The Provision of Public Services under Conditions of Financial Stress: Evidence from Spanish Autonomous Communities

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Abstract

The 2008 economic crisis had three consequences for Spanish regional governments: first, there was a substantial and sudden fall of their revenue, which they had no effective means to redress, while citizens demands for education, health and other services continued to increase as usual; second, their debt, which until then had been relatively small and stable, exploded to unknown levels; and third, there was a serious deterioration of the extent and quality of the set of public services provided by these governments. The first two consequences show up quite clearly in official statistics, while the third, on which arguably there is a high level of consensus among citizens, has not been systematically and formally documented. This article develops a simple model of public expenditure that explains these facts. It suggests that, under conditions of financial stress, it may be rational for regional governments to spend more than the resources they have, and thus to incur in debt finance, and at the same time to accept a deterioration of the extent and quality of the services provided to the public. More concretely, the model predicts that, if a meaningful measure of the gap between expenditure needs and revenue can be identified, then the optimal behaviour of governments is to absorb a part of this gap by borrowing and the rest by letting service provision to deteriorate. In a situation of financial stress, along with the traditional influence of revenue, demography plays a role of its own in the determination of governments' behaviour. We test these hypotheses with a panel of data on expenditure, revenue and a series of indicators of expenditure need (essentially demographic indicators) of the fifteen "common regime" Spanish autonomous communities over the period that goes from 2007 to 2017. None of the predictions of the model is rejected by the data.

Key words: Demography, Expenditure needs, Public expenditure, Public revenue, Deficit, Debt, Regional governments, Financial stress.

JEL Classification: H12, H63, H74, H77.

1. Introduction

The 2008 economic crisis had three consequences for Spanish regional governments: first, there was a substantial and sudden fall of their revenue, which they had no effective means to redress, while citizens demands for education, health and other services continued to increase as usual; second, their debt, which until then had been relatively small and stable, exploded to unknown levels; and third, there was a serious deterioration of the extent and quality of the set of public services provided by these governments. This article develops a simple model of public expenditure under conditions of financial stress that explains these facts. It suggests that, under these conditions, it may be rational for regional governments to spend more than the resources they have, and thus to incur in debt finance, and at the same time to accept a deterioration of the extent and quality of the services provided to the public. More concretely, the model predicts that public expenditure is determined by a weighted average of needs and revenue, and thus that the optimal behaviour of governments is to absorb a part of the gap between needs and revenue by borrowing and the rest by letting service provision to deteriorate. We test these predictions with a panel of data on expenditure, revenue and a series of geo-demographic indicators of expenditure needs of the fifteen "common regime" Spanish autonomous communities over the period that goes from 2007 to 2017. None of the predictions of the model is rejected by the data. On average, about 48% of the shortfall of resources with respect to needs experienced by Spanish regional governments during the period 2007-2017 was absorbed by borrowing and the remaining 52% by letting service provision to deteriorate.

We have not found any precedent to these results. Previous efforts in this field have been mostly directed to identify the determinants of the overall level of public expenditure/ tax revenue –the size of government. Three important contributions are the formal models proposed by Romer (1975), Roberts (1977) and Meltzer and Richard (1981). In the Meltzer and Richard general equilibrium model the size of the government, the size of the general tax/transfer program on which the median voter decides, depends on its position in the income distribution; that is, on the degree of income inequality.[1] In the model developed in this article, rather than the taxpayer deciding on the size of government, the economic agent that decides on the level of expenditure is the government, while the taxpayer, public revenue and financial markets are the constraints that set the limits on which this decision is taken. In this particular sense, Barro (1979) is a clear precedent of our model. Barro's model takes public expenditure as given, and develops a theory of tax revenue determination. Our model takes public revenue as given and develops a theory of expenditure determination. Both models, therefore, are partial equilibrium models. The constraint in Barro's model is the overall temporal budget constraint, which given initial debt and the present value of revenue, fixes the present value of taxes. What Barro's model does is, within these constraints, to determine the time pattern of taxes. In our model, the conditions of stress under which the regional government has to operate narrow down drastically both the aims of the government (it only wants to remain in office) and the constraints worth monitoring (voters' needs and public revenue). The government has to take both factors into account in order to maintain financial viability while still remaining in office. Barro's is a dynamic model, ours' is static.[2]

The conditions of stress associated to episodes of severe economic downturns has been noted in previous research efforts. Interesting analyses can be found, among others, in Poterba (1994), Ratso and Tovmo (2002), Shamsub and Akoto (2004), Borge (2005), Vartapetov (2011) and Ahrend *et al.* (2013). As far as Spain is concerned, municipalities have been the level of government that has attracted most of the attention. A non-exhaustive list includes Bosch and Suárez-Pandiello (1995), Benito and Bastida (2010), Fernández-Caballero *et al.* (2012), and López-Hernández *et al.* (2012).

The rest of the paper is organised as follows: Section 2 develops the model of public expenditure introduced above and derives the testable propositions that follow from it. Section 3, the longest of the article, presents an empirical analysis which includes: i) the definition of the data used, all of them referred to the fifteen "common regime" Spanish autonomous communities during the period 2007-2017; ii) an explanation of the economic context in which this set of data was generated; iii) the empirical specification of the testable propositions generated by the model; iv) the econometric estimates obtained using the panel of data described above; and v) a robustness check of these results. Section 4 explores the capacity of the estimated model to predict the increase of regional debt and, in particular, to analyse the extent to which each of the fifteen Spanish "common regime" regional governments recurred to borrowing and service provision deterioration in order to absorb the gap between needs and revenue that they had to face during the 2007-2017 period. Section 5 concludes.

2. A simple model of public expenditure under conditions of economic stress

The simplicity of the model we present here is not an artificial contraption but follows naturally from the conditions that characterize a stress situation. In a stress situation everything becomes more crucial, if not more tragic, but at the same time more simple. The median voter model may in normal circumstances be a reasonable analytical tool to identify the determinants of the expenditure decisions of governments. But its utility decreases at an alarming rate when politicians in government see how, for reasons that have nothing to do with them, public revenue falls suddenly and substantially while citizens demands for education and health continue to grow as usual. And this is particularly so if there is no prospect of a prompt reversal of this insufficiency. We would like to argue that in a situation such as this the median voter is no longer the crucial decision maker, and that it is more fruitful to assign that role to the government. A government in charge of the management of a crisis, whose aims can therefore be justifiably reduced to keeping itself in power and avoiding being wiped out by financial markets.

Let us consider a decentralized economy in which regional governments are responsible for the provision of a given set of public services. To finance these services, regional governments have at their disposal a given amount of resources that comes from own taxes and transfers from the federal government. As discussed above, a stress situation appears when the amount of resources that regional governments have is insufficient to maintain the provi-

sion of public services at current levels and there is no prospect of a prompt reversal of that insufficiency. In the presence of that gap between resources and needs, how will a regional government behave in order to decide its actual amount of expenditure?

To answer this question we need to add more structure to the argument. Call the amount of resources, R; expenditure needs, N; and the actual amount of expenditure undertaken by a given regional government, E.

While expenditure, E, and revenue, R, are familiar concepts, it may be useful to elaborate a little bit more on the concept of needs, N. To make things simple, suppose that the population of a jurisdiction is an adequate and sufficient indicator of the resources required to finance, at a given level of quality, the provision of public services of which the corresponding government is responsible. Denote population by P, which is expressed in heads. Now, to transform P, an indicator of needs, into a measure of *expenditure* needs, N, we need a multiplicative factor, g, that converts number of heads into amounts of euros; a factor that transforms heads into the resources needed to satisfy the demand of public services generated by these heads. So

$$N = gP$$

where, in this illustration, g is the amount of euros per capita that are needed to satisfy the demand of public services at a given level of quality. The parameter g is a policy parameter that depends on technical considerations –the type of services provided– and on the level of quality at which the government desires to provide these services. We call P an *indicator of needs* and N the amount of e*xpenditure needs*. The parameter g is constant across regional governments and over time. Given a particular level of quality, N varies across regional governments and over time according to the variation of P. Expenditure needs, N, is a variable distinct and independent from actual public expenditure, E.

To understand what a situation of financial stress is we need first to understand what would be the relationship between N and R in a normal situation, a situation without financial stress. As discussed above, the indicator of needs, P, together with the parameter g determine the amount of expenditure needs, N. In a normal situation, the index of expenditure needs determines actual expenditure E, and actual expenditure determines the amount of revenue R that is required to finance E. In a normal situation, P and g are the independent variables that jointly define the (also exogenous) variable N. Once N is known, the needed revenue R to finance these expenditure needs will be forthcoming and therefore the amount of actual expenditure E will be executed. Thus in a normal situation, expenditure needs, revenue and expenditure are all equal

$$N = R = E$$

and the public services under the responsibility of the government are provided at the level of quality g without incurring in debt finance.

It is important to understand that we are not talking of an equilibrium reached autonomously by the independent behavior of a plurality of economic agents, but of the result of

a man made system of regional finance. Although highly stylized, this is a description that contemplates the essential elements of what could be termed as a situation of equilibrium: a position of rest in which all regional governments are satisfied that the basic aim of the system of regional finance, which is to put at their disposal the amount of resources that will finance their expenditure needs, is fairly obtained. For the purposes of our model of financial stress, this is all we need.[3]

Contrary to the conditions of normality just specified, we define a situation of financial stress as a situation in which, due to the substantial exogenous fall of R that regional governments are not able to redress, expenditure needs exceed revenue, $N > R$. The only variable under the control of the regional government is E. In a situation of stress, R, as it already happens with N, becomes an exogenous variable.

With N greater than R, if debt finance is possible, the alternatives that the regional government has to consider in order to determine its actual level of expenditure lie within the range $N - R$. The closer E is to N, the lower the fall in the extent of service provision or in the quality of the services provided, but the greater the need to recur to debt finance to compensate for the shortfall in resources.[4] On the other hand, the closer E is to R, the less necessary will be for the regional government to incur in debt finance, but at the cost of inflicting a larger fall in service provision to the citizens of the region. In a stress situation as the one depicted here there is no option without cost.

Under the above conditions, any choice concerning the level of public expenditure generates two costs that the regional government has to take into account. A political cost, PC, correlated with the difference between N and E, and a financial cost, FC, correlated with the difference between E and R. By political cost we mean the increased probability that incumbent politicians in government will be ousted from office. By financial cost we mean not only the added interest charges associated with the higher level of debt, but also the greater financial vulnerability and the difficulties to accede to financial markets that the regional government may experience. We posit that these two costs can be formally represented as functions of the variable E as follows: $PC = \alpha (N - E)^2$ and $FC = (1 - \alpha)(E - R)^2$, where α is a positive fraction and all other symbols have already been defined. Both functions are continuous and convex in E.

The particular form of these functions responds to the already stated aim of simplicity in the specification of the model. The quadratic form aims at the linearity of the final hypotheses, and the fact that the two multiplicative factors, α and $(1 - \alpha)$, add to unity is posed to facilitate the calculus. As is shown below, this additive condition turns out to be not restrictive at all.

We define the total cost faced by the regional government as the sum of political and financial costs, $C = PC + FC$. Thus, in choosing the level of expenditure, the regional government must face the following total cost (loss) function:

$$C = \alpha(N - E)^2 + (1 - \alpha)(E - R)^2 \tag{1}$$

Total cost starts at the level $C = \alpha(N - R)^2$ for $E = R$; it then decreases until reaching a minimum; and finally increases to end at $C = (1 - \alpha)(N - R)^2$ for $E = N$.

