

**NEW VERSION OF THE QUARTERLY
MODEL OF BANCO DE ESPAÑA
(MTBE)**

2017

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Abstract

The Quarterly Model of Banco de España (MTBE, *Modelo Trimestral del Banco de España*), is a large-scale macro-econometric model used for medium term macroeconomic forecasting of the Spanish economy, as well as for performing scenario simulations. The model is specified as a large set of error correction equations, and, especially in the short run, is mostly demand driven. This paper presents an update of the model, estimated with data from 1995 to 2014.

In this iteration, a big revamp to the econometric techniques used in estimation has been implemented. Despite that, changes in coefficients and simulation results with respect to the previous version of the model are smaller than what we saw in earlier updates. Compared with MTBE-2014, this new version (MTBE-2017) shows less response of demand to interest rates and stock market prices but more to credit, less response of GDP to world demand but more to world prices and to the price of oil, more positive effects to output and employment from price and wage moderation, and slightly faster and bigger fiscal multipliers for some shocks (government consumption and investment, direct taxes to households) but smaller for others (indirect taxes, direct taxes to firms).

Keywords: Spanish economy, macroeconometric model.

JEL classification: E10, E17, E20, E60.

Resumen

El Modelo Trimestral del Banco de España (MTBE) es un modelo macroeconómico de gran escala utilizado en las previsiones a medio plazo de la economía española, así como para la simulación de escenarios. El modelo está especificado como un conjunto de ecuaciones de corrección del error, y, especialmente en el corto plazo, responde principalmente a los canales de demanda. Este documento presenta una actualización del modelo, estimada con datos de 1995 a 2014.

En esta iteración se ha implementado una mejora sustancial de las técnicas econométricas utilizadas en la estimación. Pese a ello, los cambios en los coeficientes y en los resultados de simulación, en comparación con la versión anterior del modelo, son menores de lo observado en actualizaciones anteriores. Comparado con el MTBE-2014, esta nueva versión (MTBE-2017) muestra una respuesta menor de la demanda a los tipos de interés y a la bolsa, pero mayor al crédito; menos respuesta del PIB a la demanda mundial, pero más a los precios mundiales y al precio del petróleo; efectos más positivos sobre *output* y empleo de la moderación de precios y salarios; y multiplicadores fiscales algo mayores y más rápidos para algunas medidas (consumo e inversión públicos, impuestos directos a hogares), pero menores para otras (impuestos indirectos, impuesto sobre sociedades).

Palabras clave: economía española, modelo macroeconómico.

Códigos JEL: E10, E17, E20, E60.

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1 Introduction

The Quarterly Model of Banco de España¹ (MTBE, for its name in Spanish: Modelo Trimestral del Banco de España) is a large scale macro econometric model used for medium term macroeconomic forecasting of the Spanish economy, as well as for performing scenario and policy simulations.

The first version of this model was developed by Estrada et al. (2004), and since then it has been continuously updated (see Ortega et al., 2007, Hurtado et al., 2011, and Hurtado et al., 2014). In the last two years, a new version of this model has been developed, using better econometric techniques and incorporating new estimates of all the parameters with a more up to date data sample (1995-2014 instead of 1995-2012). The new version also corrects some issues that had emerged using the previous one, as the Spanish crisis progressed and some macroeconomic variables started to deviate from the behaviour that could be expected by a model that was estimated mostly with data from the boom years.

The structure of MTBE is still that of a small open economy within a monetary union. The model is specified as a large set of error correction equations, and, especially in the short run, is mostly demand driven. These behavioural equations explain the main macroeconomic aggregates in terms of their key determinants:

- Private consumption and housing investment are explained by very similar sets of variables: income, wealth and interest rates, but also credit, the unemployment rate, and public deficit.
- Private productive investment is a function of demand, real interest rates, a stock price index, credit, unit labor costs, and public deficit.
- Firms decide employment taking into account aggregate demand, the stock of productive capital, and the production function (Cobb Douglas), plus other variables such as wages, working-age population, and credit.
- Core CPI inflation (in terms of the HICP without energy and unprocessed food) depends on unit labour costs, GDP growth, the level of the output gap, and indirect taxes. All other prices in the model (deflators for GDP, consumption, exports,

¹ For a detailed description of the complete model, see the following Bank of Spain documents:

- Estrada, Fernández, Moral and Regil (2004): “A Quarterly Macro-econometric Model of the Spanish Economy”, Banco de España Working Paper 0413.
- Ortega, Burriel, Fernandez, Ferraz and Hurtado (2007), “Update of the Quarterly Model of the Bank of Spain”, Banco de España Working Paper 0717.
- Hurtado, Fernandez, Ortega and Urtasun (2011), “Nueva Actualización del Modelo Trimestral del Banco de España”, Banco de España Occasional Document 1106.
- Hurtado, Manzano, Ortega and Urtasun (2014), “Update and re-estimation of the Quarterly Model of Banco de España (MTBE)”, Banco de España Occasional Document 1403.

imports, etc) are a mixture of this core CPI and the price of imports. As a result of the relatively small estimated coefficients for unit labour costs, GDP growth and the output gap in this central equation, prices respond relatively slowly to the evolution of real variables (in line with other recent estimations of the slope of the Philips curve for the Spanish economy, as those in Álvarez et al, 2015, and Álvarez and Sánchez, 2017).

- Market economy wages depend on productivity and prices, and also on other variables such as the unemployment rate and public-sector wages.
- There are three equations for real exports (of goods to the euro area, of goods to the rest of the world, and of services) and another (analogous) three for real imports. They all are mostly demand-driven, since the estimated price elasticity is, in general, small (usually below one, and in most cases below 0.4).

The remainder of this paper is organized as follows. Section 2 summarizes the main changes introduced in this 2017 update. Section 3 details the main equations of the model. Section 4 shows contribution charts for the main macro variables, according to these new equations of the model. Section 5 presents a set of common simulations used in the forecasting process and for policy evaluation. And Section 6 concludes.

2 The 2017 update

As usual, the new estimation of the model allows more recent events to be incorporated in the data sample (it now contains data from 1995 to 2014), as well as other methodological changes to be tested and implemented. In this iteration, a big revamp to the econometric techniques used in estimation has been implemented, but, despite that, changes in simulation results with respect to the previous version are not large.

In previous versions, the long-run equations only allowed a single cointegration relationship, with theoretical restrictions imposed in the estimation, and stationarity of the residuals as the main indicator that the long-run estimation was adequate. Now, in MTBE-2017, we apply the Johansen (1991) procedure in order to find N cointegration relationships for each variable of interest, without imposing any theoretical restrictions on the estimation. The number of cointegration relationships found by the Johansen procedure in our estimations ranges from $N=0$ to $N=4$. The short-term equation then contains N error correction terms, one related to each cointegration relationship identified by the procedure. The short-run equations are now estimated by OLS, directly in Matlab, whereas previous versions used full-information maximum likelihood, in PC-GIVE. A bigger effort has been done this time to avoid endogeneity issues in the estimation of these short-run equations, by ruling out contemporaneous relationships with closely-related variables.

