribution of each surprise to the change in expected GDP.

Second, the selection of the variables to be included in the estimation is conditioned by the fact that the objective of the model is to forecast GDP. Contrary to standard techniques, where the explanatory variables always increase explanatory power, in these models the incorporation of additional variables does not necessarily ensure enhanced predictive behaviour. Indeed, they may entail more idiosyncratic comovements among the variables that are not related to GDP. For example, if the additional variables are correlated with the idiosyncratic part of any of the other variables, the estimation of the common factor will be biased towards this sub-group, impairing the relationship between GDP and the factor.[7] Having a GDP forecast as an objective allows for the elimination from the specification of those variables that lessen the correlation of the common factor with GDP and for the maintenance of those others that increase the correlation.

In the model version proposed here, the common factor explains almost 92% of the variance of GDP, with this increasing to over 93% if it is related to the GDP flash estimate, which stems from the fact that the latter is based on indicators, whereas subsequent revisions of GDP are related to more structural information on the economy.

Disaggregation by component

Following the description of the modelling strategy for the short-term forecasting of Spanish GDP, this section presents a series of dynamic factor models for each demand

7 For example, the model includes the non-energy industrial production index. If more disaggregated industrial production indicators were added, the factor would be biased towards the idiosyncratic component of industrial production, thereby lessening its correlation with GDP. The variable selection criterion used in this article – to increase correlation with GDP – advises against the inclusion of this disaggregated information.

component: final consumption expenditure of households and NPISHs (non-profit institutions serving households); final consumption expenditure of general government; gross fixed capital formation (capital goods); gross fixed capital formation (construction); and exports and imports of goods and services.

The selection of the variables included in each model was drawn from the main indicators used by the INE in the preparation of the Quarterly National Accounts.[8] The databases thus constructed were used to estimate the models.

Drawing on this broad set of indicators, a staggered approach was followed, as suggested by Camacho and Pérez Quirós (2010), similar to that described earlier for aggregate GDP. First, a minimum set of indicators representative of each demand component is selected. Second, the correlation of each of these indicators with the corresponding demand component is calculated and the four indicators with the highest correlation are chosen to create a "base model", that is, a dynamic factor model made up of the demand component and those four indicators. For instance, for private consumption, the base model comprises the component itself and the following indicators: total Social Security registrations, the services business activity index, the services PMI and the consumer confidence indicator.

Third, to determine the final selection of indicators to be included in the dynamic factor model of each component, the four indicators initially used in the base model were combined with the other indicators selected as being representative of that component. Then, the variance of each component explained by the common factor is calculated. Further variables are therefore incorporated into the base model, provided in all cases that they increase the variance of the component explained by the common factor. Continuing with the private consumption example, the following indicators are finally selected: total Social Security registrations, the services business activity index, the services PMI, the consumer confidence indicator, the retail trade index, sales of large consumer goods firms, the unemployment rate and the number of credit card transactions.

The start date for the period of assessment of the indicators selected for these models is January 1995. Tables 2 to 7 summarise the indicators considered for each demand component model, the correlation between each indicator and the corresponding component (for example, between private consumption and Social Security registrations) and the indicators finally chosen for each model.

The proportion of variance of each component of GDP explained by the common factor in each model is as follows: 51% for private consumption; 79% for public expenditure; 79% for investment in capital goods; 53% for construction investment; 67% for exports of goods and services, and 78% for imports of goods and services.

The dynamic factor models for each demand component thus specified allow a separate forecast to be obtained for each macroeconomic aggregate. In order to obtain a consistent forecast for the entire system, including GDP, each separate forecast must be weighted by the weight of each component in GDP at each point in time, thus obtaining a weighted GDP forecast.