We assume that the objective of the regional government is to choose E so as to minimize total cost C. That is

$$\operatorname*{Min}_{E} C = \alpha(N - E)^2 + (1 - \alpha)(E - R)^2$$

Given the above assumptions, this minimum is obtained at the point where $dC/dE = 0$ which yields the necessary (and sufficient) condition

$$-\alpha(N - E) + (1 - \alpha)(E - R) = 0$$

from which we obtain the function that determines the optimal level of service provision:

$$E = \alpha N + (1 - \alpha)R \qquad (2)$$

The first implication of the model is that the optimal level of expenditure of the regional government is an increasing function of expenditure needs and resources; more concretely, it is a weighted average of expenditure needs and resources. The greater the value of α, the closer will actual expenditure be to needs and therefore the larger the difference between E and R (i.e., the larger the public deficit), and vice versa. If $\alpha = 0$, expenditure will equal resources and the deficit will be zero.

The weighted average form of the expenditure function (2) does not depend on the assumption that the two coefficients of the total cost function (1) add up to unity, but rather on the way the variable E enters in that function. If instead of α and $(1 - \alpha)$ we had considered the positive fractions ϕ and φ, with $\phi + \varphi \neq 1$, the expenditure function would be $E = [\phi/(\phi + \varphi)]N + [\varphi/(\phi + \varphi)]R$ which is still a weighted average of N and R.

Subtracting R from both sides of (2) we have:

$$E - R = \alpha(N - R) \qquad (3)$$

The parameter α determines the fraction of the needs-resources gap (the NR gap) that is absorbed by the excess of expenditure over resources. In other words, α is the fraction of underfinance that is absorbed by borrowing. Also, subtracting N from both sides of (2) we have:

$$N - E = (1 - \alpha)(N - R) \qquad (4)$$

The parameter $(1 - \alpha)$, therefore, shows the extent to which the NR gap has been absorbed by the shortfall in actual expenditure with respect to needs; that is, the fraction of underfinance absorbed by a fall in service provision.

According to (3) and (4), the excess of expenditure over revenue and the shortfall of expenditure with respect to needs depend only on the NR gap. The particular levels of needs and

revenue do not matter. These are the strongest implications of this model of public expenditure. See also that (3) and (4) are not independent. An increase in the parameter α shifts the absorption of the NR gap away from service provision deterioration (and therefore decreases the political cost) and into more deficit and indebtedness (thus increasing the financial cost).

Figure 1 shows the main characteristics of the public expenditure function. Excluding the origin, we assume that, in the whole range of the function, $N > R$ and $E > R$. That is, the regional government is in a situation of insufficient finance and spends more than the amount of resources it has. Regarding the relative values of E and N, it is useful to draw the broken 45^0 line, along which $E = N$. In the area to the left of this line $E > N$, and the regional government incurs in debt and rises service provision. In the area to the right, on the other hand, it still incurs in debt but, given that $E < N$, service provision deteriorates. In the particular expenditure function drawn in Figure 1, we assume $0 < \alpha < 1$, thus the function falls into the area in which expenditure is both larger than resources (the regional government incurs in debt) and smaller than needs (service provision deteriorates), $R < E <$ N.

Figure 1
THE STRESS PUBLIC EXPENDITURE FUNCTION, EXPRESSION (2)
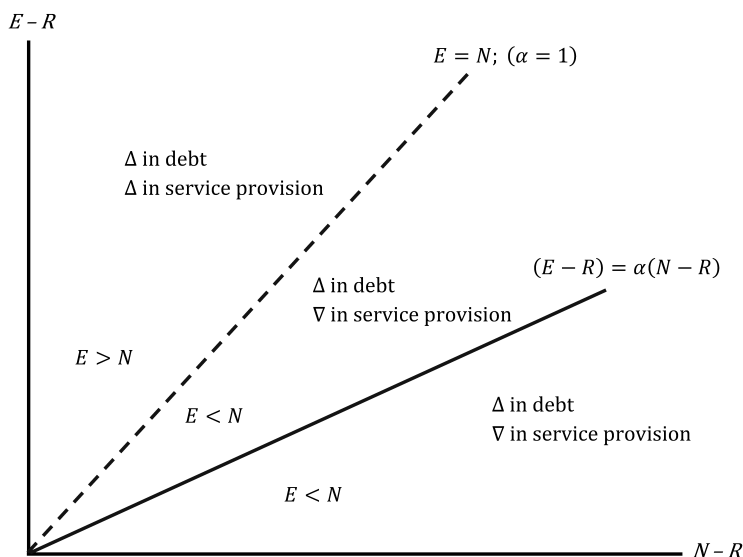
3. Empirical analysis

3.1. The data

We estimate the expenditure function using a panel of data on the fifteen common regime Spanish autonomous communities over the ten-year period that goes from 2007 to 2017.

In total there are seventeen autonomous communities in Spain: two "foral" communities –Basque Country and Navarre– and fifteen "common regime" communities –Catalonia; Galicia; Andalucía; Asturias; Cantabria; La Rioja; Murcia; Valencia; Aragón; Castile-La Mancha; Canary Islands; Extremadura; Balearic Islands; Madrid; and Castile and León. We restrict our analysis to the fifteen common regime communities because of the different regional finance systems that apply to the two groups. This yields 165 observations.

We begin the analysis in 2007 because this is the year when the official index of needs used in the regional system of finance first became available in its present form. And we take 2017 as the end of the period considered, because this is the year for which the most recent value of the index of needs and the last audited accounts of regional governments are available. Additionally, 2007 is a good starting point, because this is the year previous to the Great Recession and the last for which, at least for the aggregate of the fifteen regional governments, total revenue was very similar to total expenditure, and no significant pressure existed on them to increase their debt.

The variables considered in the analysis are the following:

Expenditure (E): Expenditure, which we denote by E, is measured by actual (audited) total public expenditure by regional governments. That is, non-financial expenditure (budget chapters I to VII) plus expenditure incurred in the purchase of financial assets (budget chapter VIII). The purchase of financial assets has been a relevant expense of autonomous communities principally through the subscription of shares of public enterprises, the participation into the capital of private enterprises and the issue of short and long term loans. Ignoring this chapter would result in an incomplete image of the expense of autonomous communities. Part of these expenses is genuine investment driven by the expectation of a commercial benefit, but most of them respond to the convenience offered by more flexible administrative forms of providing public services. The source is the Spanish Ministry of Finance and Public Administration, MINHAPF.[5]

Expenditure Needs (N): Needs are incorporated into the analysis by means of the official index of needs used in the regional finance system, *BOE* (2009). This index is a linear combination of seven regional need indicators: population (P); land area (LA); single administrative local entities, used as a measure of demographic dispersion ($DISP$); insularity (I); protected population, which is the total population legally entitled to receive assistance from the national health system (PP); 65 year old or older population ($P65$); and 16 year old or younger population ($P16$). Given that population is the dimension of the resulting index, the value of this index for year t and community i is called Adjusted Population, AP_i^t. For the initial year of the period considered, 2007, the index takes the following form:

$$AP_i^{07} = 0.3(P_i^{07}) + 1.5594(LA_i^{07}) + 4.2818(D_i^{07}) + 164.8441(I_i^{07}) +$$
$$0.3962(PP_i^{07}) + 0.5128(P65_i^{07}) + 1.2487(P16_i^{07}) \tag{5}$$

While the different variables that intervene in expression (5) are reasonable indicators of need, no justification is given in *BOE* (2009) about the weights attached to each of them.[6]

We could in principle have entered directly the need indicators as independent regressors in the expenditure function (2), but since the population indicators (P, PP, $P65$ and $P16$) are highly correlated between each other, this would have led us to quite unmanageable problems of multicollinearity. Because of this, in the empirical analysis of Section 3 we enter in the regressions the whole expression (5) and deal econometrically with the potential "errors in variables" problem that this course of action might pose.

To complement the above expression with an indicator of cost, we multiply (5) by the index of Public Administration hourly salaries compiled by the "Instituto Nacional de Estadística" (INE), W^t, which provides an annual (common) value for all fifteen autonomous communities and is defined in real terms, with $W^{07} = 1$. To arrive at the index of expenditure needs of community i, $N_i^{07\prime}$, we must also multiply (5) by the factor g introduced above in Section 2, which is nothing else than the expenditure per unit of need at which we want to calibrate the index of expenditure needs. That is,

$$N_i^{t\prime} = g A P_i^t W^t \tag{6}$$

where

$$g = \frac{E^{07}}{A P^{07} W^{07}} \tag{7}$$

E^{07} is, expressed in euros of 2010, the aggregate level of regional expenditure in 2007; AP^{07}, the aggregate level in 2007 of the Adjusted Population index defined in (5); and W^{07}, the base value, equal to unity, of the index of Public Administration hourly real salaries. Using (7), expression (6) can also be written as:

$$N_i^{t\prime} = E^{07} \left(\frac{A P_i^t}{A P^{07}} \right) \left(\frac{W^t}{W^{07}} \right) \tag{8}$$

This is the general method we follow to determine expenditure needs in regard to the common expenditure responsibilities for which the regional finance system is defined. However, in addition to these common responsibilities that all autonomous communities have, there exist a given set of specific additional responsibilities which vary significantly across regions. Examples of these particular responsibilities are, among others, the promotion of regional languages in Catalonia and Galicia, and regional police and the administration of prisons in Catalonia. Over the period that goes from 2007 to 2017, these particular responsibilities have represented 4.96% of total regional expenditure. Given that the calculation to determine the resources to cover these additional responsibilities is done on a case by case basis and outside the general mechanism of the regional finance system, a new approach has to be devised to calculate the needs associated to these specific responsibilities. Essentially, we assume that in 2007 these specific needs are 4.96% of total regional expenditure and are distributed across regions according to their average distribution over the whole 2007-2017 period. Then to the initial base formed by these specific expenditure responsibilities plus the rest of total expenditure needs, we apply the index of needs (8) to generate the remaining values for the years 2008-2017.[7] Following this procedure, this adjusted measure of expenditure needs, N_i^t, is

$$N_i^t = E^{07} \left[0.0496\beta_i + (1 - 0.0496)\frac{AP_i^{07}}{AP^{07}} \right] \left(\frac{N_i^{t\,'}}{N_i^{07\,'}} \right) \tag{9}$$

where β_i is, for region i and the period 2007-2017, the average share of the resources assigned to specific responsibilities, and the unadjusted index of expenditure needs $N_i^{t\,'}$, is defined in (8).

Revenue (R): We take resources to be the actual total revenue coming either from own regional taxes, ceded taxes, transfers from the regional finance system or obtained from other origins such as the sale of financial assets (budget chapters I to VIII). The data on resources comes from the same source as the data on expenditure: the Spanish Ministry of Finance and Public Administration, MINHAPF.

It is important to remark that the expenditure and revenue variables are both adjusted for the financial intermediation that autonomous communities undertake between the central government and the local governments of their respective community. This intermediation does not represent either expenditure or revenue of the autonomous communities and it is therefore justified to ignore it in the present exercise. Since the amount of this intermediation appears both in the expenditure and revenue sides of the accounts, this adjustment has no effect regarding the deficit or the level of debt of autonomous communities.

In principle, the model presented in Section 2 predicts that in a situation of financial stress, needs and revenue are the only determinants of expenditure. This, however, should be taken as a *ceteris paribus* prediction. If contextual conditions relevant to the behaviour of regional governments change over time, the identification of parameter α may require that these changes are controlled for. The control variables that we use are the following ones:

Normative Public Budget Balance (NBB): In order to control the rise of public debt of Spanish regional governments a required minimum public budget balance has been established by the Law of Financial Stability[8]. In 2007 the average required balance was a mere 0.1% of regional GDP; in 2010, this requirement had been raised to 2.3% and in 2017 reduced to 0.6%. In previous research (see, for instance, Delgado-Téllez *et al*., 2016) this variable has been used to study the deviations of actual over normative balances. In our case, the role we want this variable to play is exclusively that of a control factor of regional expenditure. Therefore, rather than working with the deviations of actual over normative balances, which would introduce an endogeneity bias into our analysis, we define this variable only in terms of the normative budget balance prescribed by the regulator. To the extent that this control mechanism works, we would expect this variable to have a negative effect on regional expenditure. The higher the normative budget balance (the more strict the regulation is), the lower should regional expenditure be. We take this variable directly from the annual compliance report submitted by the Ministry of Finance and Public Administration to the Economic and Financial Council.[9] The variable is expressed in (million) euros of 2010.