Compared with MTBE-2014, MTBE-2017 shows:

- Less response of demand to interest rates and stock market prices, but more to credit.
- Less response of GDP to world demand, but more to world prices, and to the price of oil.
- More positive effects to output and employment from wage moderation, and from price moderation.
- Slightly faster and bigger fiscal multipliers for some shocks (government consumption and investment, direct taxes to households) but smaller for others (indirect taxes and direct taxes to firms).
- Similar responses of the main macro variables to all other shocks considered, including house prices and public wages.

In general, though, these differences are relatively small: despite all these methodological changes, estimated coefficients and simulation results are not markedly different from what we had in MTBE-2014, in the sense that they are closer to MTBE-2014 than MTBE-2014 was from MTBE-2011, or MTBE-2011 from MTBE-2007. This may be because the sample period has only been extended by two years, which is less than what was the case in previous updates.

3 Main Equations

3.1 Household expenditure: private consumption and housing investment

In the long term, both forms of household expenditure (private consumption and housing investment) are explained mainly by a proxy of permanent income (a combination of current income and total wealth, both in real terms) and by real interest rates and credit variables. In this new version, there is no longer a restriction of unitary elasticity of total household expenditure to this proxy of permanent income. The estimation results in a similar elasticity of disposable income for consumption (0.89; it used to be 0.90) and higher for housing investment (1.54; it used to be 0.99). Also, wealth now has a smaller weight in the proxy of permanent income. Regarding financial variables, we have included credit (to consumption and housing credit) and dropped the credit-supply indicator from the Bank Lending Survey in both long-run and short-run equations (we consider this indicator to be more useful during the crisis than in the recovery, and one main purpose of this new version of the model is to be used in the forecasting exercises of the next few years).

PRIVATE CONSUMPTION			
Long run coefficients (a)		Short run coefficients	
Disposable income	0.893	Error Correction Mechanism 1	-0.007
Total wealth	0.038	Error Correction Mechanism 2	-0.060
Real interest rate	-0.001	Error Correction Mechanism 3	-0.009
Credit	0.153	Error Correction Mechanism 4	-0.017
		Disposable income	0.294
		Total wealth	0.091
		Real interest rate	-0.001
		Unemployment rate	-0.004
		Credit	0.046
		Public deficit	0.151

a Weighted average of 4 vectors.

HOUSING INVESTMENT			
Long run coefficients (a)		Short run coefficients	
Disposable income	1.539	Error Correction Mechanism 1	-0.005
Total wealth	0.041	Error Correction Mechanism 2	-0.018
Real interest rate	-0.038	Error Correction Mechanism 3	-0.011
Credit (access)	0.029	Disposable income	0.932
		Total wealth	0.055
		Real interest rate	-0.001
		Unemployment rate	-0.011
		Public deficit	0.846
		Credit (access)	0.006
		Credit	0.021

a Weighted average of 3 vectors.

As in MTBE-2014, the short term behavior of private consumption is free from inertia (which in older versions of the model was allowed to explain a great portion of the evolution of consumption; this allows the model to match the data during the boom very precisely, but reduces its usefulness as a tool that delivers a story for the observed evolution of macroeconomic variables). As in the long-run, we use total wealth instead of separate variables from financial and non-financial wealth, and the real interest rate appears with a small coefficient. Finally, we have also included the unemployment rate in the short-term.

In the short term dynamics of the housing investment equation, the elasticities to income and wealth are now smaller than in older versions of MTBE. However, the coefficient of public deficit is now significantly higher, which will provide non-Keynesian effects for fiscal consolidation simulations.

3.2 *Equipment investment*

The old private productive investment equation has been substituted by a new equation, for equipment investment. Modeling the equipment investment instead of the private productive investment presents a significant advantage in the daily use of the model, since it allows us to do simulations when the Quarterly National Accounts are published by INE (the Spanish National Statistics Office), instead of having to wait for the information on institutional sectors to come out and be processed by the experts to produce seasonally-adjusted series for government investment and private productive investment.

EQUIPMENT INVESTMENT			
Long run coefficients (a)		Short run coefficients	
Output	1.834	Error Correction Mechanism 1	-0.059
Credit	0.032	Error Correction Mechanism 2	-0.022
ULC (relative to euro area)	-0.903	Output	1.615
		Real interest rate	-0.015
		Stock price index	0.050
		Credit	0.014
		ULC (relative to euro area)	-1.044
		Exports of goods	0.290
		Public deficit	0.436

a Weighted average of 2 vectors.

The Johansen test indicates that there are two cointegration relationships and, as a consequence, there are two error correction mechanisms in the short-run of the equation. The evolution of equipment investment is highly sensitive to changes in output: the average long-run elasticity is 1.8, and the short-run elasticity is 1.6, with a bigger effect if exports are growing faster than internal demand (there is a separate coefficient for exports of goods). The real interest rates, credit, stock price index, the ULC (relative to euro area) and public deficit also appear as determinants of equipment investment in the short-run.

Because of the shift towards modeling equipment investment, there is now also a small equation for “other investment”, which includes both public investment (usually exogenous in this kind of models) and non-residential non-public construction. The evolution of this bundle is tied to that of equipment investment, with an estimated elasticity of 0.25.

3.3 Private-sector employment

In the long-run, employment is still explained mainly by output, stock of capital and the working-age population – as in the previous version of the model – but we eliminate the average long-term growth of total factor productivity (TFP) and instead introduce real wages, which were not significant in the older version of the model (probably because the boom years saw strong positive growth in both employment and wages, so, with a sample dominated by those years, the negative effect of wage shocks on employment could not be disentangled from the positive effect of demand shocks on both employment and wages).

EMPLOYMENT			
Long run coefficients		Short run coefficients	
Output	1.625	Error Correction Mechanism	-0.048
Stock of capital	-0.725	Output	0.559
Real wages	-0.083	Real wages	-0.243
Working-age population	0.584	Working-age population	0.332
		Credit	0.025

In the short-run, and compared with the previous version of the model, employment reacts less to output (elasticity of 0.6, vs 1.1 in MTBE-2014) and more to real wages (0.24 vs 0.12). Another relevant change is that credit is now a determinant in this equation, and real house prices are not.

3.4 Private-sector wages

The main changes in the equation for wages are the inclusion of the NAIRU gap and the omission of the wage drift. The Johansen test indicates that there are two cointegration vectors and, as a consequence, there are two error correction mechanisms in the short-run equation.

WAGES			
Long run coefficients (a)		Short run coefficients	
Prices	0.843	Error Correction Mechanism 1	-0.083
Output	0.430	Error Correction Mechanism 2	-0.002
Employment	-0.430	Prices (core CPI inflation)	1.000
Real public-sector wages	0.204	Productivity (Y/L)	0.363
NAIRU gap	-0.0004	Real public-sector wages	0.117
		NAIRU gap	-0.0002

a Weighted average of 2 vectors.