8 See Álvarez (1989) and Álvarez (2005).

INDICATORS SELECTED IN THE PRIVATE CONSUMPTION MODEL

TABLE 2

Potential indicators (a)	Correlation with the component	Start of series
Total Social Security registrations	**0.71**	**1995.1**
Services Sector Activity Indicator (IASS)	**0.68**	**2000.2**
Services PMI	**0.66**	**1995.1**
Consumer confidence indicator	**0.63**	**1995.1**
Retail trade index	**0.59**	**1995.1**
Sales of large firms, number of recipients	0.56	
Sales of large firms, consumer goods	**0.48**	**1995.2**
Unemployment rate	**0.47**	**1986.4**
Industrial Production Index, consumer goods	0.43	
Card transactions - amount	0.33	
Real wage income indicator	0.31	
Card transactions - number of transactions	**0.28**	**1995.2**
Imports of consumer goods	0.24	

SOURCE: Banco de España.

a The indicators finally included in the model are in bold.

INDICATORS SELECTED IN THE PUBLIC EXPENDITURE MODEL

TABLE 3

Potential indicators (a)	Correlation with the component	Start of series
Social Security registrations - general government	**0.62**	**1995.2**
Employment income - general government	**0.41**	**1996.3**
State expenditure	**0.22**	**1995.1**

SOURCE: Banco de España.

a The indicators finally included in the model are in bold.

INDICATORS SELECTED IN THE INVESTMENT IN CAPITAL GOODS MODEL

TABLE 4

Potential indicators (a)	Correlation with the component	Start of series
Industrial Production Index - capital goods	**0.66**	**1995.1**
New commercial vehicle registrations	**0.63**	**1995.1**
Domestic sales of large firms - equipment and software	**0.62**	**1995.2**
Economic Sentiment Indicator (ESI)	**0.61**	**1995.1**
Business confidence - employment expectations	0.58	
Business climate index - investment goods	0.51	
Imports of capital goods	0.43	
IBEX-35 index	0.38	
Spain's competitiveness vis-à-vis developed countries	0.32	
Capacity utilisation	0.26	
Lending to resident companies	0.12	
Spain's competitiveness vis-à-vis Euro 19	0.02	

SOURCE: Banco de España.

a The indicators finally included in the model are in bold.

INDICATORS SELECTED IN THE CONSTRUCTION INVESTMENT MODEL

TABLE 5

Potential indicators (a)	Correlation with the component	Start of series
Social Security registrations - workers in active employment - construction sector	**0.80**	**2001.2**
Confidence index - construction sector	**0.63**	**1995.1**
Financing to households and NPISHs - housing loans	**0.60**	**1995.2**
Apparent consumption of cement	**0.52**	**1995.1**
Building permits - total floorspace	**0.26**	**1995.1**
Domestic sales of large firms - construction sector	**0.17**	**1995.2**
Official tenders	0.11	
House purchases - new housing	0.09	

SOURCE: Banco de España.

a The indicators finally included in the model are in bold.

INDICATORS SELECTED IN THE EXPORTS OF GOODS AND SERVICES MODEL

TABLE 6

Potential indicators (a)	Correlation with the component	Start of series
World goods trade	**0.67**	**1995.2**
Industrial Production Index - intermediate goods	**0.63**	**1995.1**
Total goods exports	**0.60**	**1995.1**
Industry PMI	**0.59**	**1998.2**
Business climate index	0.40	
Total tourist inflows	**0.34**	**1995.2**
Sales of large firms - exports, deflated	**0.22**	**1995.2**
CPI hotels, cafés and restaurants	**0.14**	**2002.2**
Travel, credits	0.11	
Export order books - total industry	0.09	

SOURCE: Banco de España.

a. The indicators finally included in the model are in bold.