Rate of Regional Unemployment (U): This is obtained from the INE (Instituto Nacional de Estadística). In principle, regional expenditure should be positively related to *U*. Unem-

ployment acts here as a need indicator additional to those considered in *N*. High levels and a longer duration of unemployment must necessarily lead to an increase in the number of workers who are, both, without work and not covered by the unemployment insurance service[10]. In these circumstances, the expenditure of regional governments, which are responsible for social assistance services, is likely to increase. Indeed, in such a case, social assistance is about the only alternative left to these workers.

Regional Debt over Regional GDP (DOY): also obtained from INE. Regional expenditure is expected to be negatively related to *DOY*. *NBB* and *DOY* are in a sense playing the same potential role in the expenditure function: both act as warning signals of excessive debt by the part of a regional governments. *NBB* is an exogenous warning issued as a norm by the central government, and *DOY* an endogenous signal originated by the own behaviour of the regional government.

Financial Assistance (FA): *FA* is expressed in (million) euros of 2010 and the source is Ministerio de Hacienda (2019). Since 2012 the central government has provided financial help to the autonomous communities either through extraordinary mechanisms such as the Liquidity Fund for Autonomous Communities and the Fund for Suppliers, or other liquidity mechanisms such as financial advances and extensions and preferential liquidity lines form the Instituto de Credito Oficial (ICO). Towards the end of the period analysed some autonomous communities reached a situation in which, without the assistance of the central government, would have not been able to repay their debt. This assistance has been significant: In the six years that go from 2012 to 2017 the central government lent to the common regime autonomous communities resources amounting to 35.4% of their total revenue to prevent them from incurring in default. The effect of this variable on regional public expenditure is *a priory* uncertain. If regional governments take this assistance as a permanent and unconditional enlargement of their resources, their effect on regional public expenditure should be positive. However, if they take it as evidence of the critical stage reached regarding their financial situation, the effect on expenditure may be negative.

In the regressions shown below, all variables are expressed in ratios or in (million) euros of 2010.

3.2. Overview of period 2007-2017

Table 1 and Figure 2 present for the period 2007-2017 and for the aggregate of the fifteen common regime Spanish autonomous communities the data discussed in the previous section: in particular, data on *N*, *R* and *E*.

The aggregate level of *N* (the sum of the fifteen autonomous communities) in 2007 is by design equal to aggregate actual expenditure in that year. From then on, *N* varies over time according to the variation of the index of expenditure needs defined in expression (8) and is therefore determined by the change of both the demographic indicators and the index of public administration hourly salaries. Over the whole period, demographic indicators increased

at an annual average rate of 0.69%, while the index of expenditure needs increased at an average rate of 0.62%. The increase of N up to 2009 was caused principally by the upward pressure of hourly Public Administration salaries during the worst years of the crisis, probably due to inertial elements present in the negotiating practices of civil servant unions and the corresponding administrations, but in the following years this pressure eased down until 2014, it reappeared in 2015 and 2016, and eased again in 2017.

Table 1
EXPENDITURE NEEDS (N), REVENUE (R) AND ACTUAL EXPENDITURE (E)
ALL "COMMON REGIME" AUTONOMOUS COMMUNITIES
YEARS 2007-2017 (2010 million €)

	N	R	E
2007	135,050	135,099	135,050
2008	141,921	134,336	146,078
2009	147,868	139,057	156,091
2010	148,780	121,832	145,472
2011	146,821	114,606	139,963
2012	140,492	112,663	143,120
2013	140,007	112,581	130,117
2014	140,444	111,059	131,102
2015	143,724	114,440	135,364
2016	144,620	121,517	131,578
2017	143,671	127,716	135,354

Source: MINHA (various years) and own calculations.

Figure 2
EXPENDITURE NEEDS (N), REVENUE (R) AND ACTUAL EXPENDITURE (E)
ALL "COMMON REGIME" AUTONOMOUS COMMUNITIES
YEARS 2007-2017, (2010 million €)
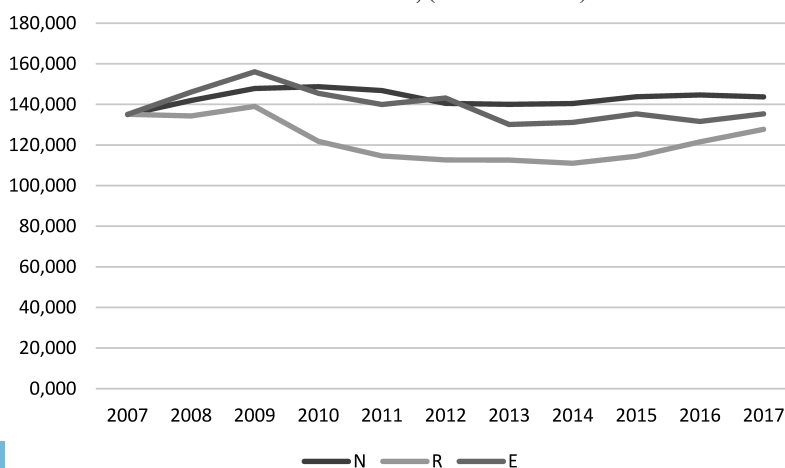
Regarding revenue, *R*, account must be taken of the fact that the regional finance system plays an important role in determining over time the amount of resources put at the disposal of regional governments, but also that the actual timing of the intakes depends crucially on: i) the timing of the revision of the regional finance system, which in principle should take place every five years; ii) the advance payments mechanism; and iii) the updating rules attached to the regional finance model. The final audited accrued value of resources that results from the finance system is known with a delay of two years. In the interim, regional governments have to do with advances of the corresponding transfers that are calculated on the basis of: i) forecasts of the revenue of those ceded taxes that are administered by the central government and of those national taxes whose base is shared; and ii) the updating mechanism of the finance model, which is based on the temporal evolution of the main national tax figures.

Despite the significant fall of tax revenue that took place in 2008 and 2009, we see that in these years the actual amount of resources put at the disposal of autonomous communities either decreased much less than tax revenue or, particularly in 2009, experienced a significant increase (-0.56% in 2008 and 3.51% in 2009). This happened for two reasons: first, the optimistic forecasts of tax revenue on which the advance payments were calculated; and second, the receipt of the first instalment of the additional resources associated to the reform of the finance system in 2009. By 2010 and 2011 the severity of the crisis had already been acknowledged, and the advance payments of those years were based on tax revenue forecasts much more accurate than those of 2008 and 2009. This, together with the correction of the forecast errors of 2008 and 2009, explains the huge fall of revenue in these years: -12.39% in 2010 and -5.93% in 2011. The severity of the fall of resources in 2010 was such that completely obliterated the second instalment of the 2009 reform of the finance system that was paid in 2010.[11] The rest of the period was less eventful, but the protracted effects of the crisis lasted until 2014 and it was only in 2015 that the first increase of revenue since 2009 took place.

Autonomous communities have a certain amount of taxing capacity, but this capacity is only exercised to a very limited extent. In 2017, for instance, the normative decisions on rates and base definition taken by autonomous communities on the Personal Income Tax (PIT) had a very minor, positive effect on actual tax revenue: 0.1% of total PIT revenue. The largest increase in revenue was that of Extremadura (6.5%) and the largest decrease that of Madrid (-4.8%). Out of the fifteen communities, ten increased revenue by an average of 2.7%, and five decreased revenue by an average of -4.1%. Also, due to the updating mechanism of the system of regional finance, between 2009 and 2017, 79.8% of the variation of the total amount of resources that the system put in the hands of regional governments (transfers and own tax revenue) is explained by the variation of national aggregates of tax revenue (both, directly through the variation of PIT, VAT and Excises revenue; and indirectly, through the variation of an updating index –the so called ITE– which is based also on these national aggregate tax figures); and only 14.7% by the variation of their own taxes (the main ones are, Tax on Wealth, Inheritance and Gift Tax, Capital Transfer Tax, Stamp Duties, Vehicles Excise and Electricity Tax).[12] Therefore, be it because of the limited amount of resources on which autonomous communities can operate, the low tax activism of regional governments or the strong dependence of regional resources on the variation of aggregate national tax figures, it

is more realistic to characterize revenue as a predetermined variable than to assume that it is under the control of regional governments. But if these considerations, which are quite general, were not sufficient, it is certainly the case that in the very particular 2007-2017 period, the 2008/2009 crisis took away whatever minimal capacity regional governments may have had to effectively steer the variation of their resources.

One of the two referees of this paper (Referee 1) points out that, given that there is a margin of fiscal autonomy as far as regional revenue is concerned, it would be interesting to see the theoretical implications of relaxing the assumption of exogeneity of the revenue variable in the model of Section 2. Rather than modifying the model, we take up on this suggestion correcting (by means of an instrumental variables method) the possible endogeneity bias that would appear if we estimated the revenue effect only with an Ordinary Least Squares (OLS) method. As can be seen below (Table 8), the differences between the OLS and IV estimates of the revenue effect on public expenditure are not overwhelming.[13] Regarding the model, we acknowledge that the exogeneity assumption of revenue, while instrumental in order to simplify the theory and sharpen its predictions, does not fully agree with reality. But models, if they are to be useful tools of analysis, must reduce reality to its essential features, and we would like to argue that, as discussed above, this assumption, in the context of the severe crisis generated by the Great Recession, is not devoid of empirical content. So much so, that to take the opposite strand and assume that revenue, along with expenditure, is a choice variable of regional governments is likely to do even more violence to reality than our exogeneity assumption does. After 2007/2008, with the national economy falling down dramatically, no regional government could effectively decide the amount of its revenue, even making full use of the limited set of instruments that the finance system puts at its disposal. Finally, it is worth remarking that, as we can see below (Section 3.4), the strong predictions that this simple model yields cannot be rejected by the data.

The last comment on Figure 2 concerns expenditure. It is remarkable that in 2008 and 2009 actual expenditure exceeded expenditure needs and therefore went outside the gap between expenditure needs and revenue. Despite the onset of the crisis and the evidence they may have had from the behaviour of those taxes under their direct administration, regional governments, perhaps misguided by the additional resources that came from the 2009 reform of the regional finance system, or still under the effects of the euphoria of the expansion up to 2007, went on a practical spree of expenditure in these two years.[14] For them the crisis, let alone the perception of a situation of financial stress, apparently was not visible. And this was quite general: in 2008 and 2009, expenditure was below expenditure needs only in two (Valencia and Madrid) out of the fifteen autonomous communities. Eventually, however, the sense of crisis and financial stress predominates, particularly from 2010 onwards, with actual expenditure keeping by and large within the limits set by expenditure needs and revenue.

The positive relationship between the expenditure-revenue gap (*ER* gap) and the needs-revenue gap (*NR* gap), which is the essential prediction of the model –equation (3)– shows up quite clearly in the data. An aggregate impression of this fact can be seen in Figure 3. The top graph, Panel 3(A), shows the time series of the aggregate of all 15 regions, a representation of the within-variation of the present set of data, and the bottom graph, Panel

3(B), shows the regional cross section of the sum of all 11 years, which represents the be-
tween-variation of the data.