The unemployment rate is not significant in the short-term equation, so the only remaining determinants are prices, productivity and the NAIRU gap, plus the imitation or signaling factor from public-sector wages.

3.5 Exports and Imports

In the external sector block, the Johansen procedure wasn't able to identify any coherent long-term relations for most of the variables. Therefore most of these equations have no long-term dynamics anymore. The exception are the exports of services, with two cointegration vectors.

In general, the main drivers of exports are demand indicators rather than relative prices. The relative unit labor costs is still a strong competitiveness factor in the equation for exports of goods to the euro area, alongside relative prices.

Elasticities in the equations of real exports		MTBE-2014		MTBE-2017	
		LT	ST	LT	ST
Goods, euro area	demand	1.15	1.27	*	1.08
	relative prices	0.85	0.01	*	0.16
	relative ULCs	0.17	0.48	*	0.89
Goods, rest of world	demand	1.05	1.15	*	1.27
	relative prices	1.86	0.54	*	0.40
Services	demand	2.66	0.95	0.90	0.61
	relative prices	0.61	0.35	0.76	0.10

* No long-run equation (no cointegration relations found).

Elasticities in the equations of real imports		MTBE-2014		MTBE-2017	
		LT	ST	LT	ST
Goods, euro area	demand	1.27	1.70	*	0.78
	relative prices	0.10	0.35	*	0.28
Goods, rest of world	demand	1.76	1.70	*	1.40
	relative prices	0.36	0.12	*	0.86
Services	demand	1.88	1.70	*	1.45
	relative prices	0.1	0.15	*	0.23

* No long-run equation (no cointegration relations found).

Imports still present high demand elasticities, but they are not as high as in previous versions, especially in the case of imports of goods from the euro area. The response of imports from the rest of the world to relative prices is now much higher, resulting on a visibly bigger competitiveness channel for imports, overall.

3.6 Prices

As in the previous version of the model, the central indicator for prices is core CPI (a consumer price index excluding both energy and unprocessed foods). All other prices in the model are a mixture of this one and external prices.

The specification of the equation for core CPI is a modified version of the ones provided by experts in this area at Banco de España (see Álvarez, Gómez-Loscos and

Urtasun, 2015, and Álvarez and Sánchez, 2017). There is no long-run equation, just a short-run one. It is basically a Phillips curve, with a slope of 0.27 with respect to output growth and an additional 0.013 response to the level of the output gap, plus an effect from relative unit labor costs and a relatively high pass-through for changes in indirect taxes (0.86, vs 0.54 in the previous version).

CORE CPI		
Long run coefficients	Short run coefficients	
	Output	0.270
	ULC (relative to euro area)	0.146
	Indirect taxes	0.864
	Output gap	0.013

This particular specification has two important consequences: first, the response of prices to changes in real variables is relatively muted; and, second, since there is no long-term equation and price-wage feedback is very low, the model does not generate inflationary spirals (which was sometimes a problem in very old versions of this model). For example, the effect of an increase in oil prices or indirect taxes will fade out after one year: price levels will remain higher but inflation will return to its baseline level.

As said before, other prices in the model are modeled as a mixture of core CPI and external prices. For example, the equation for the private consumption deflator includes oil prices, with a weight of approximately 3%.

PRIVATE CONSUMPTION DEFLATOR		
Long run coefficients	Short run coefficients	
	Core CPI	0.971
	Oil price	0.029

3.7 Credit

The model includes three equations that explain observed credit: to households for housing investment, to households for consumption and others, and to non-financial firms. These credit indicators also appear, respectively, as determinants of housing investment, consumption, and equipment investment, so there is a complete real-financial feedback channel in the model. This endogenous feedback loop will increase the simulated effect of some shock (it is a small effect, though, since the effect of demand variables on credit and the effect of credit on demand variables are both relatively subdued).

The equations that explain the evolution of these credit indicators are, to a big extent, directly taken from the experts at Banco de España. They are among the few equations in MTBE where inertia is an important explanatory variable. Apart from that, the main explanatory variables are scale variables (consumption, housing investment, equipment investment), interest rates, the unemployment rate, house prices, and wealth.

REAL CREDIT TO HOUSEHOLDS FOR HOUSING INVESTMENT			
Long run coefficients		Short run coefficients	
Consumption + Housing investment	1.539	Error Correction Mechanism	-0.013
Real interest rate	-0.077	Inertia	0.523
Prices	1.000	Prices	-0.006
		House price	-0.110
		Unemployment rate	-0.004

REAL CREDIT TO HOUSEHOLDS FOR CONSUMPTION			
Long run coefficients		Short run coefficients	
Prices	1.000	Error Correction Mechanism	-0.026
Real interest rate	-0.077	Inertia	0.646
		Total wealth	0.159
		Private consumption deflator	-0.003

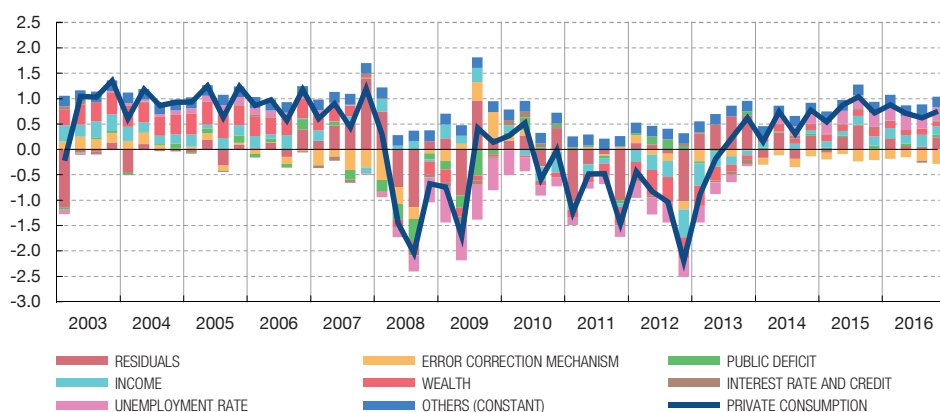
REAL CREDIT TO NON-FINANCIAL FIRMS			
Long run coefficients		Short run coefficients	
Real interest rate	-0.044	Error Correction Mechanism	-0.046
Equipment investment	0.717	Inertia	0.382
Prices	1.283	Prices	1.000
House price	0.478		

4 Contribution charts

Contribution charts show the quarterly growth rate of a variable (e.g. private consumption) as explained by the various determinants of its behavioral equation (e.g. income, wealth, etc.) and the equation residuals. These graphs are a very useful tool for validating staff projections, which is one of the main tasks for which MTBE is employed. They can also be used to show the fit of the model over the estimation sample, together with the story the model tells about the evolution of the main macroeconomic variables during that period. The contribution charts in this section portray observed data until 2016Q4, that is, two years after the end of the estimation period. In general, they show that the model has improved significantly with respect to the previous version (MTBE2014), particularly in the sense that it now matches recent events more closely.