INDICATORS SELECTED IN THE IMPORTS OF GOODS AND SERVICES MODEL

TABLE 7

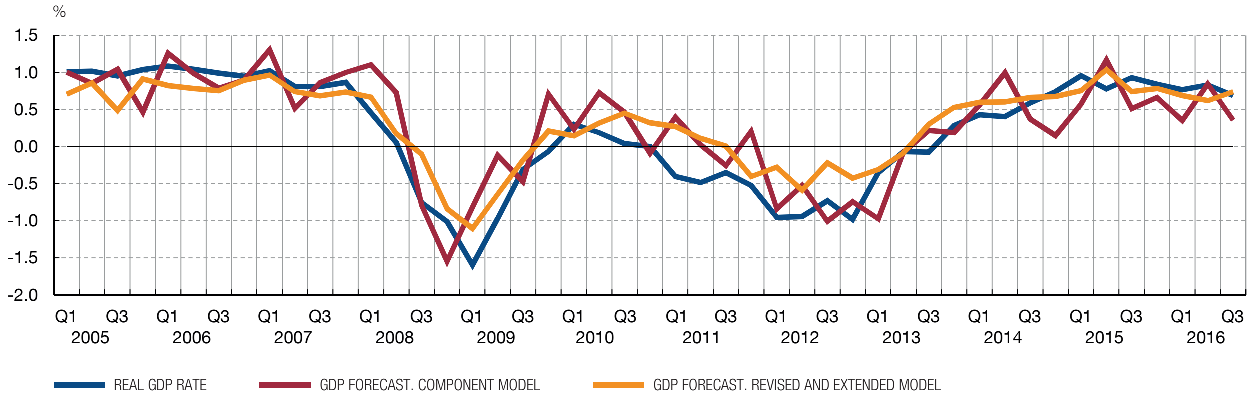
Potential indicators (a)	Correlation with the component	Start of series
Industrial Production Index - intermediate goods	**0.74**	**1995.1**
World goods trade	**0.71**	**1995.2**
Domestic sales of large firms	**0.71**	**1995.2**
Industry PMI	**0.70**	**1998.2**
Sales of large firms - imports, deflated	0.64	
Retail trade index	0.60	
Total goods imports	0.53	
Balance of payments - tourism debits	0.09	

SOURCE: Banco de España.

a The indicators finally included in the model are in bold.

GDP FORECASTS. RESULTS IN PSEUDO REAL TIME (2005 Q1-2016 Q3)

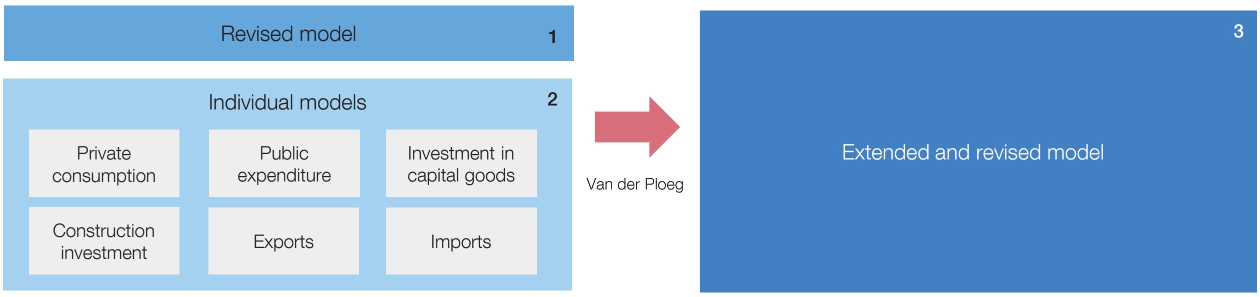
CHART 1



SOURCE: Banco de España.

SHORT-TERM FORECASTING MODEL FOR GDP AND ITS DEMAND COMPONENTS (SPAIN-STING) (a)

DIAGRAM 1



SOURCE: Banco de España.

a The revised dynamic factor model includes a technical improvement compared with the previous model. Drawing on this new model, individual models are estimated for each demand component. In this way a GDP forecast is obtained based on the revised model [1], and a weighted GDP forecast based on the individual models [2]. Owing to the enhanced predictive power of the revised model, a reconciliation method is used to ensure that the weighted sum of the forecasts of each component of GDP is equal to the revised model forecast. Thus, an extended and revised model [3] is obtained for forecasting GDP and its components.