Figure 3
TWO PERSPECTIVES (WITHIN AND BETWEEN VARIATIONS) OF THE
ER **GAP VS.** *NR* **GAP RELATIONSHIP**
(Percentages)

(A) All regions, year by year

$y = 0{,}6604x + 2{,}4583$
$R^2 = 0{,}6805$
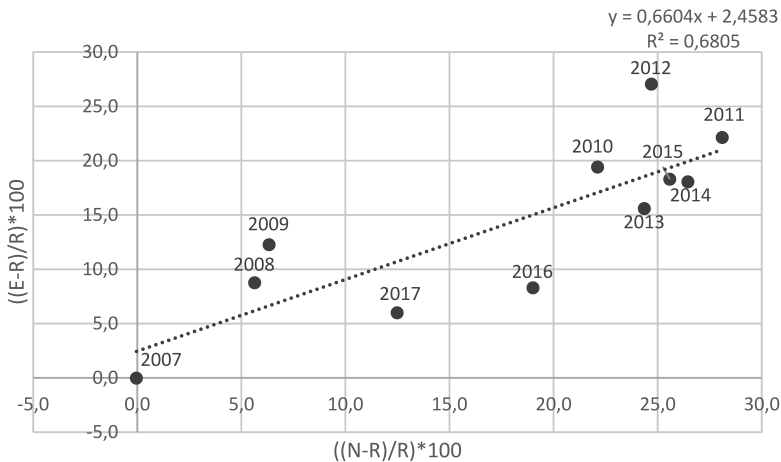
(B) All years, region by region

$y = 0{,}3899x + 8{,}0253$
$R^2 = 0{,}4633$
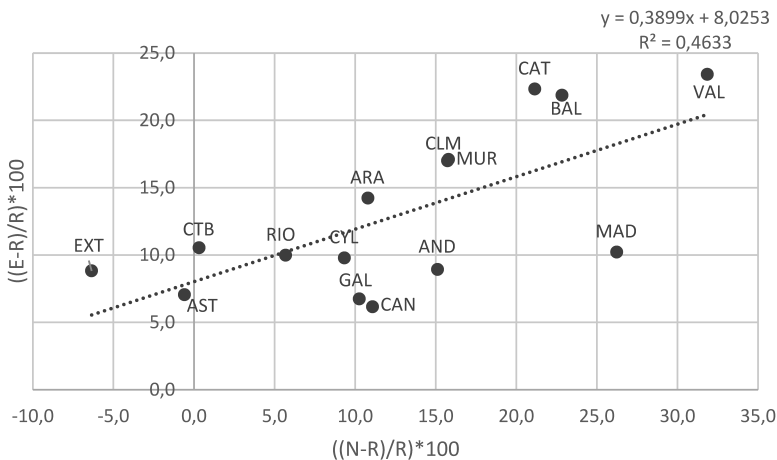
As the tendency lines show, both arrangements of the data present the same structure: a
positive relationship between the *ER* and the *NR* gaps, which is what the theory predicts. The
within-region variation and the between-region variation contribute in the same qualitative

manner to the identification of the *ER* gap / *NR* gap relationship. There is no evidence, there-fore, of the existence of systematic discrepancies in the direction of the relationship between these two dimensions, such as the ones considered in Hsiao (2014, pp. 10-12).

The complete set of data comes out either from the expansion of each of the 11 points of the top graph into the cross section of the 15 regions correspo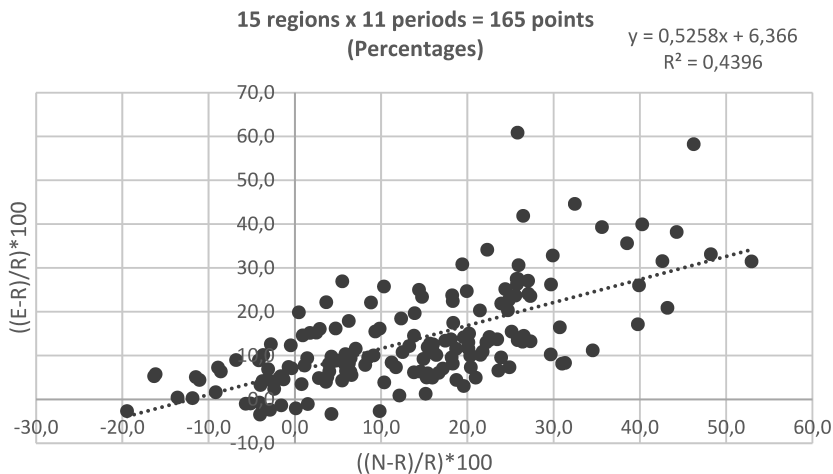nding to that year or, alterna-tively, from the expansion of each of the 15 points of the bottom graph into the time series of the 11 years of the corresponding region. Any of these two alternative routes yields the full set of 165 points shown in Figure 4.

Figure 4
FULL VARIATION IN THE *ER* GAP VS. *NR* GAP RELATIONSHIP. YEARS 2007-2017
(Percentages)

The two tendency lines attached to each of the panels of Figure 3 show the congruence between the within-variation and the between-variation of the data. Also, the similar pattern of these two particular aggregate representations and the overall disposition of the 165 points that constitute the full sample (Figure 4) confirms this congruence at the individual level. In all cases, we have a positive relationship between the *ER* gap and the *NR* gap. The extent of the variation in the full expansion of Figure 4 is naturally larger than that of the two graphs of Figure 3, but that does not alter the positive association of the two variables.

Finally, it is interesting to notice in Panel 3(B) the fairly large range that the degree of underfinance (the *NR* gap) takes across regional governments. The crisis has not affected equally all autonomous communities.[15] As Figure 5 shows, the level of underfinance aggre-gated for the whole period 2007-2017, measured by the percentage of the *NR* gap respect the total amount of resources, ranges from a maximum of 31.9% for Valencia to a minimum of -6.4% for Extremadura. Only two regional governments, Asturias and Extremadura, had a surplus of resources relative to needs, while the other thirteen experienced, in varying de-

grees, a situation of underfinance. It is precisely the association between the variability in the degree of underfinance and the corresponding variability in the expenditure decisions of regional governments, the circumstance that allows us to test empirically the theory developed in Section 2.

Figure 5
THE *NR* GAP AS PERCENTAGE OF RESOURCES, [(*N* − *R*)/*R*]*100. YEARS 2007-2017
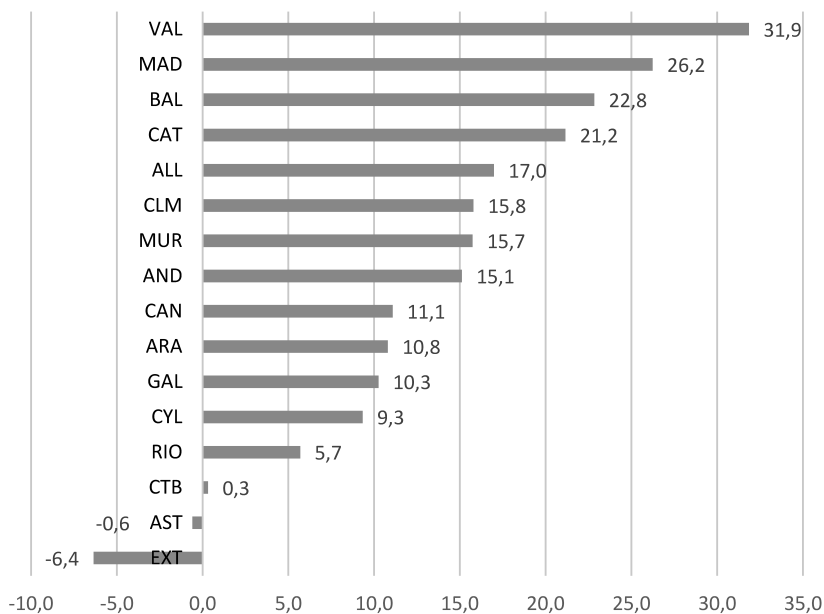
3.3. Empirical specification

Our point of departure is expression (2), which, adding to it a constant, *c*, and without the restriction that the two coefficients should add to unity, reads:

$$E_{it} = c + aN_{it} + bR_{it} + \varepsilon_{it} \tag{10}$$

where a is the estimate of α, b the estimate of $(1 - \alpha)$ and ε_{it} the error term of the regression. The theory is not rejected by the data if in (10): i) the constant c is not significantly different from zero; ii) a and b are both positive fractions, $a > 0$ and $b > 0$, and significant; iii) their sum is not significantly different from unity, $a + b = 1$; and iv) no other variables enter as relevant determinants of regional expenditure.

Expression (10) can easily be transformed into an expression that explains the public budget deficit. If in (10) we subtract R_{it} from both sides, and add and subtract aR_{it} from the right-hand side, we obtain

$$E_{it} - R_{it} = c + a(N_{it} - R_{it}) - [1 - (a + b)]R_{it} + \varepsilon_{it}. \tag{11}$$

The estimation of (11) gives the same results as the ones obtained with (10), since (11) is a mere arithmetical transformation of (10). The interest of this transformation is to highlight the point that the explanation of expenditure in terms of needs and revenue given by (10) is in fact also an explanation of the public deficit in terms of the said variables. If on the base of the estimates of (10) the theory is not rejected, then in (11), necessarily: i) the constant c will be not significantly different from zero; ii) a, the coefficient of the *NR* gap, $(N_{it} - R_{it})$, will be a positive fraction and significant; and iii) $[1 - (a + b)]$, the coefficient of R_{it}, will be not significantly different from zero.[16]

3.4. Results

In the regressions that follow, the statistical significance of the estimates is computed with robust errors. Variables *N* and *R* are in principle predetermined. However, the consideration of needs in terms of linear combination (5) with its politically determined weights, rather than in terms of each of the seven indicators of needs separately considered, could involve a problem of "errors in variables". To address this problem, and the potential endogeneity of revenue discussed above, we also present instrumental variables (IV) estimates. The use of IV estimates is further justified given the consideration of the four control variables, *NBB*, *DOY*, *U* and *FA*. Except for the unemployment rate, *U*, the other three controls are open to possible problems of endogeneity, although there are reasons (or transformations of the respective variables) that could also justify their exogeneity. The normative budget balance, *NBB*, is determined by the central government –that is, outside the sphere of action of regional governments– and this would lead us to believe that this is an exogenous variable. But it is also possible that in the process of determination of this requirement, the central government is influenced by the actual financial situation of regional governments in order to make their compliance feasible and therefore more effective. In such case, the *NBB* variable should be considered endogenous.[17] The variable debt over GDP, *DOY*, is clearly endogenous, particularly if we consider its current value. The change in annual debt is determined by the change in the regional's government deficit, which, together with revenue, is determined by expenditure, our dependent variable. The value of *DOY* lagged one year, *DOY*(-1), however, converts this variable in predetermined and presumably exogenous.[18] *FA*, Financial Assistance, is also a variable that in principle we would take as clearly endogenous, since this help is obviously called for when financial problems (that is, large deficits) arise in regional governments. But on closer inspection we see that its actual amount depends to a very large extent on the particular calendar of debt repayments or of bills due to suppliers, which vary considerably across regional governments and make the amounts received quite independent of their expenditure policy. Given this ambiguity, and in order to see to what extent they can be used as instruments, we test below whether the variables *NBB*, lagged *DOY* and *FA* are statistically exogenous and can thus be used not only as explanatory variables, but also as instruments.

We first present, in Table 2, regression 1, the results of estimating specification (10) by Panel Least Squares (Panel LS) and with no fixed effects. As a reference, it is useful to see

how well the predictions of the theory stand, assuming the exogeneity of all the explanatory variables and without considering any difference across regions or over time as far as their spending behaviour is concerned. Regression 1 is the simplest specification possible, with only the constant, the two independent variables, N and R, suggested by the model and the four controls, *NBB*, *DOY*(-1), *FA* and *U*. Despite the simplicity of the specification, the results are not at all bad. The constant is, as the theory predicts, insignificant. The estimates of parameters a and b are, also as the theory predicts, significant positive fractions, 0.3485 and 0.6421 respectively, and their sum, as indicated by the Wald test, is not significantly different from unity. The distribution of the errors of the equation, as indicated by the test of the equality of the variance of errors, does not suggest the presence of heteroskedasticity problems. The only problem with this regression is the low value of the Durbin-Watson statistic, which might indicate the presence of specification problems regarding the dynamic structure of the equation. Regarding the four control variables, the normative budget balance, *NBB*, takes the expected negative sign (it exerts the predicted restraint on public expenditure) and is significant. The effect of financial assistance, *FA*, is positive (it allows regional governments to spend more) and also significant. In this simple specification, the two other controls, *DOY*(-1) and *U*, do not have, statistically, any effect on expenditure.