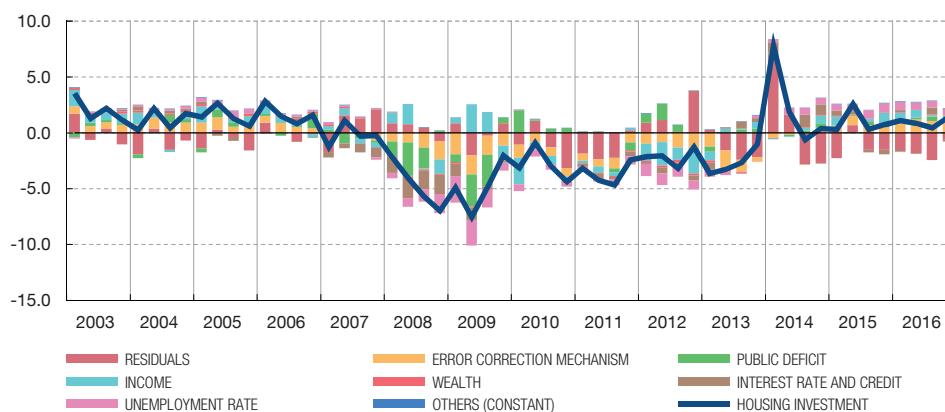
- Private consumption: the new equation gives more weight to income and wealth as determinants of the high-growth period prior to the crisis. The sharp fall in consumption during the initial stage of the crisis, in 2008-2009, is explained mainly by the rapid increase of the unemployment rate, and also by the surge in the public deficit. The fall of consumption around 2012, on the contrary, is explained mainly by the negative contributions of real income and wealth, which are only partially counteracted by the contribution of the public deficit (the model now includes some degree of Ricardian effects of fiscal consolidation, but it is still mainly Keynesian: the negative contribution from income during the years of the fiscal consolidation efforts is higher than the positive one from the reduction of public deficit). The recovery of consumption is driven initially by residuals (which means that it was a surprise for the model) and then by the continued reduction in the unemployment rate. Over the whole period, interest rates and credit now show a smaller impact than in MTBE-2014: they appear in the equation, but the estimated coefficients are relatively small.

PRIVATE CONSUMPTION



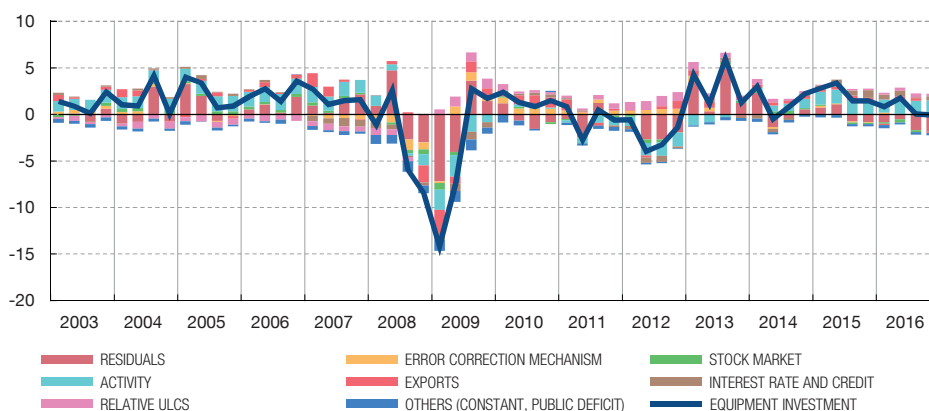
- Housing investment: the main driver of the strong fall in 2008-2009, according to MTBE, is first the fall in credit, and later the increase of the unemployment rate. The increase in real disposable income in those years is largely explained by government policy actions, and is completely counteracted by the Ricardian effect associated with the increase of the public deficit. Overall, income has a similar weight as in the previous version, but wealth is less important in this new equation.

HOUSING INVESTMENT



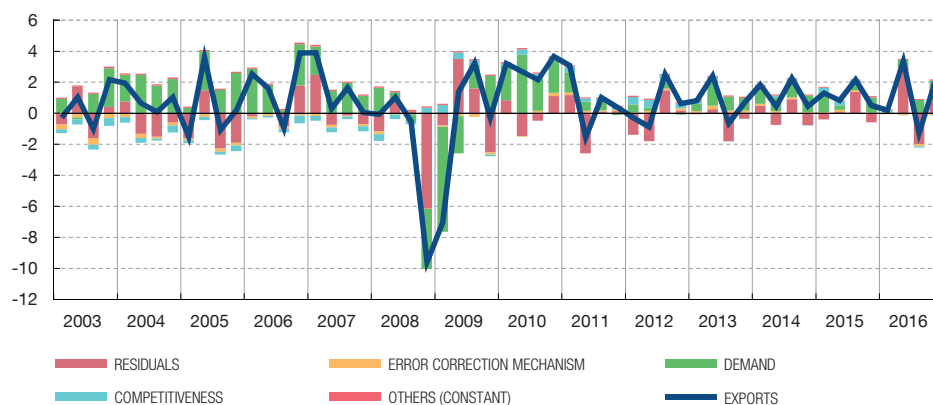
- Equipment investment: it is mainly driven by the demand that firms face, i.e. output growth, but also including a specific effect that makes investment grow faster when GDP growth is driven by exports. Variables related to interest rates, credit growth and the stock market have small coefficients and therefore a relatively limited effect. During the second half of the crisis, and in the recovery, a positive effect from competitiveness appears, as unit labor costs evolve more favorably in Spain than in the rest of the euro area.

EQUIPMENT INVESTMENT

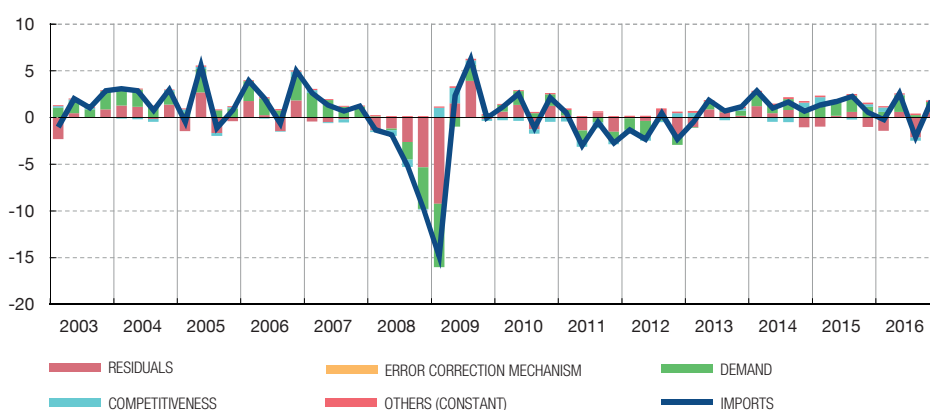


- Exports and imports: they are both mainly demand-driven, as was the case in MTBE2014. Competitiveness still plays a very small role in the contribution charts. Residuals are big but look adequately random: these variables are just difficult to forecast, regardless of the model.