However, if the revised version (described in detail in the second section) of various GDP model forecasting exercises is compared, in pseudo real-time,[9] with the GDP forecast obtained as a weighted average of the forecasts for each component (the red line in Chart 1), it is observed that the GDP forecast according to the revised version (the yellow line) was closer to the actual GDP figure (the blue line). In consequence, the GDP forecast obtained from the revised model was taken as given and the forecasts for each component were adjusted to that GDP figure.

Diagram 1 depicts the new features of this version of the forecasting system in graphic form. In order to obtain a fully consistent forecasting framework, a balancing procedure is necessary, combining both the forecast GDP according to the revised model and the forecasts of each GDP component through the individual models. To that end, the van der Ploeg (1982 and 1985) method is used, which allows consistent forecasting of

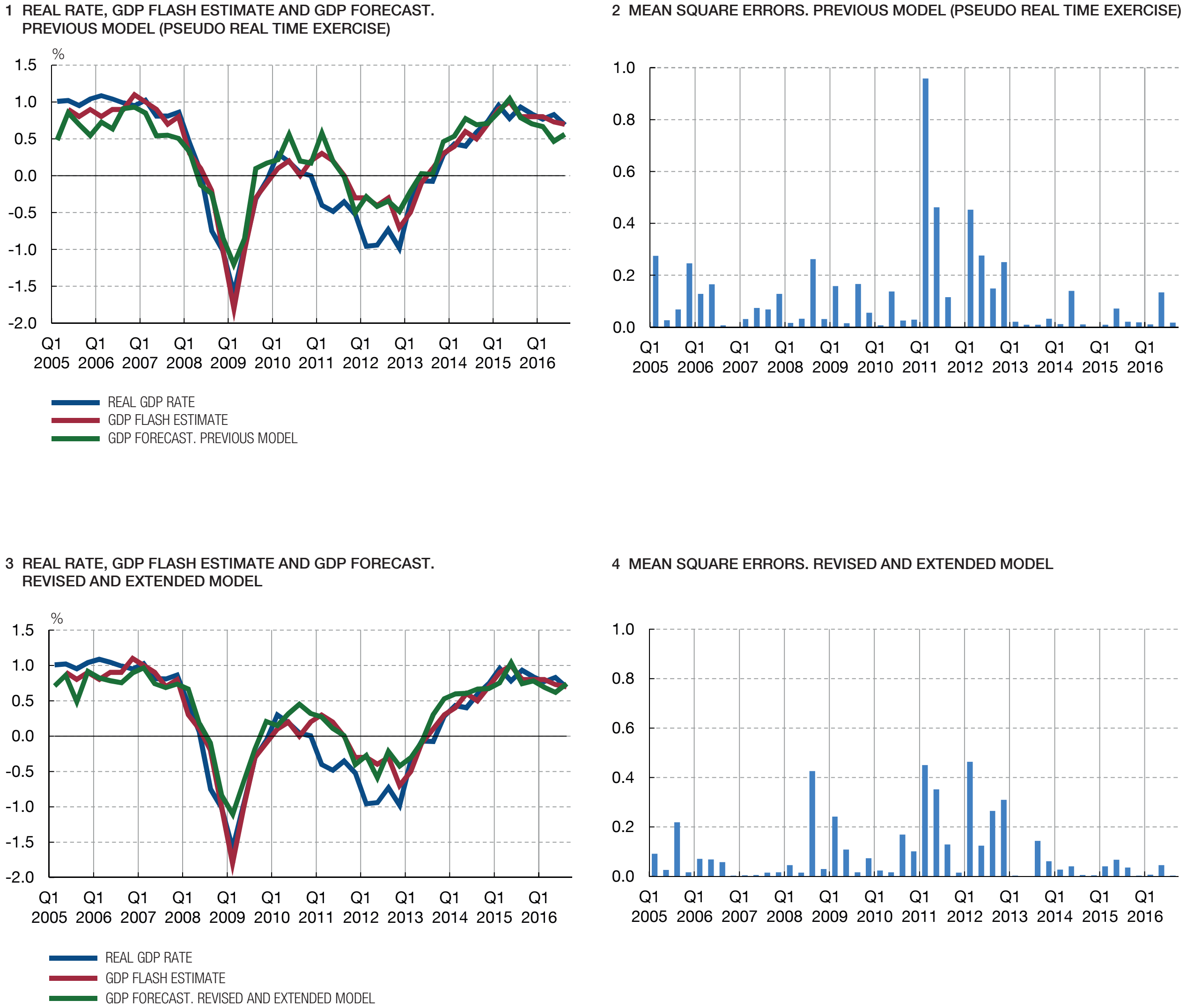
9 In this exercise the forecasts are compared out-of-sample. Specifically, the sample of the analysis runs from 2005 Q1 to 2016 Q3. In this exercise, the GDP that would have been obtained on a specific date in each quarter of the period (21 March, June, September and December) is forecast. For example, for 2005 Q1, all the indicators included are updated as at 21 March 2005. By contrast, in a real-time exercise the revisions of the different indicators are not included, but instead the figures published at the end of the sample period are used.

