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Cyclical Patterns and Sustainability of Fiscal Policy at Regional Level: the Spanish Case

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ACs: Autonomous Communities.

AEAT: Agencia Estatal de Administración Tributaria (Spanish Tax Agency).

AIREF: Autoridad Independiente de Responsabilidad Fiscal (Independent Authority for Spanish Fiscal Responsibility).

AMECO: Annual macroeconomic database of the EC's Directorate General for Economic and Financial Affairs.

BB: Budget Balance.

BDMORES: Regional database of the Spanish economy.

CG: Central Government.

DSA: Debt Sustainability Analysis.

EC: European Commission.

ECB: European Central Bank.

ECM: Error Correction Model.

EGLS: Estimated Generalized Least Squares.

EMU: European and Monetary Union.

EU: European Union.

FP: Fiscal Policy.

FRF: Fiscal Reaction Function.

GDP: Gross Domestic Product.

GMM: Generalized Method of Moments.

GVA: Gross Value Added.

HP: Hodrick and Prescott.

IGAE: Intervención General de la Administración del Estado (General State Comptroller).

IV: Instrumental Variables.

MAE: Mean Absolute Error.

NAWRU: Non-Accelerating Wage Rate of Unemployment.

OECD: Organisation for Economic Co-operation and Development

OG: Output Gap.

OLS Ordinary Least Squares

PBB: Primary Budget Balance.

PF: Production Function.

PIT: Personal Income Tax.

RATS: Regression Analysis of Time Series.

RMSE: Root Mean Squared Error.

SCGs: Sub-Central Governments.

SGP: Stability and Growth Pact.

SUR: Seemingly Unrelated Regressions.

TFP: Total Factor Productivity.

ULC: Unit Labour Cost.

UC: Unobserved Components.

VAR: Vector AutoRegression.

VAT: Valued Added Tax.

Chapter 1.

Introduction

1. Background and motivation

The cyclical patterns and the fiscal sustainability of the Autonomous Communities (ACs) have received uneven attention since the creation of the State of the Autonomies. In the early stages, sustainability was closely linked to the sufficiency of resources for the responsibilities of the ACs, which they took on gradually. Ever since the start of the definitive phase of the financing system (in 1987), one could say that there has been an "implicit" debate around sustainability in every reform of the regional financing system. This debate became especially intense during times when pressure was put on the process of regional consolidation in order to meet the EU's requirements concerning general government: throughout the 1990s to meet the Maastricht convergence criteria for joining the euro area and in the aftermath of the Great Recession to correct large fiscal imbalances under the corrective arm of the Stability and Growth Pact.

Controversy around the cyclical pattern of regional public finances has been less vigorous. In fact, the stabilisation of ACs' public finances has followed the guidelines provided by the central government, which in turn have closely followed the changes in the Stability and Growth Pact, albeit with a recentralising trend (see Viver Pi-Sunyer and Martín, 2013). As we discuss below, the fiscal federalism literature does not assign the stabilising function to sub-central governments (SCGs), but it does point to the importance of ensuring stability in the provision of their services, which in Spain represent a remarkably large part of the welfare state services. The Spanish regulation of budgetary stability**,** since its beginning in 2001, has

undergone two substantial reforms: one in 2006 and another in 2012[1]. In 2001 a zero deficit rule was set, which became more flexible in 2006 by only requiring a balance throughout the cycle. The 2012 reform was greatly inspired by the changes in the Stability and Growth Pact (SGP) which called for the adoption of a balanced budget rule in structural terms, i.e. corrected by cyclical effects net of one-off and temporary measures. Therefore, the notion of structural budget balance was introduced in the 2012 reform, an element that allows for the setting of medium term objectives (MTOs) and assessing fiscal efforts under the preventive and corrective arm of the SGP.

The latest financial and real estate crisis has had a severe impact on public finances, with significant deficit and debt increases. That is, the debt-to-GDP ratio of the euro area and Spain increased 27.6 and 64.2 percentage points respectively between 2007 and 2016, arriving at 85.1% and 99.7% respectively in 2016. In some of the main euro area countries, the imbalance between revenue and expenditure has persisted, especially in Spain, where the deficit is expected to decrease below 3% in 2018, nine years after the opening of the Excessive Deficit Procedure in 2009[2]. The need to correct these imbalances, both in terms of flows and stocks, has led to changes in the institutional framework, and especially in the fiscal governance system, in Europe and particularly in Spain. Among other consequences, the magnitude of the imbalances has led to a reconsideration of the measurement of cyclical position and fiscal stance (a proxy to fiscal effort), so the methodology used to capture those positions has also been a subject of debate and considerable changes (see the contributions of Havik et al. 2014, Mourre et al. 2014 and Borio et al., 2013). The measurement errors in the cyclical position in the expansive stage did not favour the sustainable behaviour of public finances (see Claeys et al., 2016), neither did the inaccuracy in revenue forecasting, especially around turning points.

It is in this context that this thesis introduces an analysis of the AC's fiscal policy (FP) throughout the economic cycle, with special attention to the

[1] Nevertheless, a first approach to regional budgetary stability had already been established in the 1992-2001 period, under the so-called "Budgetary Consolidation Scenarios". In this setting, the central government and each AC came to bilateral agreements on deficit and debt targets, with a leading position clearly being taken by the central government.

[2] See the 2017-2020 Stability Programme Update of the Kingdom of Spain.

cyclical behaviour and the sustainability of public finances. That is why the budget balance (and especially its structural component) and public debt become the main variables of interest. The budget balance is made up of the difference between revenue, which is much more exposed to the economic cycle, and expenditure, which is much more stable[3]. Consequently, revenue behaviour is analysed at greater length, in particular around the topic of forecasting.

The research presented here focuses on the Spanish case and covers, in general, the period from 1987 to the time of closing each analysis. This thesis is framed in a context that conditions and at the same time motivates the analysis. Some of the key background factors are:

i) The debate around the stabilising function of the public sector

From a historical point of view, the debate about the stabilising function of the public sector began mainly after the 1929 Wall Street Crash, with the response of Keynes and other scholars to the effects of the Great Depression[4]. Among other contributions, it is worth noting the Keynesian proposal to use FP as an instrument for demand management. According to Keynes, fiscal activism is necessary to ensure a socially optimal investment rate. This perspective led to a consensus regarding the use of FP in a counter-cyclical fashion, with particular attention to the role of spending multipliers in recessive contexts. Nevertheless, after World War II, Keynesianism was connected with fiscal activism in a broader sense, regarding both public expenditure and revenue. Opposition to the use of discretionary FP began at the end of the 40s, with Friedman's criticism of the lags of these measures[5]. Even so the 50s and 60s ended up becoming the golden years of Keynesianism. In the late 60s, monetarists presented their formal opposition to Keynesian policies with a revised version of the

[3] See the cyclical sensitivity of revenue and expenditure used by the European Commission in the measurement of the structural balance (Mourre et al., 2014). For the Spanish case, the elasticity of revenue level to output gap is 1.03 while that of expenditure level is -0.28 (see Table A3 in Mourre et al., 2014).

[4] Castells (2017) provides an extended and up-to-date discussion on the role of the public sector's stabilising function since the 30s. This work also provides an interesting discussion on the size of fiscal multipliers.

[5] More specifically, "(1) the lag between the need for action and the recognition of this need; (2), the lag between the recognition of the need for action and the taking of action; (3) the lag between the action and its effects" (Friedman 1948, 255).

Phillips curve, which included adaptive expectations (Phelps, 1967, and Friedman, 1968) and the proposal of a natural unemployment rate. Eventually, Keynesianim went into decline in the 70s with the oil crisis and the ineffectiveness of demand policies in counteracting supply shocks.

Under this umbrella, monetary policy gained traction and policies based on predictable rules that sustain macroeconomic stability were proposed. In this regard, it is worth mentioning the contributions of the New Classical Macroeconomics and Real Business Cycle models; the former led by Lucas and the latter by Kydland and Prescott[6]. The assumption of rational expectations in this theoretical perspective brings back concepts such as the Ricardian equivalence proposition (Barro, 1974), which questions the effectiveness of discretionary policies, both fiscal and monetary. From this point of view, economic fluctuations are the optimum response to technological change and therefore it would not be appropriate to take steps towards stabilising the cycle (regardless of the magnitude of these fluctuations). Throughout the 90s, the literature comes back to debating the stabilisation role from a federalist point of view, looking for lessons that should be considered in the formation of an economic and monetary union in Europe[7]. In these years, a new macroeconomic trend emerges based on Keynesian thinking with microeconomic foundations: the so-called New Keynesian framework (see Galí, Gertler and López Salido, 2007). The Phillips curve is reinterpreted in the context of rational expectations (Galí, 2011), and recessions are seen as periods in which the degree of capacity utilisation moves away from what we might consider an efficient level, a fact that can justify fiscal activism.

As we have seen, and without pretending to be exhaustive, there are multiple and divergent theoretical views on the role of FP throughout the economic cycle which advocate different levels of interventionism. Nowadays, in the most advanced economies, counter-cyclical discretionary

[6] De Vroey (2009) offers a critical appraisal of the research program of the New Classical Macroeconomics and Real Business Cycle models.

[7] These studies analysed the difference between regional income (before taxes and transfers) and disposable income over time, in order to assess the extent to which federal budgets were able to offset asymmetric shocks among regions (in this sense, see one of the works that had the most impact on this topic, Sala-i-Martin and Sachs, 1992). In other words, the focus was placed on the ability of a federation to counterbalance the effects of the economic cycle, especially between regions that share the same currency.

fiscal policies are a widespread practice in recessive contexts (Hou, 2013), which do not always behave asymmetrically in more favourable times.[8]

From another point of view, the literature has also examined the allocation of public sector functions between different tiers of government. The classical theory of public finance and fiscal federalism has reserved the stabilising role for the central government (Musgrave, 1959; Oates, 1972) due to the absence of sub-central monetary competences, the effects of fiscal competition and a greater degree of economic openness. However, in preceding works, Hansen and Perloff (1944), after identifying the pro-cyclical behaviour of sub-central governments (SCGs) in the US after the Great Depression, claimed there was a need to take into account, and coordinate, the FP of SCGs. The contribution of Rafuse (1965) shows that the FP of SCGs in the US became increasingly counter-cyclical in the period from the 30s to the 50s. Gramlich (1987) supported an active FP for SCGs, with the provision of rainy day funds (established in favourable times and spent in bad times) and tax rate changes throughout the economic cycle. Gramlich's main arguments point to a lack of correlation in demand shocks throughout the country, idiosyncratic regional business cycles and lower labour mobility across jurisdictions.

Since Gramlich, the literature around the topic has more frequently contemplated the possibility, and the need, for SCGs to take part in the stabilising function. As noted by Hou (2013), Gramlich's active FP proposal partially succeeded in the US. The counter-cyclical rainy day funds are still present in most SCGs, unlike the changes in tax rates throughout the economic cycle, which failed to prosper due to their unpopularity. In this regard, and to summarize the debate on the stabilising role of SCGs, Hou (2013) makes a pragmatic distinction between the role of the CG and that of SCGs: the former should be entrusted with macroeconomic stabilisation in a broad sense while the latter should ensure a certain level of provision of public services throughout the economic cycle. In other words, the budget stabilisation of fundamental public services is conceived of as a public good to be preserved by SCGs.

[8] The FP of these economies usually behaves counter-cyclically in the early stages of a crisis. The persistence of this behaviour depends, inter alia, on the available fiscal space, that is, the room for fiscal manoeuvre to be examined below.

The empirical evidence of the cyclical pattern of SCGs' finances beyond the US does not provide us with conclusive results. There are few cross-country studies that analyze the cyclical pattern of SCGs' finances. Rodden and Wibbels (2010), with a sample of 7 federations and data until 2001, identify a pro-cyclical FP of SCGs, especially with regard to their own revenues but also to SCGs' transfers and tax shares, that are either a-cyclical or pro-cyclical. These results, as the authors point out, are cause for concern given that SCGs have to cover an increasing number of competences related to welfare state functions. In a more recent work, Von Hagen and Foremny (2013), with a sample of 15 European countries of which 4 are federations and data until 2010, identify counter-cyclical behaviour in SCGs in federal countries, in contrast to SCGs in unitary countries. Consequently, it is worth highlighting, on the one hand, a more stable real expenditure in the SCGs of federal countries, and on the other hand, a significant increase in transfers from the CGs to the SCGs in unitary countries.

ii) The impact of the financial and sovereign debt crisis on public finances

The onset of the latest international financial crisis has once again revived the debate on the stabilising role of FP, in a context where traditional monetary policy has lost its effectiveness in counteracting the effects of the economic cycle (Galí, 2016). In addition, the literature also raises increasing concerns about the sustainability of public finances, which could compromise the exercise of the stabilisation function. In this sense, the concept of fiscal space introduced by Gosh et al. (2013) appears to be important. Fiscal space is the difference between the threshold after which debt would follow an unsustainable trajectory and the actual debt-to-GDP ratio. Indeed, the very notable increase in the debt-to-GDP ratio of the main advanced economies has meant that fiscal sustainability has gained interest in the literature. This is the context in which this thesis needs to be seen.