EXPORTS

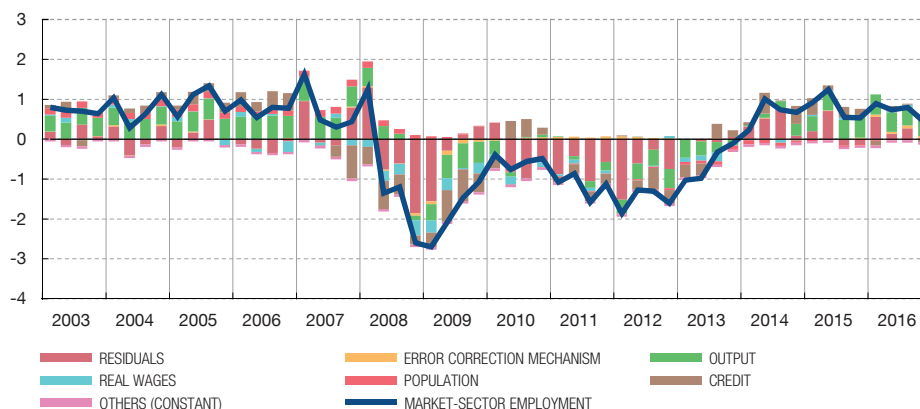


IMPORTS



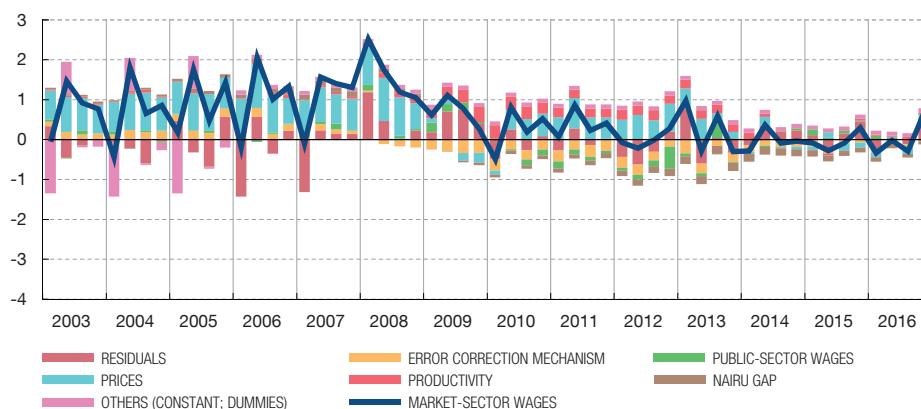
- Employment: as in MTBE-2014, it is still explained mainly by the demand that firms face (i.e. output growth), but credit now plays an important role in this equation, helping explain both stages of the crisis and also the start of the recovery.

MARKET-SECTOR EMPLOYMENT



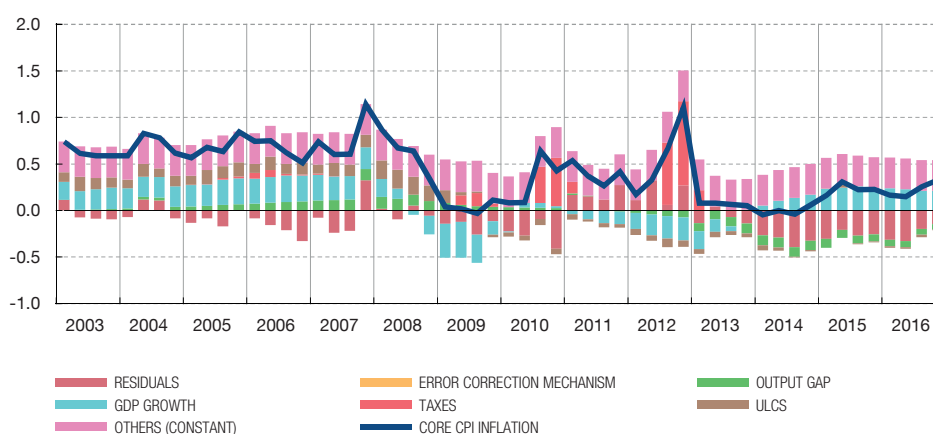
- Wages: inflation is the main factor explaining their strong growth during the boom, and also their slow growth in the recovery. The imitation effect from public sector wages was important during the crisis. The contribution from the NAIRU gap became noticeable in the second stage of the crisis, and remains negative until the end of 2016.

MARKET-SECTOR WAGES



- Core CPI inflation: apart from output growth, the level of the output gap also appears now as a determinant in this equation, providing a term with a slower response that remains negative during the first years of the recovery. Strong growth and increasing unit labor costs explain the high inflation of 2003-2007. During the crisis, rises in indirect taxes are the only factor driving inflation up significantly. The residuals of this equation in the estimation sample are small, but the deviations in the 2014-16 period are systematic; this was not fixed by trying to include additional variables because it is in line with inflation surprises being consistently negative during those years.

CORE CPI INFLATION



5 Simulations

Constructing alternative scenarios and running policy simulations is one of the most important uses of MTBE. For that purpose, one variable (or a small set of them) is made to deviate from its baseline evolution, and the model calculates the reaction of all other macroeconomic variables, taking into account all second-round and higher-order effects.

The model is mainly demand-driven, especially in the short run. Thus, this is the main channel through which contractionary shocks are propagated to the economy: with lower demand, firms reduce equipment investment and market-sector employment, so household income falls and this affects private consumption and housing investment too; higher unemployment pushes wages down, and both slower growth and falling unit labour costs reduce inflation; the external sector shows a positive contribution to growth mainly because the fall in demand reduces imports (the effect of improved competitiveness in exports and imports is also present but minor in comparison, unless the original trigger is a price shock). Additionally, there is a credit channel in the model, which works as an amplifier for this demand channel: lower activity reduces credit, and this in turn affects private consumption, equipment investment, and housing investment. The opposite happens in case of an expansionary shock.

This section presents the results from shocks to interest rates, world demand, competitiveness, oil and housing prices, the stock exchange, a wide variety of fiscal instruments, and prices and wages. In most of these simulations the transmission channel works with an initial response by a limited set of variables, and once this response is translated into a change in demand, it spreads to the rest of the model following the demand channel described above.

The model is approximately linear, so the results of simulations of shocks that are bigger, smaller, or of opposite sign can be approximated by just multiplying these results by the appropriate linear factor. Several shocks can also be added to create more complex scenarios, but in this case there is a bigger scope for nonlinearities to appear, and in some cases the sum of shocks can only be taken as a relatively good approximation.