COMPARISON OF SUM OF MEAN SQUARE ERRORS (2005 Q1-2016 Q3) | TABLE 8

MSEs compared with	Real GDP figure	GDP flash estimate
Previous model	5.3	1.9
Revised and extended model	4.4	1.7

SOURCE: Banco de España.

ASSESSMENT OF PREDICTIVE POWER | CHART 2



SOURCE: Banco de España.

macroeconomic aggregates through an equilibrium model. This method explicitly incorporates the uncertainty surrounding the flash estimates and uses it as an essential element in the balancing procedure, such that the final estimates satisfy the constraints of the system and, at the same time, include a specific measure of their accuracy.[10]

10 The method proposed by Abad *et al.* (2006) is used. It is based on minimising an objective function that penalises the level of breach of certain constraints, weighted according to the level of confidence attached by the forecaster to

Predictive power

To assess the performance of the extended and revised version of the Spain-STING model compared with its predecessor, a forecasting exercise was conducted in pseudo real-time, that is to say, out-of-sample.[11] The sample used in this exercise runs from 2005 Q1 to 2016 Q3; the forecast is that which each model would produce on a specific date in each quarter of the selected period.[12] The exercise was conducted with a data sample running from January 1990 to September 2016 and the findings obtained for each of the two models were compared.

Table 8 and Chart 2 present the mean square errors vis-à-vis GDP and the GDP flash estimate. The technical improvement included in the specification of the new extended Spain-STING model marginally enhances the forecasts of the previous model. Also, interestingly, a bias is observed between the GDP and the flash estimate series, which, *a posteriori*, causes the prediction errors of models such as that proposed in this article to increase considerably once revisions of the data series are incorporated. It is essential to stress that both the previous Spain-STING model and the extended Spain-STING model predict the GDP flash estimate better and more accurately than they do GDP; accordingly, the forecasting errors of models of this kind must be interpreted with caution once the final GDP figure is published and revised.

10.10.2017.

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the initial estimates (revised according to the degree of accuracy). In other words, the initial estimates are modified taking into account their discrepancies, weighted according to their level of reliability. The objective function weights the squared deviations of each unbalanced estimate against the balanced version inversely to the error of the estimate. These weights also take into account the variance and covariance structures of the errors.

11 Owing to data availability problems, the exercise was conducted without taking into account the revision of the explanatory variables.

12 Specifically, 21 March, June, September and December of each quarter.