Bozio et al. (2015) compare the evolution of the public finances of six European countries throughout the Great Recession. In this selected sample, Ireland and Spain experienced the greatest deterioration of public finances, followed by France, Italy, UK and Germany (whose public finances remained almost unaffected). In fact, the impact of the crisis (in terms of borrowing) was higher in those countries where public finances appeared to be sounder at first. Martí and Pérez (2015) provide a detailed analysis of

Spanish public finances throughout the financial crisis. After an early counter-cyclical response to the crisis (2008-2009), an adjustment in public finances was unavoidable. In fact, Domenech and González-Páramo (2017) suggest that the sustainability of public finances was severely in question between 2009 and 2011. The fiscal space attained in the pre-crisis period became insufficient to cope with the deterioration of public finances. In other words, the Spanish economy had few alternatives to the pro-cyclical FP implemented throughout the crisis. The situation of Spanish regional public finances presents a similar pattern to that of the general government but some singularities emerge. The pro-cyclical pattern of expenditure in good times is one of the issues highlighted by de la Fuente (2013) as well as Lago Peñas and Fernández Leiceaga (2013). Both works reveal an heterogeneous response to the crisis in ACs' public finances, which may be worth exploring in further detail.

iii) Common errors in fiscal planning due to failures in the real time measurement of cyclical position and fiscal stance as well as the accuracy of tax revenue forecasts

The deterioration of public finances throughout the crisis has led to a growing interest in measuring the cyclical position, as a tool to guide fiscal (as well as monetary) policy. In fact, recommendations stemming from the framework of the Excessive Deficit Protocol take into account the economic situation of each country and, since 2009, are expressed systematically as improvements in the structural balance. In any case, despite the growing interest in the topic, errors in the measurement of the cyclical position and in revenue forecasts have been very significant, especially when turning points occur. The seminal work of Orphanides and van Norden (2002) already pointed to the challenges of carrying out robust estimations of the cyclical position in real time. With the outbreak of the crisis, the difficulties and implications of measuring the fiscal stance in real time (i.e. the changes in the primary structural balance) have also been noted[9].

In addition, the effects of the crisis have particularly had an impact on the

[9] See the work of Darvas and Simón (2015) and Claeys et al. (2016) for a critical view of the uncertainty of these measurements in the context of the European framework for fiscal governance.

evolution of tax revenue, evidencing the complexity of the response of this revenue to the economic cycle as captured by the elasticity concept[10]. Up until recently, the response of tax revenue throughout the cycle was thought to be constant and symmetric across the economic cycle[11]. In the Spanish case, tax revenue forecasts of the CG are of key importance as advance payments of partially ceded taxes to ACs depend on them. Errors in these forecasts were very significant during the first years of the crisis (see the settlement of the regional financing system in 2008 and 2009), which contributed to delaying the unavoidable adjustment of regional public finances.

Interest in research in revenue forecasting has also increased as a result of the growing monitoring and surveillance of public budgets in the euro area, especially since the creation of the independent tax authorities established by the 2012 Treaty and the introduction of the Two-Pack in 2013. The accuracy of tax revenue forecasts is a key element in assessing the risk of non-compliance with the fiscal targets of Member States and regional governments.

iv) An institutional framework that has reinforced the control and monitoring of public finances as a response to their deterioration since the financial and sovereign debt crisis, both in Spain and Europe

The European fiscal framework has been an evolving element that has conditioned and motivated this analysis. Since the Maastricht Treaty in 1992, the institutional framework that regulates European public finances has been increasingly geared to fiscal discipline to avoid excessive public deficits and guarantee price stability in Member States. The stabilising role of FP was considered a key pillar in the formation of the euro area, in a context where autonomy in monetary and exchange rate policies would not be available at a state level, in order to counteract potential asymmetric shocks (see Sala-i-Martin and Sachs, 1992). Within this framework, the main reforms took place in 1997, with the introduction of the Stability and Growth Pact, in 2005 with the reform that made this Pact more flexible[12],

[10] See Mourre and Princen (2015), where this complexity is identified and analysed.
[11] More specifically, until the works of Sobel and Holcombe (1996) and Bruce et al. (2006) respectively.
[12] In November 2003, there was tension between the European Council and the European Commission because of the lack of consensus on establishing sanctions on France and

and since 2011 with reforms that have strengthened the institutional framework and the fiscal governance system against the effects of the financial and sovereign debt crisis (the Six-Pack in 2011, the Treaty on Stability, Coordination and Governance in 2012, the Two-Pack in 2013 and the 2015 reform)[13].

A crucial element in these reforms is the compromise between the goals of fiscal sustainability and macroeconomic stabilisation. Since 2005, the emphasis on sustaining a balanced budget throughout the cycle has enabled progress towards the achievement of both objectives. However, the fiscal consequences of the crisis (i.e. declining revenues, deteriorating budgetary balances and increasing debt-to-GDP ratios in many countries, especially those in the peripheral euro area) show that the room for manoeuvre created during the expansive period prior to the financial and sovereign debt crisis was insufficient. These imbalances became even more acute as a result of measurement errors in the cyclical position and fiscal stance, especially when done in real time.

Despite the good intentions set forth in the Treaties and reforms, breaches of the stability rules have become a widespread reality since the beginning of the Stability and Growth Pact. In addition, the stabilising function of FP seems to have been the exception in euro area countries (see Figure 3 and 4 from García Perea and Gordo, 2016).

As mentioned previously, the institutional framework in Spain has closely followed the modifications of the European framework, with a centralist trend in the regional implementation of budgetary stability regulations. In this sense, an assessment of the most recent changes in Spain can be found in Viver Pi-Sunyer and Martín (2013), Lago (2013 and 2015), Hernández de Cos and Pérez (2013 and 2015) and Delgado et al. (2015).

v) A decentralised institutional framework, with a higher degree of decentralisation for expenditure than for revenue and deteriorating fiscal and financial autonomy

Germany. It was clear that the Stability and Growth Pact left little room for maneuver to implement a counter-cyclical FP.

[13] See García Perea and Gordo (2016) for a detailed analysis of the evolution of the budgetary surveillance framework in the euro area.

As was mentioned previously, the debate on fiscal sustainability and the cyclical pattern of public finances does not exclusively concern States but also takes place at a regional level, particularly given the progress of fiscal decentralisation in some States. In the case of Spain, ACs are responsible for a third of general government expenditure (including education, health and social services responsibilities), whereas the degree of revenue decentralisation is considerably lower but rather significant from a comparative perspective (see Blöchliger and Nettley, 2015). In 2011, the majority of the regional financing model resources were derived from tax revenue (84.5%). However ACs do not have tax autonomy over VAT and excise duties, which reduces the resources over which ACs enjoy taxing power to 45.6%. Fiscal autonomy in tax collection is very limited, given that ACs only manage 9.6% of the resources of the regional financing model (see Generalitat of Catalonia, 2015a).

This high degree of decentralisation is more apparent than real, since the fiscal and financial autonomy of ACs has become increasingly dependent on guidelines from the central government, especially as a result of the recentralization process of the regional financing system due to the crisis in public finances caused by the latest financial and real estate crisis (Viver Pi-Sunyer and Martín, 2013). This process of recentralisation has impacted many areas, from the fiscal stimulus measures in the early stage of the crisis (which especially affected local governments), to the discretionary allocation of budget stability objectives (which were unrelated to any reasonable criterion such as the distribution of expenditure by levels of government; see Generalitat of Catalonia, 2015b), to the reform of the budget stability regulations in 2012. The evolution of these regulations, along with the CG's extraordinary liquidity mechanisms, has led regional public finances to be subject to greater control and conditionality by the CG.

The literature on fiscal federalism (Rodden, 2002) points out that expenditure decentralisation and financial autonomy should not be detached from the taxing power of SCGs. In this sense, revenue decentralisation is a key element in fostering hard budget constraints on SCGs. The strength of these restrictions is an institutional feature that is especially relevant to avoiding the negative effects that decentralisation can have on budgetary stability and fiscal discipline. This strength reflects the expectations of

bailouts from a higher level of government that may help to address fiscal imbalances in SCGs, by means of debt payback or additional transfers of resources. The goals of the CG are often not consistent over time, which increases the likelihood of this type of intervention (i.e. rescue or bailout). The CG may make a formal no-bailout announcement, but ex-post the government cedes in order to avoid the negative consequences of a crisis in its SCGs' finances[14]. García-Mila et al. (2001), Esteller-Moré and Solé-Ollé (2004) and Sorribas-Navarro (2011) provide evidence for this hypothesis in the Spanish case[15].

2. Objectives, structure, research questions, methodology and main results

This thesis is structured into four chapters with a twofold common denominator. On the one hand, it analyses the cyclical behaviour of ACs' FP, with the aim of assessing the stabilising role of SCGs and the sustainability of their public finances. The behaviour of public finances throughout the economic cycle is a key element in guaranteeing their sustainability. In this sense, pro-cyclical behaviour in an expansive period can jeopardize the sustainability of public finances, especially if accompanied by a counter-cyclical FP response in bad times. That is why, the 2015 reforms of the European budgetary stability framework aim to find a compromise between stabilisation and fiscal sustainability (see a detailed discussion in European Commission (2016)).

On the other hand, this thesis aims to bring the analytical tools that guide the FP of EU Member States (such as fiscal reaction function, debt limit, tax elasticity, output gap and fiscal stance) closer to the regional case. In short, we explore instruments that allow better planning of the regional FP in order to guarantee both the stabilising role of SCGs and their fiscal

[14] Among the above-mentioned negative consequences, as noted by Solé-Ollé (2008), one must point out, first of all, the externalities in terms of financial costs for the rest of the SCGs and the economy, secondly, the reduction in the level of provision of SCGs' services resulting from a fiscal crisis, and finally, the differences in the level of provision of basic services such as education, health and social services (which can not be assumed by CG in terms of horizontal equity).

[15] It should be noted that the soft budget constraint hypothesis as a decisive factor in the SCGs' budgetary discipline is not incompatible with the existence of a vertical fiscal imbalance not adequately covered by transfers from the CG (Esteller-Moré and Solé-Ollé, 2004).

sustainability. There are several factors that suggest a potential heterogeneity in the cyclical patterns of ACs' FP, which may be caused by different preferences regarding the stabilisation function of SCGs, heterogeneity in regional business cycles (Bandrés and Gadea, 2013, provide evidence of such heterogeneity, although the Great Recession has led to greater regional synchronicity with the Spanish cycle), and even to varying exposure to corruption activities (in this regard, see the contribution of Alesina et al. 2008, which states that pro-cyclicality is more pronounced in more corrupt democracies) or to media information (Solé-Ollé and Viladecans-Marsal, 2017). The increasing regional dispersion in public debt ratios, in turn, also advises an examination of the potential heterogeneity of regional fiscal sustainability. Nevertheless, this thesis especially examines in depth in the first line of work (i.e. the cyclical pattern of public finances) while contributing with aggregate results on the second part (i.e. the sustainability of public finances).

After presenting the main objectives, we now introduce the four chapters that make up this thesis, presenting their specific goals, methodologies and main results.

i) *Fiscal Decentralisation and the Cycle in Spain: an Empirical Analysis of FP Responses*

As previously mentioned, ACs are responsible for a significant part of spending on the functions of the welfare state. The cyclical patterns of regional public finances as well as the sustainability of their debt are key issues in guaranteeing stability in the provision of these services. To what extent has the behaviour of ACs' FP been pro-cyclical? How has the overall FP and its discretionary part behaved[16]? Are there any significant asymmetries in the behaviour of regional FP through the economic cycle or between ACs? What role does the institutional framework play in budgetary balances, and in particular i) the degree of fiscal decentralisation (both in terms of revenue and expenditure), ii) the asymmetry between the common and foral regimes, and iii) the disparity in per capita resources between ACs as a result of the regional financing system? Is the debt of ACs sustainable? Has the primary balance response to the accumulation of the debt been subject to any structural changes?

[16] It should be noted that the cyclical part of FP always behaves counter-cyclically.