5.1 Interest rates

Households react to two different interest rates: housing investment depends on the average interest rate in loans to households for housing purchases, and private consumption responds to the average interest rate of other bank loans to households. Equipment investment by firms depends on the average interest rate in loans of less than one million euros to non-financial corporations.

The model includes transfer equations that describe how these interest rates react to changes in reference short term and long term interest rates (the 3-month Euribor rate and the interest rate for 10 year Spanish government bonds, respectively). Thanks to this, the model can

show both how the economy reacts to changes in the interest rates for bank loans (the ones that appear in the equations) and also to basic short-term and long-term interest rates. Changes in any of these interest rates will trigger the demand channel described above.

In MTBE-2017, the response of GDP to interest rate shocks is slightly smaller than in MTBE-2014, mainly because of a smaller effect on private consumption. The response is also smaller than what we would obtain with a DSGE model for the Spanish economy (see, e.g., BEMOD or FiMod²), both because MTBE is not forward-looking (DSGE models tend to bring effects forward and display a faster response) and because MTBE includes many other explanatory variables (wealth, credit, unemployment rate, public deficit, etc.) and has to explain the observed evolution of the macroeconomic variables as the sum of the effects from all of these, which means each explanatory variable necessarily has a small effect (unless they work in different directions and counteract each other).

MTBE update: interest-rate simulations

Accumulated level differences.

	All interest rates (+100 bp)			Short-term interest rate (+100 bp)			Long-term interest rate (+100 bp)		
	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
GDP	-0.10	-0.21	-0.23	-0.07	-0.19	-0.23	-0.01	-0.04	-0.07
Private consumption	-0.09	-0.18	-0.26	-0.04	-0.15	-0.25	0.00	-0.01	-0.04
Private productive investment	-0.60	-1.10	-0.89	-0.51	-1.04	-0.97	-0.05	-0.25	-0.36
Housing investment	-0.31	-0.98	-1.49	-0.26	-0.96	-1.39	-0.05	-0.25	-0.51
Exports (goods and services)	-0.02	-0.01	0.03	0.00	0.02	0.05	0.00	0.00	0.01
Imports (goods and services)	-0.14	-0.29	-0.32	-0.09	-0.25	-0.31	-0.01	-0.05	-0.09
Contributions to GDP growth									
Domestic demand	-0.15	-0.31	-0.36	-0.10	-0.28	-0.36	-0.01	-0.05	-0.10
Net exports	0.04	0.09	0.12	0.03	0.09	0.12	0.00	0.02	0.03
Core CPI	-0.02	-0.06	-0.10	-0.01	-0.06	-0.10	0.00	-0.01	-0.03
HICP	-0.02	-0.06	-0.09	-0.01	-0.06	-0.10	0.00	-0.01	-0.02
GDP deflator	-0.02	-0.08	-0.12	-0.02	-0.07	-0.12	0.00	-0.01	-0.03
Compensation per employee	-0.01	-0.05	-0.06	0.00	-0.01	-0.03	0.00	0.00	0.00
Total employment	-0.03	-0.15	-0.19	-0.06	-0.24	-0.27	0.00	-0.04	-0.08
Net lending/borrowing (% GDP)	0.04	0.08	0.10	0.02	0.09	0.12	0.02	0.06	0.09
Public deficit (% GDP)	-0.04	-0.10	-0.13	-0.03	-0.10	-0.14	-0.03	-0.08	-0.12

5.2 External sector

An increase in world demand makes exports grow, and this triggers the demand channel described previously. The effect on exports is smaller than in MTBE-2014, and investment by firms also reacts less to the demand increase. As a result, both GDP and employment react less to world demand shocks in this new version of the model than they did in MTBE-2014.

² See Andrés et al (2010) and Stähler and Thomas (2012).

MTBE update: external-sector simulations

Accumulated level differences.

	World demand (+1%)			Depreciation of the euro (1%)			Oil prices (+10%)		
	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
GDP	0.25	0.31	0.33	0.06	0.10	0.11	-0.07	-0.18	-0.25
Private consumption	0.04	0.13	0.19	0.00	0.02	0.04	-0.11	-0.30	-0.39
Private productive investment	0.53	0.65	0.56	0.09	0.18	0.16	-0.05	-0.21	-0.31
Housing investment	0.16	0.41	0.50	0.02	0.09	0.13	-0.31	-0.57	-0.74
Exports (goods and services)	1.00	1.04	1.02	0.09	0.17	0.18	0.00	0.00	0.00
Imports (goods and services)	0.59	0.74	0.76	-0.05	-0.01	0.00	-0.05	-0.15	-0.22
Contributions to GDP growth									
Domestic demand	0.10	0.19	0.22	0.01	0.04	0.05	-0.08	-0.23	-0.31
Net exports	0.16	0.13	0.12	0.05	0.06	0.06	0.01	0.04	0.04
Core CPI	0.05	0.11	0.15	0.01	0.03	0.05	-0.01	-0.06	-0.09
HICP	0.05	0.10	0.14	0.04	0.06	0.08	0.34	0.34	0.31
GDP deflator	0.05	0.11	0.16	0.01	0.04	0.06	0.01	-0.04	-0.08
Compensation per employee	0.04	0.08	0.09	0.01	0.04	0.05	0.09	0.19	0.13
Total employment	0.09	0.24	0.28	0.02	0.07	0.09	-0.03	-0.15	-0.21
Net lending/borrowing (% GDP)	0.15	0.13	0.12	-0.03	-0.01	-0.02	-0.34	-0.35	-0.35
Public deficit (% GDP)	0.08	0.14	0.17	0.02	0.05	0.06	0.02	-0.03	-0.07

The effect of a depreciation of the euro on aggregate exports is similar to that of the old model; however, now this shock has a negative impact on imports, contrary to what we observed with the earlier version: the positive demand channel still exists, but the negative competitiveness channel on imports is now stronger and dominates the former in this shock. This negative response of imports, plus a higher increase in private productive investment and housing investment, make for a bigger response of GDP. The pass-through of the exchange rate to prices and wages is very small, and the increase in inflation in the simulation is a Philips-curve effect that appears as a result of the faster growth of GDP.

As in MTBE-2014, an increase in oil prices generates an increase in the price level, but not a persistent acceleration of inflation beyond the initial direct effect: after a permanent 10% rise in oil prices, HICP inflation is 0.34 percentage points higher in the first year, but remains basically unchanged thereafter (the initial price increase is consolidated, but not extended upon). The shock is transmitted to the real side of the economy because higher prices reduce households' real disposable income, so they reduce consumption and housing investment and this triggers the usual demand channel of the model. Compared with the previous version, in MTBE-2017 there is more impact on GDP, private consumption and housing investment, but less on private productive investment.

5.3 Wealth

In MTBE, financial and non-financial wealth have an effect on both private consumption and housing investment, and equipment investment also responds directly to the stock price index. The reaction of all these macro variables to the wealth shock is what will trigger the demand channel in these simulations.