Regression 2 repeats the specification, but now adding both cross-section and period fixed effects. The specification is not accepted by the data. While cross-section effects are shown to be jointly significant, period fixed effects are jointly insignificant (using the redundant fixed effect test, the p-value is 0.0000 for cross-section fixed effects and 0.1344 for period fixed effects). We thus discard the consideration of period fixed effects, and in regression 3 we show the estimates of the expenditure function with only cross-section fixed effects. The constant is not significantly different from zero, the estimates of a and b are both positive fractions (0.6128 and 0.6168) and significant, and their sum is not significantly different from unity. Except for the financial assistance variable, *FA*, which is not significant, the other three controls take the expected sign and are all significant at least at the 10 per cent level. *NBB* and *DOY*(-1) both exert the expected restraining effect on regional expenditure; the first with a significance level barely above the 5 per cent level (p-value of 0.0588) and the second with a significance level below the 1 per cent level (p-value of 0.0000). The unemployment rate, *U*, elicits more public expenditure (it acts as an indicator of needs, additional to those considered in the variable *N*) and again is practically significant at the 5 per cent level (p-value of 0.0507). Finally, with respect to regression 1, the presence of cross-section fixed effects improves notably the Durbin-Watson statistic (1.6211 versus 1.1489).

Interesting as they are, these results present two problems: The first is the relatively low value of the Durbin-Watson statistic, which suggests that the dynamic specification of the model may not be adequate. We deal below with this problem investigating to what extent there is inertia in the public expenditure decisions of regional governments. The second is the potential bias of endogeneity that the OLS estimates of Table 2 may contain. As discussed above, only one of the six explanatory variables –namely, the rate of unemployment, *U*– is clearly exogenous.[19] We have reasons to maintain that *DOY*(-1) is also a predetermined variable, but before presenting the IV estimates of the expenditure function we must check statistically on the endogeneity/exogeneity of the remaining controls: that is, *NBB* and *FA*.

Table 2
ESTIMATES OF THE EXPENDITURE FUNCTION
Method: Panel Least Squares
Periods: 11 years (2007-2017)
Cross-sections: 15 Autonomous Communities

	Dependent variable:		
	E_{it}		
Regression number	1	2	3
c-s/period fixed effects	No/No	Yes/Yes	Yes/No
Number of observations	165	165	165
Constant	295.35	245.31	-2,009.18
	(0.1896)	(0.9503)	(0.4859)
N_{it}	0.3485	0.4238	0.6128
	(0.0221)	(0.1977)	(0.0218)
R_{it}	0.6421	0.6070	0.6168
	(0.0001)	(0.0017)	(0.0002)
NBB_{it}	-0.7151	-0.5669	-0.3942
	(0.0046)	(0.0264)	(0.0588)
DOY_{it-1}	-10. 4844	-26.3629	-39.9246
	(0.2649)	(0.3564)	(0.0000)
FA_{it}	0.1208	0.0433	0.0729
	(0.0383)	(0.5396)	(0.2251)
U_{it}	-2.8336	-0.0509	32.3756
	(0.7466)	(0.9988)	(0.0507)
$\bar{R}^2$	0.9885	0.9929	0.9927
DW	1.1489	1.6685	1.6211
Test unitary sum coefficients N & R	(0.7551)	(0.9384)	(0.4533)
Test equality variances of errors	(0.2658)	(0.2061)	(0.6933)
Fixed effects test			
Cross-section		(0.0000)	(0.0000)
Period		(0.1344)	

P-values in parenthesis. All variables are expressed in real terms (euros of 2010).

All regressions are estimated with White robust standard errors and covariance (d.f. corrected).

The null hypothesis of the test for the unitary sum of the coefficients on N_{it} and R_{it} (Wald test) is H_0: $-1 + C(2) + C(3) = 0$, where $C(i)$ is the ith estimated coefficient, including the constant.

The test value for the equality of variances of errors is that of Bartlett. In all cases, the values of the Levene and Brown-Forsythe tests consistently give the same qualitative result.

The 165 observations correspond to those generated for 15 autonomous communities during the period 2007-2017.

We take regression 3 of Table 2 as the reference on which to perform the regression-based test of endogeneity (Wooldridge, 2016) of the controls, *NBB* and *FA*. Under the maintained assumption that these variables are endogenous, we first regress by Panel LS, with robust errors and with cross-section fixed effects (the method of estimation used in regression 3 of Table 2), each of the two controls, *NBB* and *FA*, on the remaining instruments and save the

residuals of each regression. We call these residuals, respectively, *RESNBB* and *RESFA*. Table 3 shows the results of adding these two new variables to regression 3 of Table 2. The Wald test of joint significance yields a value of the Chi squared distribution (1.2809) which, with two degrees of freedom is strongly insignificant (p-value 0.5271). The evidence in favour of joint exogeneity of *NBB* and *FA* is therefore overwhelming: it cannot be rejected with a 52.7% level of confidence.

Table 3
TEST OF ENDOGENEITY OF *NBB* AND *FA*
Method: Panel Least Squares
Periods: 11 years (2007-2017)
Cross-sections: 15 Autonomous Communities

	Dependent variable:
	E_{it}
C-s fixed effects	Yes
Number of observations	165
Constant	-1,246.79
	(0.7510)
N_{it}	0.5796
	(0.0730)
R_{it}	0.5626
	(0.0020)
NBB_{it}	-0.4497
	(0.3072)
DOY_{it-1}	-31.5841
	(0.0150)
FA_{it}	0.0206
	(0.7751)
U_{it}	28.9373
	(0.2146)
$RESNBB_{it}$	0.0810
	(0.2628)
$RESFA_{it}$	0.0636
	(0.9124)
$\bar{R}^2$	0.9937
DW	1.5992
Wald test of joint significance H_0: $C(8) = 0$, $C(9) = 0$	
$\chi^2(2)$	(0.5271)

Table 4 presents the Dynamic Panel GMM (DP GMM) estimates (Arellano and Bond, 1991), using first differences (FD) as a transformation to remove cross-section fixed effects, a White period instrument weighting matrix and White period standard errors and covariance (d. f. corrected). The specification, to test possible inertia effects in the expenditure decisions

of regional governments, includes the lagged dependent variable, E_{it-1}, as an explanatory variable, additional to the whole set of right hand side variables considered in Table 2.

Table 4
ESTIMATES OF THE EXPENDITURE FUNCTION. TOTAL BUDGET OPERATIONS
Method: Dynamic Panel GMM (DP GMM)
Transformation: First Differences (FD)
Periods (adjusted): 9 years (2009-2017)
Cross-sections: 15 Autonomous Communities

	Dependent variable:		
	E_{it}		
Regression number	1	2	3
Number of observations	135	135	135
E_{it-1}	0.1376	0.0803	0.1001
	(0.0000)	(0.0001)	(0.0000)
N_{it}	0.3058	0.4374	0.4622
	(0.0000)	(0.0000)	(0.0000)
R_{it}	0.5295	0.4142	0.3915
	(0.0000)	(0.0000)	(0.0000)
NBB_{it}	-0.0880	-0.0302	
	(0.0127)	(0.2839)	
DOY_{it-1}	-55.7930	-77.8541	-76. 2893
	(0.0000)	(0.0000)	(0.0000)
FA_{it}	0.0654	0.0713	0.0816
	(0.0000)	(0.0002)	(0.0000)
U_{it}	19.1001	9.0701	
	(0.0000)	(0.1694)	
J	7.7902	10.6261	12.1507
Instrument rank	15	15	15
Test unitary sum coefficients N & R	(0.5128)	(0.0826)	(0.0800)
Test equality variances of errors	(0.7358)	(0.2774)	(0.2602)
Test over-identification restrictions	(0.4542)	(0.2238)	(0.2751)

(P-values in parenthesis. All variables are expressed in real terms (euros of 2010).

All regressions are estimated with White robust standard errors and covariance (d. f. corrected).

The null hypothesis of the test for the unitary sum of the coefficients on N_{it} and R_{it} (Wald test) is H_0: $-1 + C(1) + C(2) + C(3) = 0$, where $C(i)$ is the ith estimated coefficient.

List of instruments regression 1: @DYN(ET, -2) H H16 H65 PH DISP SAL YR U NBB DOY(-1) FA.

List of instruments regressions 2 and 3: @DYN(ET, -2) H H16 H65 PH DISP SAL YR U NBB FA.

Instruments H to DISP are need indicators of the Adjusted Population index defined in Section 3.1 and shown in expression (5) above.

The test value for the equality of variances of errors is that of Bartlett. In all cases, the values of the Levene and Brown-Forsythe tests consistently give the same qualitative result.

In regression 1, consistently with the results obtained above and under the maintained assumption that *DOY*(-1) is exogenous, we treat controls *NBB* and *FA* as exogenous variables and therefore include them into the list of instruments. There is inertia in regional government's behaviour regarding public expenditure, but the effect is not very large: last year expenditure explains less than 14% of this year expenditure. Furthermore, the presence of this lagged effect does not alter qualitatively the OLS results of Table 2. The long run estimate of *a*, the estimated coefficient of *N* divided by (1-0.1376), is 0.3546, a bit higher than the estimate of *a* in regression 1 of Table 2 (0.3485), but lower than the corresponding estimates of regressions 2 and 3 of that table (0.4238 and 0.6128 respectively). The prediction of the theory that $a + b = 1$ is again not rejected by the data in this dynamic specification. To be comparable with the results of Table 2, the null of the Wald test in this case has to be formulated in terms of the long term values of *a* and *b*, which implies that the sum of the two estimates has to be statistically equal to 1-0.1376; that is, equal to 0.8624. Or alternatively, that the sum of the coefficients of the lagged dependent variable, needs and revenue has to be equal to 1. That is, $H_0: 1 - C(1) - C(2) - C(3) = 0$. As can be seen from the p-value of 0.5128 shown in the third row from the bottom, the data cannot reject the null of the Wald test. The four controls are highly significant. The normative budget balance, *NBB*, and the lagged ratio of debt over GDP, *DOY*(-1), both act as warning signals of stress that restrict regional public expenditure. Financial assistance, *FA*, is seen as an increase of resources by regional governments and has a positive impact on expenditure. And the rate of unemployment, *U*, adds an additional criterion of need and rises public expenditure.

The variance of the errors of the regression do not show significant differences across regions and over time. The test of over-identifying restrictions is carried out with the *J*-statistic (Hansen, 1982), which is distributed as a Chi-squared distribution. This is essentially a test of specification. If the value of *J* is sufficiently large, it means that the orthogonality condition is likely to be false and that there is evidence of endogeneity of some of the instruments (Hayashi, 2000). For regression 1, the relevant p-value of the chi-squared distribution, with 8 degrees of freedom (the excess instruments over estimated parameters), is 0.4542. Thus the data fail to reject the null that the set of instruments satisfy the orthogonality condition and are therefore relevant.

We now check how results would change if, instead of assuming that *DOY*(-1) was exogenous as is done in regression 1, our maintained assumption was that this variable was endogenous and therefore could not be used as an instrument. It easy to check that this new maintained assumption does not alter the qualitative result of the test of endogeneity/exogeneity of *NBB* and *FA*: statistically they both keep being exogenous variables[20]. Regressions 2 and 3 repeat the estimation of the equation excluding *DOY*(-1) from the instrument list. The *J*-statistics of both regressions, although slightly higher than that of regression 1, are perfectly acceptable. The estimates of *a* increase significantly (in long term values, to 0.4756 and 0.5136 in regressions 2 and 3 respectively versus 0.3546 in regression 1), and the unitary sum condition cannot be rejected in either regression. The effects of the control variables have the same sign as in regression 1, but *NBB* and *U* cease to be significant in regression 2 and are excluded in regression 3. In both regressions the variance of the errors behaves satisfactorily

and, although the p-values of the tests for the over-identification of restrictions are lower than in regression 1, they still cannot reject (by a comfortable margin) the null that the instrument set is statistically relevant.