Chapter 2 addresses the above-mentioned issues for the period 1987-2012 through the estimation of a fiscal reaction function (see the seminal contribution of Bohn, 1998) to examine the determinants of the ACs' primary balances, and in particular the effect of the economic cycle, the response to the accumulation of debt, the institutional framework and other political economy factors. Regarding the institutional framework, we assessed the effect of fiscal autonomy, the differences in per capita resources provided by the regional fiscal model as well as the process of decentralisation of the major competences. This analysis is carried out by means of a panel data of ACs that enables us to:

a) deal with the endogeneity problem derived from the feedback between the primary balance and the cyclical conditions,

b) incorporate the contemporaneous correlation between the error terms by applying the SUR methodology (this methodology enables the capture of common shocks to all ACs, thereby gaining efficiency in estimation),

c) assess both the cyclical pattern of the FP as well as its discretionary part,

d) check for asymmetries in the response of the primary balance throughout the economic cycle,

e) check for asymmetries between ACs in the response of their structural balance throughout the economic cycle.

Our results suggest that the ACs FP presented counter-cyclical behaviour throughout the period 1987-2008, which turns out to be a-cyclical for the whole sample (1987-2012). The FP for those ACs under the foral regime is significantly more counter-cyclical and, unlike the ACs under the common regime, this behaviour has intensified since the outbreak of the crisis. In addition, the budget balance response throughout the economic cycle is symmetrical, i.e. the primary balance presents the same response at times of expansion and at times of recession. The analysis of the discretionary component of FP allows us to identify pro-cyclical behaviour that has been further accentuated since the onset of the financial and real estate crisis, which is especially worrying given the nature of the expenditure of these administrations (i.e. closely linked to the welfare state functions). However, this pro-cyclical behaviour differs across ACs. A preliminary analysis of such differences suggests that these different behaviours could be

determined, among other factors, by inertia as well as initial debt. The results also point to the sustainability of regional debt, although the primary balance response to debt has weakened significantly since 2008.

The institutional framework also plays a crucial role in sub-central fiscal performance. First, as ACs acquired greater welfare-state responsibilities (when education and health competences were devolved) their primary balances worsened. Regarding this effect, Asatryan et al. (2012) argue that a sufficient degree of revenue autonomy is a necessary condition for the internalization of the implications of spending decisions. Therefore, one negative effect of expenditure decentralisation may be due to soft budget constraint, as a result of the uneven fiscal decentralisation of both the revenue and the expenditure side. Second, the distribution of per capita resources between ACs also determines the soundness of regional public finances; i.e. higher per capita revenues favour sound budget balances. Third, the effect of fiscal autonomy on fiscal discipline is surprising, as this takes negative values when considering the whole sample. This unexpected effect presents two plausible explanations. One is the high correlation of the fiscal co-responsibility indicator with the economic cycle, as an important share of own-source taxes is directly linked to the real estate cycle (in particular, capital transfer tax and stamp duty). Secondly, the degree of fiscal autonomy could have been insufficient to cope with the huge imbalances caused by the crisis, in particular the very significant decrease in revenues from totally devolved taxes[17]. Therefore, this result (the negative effect of fiscal autonomy on fiscal discipline) should be treated with caution due to identification problems.

ii) Fiscal Responsiveness to Public Debt: an Analysis of Regional Debt

[17] Internationally comparative indicators suggest that Spanish ACs have a high level of taxing power (Blöchliger and Nettley, 2015), especially in relation to direct taxation. Nevertheless, this appraisal hides significant differences when comparing the potential for growth of direct taxation as opposed to indirect taxation. As shown in Cuerpo (2018), the cumulated impacts of discretionary measures regarding direct and indirect taxation have been completely opposite since 2000. The former measures follow a downward trend (partially offset by contractionary measures during crisis years), while the latter measures have presented an upward trend, especially since the Great Recession. It is beyond the scope of this thesis to explore these trends but they could be related to global tax trends, the effects of regional tax competition in direct taxation, the harmonization of indirect taxation in the EU, and, last but not least, SCGs incentives due to soft budget constraints and the dynamics of vertical equity between tiers of government, inter alia.

Limit Uncertainty

In recent years the debt increase of ACs has been very significant, going from 6.3% in 2007 to 26.8% in 2015 (as a percentage of GVA). This upward trend motivated a further exploration of the primary balance's response to the accumulation of debt, as a critical element in guaranteeing ACs' fiscal sustainability. This research aims to examine the following questions: How does the AC's budget react to the accumulation of debt? What is its functional form? What is the real margin for manoeuvre available to ACs in relation to the so-called debt limit (i.e. the threshold from which the dynamics of debt become explosive)? What is the uncertainty associated with the delimitation of this debt limit?

Chapter 3 provides an update (with data until 2015) of the fiscal reaction function presented in chapter 2 in order to examine the primary balance response to debt accumulation in more detail. Thus, in addition to addressing the issues mentioned in chapter 2, this third chapter:

a) assesses the linearity of the primary balance response to the accumulation of debt,

b) estimates confidence intervals (by applying simulation techniques) to evaluate the degree of uncertainty of the debt limit estimates,

c) reveals that the asymptotic distribution of the estimator may lead to a biased inference in finite samples, particularly when an asymmetric distribution lies behind the statistical relationship to be tested.

Broadly speaking, the results of this chapter allow us to confirm a nonlinear relationship between the primary balance and public debt, which points to a situation of "fiscal fatigue" for high levels of debt-to-GDP-ratio. The fiscal space of ACs seems to be quite limited, according to simulations with a confidence interval of 90%. Therefore, these results call for measures to ensure a sustainable debt trajectory and to regain some room to deal with potential negative shocks (Ghosh et al., 2013).

iii) *Dynamic Personal Income Tax Elasticities in Spanish Autonomous Communities*

The effects of the recent fiscal and financial crisis have also impacted the

evolution of tax revenues, and have highlighted the complexity of the response of tax revenues to the economic cycle. Up until recently, the response of tax revenues to economic activity (which is reflected in the concept of elasticity) was considered to be constant throughout the economic cycle. However, does it make sense to apply the same elasticity when making forecasts over the cycle? Can we expect a similar response of tax revenues to the economic cycle across ACs?

Chapter 4 focuses on the incidence of economic activity on the Personal Income Tax (PIT) revenue of ACs, with the aim of obtaining more accurate projections that contribute to a sounder FP. This work estimates PIT revenue elasticities through an error correction mechanism by specifying a cointegration relationship (see the seminal work of Sobel and Holcombe, 1996). The article presents a panel data analysis for the period 1987-2013 that:

a) differentiates between the short and long-term responses,

b) assesses potential asymmetries in elasticities through simulation methods,

c) evaluates differentiated responses between ACs based on their per capita income,

d) assesses the predictive ability of the different estimation methods (OLS vs IV).

The results of the fourth chapter suggest that the notion of tax elasticity should be more flexible in both its temporal and geographic dimension, as the analysis presented identifies significant differences in elasticities over time and between ACs. The differences between ACs confirm the decreasing pattern of PIT elasticities on a per capita income basis pointed out in Sanz-Sanz et al. (2016).

These findings may have implications for revenue forecasts and structural balance estimates. However, the assessment of the predictive capacity of these models suggests that those that consider different possible responses of tax revenues throughout the economic cycle do not systematically lead to better results when compared to models assuming a constant elasticity. In addition, the predictive ability of OLS and IV estimators has been evaluated

when endogeneity problems arise. The superiority of OLS over IV suggests that robustness in estimation does not always imply a better forecasting performance.

iv) *Estimating Potential Output at Regional Level with the European Commission's Methodology. An Assessment of the Fiscal Stance of the Generalitat of Catalonia*

The impact of the economic cycle when assessing the fiscal position of EU Member States is becoming increasingly important and, in fact, the European Commission, and the Member States themselves, monitor the orientation of fiscal policies several times throughout the year. Nevertheless, these evaluations only take into account the common cyclical position, disregarding more disaggregated information on a regional scale. Chapter 5 aims to fill this gap in the case of the Catalan economy, following the EC's methodology (in order to obtain the output gap and the structural balance). These estimates will allow us to assess whether the cyclical position of the Catalan economy is the same as that of Spain and the extent to which the discretionary part of the Generalitat's FP is pro-cyclical. It also highlights the main limitations of the EC's methodology. The Appendix includes alternative estimates of the cyclical position of the Catalan economy that are based on the seminal works of Watson (1986), Clark (1987) and Kuttner (1994). A preliminary evaluation of the properties of these unobserved components models (in pseudo-real time) does not provide satisfactory results. Nevertheless, we consider it appropriate to include them in order to guide future research. From a methodological point of view this fifth chapter:

a) applies for the first time the EU's commonly agreed production function methodology to a regional case,

b) explores the limitations of the unobserved components (UC) models used by the European Commission in the production function methodology,

c) estimates the regional cyclical position by means of UC models, but also explores the robustness of these estimates,

d) obtains the structural balance following the EU's methodology.

In fact, the results indicate that there are significant differences between the

cyclical position of the Catalan economy and that of the Spanish economy, according to the methodology of the European Commission. Measuring the cyclical position enables us to make an appraisal of the Catalan fiscal stance since 2004. In short, the fiscal policy of the Generalitat of Catalonia has been pro-cyclical, except for the first budgetary response to the crisis and the recovery period beginning in the second half of 2013.

Furthermore, the methodology used by the EC to measure the cyclical position presents some problems of robustness, especially with regard to the structural unemployment rate and the structural component of TFP, both of which are based on integrated variables of order 2. This approach may be a valid approximation during a certain period of time, but its economic meaning becomes weaker as there is an increasing impact from shocks as we go further on in time[18]. We have also compared the estimation of the output gap of the Catalan economy based on the EC method to other estimates based on established UC models. These UC models have not led us to any better results than other simpler methods such as the cyclical conditions derived from indicators like the degree of capacity utilisation in the economy[19]. However, this journey has been useful in that it has stressed some limitations surrounding key variables governing the EU's and the Spanish fiscal framework.

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[18] In the modeling of the TFP's structural component, the order of integration of the variables is allowed to be between 1 and 2. In fact, the above-mentioned problem is accentuated as the order of integration approaches 2.

[19] The evaluation is inspired by the approach of Hjlem and Jönsson (2010) and Marcellino and Musso (2011), thereby taking into account the following factors: a) the uncertainty of the estimates, b) the correlation with other indicators of the economic cycle and c) the forecasting performance regarding inflation and GDP. The first evaluation was carried out in pseudo-real time while the last two were done with ex-post data. For reasons related to the scope of this thesis, the first evaluation does not cover the method of the European Commission, which means we cannot draw robust conclusions.

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Chapter 2

Fiscal Decentralisation and the Cycle in Spain: an Empirical Analysis of Fiscal Policy Responses*

1. Introduction

The stability of public finances throughout the economic cycle is a central question in the study of public economics, and this has become even more stressed after the recent international financial crisis. From an institutional point of view, stability is increasingly important in the context of the Stability and Growth Pact, which provides a rule-based framework for the coordination of national Fiscal Policy (FP). However, sub-central FPs have received much less attention in the literature.

This work mainly explores the cyclical characterization of regional public finances in Spain over the period 1987-2012. Before turning to Spanish regional public finances, it is worth placing the fiscal performance of Spain in the European context. Bozio et al. (2015) compare the evolution of the public finances of six European countries throughout the Great Recession. In this selected sample, Ireland and Spain experienced the greatest deterioration of public finances, followed by France, Italy, UK and Germany (almost unaffected). In fact, the impact of the crisis (in terms of borrowing) was higher in those countries where public finances appeared to be sounder. Martí and Pérez (2015) provide a detailed analysis of Spanish public finances through the financial crisis. After an early counter-cyclical response to the crisis (2008-2009), an adjustment in public finances was

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unavoidable. In fact, Domenech and González-Páramo (2017) suggest that the sustainability of public finances was severely in question between 2009 and 2011. The fiscal space attained in the pre-crisis period became insufficient to cope with the deterioration of public finances. In other words, the Spanish economy had few alternatives to the pro-cyclical FP implemented throughout the crisis. The situation of Spanish regional public finances presents a similar pattern to that of the general government but some singularities emerge. The pro-cyclical pattern of expenditure in good times is one of the issues highlighted by de la Fuente (2013) and Lago Peñas and Fernández Leiceaga (2013). Both works reveal a heterogeneous response to the crisis in ACs' public finances, which may be worth exploring in further detail.

From an international perspective, the empirical evidence of the cyclical pattern of sub-central public finances does not provide us with conclusive results. Rodden and Wibbels (2010), with a sample of seven federations and data until 2001, identify pro-cyclical FPs of sub-central governments (SCGs), especially with regard to their own revenues but also with regard to SCGs' transfers and tax shares, which are either neutral or pro-cyclical. These results, as the authors point out, are disturbing given that SCGs cover an increasing number of competences related to the welfare state. In a more recent work, Von Hagen and Foremny (2013), with a sample of 15 European countries of which 4 are federal and data until 2010, identify counter-cyclical behaviour in SCGs in the group of federal countries, in contrast to the SGCs in the group of unitary countries. From this analysis, it is worth highlighting, on the one hand, a more stable real expenditure in SCGs in federal countries, and on the other hand, a significant increase in transfers from central governments to SCGs in unitary non-crisis countries (in particular throughout the Great Recession).