After a housing price shock, the effect is not bigger now than in the previous version of the model, but it appears faster, with a bigger short-term impact because, even if housing investment itself now reacts less on impact, there is a faster response by private consumption and firms' investment. After three years, the effect on GDP is very similar to what we had in MTBE-2014.

Stock prices have a significantly smaller effect now than they had in MTBE-2014: private consumption, private productive investment and housing investment now show a smaller and less persistent reaction.

MTBE update: consumer-wealth simulations

Accumulated level differences.

	House prices (-10%)			Stock exchange (-10%)		
	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
GDP	-0.35	-0.60	-0.49	-0.06	-0.10	-0.08
Private consumption	-0.68	-1.12	-0.99	-0.08	-0.12	-0.12
Private productive investment	-0.45	-1.00	-0.61	-0.25	-0.44	-0.31
Housing investment	-0.63	-1.64	-1.72	-0.07	-0.18	-0.19
Exports (goods and services)	-0.04	0.07	0.20	-0.01	0.00	0.02
Imports (goods and services)	-0.47	-0.81	-0.65	-0.08	-0.13	-0.11
Contributions to GDP growth						
Domestic demand	-0.50	-0.91	-0.80	-0.09	-0.14	-0.13
Net exports	0.14	0.29	0.31	0.02	0.04	0.05
Core CPI	-0.06	-0.22	-0.29	-0.01	-0.03	-0.04
HICP	-0.06	-0.21	-0.28	-0.01	-0.03	-0.04
GDP deflator	-0.39	-0.73	-0.90	-0.02	-0.04	-0.05
Compensation per employee	-0.04	-0.13	-0.17	-0.01	-0.03	-0.02
Total employment	-0.20	-0.65	-0.68	-0.02	-0.08	-0.08
Net lending/borrowing (% GDP)	0.14	0.26	0.27	0.02	0.04	0.04
Public deficit (% GDP)	-0.25	-0.47	-0.48	-0.02	-0.05	-0.05

5.4 Fiscal shocks

The following table summarizes the ex-ante and ex-post fiscal multipliers for different shocks. The ex- ante multiplier is the fall in GDP after a fiscal consolidation measure of size 1 pp of GDP, which will typically lead to a reduction of public deficit smaller than 1 pp of GDP. The ex post multiplier is the fall in GDP after a fiscal consolidation measure of whatever size is needed in each case to achieve an actual reduction of 1 pp in public deficit as a percentage of GDP.

The basic public investment and public consumption shocks now show slightly higher effects to those seen in MTBE-2014: the short term multiplier is 0.8 for public investment and 0.9 for public consumption, both in ex ante terms (see below). Medium term effects are also found to be bigger, due mainly to a bigger effect on private consumption.

	Ex ante fiscal multiplier						Ex post fiscal multiplier					
	MTBE 2014			MTBE 2017 update			MTBE 2014			MTBE 2017 update		
Fiscal shock	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
Public investment	0.7	0.7	0.7	0.8	0.9	0.9	1.0	1.0	1.1	1.0	1.5	1.9
Public consumption	0.7	0.7	0.8	0.9	1.0	1.0	0.9	1.0	1.0	1.1	1.5	1.9
Public employment	1.1	1.2	1.2	1.0	1.3	1.4	2.2	2.6	2.9	1.7	4.0	8.0
Public wages	0.1	0.2	0.2	0.1	0.1	0.2	0.2	0.5	0.9	0.1	0.4	0.6
Direct taxes to households	0.2	0.4	0.5	0.2	0.6	0.8	0.2	0.5	0.8	0.2	0.7	1.1
Direct taxes to firms	0.2	0.4	0.6	0.1	0.2	0.2	0.2	0.3	0.4	0.1	0.2	0.2
Indirect taxes	0.3	0.6	0.7	0.1	0.3	0.5	0.3	0.6	0.7	0.1	0.4	0.6
Social contributions	0.2	0.4	0.5	0.2	0.5	0.8	0.2	0.5	0.7	0.2	0.7	1.1
Unemployment benefits	0.1	0.2	0.2	0.1	0.2	0.3	0.2	0.5	0.8	0.2	0.8	1.4
Pensions	0.2	0.3	0.5	0.1	0.5	0.6	0.2	0.5	0.7	0.2	0.7	1.2
Transfers to households	0.2	0.4	0.5	0.2	0.5	0.7	0.2	0.5	0.7	0.2	0.7	1.2
Transfers to firms	0.3	0.4	0.6	0.1	0.2	0.2	0.3	0.6	0.8	0.1	0.3	0.2
Shock to 6 instruments	0.3	0.5	0.6	0.3	0.6	0.7	0.5	0.7	0.9	0.4	0.8	1.2

The following tables provide detailed results for a subset of these fiscal simulations.

MTBE update: public sector simulations

Accumulated level differences.

	Public investment (-1% of GDP)			Direct taxes (+1% of GDP)			Indirect taxes (+1% of GDP)		
	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
GDP	-0.80	-0.89	-0.91	-0.19	-0.57	-0.79	-0.05	-0.34	-0.48
Private consumption	-0.01	-0.29	-0.46	-0.35	-1.08	-1.52	-0.05	-0.37	-0.66
Private productive investment	-0.34	-0.41	-0.32	-0.05	-0.63	-0.98	-0.93	-2.21	-2.32
Housing investment	0.25	-0.45	-0.79	-0.83	-1.66	-2.41	0.17	-0.25	-0.86
Exports (goods and services)	-0.12	0.08	0.20	-0.03	-0.06	0.03	-0.05	-0.22	-0.18
Imports (goods and services)	-1.07	-1.21	-1.24	-0.25	-0.78	-1.08	-0.22	-0.68	-0.88
Contributions to GDP growth									
Domestic demand	-1.12	-1.35	-1.45	-0.26	-0.83	-1.19	-0.11	-0.49	-0.72
Net exports	0.30	0.43	0.50	0.07	0.23	0.37	0.06	0.13	0.21
Core CPI	-0.16	-0.33	-0.45	-0.03	-0.15	-0.28	0.66	0.80	0.73
HICP	-0.16	-0.32	-0.43	-0.03	-0.14	-0.27	0.64	0.78	0.71
GDP deflator	-0.13	-0.30	-0.43	-0.06	-0.23	-0.39	0.61	0.70	0.63
Compensation per employee	-0.13	-0.24	-0.26	-0.02	-0.13	-0.21	0.16	0.43	0.43
Total employment	-0.30	-0.70	-0.84	-0.05	-0.30	-0.58	0.10	-0.16	-0.42
Net lending/borrowing (% GDP)	0.28	0.35	0.40	0.06	0.20	0.31	-0.07	0.01	0.07
Public deficit (% GDP)	0.80	0.61	0.48	1.03	0.83	0.71	0.96	0.92	0.83