3.5. Robustness checks

As discussed in Section 3.1, the analysis so far has been conducted in terms of the most comprehensive measure of budget operations: total expenditure and total revenue. As a robustness exercise, we check how the above results change if we consider more narrowly defined budget operations: we present in this section results on the determinants of primary expenditure and non-financial expenditure. Non-financial expenditure is simply total expenditure less the purchase of financial assets; and primary expenditure is non-financial expenditure less interest charges. The independent needs and revenue variables in each of these two cases are as follows. When the dependent variable is non-financial expenditure, the needs variable is given by expression (9) above, only that E^{07}, instead of being total expenditure, is now the aggregate level of non-financial expenditure in 2007; and the revenue variable is simply non-financial revenue (that is, total revenue less the sale of financial assets). When the dependent variable is primary expenditure, the needs variable is again given by expression (9), only that E^{07} is now the aggregate level of primary expenditure in 2007; and the revenue variable is the amount of non-financial revenue left over once the resources needed to pay interest charges have already been taken away –that is, the amount of resources available to finance primary expenditure needs.

Regressions 1 and 2 of Table 5 show Panel LS estimates for primary and non-financial operations, respectively. None of predictions of the model are rejected by the data, whether we consider primary or non-financial expenditure. The estimate of the parameter a is in both cases higher than that found in Table 2 for total expenditure (0.7058 and 0.6787 for primary and non-financial expenditure respectively versus 0.6128 for total expenditure –regression 3 of Table 2), and the restriction $a + b = 1$ is also accepted by the data. As far as the control variables are concerned, qualitative results are also very similar to those obtained for total expenditure, including the non-significance of the estimated coefficients of *NBB* and *FA*. Finally, in none of the two equations, as it is the case with the regressions of total expenditure, does the distribution of errors suggest the presence of problems of heteroskedasticity.

Similar considerations can be made regarding the Dynamic Panel GMM results. Out of the two options used in the case of total expenditure, in the present illustration we assume that, along with *NBB* and *FA*, *DOY*(-1) is exogenous. In general, and with one exception, the results are very similar to those obtained for total expenditure. The exception is that in regression 3 (primary expenditure) the data reject the unitary sum of the estimates of *a* and *b*. However, when in regression 4, the non-significant *U* variable is omitted, the data, as is the case with total expenditure, fails to reject the unitary sum restriction imposed by the theory. The tests of equality of variances of errors and of the over-identification restrictions, as it was the case with total expenditure, show that the nulls of equality of variances of errors and of adequacy of instruments cannot be rejected by the data.

Table 5
ESTIMATES OF THE EXPENDITURE FUNCTION. PRIMARY AND NON-FINANCIAL OPERATIONS

	Dependent variable:				
	E_{it}				
Regression number	1	2	3	4	5
Budget operations	Primary	Non-Financial	Primary	Primary	Non-Financial
Method of estimation	Panel LS	Panel LS	DP GMM	DP GMM	DP GMM
c-s fixed effects	Yes	Yes			
Transformation			FD	FD	FD
Number of observations	165	165	135	135	135
$Constant$	3,186.13	3,175.24			
	(0.1627)	(0.1886)			
E_{it-1}			0.0796	0.0926	0.1094
			(0.0136)	(0.0006)	(0.0000)
N_{it}	0.7058	0.6787	0.4503	0.4496	0.3916
	(0.0039)	(0.0063)	(0.0000)	(0.0000)	(0.0000)
R_{it}	0.6586	0.6712	0.5621	0.5392	0.5374
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
NBB_{it}	-0.3203	-0.3331	-0.0889	-0.0969	-0.0527
	(0.1210)	(0.1123)	(0.0318)	(0.0376)	(0.0348)
DOY_{it-1}	-31.1053	-32.9192	-48.7408	-45.6651	-44.6517
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
FA_{it}	0.04560	0.0582	0.0296	0.0304	0.0230
	(0.4043)	(0.2784)	(0.0318)	(0.0173)	(0.0042)
U_{it}	24.9143	32.2322	9.9644		15.4022
	(0.0407)	(0.0162)	(0.1914)		(0.0000)
$\bar{R}^2$	0.9930	0.9935			
DW	1.7603	1.7514			
J			7.9197	8.1170	12.6217
Instrument rank			15	15	15
Test unitary sum coefficients N & R	(0.1627)	(0.1760)	(0.0164)	(0.1491)	(0.0570)
Test equality variances of errors	(0.1486)	(0.4787)	(0.7511)	(0.7118)	(0.6600)
Test over-identification restrictions			(0.4414)	(0.5224)	(0.1805)

P-values in parenthesis. All variables are expressed in real terms (euros of 2010).

Regressions 1 and 2 are estimated with White cross-section standard errors and covariance (d.f. corrected).

Regressions 3, 4 and 5 are estimated with White period standard errors weighting matrix and White period standard errors and covariance (d.f. corrected).

The null hypothesis of the Wald test for the unitary sum of the coefficients on N_{it} and R_{it} is H_0: $-1 + C(2) + C(3) = 0$ for regressions 1 and 2, and H_0: $-1 + C(1) + C(2) + C(3) = 0$ for regressions 3, 4 and 5.

$C(i)$ is the ith estimated coefficient, including the constant if present.

List of instruments of regressions 3, 4 and 5: @DYN(ET, -2) H H16 H65 PH DISP SAL YR U NBB DOY(-1) FA.

The test value for the equality of variances of errors is that of Bartlett. In all cases, the values of Levene and Brown-Forsythe consistently give the same qualitative result.

The 165 observations of regressions 1 and 2 correspond to those generated for 15 autonomous communities during the period 2007-2017. The 135 observations of regressions 3 to 5 correspond to those generated for 15 autonomous communities during the period 2009-2017.

4. The explosion of regional debt

4.1. Annual regional debt

Essentially, our theory says that the total budget deficit, $(E - R)$, is determined by α times the NR gap, $(N - R)$. But debt is nothing more than accumulated total budget deficits over a given period of time. Thus one way of finding out how well the theory explains reality is to predict debt from the estimated total budget deficit. This is in a sense a strong test, since data on debt and budget deficits, although related, come from different sources and are measured somewhat differently. In particular, the stock of debt provided by the Bank of Spain is measured by the balances at the end of each period, while the budget deficit issued by the General Auditor of the Spanish government is measured by means of the corresponding expenditure and revenue flows over the whole annual period. Also, among others, there are differences in the way short run assets and assets denominated in foreign currencies are accounted for. Despite these differences, it is interesting to see how far the simple model of public expenditure of Section 2 can take us to predict the enormous increase in debt experienced by the Spanish autonomous communities during the period 2007-2017. For this purpose, we measure predicted debt for all the fifteen regional governments, D_{it}^*, using the following recursive equation:

$$D_{it}^* = D_{it-1}^* + \left(E_{it}^f - R_{it} \right) \tag{12}$$

where E_{it}^f is the level of public expenditure predicted by our model.

Table 6
OBSERVED AND PREDICTED REGIONAL PUBLIC DEBT
(2010 million €)

	Observed debt (1)	Predicted debt (2)
2007	62,215	62,215
2008	72,845	71,614
2009	89,652	86,463
2010	117,479	113,438
2011	137,862	136,400
2012	179,224	163,565
2013	198,527	185,221
2014	225,706	205,316
2015	248,850	221,621
2016	261,069	233,383
2017	267,988	237,323
2017-2007	205,772	175,107
Debt variation explained (%):		85.1

Figure 6
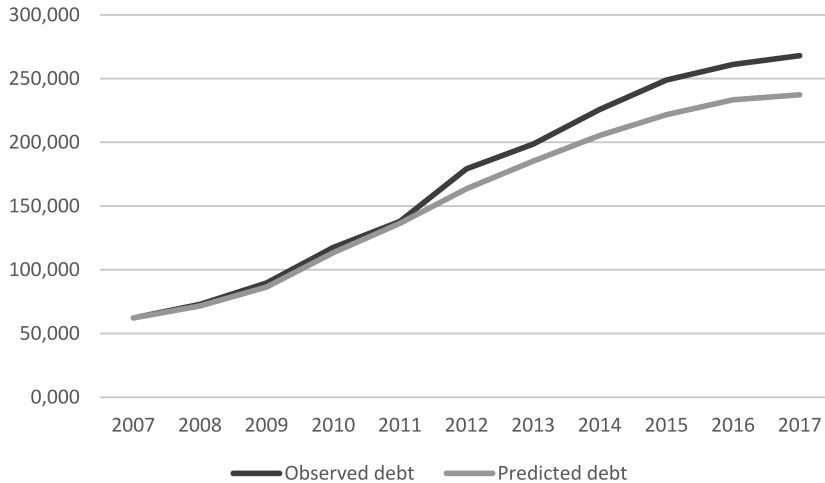**OBSERVED AND PREDICTED REGIONAL DEBT**
(2010 million €)

Table 6 and Figure 6 compare the aggregate annual levels of observed regional debt (obtained from the Bank of Spain) and the annual predicted regional debt that follows from equation (12), where E_{it}^{f} is the level of public regional expenditure fitted with regression 3 of Table 2, in which none of the predictions of the model are rejected by the data. Between 2007 and 2017 regional debt increased by €205,772 million, measured in 2010 euros (last row of Table 6); the increase of debt predicted by equation (12) is €175,107 million, 85.1% of the actual increase.

Now, regression 3 of Table 2, in addition to the variables suggested by the model is specified with four control variables, a constant and a set of fifteen cross-section fixed effects. It is therefore interesting to see what part of the variation of observed regional debt is explained strictly by the model (that is, strictly explained by the *NR* gap), and what part is explained by the remainder of the variables that enter into the regression.

Table 7 presents this partition in columns (2) and (3). We measure the contribution of the "*NR* Gap" to the variation of debt, column (2), as $a'(N_t - R_t)$ with $a' = 0.4984$, the estimated coefficient of the needs variable in regression 3 of Table 2. And the "Remainder", column (3), is simply the difference between column (2) of Table 6 and column (2) of Table 7. We have (last row of the table) that out of the total €205.730 million increase in regional debt during the period 2007-2017, the model, the "*NR* Gap", explains 68.1% and the rest of the variables included in the regression, the "Remainder", explains 17.0%.

Table 7
CONTRIBUTION OF NR GAP AND REMAINDER OF THE MODEL TO THE
INCREASE IN DEBT
(2010 million €)

	Observed debt (1)	NR Gap (2)	Remainder (3)	Predicted debt (4)
2007	62,215	62,215	0	62,215
2008	72,845	66,863	4,751	71,614
2009	89,652	72,262	14,201	86,463
2010	117,479	88,774	24,663	113,438
2011	137,862	108,515	27,885	136,400
2012	179,224	125,568	37,997	163,565
2013	198,527	142,373	42,848	185,221
2014	225,706	160,379	44,937	205,316
2015	248,850	178,323	43,298	221,621
2016	261,069	192,480	40,903	233,383
2017	267,988	202,257	35,066	237,323
2017-2007	205,772	140,041	35,066	175,107
Debt variation explained (%):		68.1	17.0	85.1

4.2. Differences in behaviour across regional governments

These aggregate results do not tell us much about the behaviour of each of the fifteen regional governments during the crisis. In particular, they do not tell us how during the period 2007-2017 regional governments absorbed the *NR* gap. Whether it was absorbed by increasing the amount of debt, by reducing service provision or by a combination of both. To find out this, the parameter α is crucial and we would like to focus on a value of this parameter that is representative of the set of results obtained in the estimation exercise of Section 3.4 rather than just use a single equation, as we have done in the previous section to illustrate the predictive capacity of the model.