There are few econometric analyses that have dealt with the cyclicality of regional public finances in Spain. Argimón and Hernández de Cos (2012) find counter-cyclical behaviour in the *foral* ACs and ACs with more responsibilities. In contrast, Barrios and Martínez (2013) find pro-cyclical behaviour in Spanish ACs, much more pronounced than in Canadian provinces and German Länder.

In order to evaluate the cyclical characterization of regional public finances in Spain, we take a standard Keynesian definition of pro-cyclical or counter-cyclical FP. According to de Castro et al. (2010) the measurement of "fiscal stimulus" or "fiscal impulse" [1] may be approached from an "input side" perspective (that is, measuring changes in government finances) or from an "output side" perspective (that is, in terms of its macroeconomic effects). In our work we use a comprehensive "input side" indicator for the fiscal impulse[2] (that is the change in the primary balance-to-GDP ratio) and a proxy for the role of discretionary policies (that is, the change in the cyclically adjusted primary balance-to-GDP ratio, the so-called "fiscal stance")[3]. It must be noted that it is common practice to take the fiscal stance as a measure of fiscal activism (see the European Commission's annual assessments in *Report on Public Finances in EMU*), but this measure only provides a partial view of the fiscal impulse. Thus, we also take into account the change in the primary balance, so that it includes the reaction of automatic stabilizers[4].

In this paper, we offer a detailed assessment of the cyclicality of regional public finances in Spain. On the one hand, our comprehensive "input side" measure suggests that FP was counter-cyclical over the period 1987-2008 but our results turn this into an a-cyclical impulse over the whole sample. We confirm the results of Argimón and Hernández de Cos (2012), as *foral* ACs present a more counter-cyclical FP, especially over the 2009-2012

[1] For an overview of fiscal impulses and their components, see Section 3.2 of Van Riet (2010).

[2] Our focus on the "input side" perspective is related to our interest regarding the cyclical characterization of public finances, whereas the "output side" perspective examines the macroeconomic consequences of government measures. In this regard, there is a large strand of literature examining the output effects of recent fiscal adjustments (e.g. Blanchard and Leigh, 2013; Hernández de Cos and Moral-Benito, 2016; Alesina et al., 2015).

[3] From a theoretical point of view the best indicators for assessing the cyclicality of public finances are government spending and tax rates (see a detailed explanation in Kaminsky et al., 2004). However, regional expenditures and revenues in Spain have experienced structural changes (as a result of the decentralisation process), which preclude this approach.

[4] The rationale for analysing both indicators is also reinforced by the design of Spanish budgetary stability regulations. Structural deficits are not allowed (unless under exceptional circumstances) in the *Organic Law 2/2012 on Budget Stability and Financial Sustainability*, but in practice stability budget targets are set in terms of a comprehensive measure, "the budget balance-to-GDP ratio". It may be therefore interesting to perform both analyses.

period. In addition, we also note that as education and health were devolved ACs' budgets became more counter-cyclical, which may be due to downward expenditure rigidity. We also explore differences between cyclical behaviour in good and bad periods for the economy, an issue not covered in the literature for ACs to the best of our knowledge. This is an important issue as counter-cyclical measures in good periods allow supportive fiscal behaviour in bad ones. We do not find any systematic differences between good and bad times. The European Commission (2006) provides evidence of pro-cyclical FP both in both good and bad times, although this evidence is not based on a comprehensive measure but on the discretionary part of the fiscal impulse.

Our assessment of the discretionary FP of ACs indicates pro-cyclical fiscal behaviour, in line with the above-mentioned evidence (European Commission, 2006). This pro-cyclical behaviour has sharpened since the last crisis and is stronger than that of the general government. This shift in the cyclical properties of FP may not represent an improvement in welfare as ACs are responsible for stable expenditures such as health, education and social services. In this regard it is important to indicate the literature examining how central governments have shifted the burden of consolidation to sub-central governments (see Von Hagen and Foremny, 2013; Vammalle and Hulbert, 2013 and Foremny et al., 2017). In addition, our data suggest asymmetries in the discretionary response across ACs, which may be related to different preferences regarding the stabilization function, heterogeneity in regional business cycles (Bandrés and Gadea, 2013, provide evidence of such heterogeneity, although the Great Recession has led to greater regional synchronicity with the Spanish cycle), and even to varying exposure to corruption activities (in this regard, see the contribution of Alesina et al. 2008, which states that pro-cyclicality is more pronounced in more corrupt democracies) or to media information (Solé-Ollé and Viladecans-Marsal, 2017). A first attempt at identifying the determinants of these asymmetries throughout the crisis points to the role of persistence and initial debt level.

Our empirical analysis of FP over the cycle is based on the estimation of a fiscal reaction function (FRF), where a measure of fiscal impulse or fiscal stance is regressed against several factors explaining the behaviour of fiscal authorities, notably the past level of deficit, lagged debt and a measure of

cyclical conditions. However, other determinants also play a crucial role regarding sub-central fiscal performance, in particular institutional settings. There is a considerable literature that deals with these institutional factors that we take into account to improve the specification of our FRF[5]. To be specific we deal with intergovernmental relations (soft budget constraint, fiscal adjustment across tiers of government and singularities of the regional financing system), political economy variables, and last but not least, the role of fiscal autonomy and fiscal rules. These are not the main issues of our paper but it may be important to consider them as some may have a direct effect on pro-cyclicality (e.g. fiscal adjustment across tiers of government and fiscal rules) and the remainder on fiscal discipline (soft budget constraint, electoral cycle, per capita fiscal resources).

This chapter is structured in five sections. After this introduction we discuss the institutional background, in particular fiscal decentralisation issues. In section 3 we lay out our empirical strategy. Section 4 presents and discusses data issues and results. Finally, section 5 concludes.

2. Institutional Background

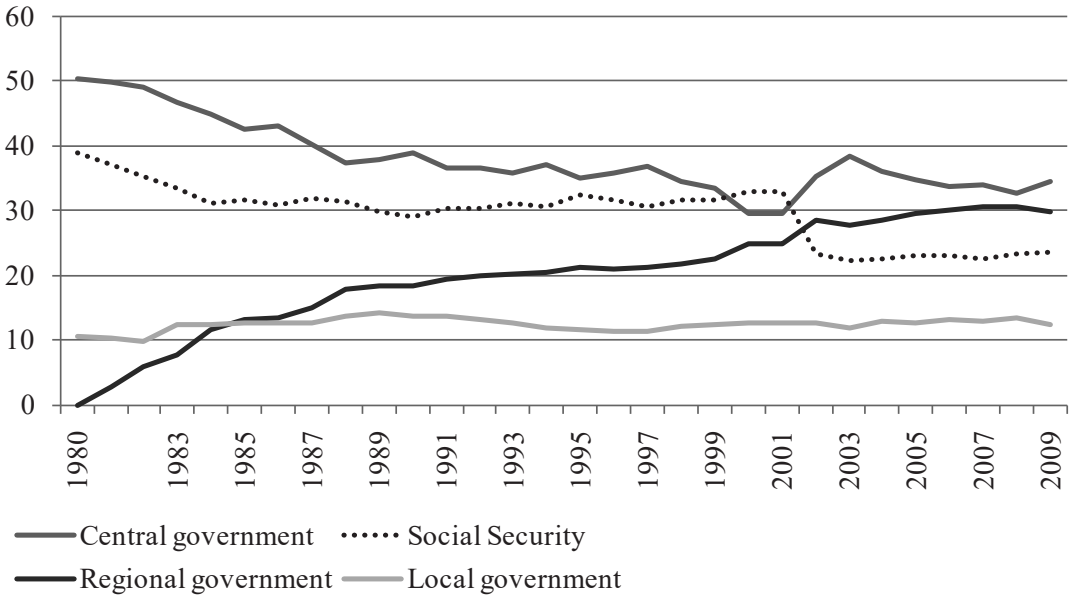
Over the past 30 years Spain has moved from having a highly centralized public sector to a distribution of revenues and expenditures similar to federal countries like Australia, Germany or Switzerland (see Molina and Mussons, 2010). The 1978 Spanish Constitution organises the territorial structure into municipalities and provinces at the local level, and 17 ACs at the intermediate level and recognizes their autonomy in managing their own interests. The decentralisation process in Spain has been very fast regarding expenditures, in contrast to the revenue side. Figure 2.1 reflects Spanish territorial decentralisation from the expenditure side[6]. All the ACs have assumed responsibilities in fundamental areas of the welfare state such as education, health and social services. ACs represent one third of non-financial public expenditure in Spain according to 2011 data (see Table 2.1). However, ACs' non-financial revenues account for 23.4 % of that of general government (Table 2.1). Therefore, despite these institutional changes, vertical fiscal imbalance is still important at the intermediate level

[5] In section 4.2.1, we present a brief summary on the role of these factors and we link our results with the related literature.

[6] The data in Figure 2.1 include financial expenditure, and therefore differ from data presented in Table 2.1, which refer to non-financial expenditure.

in Spain. It should be highlighted that dependence on central government transfers is generally associated with lower sub-central fiscal performance (e.g. Rodden, 2002).

Figure 2.1. Distribution of general government expenditure by tiers of government (as a % of general government expenditure including interest payments)



Source: Spanish Ministry of Finance and Public Administration.

This decentralisation process is one of the main issues to bear in mind in order to ensure an appropriate evaluation of the budgetary policy of ACs. There are some asymmetries that should be noted in the Spanish case. On the one hand, there are two regimes with important differences regarding the authority to raise taxes and regarding per capita public resources: the *foral* regime and the common regime. The *foral* regime, which is in force in the Basque Country and Navarre ACs, is characterised by a high level of fiscal autonomy, low interregional solidarity and greater (per capita) public resources with respect to common regime ACs. Another fundamental asymmetry is related to the process of devolving spending responsibilities. There was a fast and a slow path to assuming ACs' responsibilities. High responsibility regions (Andalusia, Canary Islands, Catalonia, the Valencian Community, Galicia, the Basque Country and Navarre) have been responsible, in general, for health and education since the 80s; the other

ACs only completed the decentralisation process in 2002. Health and education account for the largest part of the budget, representing 65.7 percent in 2007 of the total spent by ACs (Molina and Mussons, 2010). Nevertheless, we should keep in mind that the central government is able to establish basic legislation on these areas, and therefore it can condition the expenditure of ACs.

Table 2.1. Distribution of non-financial general government expenditure and revenue by tiers of government

(as a % of total non-financial general government expenditure)

	Central government	Social Security	Regional government	Local government
2002	24.4	30.3	32.3	13.1
2009	20.7	29.7	35.7	13.8
2011	21.6	31.9	34.3	12.3

(as a % of total non-financial general government revenue)

2002	39.5	31.1	19.3	10.1
2009	29.8	34.9	24.2	11.1
2011	32.4	33.2	23.4	11.0

Source: Spanish Ministry of Finance and Public Administration.

Furthermore, within the common regime we must point out the main changes in the regional financing agreements of our period of reference, as they condition the responsiveness of ACs' FP to cyclical conditions. There have been five financing agreements since 1987 that cover these periods: 1987-1991, 1992-1996, 1997-2001, and 2002-2008; the current agreement came into force in 2009. Initially the common regime was characterized by there being a fair amount of expenditure responsibility, but very little revenue autonomy. The regions in this regime were mainly financed through central government transfers until 2001. The 2001 agreement increased the number of ceded taxes as well as ACs' tax power in order to improve their fiscal responsibility. In fact, it was intended to be the definitive agreement but it could not cope with the uneven population increase across regions. The current agreement represented an improvement in terms of autonomy and financial sufficiency.

The tax basket of ACs is made up of partially and totally (also called "traditional") ceded taxes. The former includes personal income tax, VAT

and excise taxation; the latter comprises the retail tax on hydrocarbons, capital transfer tax, stamp duty, inheritance and gift tax, car registration tax, gambling tax, wealth tax, and electricity tax. The current tax shares of ACs, regulatory powers and tax collection responsibilities are summarized in Table 2.2. In 2009 the shares of ACs in state taxes increased: personal income tax from 33% to 50%, VAT from 35% to 50% and excise taxes from 40% to 58%. Tax autonomy is limited to totally ceded taxes and to certain elements of personal income tax, while ACs' responsibilities for tax collection are even more limited. ACs are only responsible for the collection of taxes on inheritance, gambling, wealth and property transactions (capital transfer tax and stamp duty); those remaining are collected by the Spanish Tax Agency (AEAT); see Bosch (2010) for a more detailed description of the tax system.