	Public consumption (-1% of GDP)			Public wages (-1% of GDP)			Public employment (-1% of GDP)		
	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
GDP	-0.85	-0.96	-1.00	-0.06	-0.14	-0.16	-0.95	-1.32	-1.44
Private consumption	-0.02	-0.32	-0.52	-0.24	-0.68	-0.85	-0.44	-1.15	-1.47
Private productive investment	-1.05	-1.27	-1.14	0.33	0.92	1.20	0.15	-0.44	-0.69
Housing investment	0.22	-0.52	-0.88	-0.63	-0.99	-1.20	-1.52	-2.64	-3.07
Exports (goods and services)	-0.14	0.04	0.15	0.16	0.39	0.52	0.03	0.01	0.12
Imports (goods and services)	-1.15	-1.33	-1.37	-0.05	-0.10	-0.09	-1.18	-1.69	-1.86
Contributions to GDP growth									
Domestic demand	-1.20	-1.45	-1.56	-0.13	-0.32	-0.39	-1.37	-1.92	-2.18
Net exports	0.32	0.45	0.53	0.07	0.18	0.23	0.39	0.56	0.69
Core CPI	-0.17	-0.34	-0.46	-0.06	-0.20	-0.27	-0.01	-0.12	-0.23
HICP	-0.17	-0.33	-0.45	-0.05	-0.19	-0.26	-0.01	-0.11	-0.22
GDP deflator	-0.14	-0.31	-0.44	-1.07	-1.23	-1.28	-0.05	-0.24	-0.39
Compensation per employee	-0.14	-0.26	-0.27	-2.76	-3.26	-3.45	-0.25	-0.41	-0.52
Total employment	-0.32	-0.75	-0.89	0.08	0.14	0.13	-1.62	-1.81	-2.04
Net lending/borrowing (% GDP)	0.30	0.38	0.43	0.08	0.15	0.19	0.39	0.52	0.62
Public deficit (% GDP)	0.81	0.63	0.53	0.51	0.35	0.28	0.56	0.33	0.18

For direct taxes to households, social contributions, and transfers to households (fiscal measures that have a direct effect on households' income), the new model displays the same short-term multipliers as the old one, but bigger effects after three years, with stronger medium term responses by all the relevant demand components (consumption, housing investment and private productive investment).

On the other hand, indirect taxes and direct taxes to firms are now found to have smaller multipliers, both in the short and in the medium term, with consumption and investment showing a slower and smaller response to the initial shock.

Finally, reductions in public wages show a relatively small multiplier both in the short and in the medium term, very much in line with the results from MTBE-2014.

As can be seen in the results above, some measures, like net purchases and public investment, have strong short-term effects on output, because the item that is being reduced is, in accounting terms, part of GDP. It is not just an accounting effect, though, since these measures also have a relatively high cost in terms of employment. Other measures, like personal income taxes, social contributions and benefits, have almost no direct impact, but their effect on output and employment increases as agents react to the reduction in their disposable income. Public employment, on the other hand, has both a big direct impact (in national accounting terms, it is a shock to real public consumption, which is part of GDP) and big second-round effects (it reduces households' income, and it increases the unemployment rate, which is also an important explanatory variable for both private consumption and housing investment); and of course a very big cost in terms of total employment. These second-round effects reduce the

effectiveness of all fiscal consolidation measures in the medium term: as agents reduce their expenditure, tax receipts fall, and the observed reduction in the fiscal deficit ends up being significantly smaller than one-to-one.

In summary, we find that different fiscal consolidation measures have varying degrees of effectiveness (tax increases being more effective, and employment and wage cuts less so) and generate very different costs in terms of output and employment (with cuts in public employment being extremely costly, and tax increases, wage cuts and reductions in benefits being less costly in the short term).

5.5 Wages and prices

As in the previous version of the model, the price-wage feedback is found to be relatively small, with wage indexation greatly reduced in the last decade, and price markups absorbing a big part of these nominal shocks.

When wage moderation is coupled with price moderation (in line with recommendations found in Banco de España publications in recent years, see for example Box 1.3 in Annual Report 2011), real effects are found to be clearly positive, and bigger in the medium term than was the case in MTBE-2014, thanks mainly to a stronger and more lasting effect on private productive investment.

MTBE update: price and wage simulations

Accumulated level differences.

	Prices (-1%)			Private-sector wages (-1%)			Prices and wages (-1%)		
	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
GDP	0.21	0.54	0.70	0.06	0.12	0.13	0.21	0.48	0.58
Private consumption	0.14	0.46	0.76	-0.05	-0.05	-0.02	0.08	0.34	0.56
Private productive investment	0.84	2.06	2.27	0.51	0.99	1.00	1.03	2.12	2.19
Housing investment	0.30	0.86	1.50	-0.18	-0.01	0.04	0.15	0.69	1.13
Exports (goods and services)	0.29	0.59	0.53	0.22	0.30	0.28	0.39	0.59	0.53
Imports (goods and services)	0.07	0.54	0.76	0.12	0.24	0.25	0.17	0.56	0.69
Contributions to GDP growth									
Domestic demand	0.15	0.53	0.78	0.02	0.10	0.12	0.14	0.47	0.64
Net exports	0.08	0.03	-0.06	0.04	0.03	0.02	0.08	0.02	-0.04
Core CPI	-1.01	-0.98	-0.87	-0.05	-0.09	-0.07	-0.77	-0.75	-0.65
HICP	-0.98	-0.95	-0.85	-0.05	-0.08	-0.06	-0.74	-0.73	-0.64
GDP deflator	-0.83	-0.78	-0.65	-0.05	-0.08	-0.06	-0.64	-0.60	-0.49
Compensation per employee	-0.24	-0.49	-0.46	-0.72	-0.73	-0.69	-0.71	-0.74	-0.71
Total employment	-0.22	0.25	0.53	0.14	0.24	0.25	-0.05	0.33	0.53
Net lending/borrowing (% GDP)	-0.07	-0.11	-0.19	0.03	0.01	0.01	-0.04	-0.08	-0.14
Public deficit (% GDP)	-0.24	-0.11	0.02	-0.09	-0.07	-0.06	-0.23	-0.11	-0.01

6 Conclusion

This document presents the new version of the Quarterly Model of Banco de España, MTBE-2017. In this update, a big revamp to the econometric techniques used in estimation has been implemented, but, despite that, changes in coefficients and simulation results with respect to the previous version of the model are smaller than what we saw in earlier updates.

Compared with MTBE-2014, this new version shows less response of demand aggregates to interest rates and stock market prices but more to credit, less response of GDP to world demand but more to world prices and to the price of oil, more positive effects to output and employment from price and wage moderation, and slightly faster and bigger fiscal multipliers for some shocks (government consumption and investment, direct taxes to households) but smaller for others (indirect taxes, direct taxes to firms).

The updated model describes an economy that is fairly reactive to financial shocks other than changes in interest rates, where price and wage moderation can generate growth and employment, and where fiscal consolidation reduces public deficit and has negative but moderate effects on GDP.

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