But to average results, we need to make the point estimates of *a* and *b* comparable one to another across different specifications. In particular, to compare the values of the parameters *a* and *b*, account must be taken of the fact that, even if the sum of the two estimated parameters is statistically not different from unity, the sum of the two point estimates may differ from unity. Since in all these regressions, the sum of the estimated parameters *a* and *b* is not significantly different from unity, in order to compare them across different specifications and estimation methods, we adjust the estimated parameters dividing their value by the sum $a + b$. In other words, we distribute proportionally the non-significant deviation of the point estimates *a* and *b* between both of them and define the adjusted parameters as $a' = a/(a + b)$ and $b' = b/(a + b)$. In terms of adjusted values, Table 8 shows that the overall mean of the parameter *a'* is 0.4799. During the period 2007-2017, Spanish regions absorbed 48% of their *NR* gap by increasing debt and the remaining 52% by letting service provision to deteriorate.

Table 8
ESTIMATED AND ADJUSTED VALUES OF PARAMETERS *a* AND *b*.
TOTAL BUDGET OPERATIONS
SELECTED REGRESSIONS WITH ALL MODEL RESTRICTIONS ACCEPTED

	Estimated values			Adjusted values[**]		
	a	*b*	*a + b*	*a'*	*b'*	*a' + b'*
R3/T2[*]	0.6128	0.6168	1.2296	0.4984	0.5016	1.0000
R1/T4	0.3546	0.6140	0.9686	0.3661	0.6339	1.0000
R2/T4	0.4756	0.4504	0.9260	0.5136	0.4864	1.0000
R3/T4	0.5136	0.4350	0.9486	0.5414	0.4586	1.0000

[*] Regression/Table.

[**] $a' = a/(a + b)$; $b' = b/(a + b)$.

Another issue that needs attention is the scope of the simulation analysis to ascertain differences in the fiscal behaviour of the regions. As seen above (Table 7), the mechanism of absorption of the *NR* gap contributes only a part (albeit a large one) of the explanation reached with the empirical regression model, which besides *E*, *N* and *R* contains other variables. To obtain an adequate measure of regional differences we must ensure that the simulation model restricts itself, both in the aggregate and in each of the fifteen communities, to the level of public expenditure over which the absorption mechanism operates.[21] This, in turn, depends on the value of parameter *a'*. Let us call the aggregate of the fifteen communities over the period 2007-2017 of a variable *X*, *AX*. That is, $AX = \sum_{i=1}^{15} \sum_{t=07}^{17} X_{it}$. Then aggregate level of expenditure over which the absorption mechanism operates, AE^*, is, using expression (3) and $a' = 0.4799$, $AE^* = a'(AN - AR) + AR = 1{,}455$ billion euros of 2010, whereas the equivalent figure for observed expenditure, *AE*, is 1,529 billion euros. In order to identify the relative differences in fiscal behaviour across communities, the relevant aggregate figure of expenditure is 1,455 million euros, which means that the observed expenditure of each of the fifteen communities has to be adjusted by the following factor: $(AE^*/AE) = 0.9511$.

Therefore, all the results obtained in Table 10 for each of the fifteen autonomous communities have to be understood with reference to an aggregate position for all regions and all years, which after the above adjustment, is shown in Table 9. The first row of the table shows in the first column the aggregate of the *NR* gap (*ANRG*), the shortage of resources of all regions for all years, the difference between aggregate expenditure needs, *AN*, and aggregate revenue, *AR*, expressed as a percentage of aggregate revenue. That is, $ANR = ((AN - AR)/AR) * 100$. This gap of resources was absorbed by incurring in debt, the amount of which is measured in the first row, second column by $((AE - AR)/AR) * 100$, where *AE* is (adjusted) observed expenditure; and by letting service provision to deteriorate, measured in the first row, third column by $((AN - AE)/AR) * 100$. The *ANRG* faced by the fifteen Spanish common regime autonomous communities was, as percentage of revenue, 16.99%. This gap was absorbed by borrowing an amount equivalent to 8.15% of revenue (first row, second column), and by letting service provision to deteriorate for an amount equivalent to 8.84% of revenue (first row, third

column). That is, borrowing accounted for 48% of the adjustment, and savings on service provision for the remaining 52%.

Table 9
ABSORPTION OF THE AGGREGATE NR GAP THROUGH DEBT AND SERVICE VARIATION
PERIOD 2007-2017
(Percentages of regional revenue)

	Shortage of resources	Debt variation	Fall in service provision	Excess indebtedness
Observed[1]	16.99	8.15	8.84	
Reference	16.99	8.15	8.84	0.00

[1] Adjusted as described in the text.

The second row shows the corresponding figures for the optimal/reference policy. Variables AN and AR are the same as those discussed for the observed policy in the first row. Therefore, the first entry, $ANRG$, is the same as that in the observed row because AN and AR are the same. The debt variation effect and the fall in service provision effect are also the same, but for another reason. The definition of these two effects are now $((AE^* - AR)/AR) * 100$ and $((AN - AE^*)/AR) * 100$ respectively. But as explained above, optimal aggregate expenditure, AE^*, equals aggregate (adjusted) observed expenditure, AE. Thus, since at this level of aggregation $AE^* = AE$, the two expressions yield the same figures as those shown in the first row. In aggregate terms (all regions, all years) the optimal/reference policy coincides with the (adjusted) observed policy.

Table 10 presents the comparison between the observed and optimal/reference absorption policies of each of the fifteen regional governments. The definition of the terms are the same as those discussed for Table 9, but now, instead of working with variables aggregated for all regions and all years, we only aggregate for all years.

Table 10
ABSORPTION OF THE NR GAP THROUGH DEBT AND SERVICE VARIATION
PERIOD 2007-2017
(Percentages of regional revenue)

		Shortage of resources	Debt variation	Fall in service provision	Excess indebtedness
Group A: Smaller variation of debt and larger fall of service provision[1]					
MAD	Observed[2]	26.24	4.84	21.40	
	Reference	26.24	12.59	13.65	-7.75
CAN	Observed	11.08	0.97	10.11	
	Reference	11.08	5.32	5.76	-4.35
AND	Observed	15.12	3.60	11.51	
	Reference	15.12	7.25	7.86	-3.65
GAL	Observed	10.26	1.52	8.73	
	Reference	10.26	4.92	5.33	-3.40
CYL	Observed	9.34	4.42	4.92	
	Reference	9.34	4.48	4.86	-0.06

(*Continued*)

		Shortage of resources	Debt variation	Fall in service provision	Excess indebtedness
Group B:	**Larger variation of debt and smaller fall of service provision**[1]				
RIO	Observed	5.69	4.61	1.08	
	Reference	5.69	2.73	2.96	1.88
VAL	Observed	31.85	17.39	14.47	
	Reference	31.85	15.29	16.57	2.10
ARA	Observed	10.80	8.64	2.16	
	Reference	10.80	5.18	5.62	3.46
MUR	Observed	15.74	11.28	4.46	
	Reference	15.74	7.55	8.19	3.73
CLM	Observed	15.79	11.38	4.41	
	Reference	15.79	7.58	8.21	3.80
BAL	Observed	22.84	15.91	6.93	
	Reference	22.84	10.96	11.88	4.95
CAT	Observed	21.15	16.35	4.81	
	Reference	21.15	10.15	11.00	6.19
Group C:	**Larger variation of debt and higher level of service provision**[3]				
AST	Observed	-0.59	1.82	-2.42	
	Reference	-0.59	-0.28	-0.31	2.11
CTB	Observed	0.32	5.14	-4.82	
	Reference	0.32	0.15	0.17	4.99
EXT	Observed	-6.35	3.51	-9.87	
	Reference	-6.35	-3.05	-3.30	6.56

[1] The smaller/larger variation of debt and smaller/larger fall of service provision is with respect to the reference policy for each autonomous community.

[2] Adjusted observed expenditure so that the simulation is circumscribed to the level of expenditure over which the mechanism of absorption of the *NR* gap operates.

[3] The higher level of service provision is with respect to 2007.

Depending on their absorption policy, regions are classified in three groups (A, B, and C) and within each group ordered (in an increasing fashion) according to the divergence between observed and optimal borrowing.

Group A is formed by: Madrid, Canary Islands, Andalucía, Galicia, and Castile & León. Over 2007-2017, these regions, despite having faced a shortage of resources, incurred in debt to a smaller extent than that suggested by their respective optimal policy and reduced service provision to a larger extent than that recommended by their optimal policy. The government of Castile & León followed almost to the point its optimal policy, and the rest behaved in a particularly virtuous manner from a financial point of view. Madrid, in particular, borrowed (as a percentage of revenue) 7.75% less, and therefore was able to increase service provision over the optimal level by an equivalent amount. The corresponding percentages in Canary Islands, Andalucía and Galicia, were 4.35, 3.65 and 3.40.

Group B is formed by La Rioja, Valencia, Aragón, Murcia, Castile-La Mancha, Balearic Islands and Catalonia. As in the previous group, their *NR* gap was positive, but these regions incurred in debt to a larger extent than what their optimal policy recommended and, although they allowed service provision to deteriorate, the fall was smaller than that suggested by their reference policy. As a percentage of revenue, the excess of debt (and therefore the deficiency of savings in service provision) ranges from a maximum of 6.19% in the case of Catalonia to a minimum of 1.88% in the case of La Rioja.

Finally, Group C is formed by Asturias, Cantabria and Extremadura. Asturias and Ex-tremadura, rather than facing a shortage, benefited from a surplus of resources; of a minor extent in the case of Asturias, but relatively large in the case of Extremadura. Cantabria, on the other hand, experienced a small shortage of resources. What distinguishes this group from the other two groups is that the three governments improved service provision along the period 2007-2017. In the case of Asturias and Extremadura to an extent larger than what their optimal policy dictated, and in the case of Cantabria contravening the recommendation that service provision in this community should have been reduced.

5. Concluding remarks

The empirical exercise presented in this article shows that the main two testable hypoth-eses derived from our model –that public expenditure should positively depend on needs and public revenue, and that the two effects should add up to unity– are not rejected by the data. We find that on average demography (which is the essential component of our indicator of needs) has a strong, positive and significant effect on expenditure. Our estimates suggest that, on average, 48% of the shortfall in resources with respect to needs experienced by Spanish regional governments during the period 2007-2017 was absorbed by increasing debt and the remaining 52% by letting service provision to deteriorate. We have not found any clear prec-edent to these results. Admittedly, this is a finding that refers to a very particular context –the situation of financial stress that Spanish regional governments had to face as a consequence of the 2008/2009 economic crisis– and to public agents that have clearly defined expenditure responsibilities, all of them closely related to the provision of public services. But we believe that this result may be more general.

The model that yields the above testable hypotheses is based on a simple theory of gov-ernment behaviour under conditions of financial stress. In its equilibrium position, the gov-ernment spends more than the resources available and leaves unfulfilled the expectations of citizens regarding the satisfaction of needs. The optimal government's expenditure decision both weakens its financial position and worsens the odds of remaining in power. We argue that, in a situation of stress such as the one considered in this exercise, this is the least harmful of all the available courses of action: in a situation of stress there is no option without cost.

This naturally raises issues of sustainability and of financial assistance that have not been addressed in this exercise, and suggests possible extensions of the approach adopted here. Although the effect that the financial assistance received by regional governments from 2012

onwards may have had on regional public expenditure is taken into account in the empirical analysis, possible interactions between central and regional levels of government to assist those parties in difficulties are not formally considered in the theoretical model presented here. The fact that over the six years that go from 2012 and 2017 the central government lent to the common regime autonomous communities resources amounting to 35.4% of their total revenue to prevent them from incurring in default highlights the relevance of this issue. This financial help, which somehow transfers the problem of sustainability from regional governments to the central government, poses important issues of soft budget constraints, bailouts and commitment (Rodden *et al*., 2003), and of interactions between different levels of government (Molina-Parra and Martínez-López, 2018), that surely merit further research efforts.