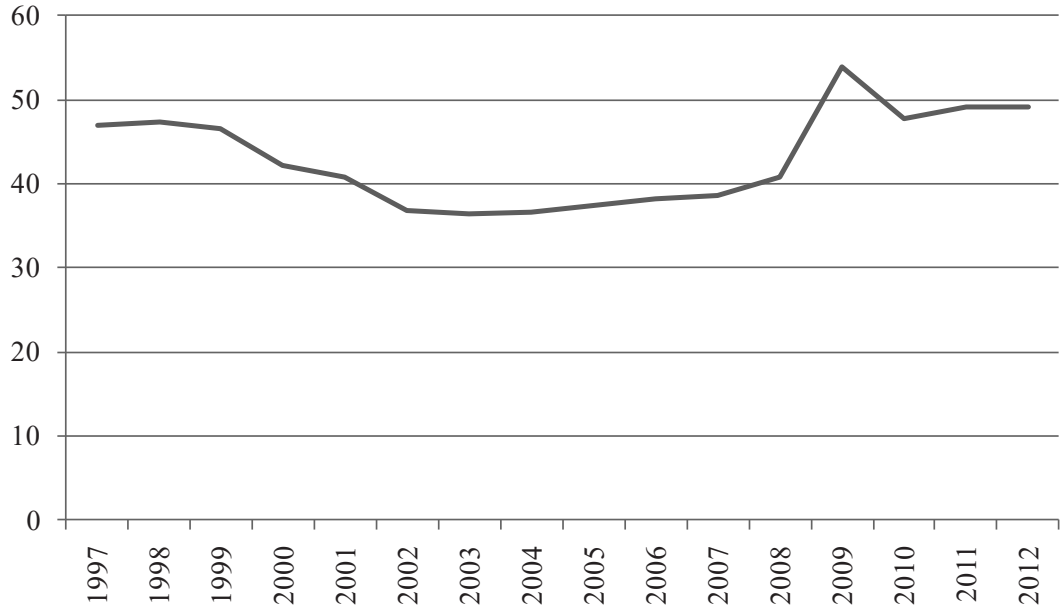
Table 2.2. Taxes ceded to common regime ACs since 2009

Tax	ACs' share	ACs' legal powers	Administration
Income tax	50%	Yes	State
VAT	50%	No	State
Tobacco excise	58%	No	State
Alcohol excise	58%	No	State
Tax on hydrocarbons			
Excise	58%	No	State
Retail tax	100%	Yes	State / AC *
Capital transfer tax	100%	Yes	AC
Stamp duty	100%	Yes	AC
Inheritance and gift tax	100%	Yes	AC
Car registration	100%	Yes	State / AC *
Gambling tax	100%	Yes	AC
Wealth tax **	100%	Yes	AC
Electricity tax	100%	No	State

Source: Own compilation based on Bosch and Duran (2008).
Notes: * State currently administers the tax, although it could be carried out by the AC.
** In 2008, the State established an allowance of 100% of the quota and a compensation for the autonomous communities for the loss of their tax revenue (Law 4/2008). However, in 2011, Royal Decree Law 13/2011 was passed, temporarily re-establishing wealth tax for the years 2011 and 2012. This re-establishment of wealth tax has been subsequently renewed.

Overall revenue autonomy has increased over the last 30 years as shown in Figure 2.2, where we present our index of fiscal co-responsibility (that is, the percentage of own-source taxes in total revenues), in line with the literature that deals with the effects of revenue autonomy on fiscal discipline (e.g. Asatryan et al. 2012; Foremny, 2014). In practice, there are important caveats when dealing with Spanish ACs, as an important share of own-source taxes is strictly linked to the real estate cycle (in particular, capital transfer tax and stamp duty)[7]. As a matter of fact, we can only appreciate an increase in revenue autonomy as a result of the real estate tax boom and the 2009 agreement. The decline in the late nineties was due to the devolution of education and health, while in the last crisis the dynamics of totally devolved taxes has triggered a sharp fall. Therefore the results of the econometric investigation that we can infer from this indicator should be taken with due caution.

Figure 2.2. Aggregate fiscal co-responsibility index
(% of own-source taxes as a share of total revenues)



Note: These data correspond to ACs' financing system resources.
Source: Own compilation based on definitive data from Spanish Ministry of Finance and Public Administration.

[7] See Lago Peñas and Fernández Leiceaga (2013) and Leal Marcos and López Laborda (2013) for a descriptive analysis of the dynamics of totally ceded taxes during the crisis.

After the allocation of tax revenues, equalisation mechanisms come into play. The 2009 agreement introduced a partial equalization mechanism (the Guarantee Fund) the results of which have been very much distorted by subsequent vertical transfers (the Sufficiency Fund, the Cooperation Fund and the Competitiveness Fund). Its objective is to ensure that ACs have the same amount of potential resources per capita to provide the essential services of the welfare state. The Guarantee Fund is financed with 75% of ACs' tax revenues and a vertical transfer. These resources are distributed according to an indicator that is supposed to capture spending needs. This indicator, the so-called adjusted population, is mainly determined by population variables (i.e. equivalent population for health care purposes, population, population between 0 and 16 years and population over 65 years). In fact, population variables account for 97% of this indicator. The main goal of the Sufficiency Fund is to guarantee that no AC is penalized by the equalization mechanism, or in other words, to guarantee that all ACs reach the so-called "revised status quo". The Cooperation Fund is allocated to low income per capita ACs, low population density ACs and ACs with a stagnant population, whereas the Competitiveness Fund provides additional resources to narrow the differences in resources per capita. The latter fund is distributed either to ACs which end up with a level of per capita resources below the average or to ACs with a per capita resource index below the adjusted index of fiscal capacity. The pattern of total per capita resources after the implementation of all these funds is very different from the pattern of potential per capita tax revenues, which does not ensure the fulfilment of the ordinality principle (i.e. if an AC has potential per capita tax revenues higher than another, it cannot end up with less per capita resources than the latter); see Vilalta (2017), Table 1.

In addition to equity and efficiency concerns, these funds make the prediction of regional revenues really challenging, a deficiency which may hinder the adoption of an appropriate fiscal stance.

Finally, another important issue in ensuring an appropriate evaluation of ACs' budgetary policy is the legislative fiscal rules in force. In fact, budgetary activity in ACs is restricted by a group of fiscal rules that condition their performance, in particular, the LOFCA (the Organic Law on the Financing of ACs), Budgetary Consolidation Scenarios over the period 1992-2001 as well as more recent budgetary stability legislation (see

Argimón and Hernández de Cos (2012), and Hernández de Cos and Pérez (2013a)).

3. Empirical strategy

As mentioned in the introduction, in order to evaluate the cyclicality of ACs' public finances we use a comprehensive "input side" indicator for the fiscal impulse and a proxy for the role of discretionary policies (see de Castro et al. (2010) for a careful explanation regarding how to measure a fiscal stimulus). The empirical analysis of the behaviour of FP over the cycle is based on the estimation of FRFs (for which we also use "FP rules" as a synonym), where a measure of fiscal impulse or fiscal stance is regressed against potential factors explaining the behaviour of fiscal authorities, notably the past level of deficit, lagged debt and a measure of cyclical conditions. In this section we first pay attention to the empirical literature that deals with FRF, with regard to our empirical choices and the critical issues of our analysis. Second, we present our empirical specifications to assess the cyclicality of ACs' fiscal impulse, including a symmetric and an asymmetric specification. Finally, we turn to the empirical strategy to deal with discretional FP.

Since the seminal work of Bohn (1998), the literature on FRF has been extensive[8]. The empirical choices regarding the specification of FRF are crucial, and therefore we provide a short discussion on the core elements of FP rules (type of rule, dependent variable, independent variables, method of estimation, robustness analysis), without any pretensions to being exhaustive.

(i) Type of rule. Do we base our policy rule on the expectations of the output gap (forward-looking rule) or on the past values of the output gap (backward-looking rule)? Galí and Perotti (2003) and Ballabriga and Martínez-Mongay (2002) base their main estimates on a forward-looking approach. The potential autocorrelation of budget decisions should also be taken into account by including the lagged dependent variable as a regressor

[8] See Golinelli and Momigliano (2009) for an interesting review of the empirical literature regarding the cyclical response of FP in the euro area. However, it must be stressed that most of the literature focuses on debt sustainability, that is, on the response of the primary balance to the accumulation of debt. Berti et al. (2016) and Checherita-Westphal and Zdarek (2017) provide a useful summary of this strand of the literature.

(for instance, by specifying a partial-adjustment model). Nonlinear issues related to debt and related to switching models are also interesting extensions to the baseline model.

(ii) Dependent variable. The choice of the dependent variable is not neutral. In fact there are various issues that need to be addressed. Firstly, we should choose the specification in levels or in first differences. Secondly, the cyclical adjustment of fiscal data is also of great relevance, as we have already remarked. If we cyclically adjust our data we are dealing with discretionary measures, whereas if we do not make this adjustment we are analysing the whole effect of FP (both automatic and discretionary measures). In addition, the analysis of both revenue and expenditure seems of particular interest, as these might follow different patterns (see Turrini, 2008).

(iii) Independent variables. The baseline model includes variables that capture the debt stabilisation motive (a test of government solvency) as well as the output gap stabilization motive (a test of government response to cyclical conditions). "The choice of the output gap in levels focuses on whether the position of the economy is above or below its trend and on its distance from it, while the reference to growth measures focuses on whether the economy is in an upturn or in a downturn and its intensity" (Golinelli and Momigliano, 2009, 41).

Other determinants may also play a crucial role regarding fiscal performance, in particular institutional settings: for instance, the role of intergovernmental relations (soft budget constraint, fiscal adjustment across tiers of government, and the singularities of sub-central financing systems), political economy variables, the role of fiscal autonomy and fiscal rules (Argimon and Hernández de Cos, 2012, explore some of these issues concerning ACs); see a discussion of this literature in section 4.2. Moreover, in some analyses the roles of monetary policy variables are also considered (e.g. Claeys, 2005).

(iii) Method of estimation. If FP is endogenous with respect to our cyclical indicator we should use instrumental variables or GMM methods (e.g. Galí and Perotti, 2003). Besides, it seems interesting to assess differences between single equation and panel data results. When dealing with panel data we might allow for contemporaneous correlation between error terms,

and therefore apply seemingly unrelated regression equations (e.g. García et al., 2009).

(iv) Robustness analysis. It is a central issue to assess the robustness of the main results. Accordingly, it is interesting to account for alternative measures of the cyclical position, different data sources and vintages (see Golinelli and Momigliano, 2009).

Our baseline specification takes the **primary balance to gross value added ratio** of each AC (*PBB*) as the policy instrument and sets its target as a function of **cyclical conditions** (real gross value added growth (ΔGVA), change in the unemployment rate or employment growth), the **lagged dependent variable**, the **lagged level of public debt to GVA ratio** (*DEBT*), an **index of expenditure responsibilities** (*IRES*) and an **electoral cycle variable** (*ECYCLE*); see Appendix section 7.1 for variable definitions and data sources. By including the lagged dependent variable we are taking the strong inertia related to policy processes into account. As Ballabriga and Martínez-Mongay (2002, 9-10) state "inertia is to a large extent explained by the political difficulty of changing past spending commitments and carrying out regular and recurrent drastic adjustments in tax codes".

$$PBB_{it} = \gamma_1 + \gamma_2 E_{t-1}\Delta GVA_{it} + \gamma_3 PBB_{it-1} + \gamma_4 DEBT_{it-1} + \gamma_5 IRES_{it} + \gamma_6 ECYCLE_{it} + u_{it} \quad (1)$$

,where *i* stands for AC and *t* stands for year.

Specification (1) is close to the Argimón and Hernández de Cos (2012) approach. Nevertheless, the specification of cyclical conditions is close that of Galí and Perotti (2003), that is a forward-looking approach. Most of the time FP measures are taken in the year before they become effective. Accordingly, our FP rule should respond to the one-year-ahead expectations (E_{t-1}) of the cyclical position. In practical terms, as this information is not available at regional level, $E_{t-1}\Delta GVA_{it}$ is replaced by ΔGVA_{it}. That is, we assume that policy makers are provided with accurate forecasts.

In some specifications we allow for asymmetric reactions over the cycle by including two variables that capture the change in cyclical conditions in upturns and downturns. The identification of **good and bad times** is drawn from Kaminsky et al. (2004). We divide the sample into episodes where our cyclical position variable (real gross value added growth, change in the

unemployment rate or employment growth) is above the median (good times) or below it (bad times); it works the other way round for changes in the unemployment rate. The relevant median is calculated for each AC.

$$PBB_{it} = \gamma_1 + \gamma_2 E_{t-1}\Delta GVA_{it} * good\ times_t + \gamma_3 E_{t-1}\Delta GVA_{it} * bad\ times_t + \gamma_4 PBB_{it-1} + \gamma_5 DEBT_{it-1} + \gamma_6 IRES_{it} + \gamma_7 ECYCLE_{it} + u_{it} \quad (2)$$

Other extensions of this FP rule are also considered by including institutional and political economy variables. Concerning political economy variables, we should distinguish between variables related to incumbents and the influence of the institutional framework.

As the ideology of incumbents is a factor that may lie behind primary budget balance determinants, we include the number of seats in legislative assemblies corresponding to the ideology concerned (**percentages of left-wing seats and of nationalist seats**). In addition, we include a **political alignment** variable indicating whether an incumbent party (or a party leading an incumbent coalition) in the regional government is the same as the incumbent party in the central government (or the party leading an incumbent coalition).

The influence of the institutional framework is hard to proxy, especially in Spain with its decentralised government. For this purpose we have included a wide range of variables: an **index of expenditure responsibilities**, which tracks the increase in regional per capita expenditure spending needs due to the assignment of health care and education, an **index of aggregate fiscal co-responsibility**, which captures the percentage of own-source taxes as a share of total revenues[9], an **index of per capita fiscal resources**, an **index**

[9] When dealing with the fiscal co-responsibility index we do not allow for cross section variation. As our index captures the percentage of ACs fiscal resources that may be changed, it is very likely that by construction this variable would lead to a negative estimate of the effect of co-responsibility on ACs primary budget balance. The reason that lies behind this conditioned correlation is the dynamics of the different type of fiscal resources: totally devolved taxes, partially devolved taxes and transfers. We expect a negative impact of fiscal co-responsibility as those ACs with a higher index also have a greater weight of totally devolved taxes that shrank (much more than transfers) throughout the crisis. Therefore, the index in the aggregate form seems to be more appropriate, although it is subject to the same *caveats*, albeit limited in extent.

of fiscal rules[10], and binary dummies for ***foral*** **ACs** (1 for the Chartered Community of Navarre and the Basque Country, 0 otherwise) and **ACs with a single province** (1 for the Community of Madrid, the Chartered Community of Navarre, the Balearic Islands, La Rioja, Cantabria, the Principality of Asturias and the Region of Murcia, 0 otherwise)[11].

The estimation method used is seemingly unrelated regressions (Zellner, 1962), which considers the possibility that the error terms may be correlated across the equations of the system[12]:

$$E(u_{it}, u_{jt}) = \sigma_{ij} \text{ for all } t,\ E(u_{it}, u_{js}) = 0 \text{ for all } t \neq s \qquad (3)$$

Indeed, we might expect that central government measures that affect the primary budget balance in one AC would simultaneously affect the primary budget balance in other ACs as well.

In addition, as suggested by the results of endogeneity tests, our estimates rely on an instrumental variables estimator. Galí and Perotti (2003) instrument their endogenous variable with that of another country (or group of countries) with which it is likely to be correlated for reasons other than the existence of coordinated FP. Endogeneity of cyclical conditions has been checked using the Hausman test and, as we reject the null hypothesis, we instrument the changes in the cyclical position with the changes in the output gap of the five biggest Spanish export markets (weighted by export shares). This variable is much less volatile than our competing indicators for the cyclical position (see Figure 2.4). To test for the weak instrument issue, we provide Shea's partial R^2. Results do not indicate any weakness in our instrument, with the exception of some asymmetric specifications, such as those related to employment growth and changes in the unemployment rate (see Tables 2.4 and 2.5).

Finally, we turn to the empirical strategy adopted to deal with discretional FP. Disentangling the structural from the cyclical part of the PBB is an open issue in the literature. We can distinguish two main approaches: the

[10] We use the European Commission's fiscal rules index, which is constructed by adding together all fiscal rule strength indices in force in the respective Member State weighted by the coverage of the respective rule in general government finances.

[11] In single-province ACs, the regional government also assumes the functions of provincial local governments.

[12] García et al. (2009) estimate FP rules for EMU countries using the same method.

first is used by the European Commission (see Mourre et al. 2014), which evaluates the automatic response of different budget items from a disaggregate point of view; the second obtains the cyclical part of the PBB from an aggregate point of view, though there are different methods of computation. A straight-forward approach (e.g. Raymond, 1996) computes the adjusted PBB partialling out the effect of a median growth scenario); an approach based on unobserved components uses macroeconomic relationships (such as the Phillips Curve or Okun's Law) to infer the structural component of PBB (e.g. Corrales et al., 2002). Our approach relies on the former, which can be expressed as (4) and (5).

$$\widehat{structural}\ PBB_{it} = PBB_{it} - \widehat{cyclical}\ PBB_{it} \tag{4}$$

$$\widehat{cyclical}\ PBB_{it} = \widehat{PBB_{it}} - \left[\widehat{PBB_{it}} | GVA\ growth_i = median\ GVA\ growth_i\right] \tag{5}$$

In order to assess counter-cyclicality we focus on a marginal concept (as done by Turrini, 2008), namely we appraise the correlation between changes in the structural PBB and gross value added growth. A positive correlation between the fiscal stance and the variation in the cyclical conditions is indicative of counter-cyclicality, while the opposite indicates pro-cyclicality. Moreover, we carefully examine the response to the Great Recession in the whole sample, as well as for regional asymmetries. In addition to the analysis of discretional FP of ACs, we deal with that of the general government. This allows for regional findings to be placed in connection with Spanish public finances as a whole. It is worth mentioning that by comparing general government and regional governments estimates one can guess the behaviour of the central public sector (as local governments are playing a less significant role, around 12% of general government expenditure).

4. Empirical analysis

4.1. Data and descriptive evidence

Before the econometric analysis we provide some remarks concerning the dependent variable in the econometric analysis (i.e. primary budget balance-to-GVA ratio) and related to the co-movement between cyclical conditions and primary budget balance. Appendix section 7.2 provides some descriptive statistics.

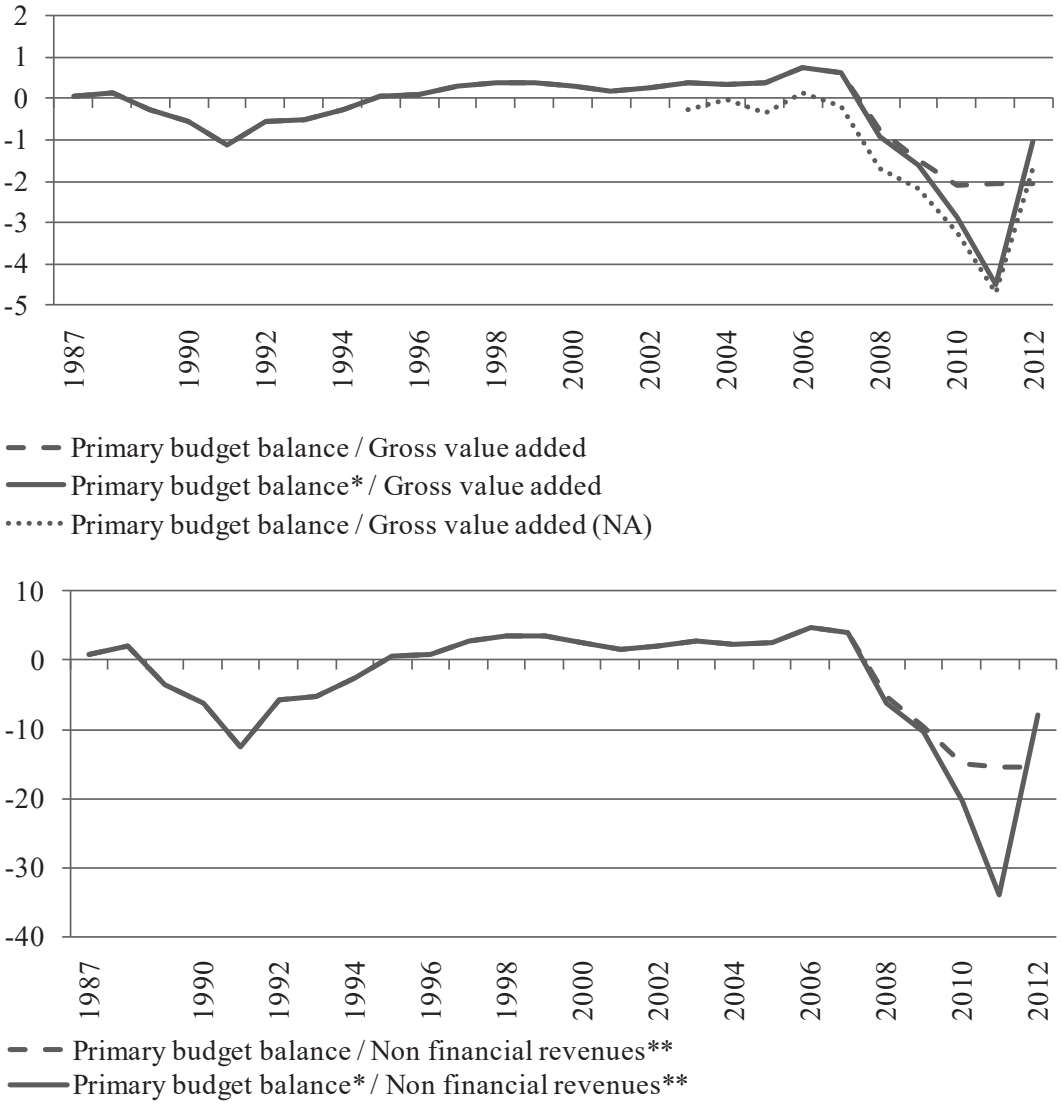
We restrict our analysis to the period 1987-2012. Before 1987, the central government provided the funding for the transferred services according to the *effective cost* (the cost before decentralisation), which included direct and indirect costs, as well as investment outlays. Thus, we exclude from our analysis the previous period, as ACs had little influence over the evolution of budget balances.

To start with, the primary budget balance of each AC is computed according to budgetary criteria both regarding the institutional range covered as well as the accounting rules, with adjustments following de la Fuente (2013) and Lago Peñas and Fernández Leiceaga (2013). On the one hand, we make corrections for negative settlements from the funding system (for the years 2008 and 2009), payments of which were deferred: by construction these negative results are cancelled in 2010 and 2011 respectively (as provided for initially by law), and accordingly we do not apply revenue withholdings in 2011 and 2012 (to return those deferred payments). On the other hand, we make adjustments related to outstanding invoices (misplaced public expenditure), which are captured by annual changes in accounts payable for accrued liabilities. After these adjustments our data are very close to national accounts criteria (see Figure 2.3). In addition, as in Lago Peñas and Fernández Leiceaga (2013), we have also considered another definition of the dependent variable (primary budget balance to non-financial revenues), but the results did not cause significant changes.

Turning to the co-movement between cyclical conditions and primary budget balance, we assess the adequacy of three competing indicators: real gross value added (GVA) growth, employment growth and changes in the unemployment rate (see Figure 2.4)[13]. The first indicator is the one we selected for the whole analysis, as it is the one more easily instrumented with the changes in the output gap of the five biggest Spanish export markets, in line with the empirical strategy of Galí and Perotti (2003).

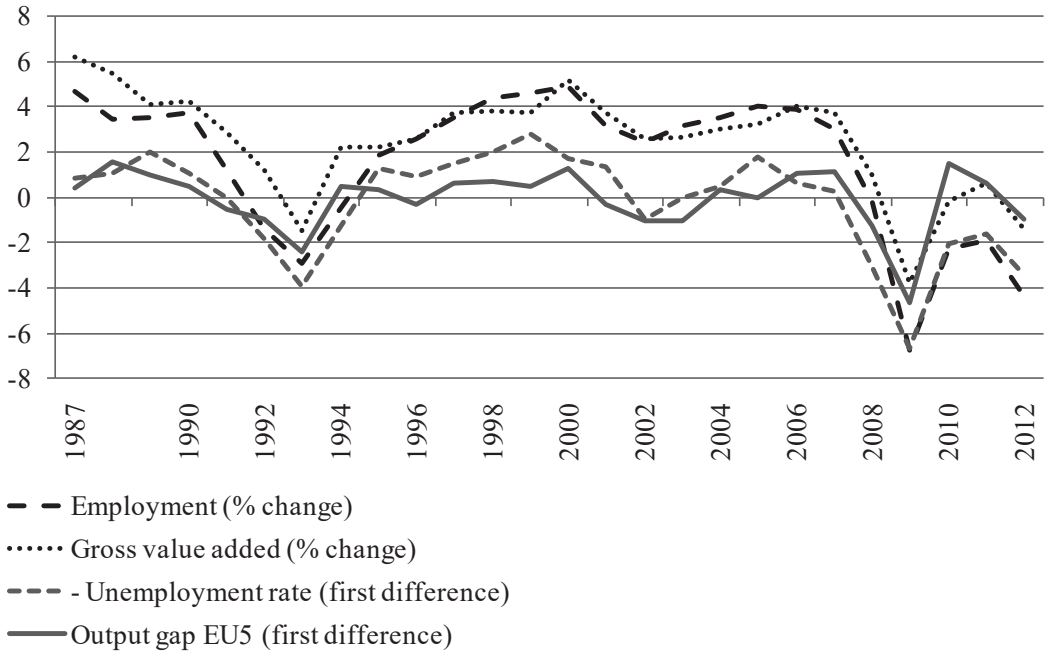
[13] We have also estimated the cyclical conditions with a Hodrick-Prescott (HP) filter on GVA. Nevertheless, the HP filter failed to capture the intensity of the most recent crisis.