The results of this exercise are obtained on the basis of a very parsimonious empirical specification. With the exception of four control variables, the normative budget balance variable, the regional rate of unemployment, the ratio of regional debt over regional *GDP* and the level of financial assistance, the specifications used in this article restrict themselves to the explanatory variables suggested by the theoretical model. They ignore, in particular, the possible effects that institutional and political factors may have had on public expenditure. This strategy, as the empirical results corroborate, depicts reasonably well what happened during the situation of financial stress that arose in the period 2007-2017. The effects of institutional factors are bound to be small given the complete institutional homogeneity of the fifteen regional governments of our sample. And regarding political differences, the only meaningful difference is the ideological stand of the regional governments in power. Our conjecture is that, in a situation of financial stress as serious as the one analysed here, ideological differences give way to the fundamental urgencies posed by the deterioration of public service provision and the unsurmountable impediments of financial markets. And when this happens, the potential effect of political ideology on regional public expenditure is overshadowed by the pressure exerted by needs and revenue.[22]

Annex A: Derivation of expression (5)

BOE (2009) defines, in units of population which receive the name of "adjusted population", the needs of region i in 2007 as follows:

$$AP_i^{07} = \left[\begin{array}{l} 0.3 \left(\dfrac{P_i^{07}}{P^{07}} \right) + 0.018 \left(\dfrac{LA_i^{07}}{LA^{07}} \right) + 0.006 \left(\dfrac{D_i^{07}}{D^{07}} \right) + 0.006 \left(\dfrac{I_i^{07}}{I^{07}} \right) \\[3mm] +0.38 \left(\dfrac{PP_i^{07}}{PP^{07}} \right) + 0.085 \left(\dfrac{P65_i^{07}}{P65^{07}} \right) + 0.205 \left(\dfrac{P16_i^{07}}{P16^{07}} \right) \end{array} \right] P^{07} \qquad \text{(A.1)}$$

That is, it distributes 30% of P^{07} according to population, 1.8% according to land area, 0.6% according to dispersion, 0.6% according to insularity, 38% according to protected population, 8.5% according to population aged 65 or older and 20.5% according to population aged 16 or younger. These percentages are not entirely capricious, but the result of negotiations between regional governments and the central government that have taken place regularly since the regional finance system was introduced in 1987. However, the last word has always been that of the central government and we cannot exclude the influence of pressures from the most politically powerful regional governments in order to raise the weights of the indicators most favourable to them.

Exactly the same result as that of expression (A.1) can be obtained if we define the index as a function of the different indicators. See that expression (A.1) can also be written as follows:

$$AP_i^{07} = \left(\frac{0.3P^{07}}{P^{07}} \right) P_i^{07} + \left(\frac{0.018P^{07}}{LA^{07}} \right) LA_i^{07} + \left(\frac{0.006P^{07}}{D^{07}} \right) D_i^{07} + \left(\frac{0.006P^{07}}{I^{07}} \right) I_i^{07}$$
$$+ \left(\frac{0.38P^{07}}{PP^{07}} \right) PP_i^{07} + \left(\frac{0.085P^{07}}{P65^{07}} \right) P65_i^{07} + \left(\frac{0.205P^{07}}{P16^{07}} \right) P16_i^{07} \qquad \text{(A.2)}$$

That is, in terms of a linear combination of the seven need indicators of region i where the coefficients (the terms in parenthesis) are defined by the weights prescribed in *BOE* (2009) and by total values of the need indicators for 2007. These coefficients do not vary across regions, nor over time. Therefore, working out the value of the terms in parenthesis, we obtain the index of needs as:

$$AP_i^{07} = 0.3(P_i^{07}) + 1.5594(S_i^{07}) + 4.2818(D_i^{07}) + 164.8441(I_i^{07}) +$$
$$0.3962(PPE_i^{07}) + 0.5128(P65_i^{07}) + 1.2487(P17_i^{07}), \qquad \text{(A.3)}$$

which is precisely expression (5) of the main text.

Annex B: The treatment of specific responsibilities in the calculation of *N*

We assume that the temporal evolution of expenditure needs as far as specific responsibilities are concerned depends also on the index of needs (8). This assumption, however, cannot be applied to the base year, given that the distribution of specific responsibilities is extremely unequal among regions and very different from the distribution of needs. For instance, over the period 2007-2017 Catalonia had on average 40% of the total resources assigned to specific responsibilities but only represented 17% of the total expenditure needs according to (5). Consequently, the method we follow here is as follows: For 2007, we define the aggregate of specific responsibility expenditure needs as $SREN^{07} = 0.0496E^{07}$, and the aggregate of common responsibility expenditure needs as $CREN^{07} = (1 - 0.0496)E^{07}$, where 0.0496 is the average proportion over the period 2007-2017 that specific responsibilities have represented with respect total expenditure. To find out the specific responsibility needs of each region in 2007 we apply the average regional distribution (over the period 2007-2017) of the resources assigned to these responsibilities to $SREN^{07}$ so that $SREN_i^{07} = \beta_i SREN^{07}$ where β_i is, for region i, the average share of the resources assigned to specific responsibilities. To find out the common responsibility needs of each region in 2007, $CREN_i^{07}$, we apply the index (5) to $CREN^{07}$. And we define the initial 2007 needs base as the sum of these two components; that is, $N_i^{07} = CREN_i^{07} + SREN_i^{07}$. Then, as indicated above, we assume that over time, both common and specific responsibility needs evolve according the needs index (5), and we apply this index to generate the values of the N_i^t variable for the remaining years: 2008-2017.

Notes

1. See Mueller (2003) for a review of the Metzler-Richard model and for an extensive survey of the literature on the determinants of public expenditure. Other very complete surveys of this field can be found in Drazen (2000) and Persson and Tabellini (2000).

2. Bohn (1998) is an important variant of Barro (1979) model. In his study of the behavior of the US public deficit he re-specifies Barro's empirical hypothesis to transform it in what has subsequently been widely used as a public budget reaction function.

3. In the actual Spanish system of regional finance, for instance, regional governments have some leeway in the determination of public revenue that allows them to increase or decrease the quality of the public services they provide: it allows them to vary the value of the parameter g. But this circumstance would still fall within the conditions of a normal situation, because the variation of g in a particular region would elicit the corresponding variation of R in that region, and the overall condition that $N = R = E$ would still be fulfilled both for the regional government in question and for the whole system of regional finance. Naturally, with respect to the mean levels contemplated in the system, a higher level of service provision would be achieved at the cost of more fiscal effort (more revenue per unit of need) and a fall of service provision would permit a fall of fiscal effort (less revenue per unit of need).

4. To simplify we will call a fall in the extent of service provision and/or a fall in the quality of the services provided a "fall in service provision".

5. The data on both expenditure (E) and revenue (R) can be found at: https://serviciostelematicosext.hacienda.gob.es/SGCIEF/PublicacionLiquidaciones. The variable R is described below.

6. In fact, *BOE* (2009) presents this index for 2007 (the base year) in terms of the distribution across regions of each of the seven need indicators of (5) and of the percentages of the total population of that year, P^{07}, that should be distributed among regions according to each indicator. The Annex A of this article explains this procedure. See also López-Laborda and Zabalza (2011) and Zabalza (2017) for a discussion of the role of this index of needs in the Spanish system of regional finance.

7. Annex B explains the details.

8. See Martí and Pérez (2016) and Hernández de Cos and Pérez (2013b) for a detailed analysis of the effects of the 2008/2009 crisis over the different levels of government, and of the different mechanisms of control put in operation to supervise the fiscal behavior of regional governments.

9. Available at www.minhap.gob.es/esES/CDI/SeguimientoLeyEstabilidad/Paginas/InformesCompletosLEP.aspx.

10. Either because they have not worked long enough to be entitled to unemployment benefits or because, due to the long duration of their condition of unemployed, have exhausted their benefits.

11. See Zabalza and López-Laborda (2011) for an analysis of the 2009 reform of the Spanish regional finance system.

12. The remaining 5.5% was explained by the new "Convergence Funds" introduced in the 2009 reform of the regional finance system. The variation of expenditure needs had no aggregate effect whatsoever on the variation of the resources that the system put at the disposal of regional governments, and only a minor redistributive impact between them. See Zabalza (2021).

13. Table 8 shows that the OLS estimate (R3/T2) is 0.5016 and the average of three IV estimates (R1/T4, R2/T4 and R3/T4) is 0.5263.

14. Another possible factor behind the increase in regional expenditure in 2008 and 2009 is, as it has been pointed out above, the optimistic forecast errors about the expected tax revenue made by the central administration in the calculation of the advance payments.

15. On this, see Pérez-García and Cucarella (2013).

16. The level of significance of the coefficient of R_{it} in (11) is precisely the p-value of the null H_0: $1 - a - b = 0$ of the Wald test in (10).

17. See Foremny (2014) for arguments that, in the context of the estimation of fiscal reaction functions, could justify the consideration of the normative budget balance as a variable that depends on the fiscal behavior of sub-national governments.

18. In the context of a fiscal rule analysis, Galí and Perotti (2003) justify the use of a lagged measure of the debt over GDP ratio in order to take into consideration the effect of the budgetary process on fiscal policy decisions. For them, the relevant available information to policy makers is the size of debt outstanding at the time of the budget decision.

19. Although the size of Spanish regional governments is relatively large, the impact of their budget on the region's economy is pretty stable over time and unlikely to influence its cyclical position in a significant manner. The variation of regional unemployment, therefore, depends more on the cyclical position of the whole Spanish economy than on the regional government's budget.

20. Under this new maintained assumption, the coefficients (and p-values) of *RESFA* and *RESNBB* in the equivalent of Table 3 above are, respectively, 0.0860 (0.2046) and 0.0495 (0.9303); and the value of the Wald test statistic of joint significance, 1.6864. This statistic is distributed as a Chi-squared function with 2 degrees of freedom; therefore, its p-value is 0.4303. That is, even with the new maintained assumption about *DOY*(-1), the null that *FA* and *NBB* are exogenous cannot be rejected.

21. I wish to thank Referee 2 for drawing my attention to this issue.

22. See, however, Leal and López-Laborda (2015) and Lago-Peñas *et al*. (2017) as two empirical examples of the influence of institutional and political variables on the fiscal behavior of Spanish regional governments.

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Resumen

La crisis económica de 2008 tuvo tres consecuencias para los gobiernos regionales españoles: en primer lugar, se produjo una sustancial y repentina reducción de ingresos, que no pudieron contrarrestar, mientras la demanda de educación, sanidad y otros servicios sociales seguía creciendo como de costumbre; en segundo lugar, su deuda, que hasta entonces había sido relativamente pequeña y estable, explotó hasta niveles nunca vistos; y en tercer lugar, hubo un serio deterioro del volumen y calidad del conjunto de servicios públicos suministrados por estos gobiernos. Las dos primeras consecuencias quedan recogidas en las estadísticas oficiales, pero la tercera, acerca de la cual existe un razonable consenso entre la ciudadanía, no ha sido sistemática y formalmente documentada. Este artículo desarrolla un sencillo modelo de gasto público que explica estos hechos. El modelo postula que, bajo condiciones de estrés financiero, puede ser racional para los gobiernos regionales gastar por encima de los recursos disponibles, y por tanto endeudarse, a la vez que aceptar un deterioro del volumen y calidad de los servicios suministrados al público. Si una medida adecuada de la brecha entre las necesidades de gasto y los ingresos puede ser identificada, el modelo predice que el comportamiento óptimo de los gobiernos es absorber una parte de esta brecha a través del endeudamiento y la restante dejando que la provisión de servicios públicos se deteriore. En una situación de estrés financiero, además del tradicional efecto de los ingresos, la demografía juega un papel propio en la determinación del comportamiento económico de los gobiernos. El artículo contrasta estadísticamente estas hipótesis utilizando un panel de datos sobre gasto, ingresos y una serie de indicadores de necesidades de gasto (esencialmente indicadores demográficos) de las quince comunidades autónomas españolas de "régi-

men común" a lo largo del periodo 2007-2017. Ninguna de las predicciones del modelo es rechazada por los datos.

Palabras clave: demografía, necesidades de gasto, gasto público, ingreso público, déficit, deuda, gobiernos regionales, estrés financiero.

Clasificación JEL: H12, H63, H74, H77.