Figure 2.3. Dependent variable: alternative definitions (%)



Notes: * Adjusted for 2008 and 2009 negative settlements and outstanding payments to suppliers. ** Adjusted for FEOGA revenues and local funding revenues. *NA* stands for national accounts data.
Sources: Own compilation based on data from Spanish Ministry of Finance and Public Administrations, BDMORES and INE.

Figure 2.4. Cyclical position measures for Spain



Sources: Own compilation based on data from BDMORES, INE and AMECO.

According to changes in the cyclical position we can identify different sub-periods; two upturn periods (1987-1990 and 1997-2007) and two downturn periods (1991-1996 and 2008-2012). For each AC and sub-period, we compute the mean of the gross value added growth and the mean of the primary budget balance as a share of GVA. These statistics are shown in Table 2.3, which also reports the ratio between both variables. The latter ratio can be interpreted as a simple statistic that captures the sign and intensity of the fiscal response. A scatter plot of the same data is displayed in Figure 2.5.

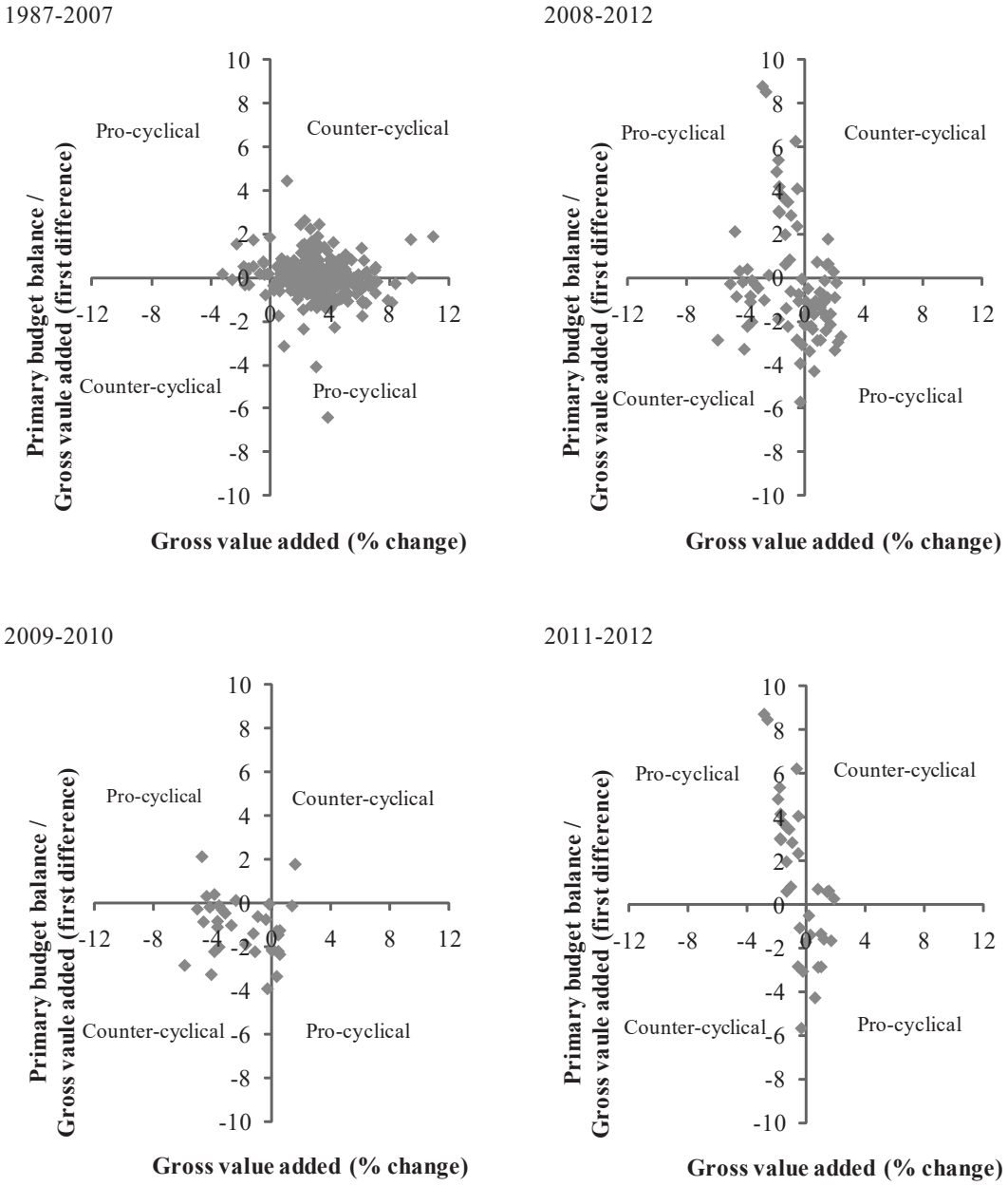
Table 2.3. Descriptive statistics by sub-periods
(Mean of the indicated period by AC)

	1987-1990				1991-1996			
	(1) Gross value added (% change)	(2) Primary budget balance / GVA (%)	Debt / GVA (%)	(2) / (1)	(1) Gross value added (% change)	(2) Primary budget balance / GVA (%)	Debt / GVA (%)	(2) / (1)
Andalusia	5.4	-0.9	1.5	-0.2	1.3	-0.5	6.9	-0.4
Aragon	5.1	0.2	0.6	0.0	1.6	-0.7	3.7	-0.4
Asturias	3.0	-0.3	1.0	-0.1	0.5	-0.1	3.5	-0.3
Balearic Islands	3.7	-0.3	0.4	-0.1	2.5	-0.0	2.9	-0.0
Canary Islands	3.3	0.1	1.7	0.0	2.3	-0.5	4.2	-0.2
Cantabria	5.9	-1.0	4.0	-0.2	1.0	1.2	5.3	1.2
Catalonia	6.0	-0.2	2.5	-0.0	2.1	-0.4	6.4	-0.2
Castile and León	3.4	0.2	0.4	0.1	1.9	-0.3	2.4	-0.2
Castile–La Mancha	6.4	0.4	0.5	0.1	1.8	-0.4	2.3	-0.2
Extremadura	5.1	0.5	0.3	0.1	1.6	-0.5	5.0	-0.3
Galicia	3.9	-0.5	0.6	-0.1	1.7	-0.8	6.6	-0.5
Madrid	5.0	-0.3	0.9	-0.1	1.9	-0.2	3.5	-0.1
Murcia	4.5	-0.3	2.7	-0.1	1.1	0.2	5.6	0.1
Navarre	5.5	1.9	0.9	0.3	1.9	-1.5	7.4	-0.8
Basque Country	3.5	0.1	2.3	0.0	0.7	0.1	5.9	0.1
La Rioja	4.0	0.1	1.1	0.0	2.2	-0.0	3.9	-0.0
Valencian Community	4.4	0.1	1.1	0.0	1.3	-0.8	5.4	-0.6
Total	4.6	0.0	1.3	0.0	1.6	-0.3	4.8	-0.2

	1997-2007				2008-2012			
	(1) Gross value added (% change)	(2) Primary budget balance / GVA (%)	Debt / GVA (%)	(2) / (1)	(1) Gross value added (% change)	(2) Primary budget balance / GVA (%)	Debt / GVA (%)	(2) / (1)
Andalusia	3.9	0.8	8.0	0.2	-1.2	-2.6	10.0	2.2
Aragon	3.4	0.1	5.0	0.0	-0.6	-2.2	9.4	3.7
Asturias	2.8	0.1	4.7	0.0	-0.9	-2.0	8.2	2.2
Balearic Islands	3.1	0.0	4.9	0.0	-0.6	-3.0	16.8	5.1
Canary Islands	3.6	0.3	4.2	0.1	-0.8	-1.9	8.6	2.3
Cantabria	3.2	0.3	3.7	0.1	-0.8	-2.8	9.4	3.4
Catalonia	3.3	0.3	9.3	0.1	-0.8	-2.3	19.7	2.9
Castile and León	2.7	0.2	3.8	0.1	-0.3	-2.2	9.2	6.3
Castile–La Mancha	3.9	-0.2	3.8	-0.0	-0.9	-5.1	17.7	5.6
Extremadura	3.4	0.7	6.5	0.2	-0.9	-3.4	10.6	3.9
Galicia	3.2	0.5	9.2	0.2	-0.3	-1.7	11.8	6.2
Madrid	4.2	0.4	6.0	0.1	-0.3	-0.6	8.3	2.1
Murcia	4.6	0.5	4.0	0.1	-1.0	-3.1	9.3	3.2
Navarre	3.7	1.1	6.1	0.3	0.1	-1.7	10.7	-21.5
Basque Country	3.4	1.1	4.4	0.3	-0.3	-2.1	7.3	7.8
La Rioja	3.7	-0.3	3.3	-0.1	-0.5	-2.0	9.8	4.5
Valencian Community	4.0	-0.0	11.2	-0.0	-1.5	-3.1	21.5	2.0
Total	3.5	0.3	5.8	0.1	-0.7	-2.5	11.6	3.6

Sources: Own compilation based on data from INE, BDMORES, Spanish Ministry of Finance and Public Administration and Bank of Spain.
Notes: The primary budget balance is adjusted for 2008 and 2009 negative settlements and outstanding payments to suppliers. Total refers to the unweighted mean.

Figure 2.5. ACs' Primary budget balance (first difference) vs ACs' Gross value added growth



Note: The primary budget balance is adjusted for 2008 and 2009 negative settlements and outstanding payments to suppliers.

4.2. Results and discussion

4.2.1. *The response of the fiscal impulse to cyclical conditions*

This section examines the determinants of ACs' primary budget balances, with special attention given to the sensitivity of primary budget balances to changes in cyclical conditions. Our results (see Table 2.4) suggest that the fiscal impulse of ACs was counter-cyclical[14] over the 1987-2008 period, but a-cyclical over the whole sample (1987-2012). In the former period, one additional point of economic growth would have increased the primary balance by nearly 0.2 percent of GDP.

Before turning to cyclical asymmetries (between good and bad times) and cyclical sensitivity to institutional factors, we analyse the responses to debt accumulation and the persistence component. Our estimates indicate that the public finances of ACs were sustainable (as the primary balance response to debt is positive), although from 2009 onwards the fiscal performance of ACs is weaker as a result of an upward trend in regional government indebtedness. The findings obtained in the literature are not conclusive in this regard. Most of the available literature for ACs suggests that the reaction is linear or not significant, with the exception of Esteller-Moré and Solé-Ollé (2004), who identify a nonlinear adjustment over a certain threshold. Argimón and Hernandez de Cos (2012), Molina-Parra and Martínez (2015) and Leal Marcos and López Laborda (2015) obtain a non significant response, whereas Hernández de Cos and Pérez (2013b) identify a corrective action of the budget balance to the accumulation of debt.

The results also show that there is great inertia in the budgetary process, as the lagged dependent variable is very significant, with an estimated coefficient around 0.50. This inertia has recently increased as a result of the latest international financial crisis. Estimations of the baseline specification until 2004 led to an estimated coefficient of 0.42, in line with Argimón and Hernández de Cos (2012).

[14] That is, when the economic situation improves (worsens) the conditioned primary balance also improves (worsens).

Table 2.4. ACs' fiscal reaction functions: the response of the primary budget balance over the cycle

Dependent variable: Primary balance / Gross value added

	all ACs					
	(1)	(2)	(3)	(4)	(5)	(6)
Constant term (x1000)	**-1.90**	**0.26**	**-8.24**	**0.06**	**-6.04**	**0.23**
	(-4.74)***	(0.38)	(-7.47)***	(0.05)	(-7.46)***	(0.19)
Unemployment rate	**-0.12**	**-0.01**				
(first difference)	(-2.96)***	(-0.23)				
Gross value added (% change)			**0.19**	**0.01**		
			(5.18)***	(0.20)		
Employment (% change)					**0.18**	**0.00**
					(6.39)***	(0.13)
Primary budget balance	**0.44**	**0.50**	**0.36**	**0.50**	**0.23**	**0.50**
/ Gross value added (-1)	(11.12)***	(11.84)***	(9.99)***	(11.91)***	(4.67)***	(11.81)***
Index of expenditure	**-1.06**	**-1.52**	**-1.85**	**-1.52**	**-2.01**	**-1.53**
responsibilities (x 1000)	(-4.05)***	(-4.41)***	(-10.73)***	(-4.26)***	(-7.47)***	(-4.25)***
Electoral cycle (dummy)	**-0.80**	**-1.90**	**-0.88**	**-1.87**	**-0.12**	**-1.84**
(x1000)	(-2.41)**	(-5.12)***	(-4.46)***	(-4.47)***	(-0.39)	(-4.95)***
Debt / Gross value added (-1)	**0.06**	**0.01**	**0.09**	**0.01**	**0.09**	**0.01**
	(8.8)***	(2.73)***	(12.96)***	(2.54)**	(11.26)***	(2.20)**
Number of observations	374	442	374	442	374	442
Sample	1987-2008	1987-2012	1987-2008	1987-2012	1987-2008	1987-2012
Adjusted R^2	0.61	0.35	0.81	0.35	0.51	0.34
Estimation method	IV	IV	IV	IV	IV	IV
Hausman exogeneity test						
t-statistic	3.05	-3.59	-4.17	3.33	-3.15	3.78
(p-value)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Shea partial R^2	0.36	0.43	0.26	0.35	0.38	0.44

Notes: All regressions are estimated by Panel EGLS (Cross-section SUR weights). ***, ** and * statistically significant at 99%, 95% and 90%. t-Statistics within brackets. Changes in the output gap of the five biggest Spanish export markets - weighted by their export shares- are used as an instrument of ACs' cyclical conditions. Shea R^2 above 0.10 is generally regarded as support of predictive power. The primary budget balance is adjusted for 2008 and 2009 negative settlements and outstanding payments to suppliers.

We also explore differences between cyclical behaviour in good and bad times, an issue not covered in the literature for ACs to the best of our knowledge. When asymmetries are allowed (see Table 2.5) we cannot infer an asymmetric reaction of the fiscal impulse of ACs over the cycle (see the Wald test for the equality of cyclical position coefficients in specifications 9 and 10). We assess the adequacy of our three competing indicators for the cyclical position and the measure of GVA growth stands out from the rest, as it does not suffer from weak identification (check Shea's partial R^2 for specifications 7 to 12)[15].

[15] The evolution of the Spanish labour market is very difficult to instrument, especially

Table 2.5. ACs' asymmetric fiscal reaction functions: the response of the primary budget balance over the cycle

Dependent variable: Primary balance / Gross value added

	all ACs					
	(7)	(8)	(9)	(10)	(11)	(12)
Constant term (x1000)	**-3.06**	**14.96**	**-8.16**	**0.11**	**-6.94**	**-9.83**
	(-0.73)	(0.29)	(-8.11)***	(0.05)	(-1.76)*	(-0.95)
Unemployment rate (1st difference) * **good times**	**0.04**	**1.24**				
	(0.08)	(0.22)				
Unemployment rate (1st difference) * **bad times**	**-0.03**	**-0.83**				
	(-0.13)	(-0.52)				
Gross value added (% change) * **good times**			**0.15**	**-0.03**		
			(3.61)***	(-0.37)		
Gross value added (% change) * **bad times**			**0.39**	**0.03**		
			(2.3)**	(0.21)		
Employment (% change) * **good times**					**0.22**	**0.58**
					(0.86)	(0.96)
Employment (% change) * **bad times**					**0.10**	**0.11**
					(0.13)	(0.72)
Primary budget balance / Gross value added (-1)	**0.44**	**0.53**	**0.40**	**0.55**	**0.25**	**0.48**
	(8.28)***	(2.92)***	(10.18)***	(12.67)***	(0.88)	(7.11)***
Index of expenditure responsibilities (x 1000)	**-1.21**	**-3.00**	**-1.00**	**-0.47**	**-2.09**	**-1.06**
	(-1.34)	(-0.3)	(-1.32)	(-0.70)	(-0.86)	(-1.33)
Electoral cycle (dummy) (x1000)	**-0.63**	**0.64**	**-0.75**	**-1.47**	**-0.05**	**-1.02**
	(-0.47)	(0.1)	(-2.01)**	(-2.22)**	(-0.09)	(-0.85)
Debt / Gross value added (-1)	**0.06**	**0.04**	**0.08**	**0.01**	**0.09**	**0.09**
	(5.13)***	(0.73)	(5.82)***	(1.06)	(4.77)***	(2.25)**
Number of observations	374	442	374	442	374	442
Sample	1987-2008	1987-2012	1987-2008	1987-2012	1987-2008	1987-2012
Adjusted R^2	0.24	-	0.57	0.35	0.49	-
Estimation method	IV	IV	IV	IV	IV	IV
Wald test for equality of coefficients						
Chi2	0.00	0.08	1.55	0.11	0.02	0.41
(p-value)	(0.92)	(0.77)	(0.21)	(0.74)	(0.90)	(0.52)
Hausman exogeneity test						
F-statistic	3.21	11.48	10.26	18.05	5.60	12.21
(p-value)	(0.04)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Shea partial R^2						
good times	0.01	0.01	0.38	0.20	0.03	0.03
bad times	0.02	0.06	0.16	0.40	0.03	0.12

Notes: See Table 2.4. The Wald test for equality of coefficients is testing for a symmetric response to cyclical conditions.

since the onset of the crisis. In fact, standard errors for instrumental variable estimates are very large in the asymmetric specifications with labour market variables (see specifications 7, 8, 11 and 12 of Table 2.5).

Turning to cyclical sensitivity, we have also tested whether the reaction to the cycle differs depending on ACs' institutional status (see specifications 13 to 16 in Table 2.6). To this aim we have interacted some institutional variables with changes in the cyclical position to allow for differences in slopes (we allowed for assumed responsibilities and *foral* regime status to depend on cyclical conditions). On the one hand, the results of Argimón and Hernández de Cos (2012) were confirmed, as *foral* ACs present a more counter-cyclical FP, especially over the 2009-2012 period. This result is noteworthy, as an additional point of economic growth would have increased the primary balance by nearly 0.5 percent of GDP, whereas the response is not significant for the common regime ACs. Potential explanations of these differences may be related to the disparity of per capita resources between common and *foral* regimes as well as substantial differences regarding the tax basket. The negative coefficient that relates *foral* ACs to fiscal performance also stands out. In this regard, one should take into account that the effect of a being a *foral* AC depends on cyclical conditions. A simulation with the average GDP growth of *foral* ACs suggests (on average) an a-cyclical fiscal impulse[16]. On the other hand, results partially (only over the 1987-2008 period) indicate a greater sensitivity to the cycle as education and health were devolved, which could be due to downward rigidity regarding public welfare expenditure. In this case, the cyclical sensitivity is milder (one tenth).

In Table 2.6 we have also included a wide range of variables to capture differences in ACs' responsibilities, fiscal co-responsibility, strength of fiscal rules and per capita resources of the autonomous financing system. These are not the main issues of our paper but it may be worth considering them as some may have a direct effect on pro-cyclicality. In this regard, it is worth bearing in mind that fiscal discipline in good times is a necessary condition for a counter-cyclical fiscal response in bad times.

[16] See Brambor et al. (2006) for a discussion on marginal effects in multiplicative interaction models.

Table 2.6. ACs' fiscal reaction functions: the response of the primary budget balance over the cycle and to political and institutional features
Dependent variable: Primary balance / Gross value added

	common regime ACs		all ACs	
	(13)	(14)	(15)	(16)
Constant term (x1000)	**-10.21**	**-5.34**	**-4.36**	**-0.38**
	(-4.79)***	(-1.65)*	(-3.33)***	(-0.25)
Gross value added (% change)	**0.05**	**-0.01**	**0.06**	**0.02**
	(2.13)**	(-0.3)	(1.86)*	(0.57)
Gross value added (% change) * **Index of expenditure responsabilities**	**0.14**	**0.01**	**0.10**	**-0.04**
	(12.11)***	(0.22)	(9.21)***	(-1.28)
Gross value added (% change) * **foral ACs**			**0.24**	**0.47**
			(3.96)***	(7.54)***
Foral ACs (dummy) (x1000)			**-2.47**	**-7.23**
			(-1.5)	(-4.73)***
Primary budget balance / Gross value added (-1)	**0.31**	**0.53**	**0.35**	**0.46**
	(8.53)***	(12.24)***	(9.75)***	(11.76)***
Index of expenditure responsibilities (x 1000)	**-7.38**	**-1.36**	**-5.10**	**-1.11**
	(-12.16)***	(-1.58)	(-10.84)***	(-1.28)
Electoral cycle (dummy) (x1000)	**0.25**	**-1.24**	**-0.79**	**-2.11**
	(0.58)	(-2.83)***	(-2.21)**	(-5.01)***
Debt / Gross value added (-1)	**0.11**	**0.03**	**0.08**	**0.01**
	(12.68)***	(3.75)***	(10.72)***	(1.68)*
Index of aggregate fiscal corresponsibility (x1000)	**-2.68**	**-7.38**		
	(-1.47)	(-2.15)**		
Index of relative fiscal resources (x1000)	**0.06**	**0.05**		
	(4.5)***	(2.64)***		
Index of fiscal rules (x1000)	**2.01**	**0.65**		
	(5.37)***	(0.91)		
Alignment (dummy) (x1000)	**-0.49**	**1.54**		
	(-1.67)*	(4.01)***		
% of nationalist seats (x1000)	**-0.08**	**1.68**		
	(-0.06)	(0.99)		
% of left-wing seats (x1000)	**0.14**	**0.85**		
	(0.07)	(0.31)		
uniprovincial ACs (dummy) (x1000)	**0.43**	**0.33**		
	(0.86)	(0.6)		
Number of observations	330	390	374	442
Sample	1987-2008	1987-2012	1987-2008	1987-2012
Adjusted R^2	0.82	0.49	0.68	0.46
Estimation method	IV	IV	IV	IV

Note: See Table 2.4.

First, as ACs acquired greater responsibilities (when education and health competences were devolved) their primary balances worsened. This result is captured by the negative expenditure responsibility index coefficient in

most of the specifications. Regarding this Asatryan et al. (2012) remark that a sufficient degree of revenue autonomy is a necessary condition for the internalization of the implications of spending decisions. Therefore, a negative effect of expenditure decentralisation may be due to soft budget constraint[17] as a result of uneven fiscal decentralisation (when regarding both the revenue and the expenditure side). García-Mila et al. (2001), Esteller-Moré and Solé-Ollé (2004) and Sorribas-Navarro (2011) provide evidence for this hypothesis in the Spanish case, while Bordignon and Turati (2009) also provide support for the bailing-out story concerning public health expenditure in Italy.

Concerning fiscal autonomy and fiscal rules, we must relate our results to those of Foremny (2014) for the European context. The effectiveness of fiscal rules and tax autonomy depends on the constitutional structure. Fiscal rules would decrease deficits only in unitary countries, whereas tax autonomy would foster budget discipline in federations. Therefore, in the Spanish case (a quasi-federation) we would expect fiscal rules not to have a significant effect, whereas we would expect a positive effect for fiscal autonomy. The evidence found in our paper partly supports Foremny's results. Fiscal rules have not avoided the striking deterioration of regional public finances throughout the crisis, but we do not obtain the expected effect for fiscal autonomy. In fact, we obtain a non-significant effect over the 1987-2008 period and a negative effect when considering the whole sample[18,19]. As previously stated, this could be due to an insufficient degree

[17] The literature on fiscal federalism (Rodden, 2002) points out that expenditure decentralisation and financial autonomy cannot be detached from revenue decentralisation (the backing of autonomous tax resources). In this regard, revenue decentralisation is a key element in enforcing strong budget constraints on SCGs. The strength of these constraints is an institutional feature that is especially relevant to avoiding the negative effects that decentralisation may have on fiscal performance. This strength reflects the bailout expectations from a higher level of government that can cover all or part of the deficit generated. In this sense, sometimes the goals of the CG are not consistent over time, which increases the likelihood of this type of intervention (i.e. bail-out). That is, ex-ante the CG may make a formal non-bailout announcement, but ex-post this government would budge in order to avoid the negative consequences on sub-central public finances. In this paper, we do not attempt to test the bail-out hypothesis but our findings suggest that regional decentralisation is detrimental to a sound fiscal performance.

[18] These estimates refer only to the subset of ACs belonging to the common regime, as our fiscal co-responsibility indicator does not properly capture the higher fiscal co-responsibility of *foral* ACs.

of fiscal autonomy to cope with the huge imbalances caused by the crisis (in particular the huge decrease in revenues from totally devolved taxes) as well as to the caveats regarding the definition of the indicator (see fn. 9). It is also worth mentioning the contribution of Argimón and Hernández de Cos (2012), which provides evidence of a positive relationship between sub-central revenue autonomy and fiscal discipline as well as of the irrelevance of fiscal rules[20]. The international evidence on the role of fiscal autonomy suggests a positive relationship with fiscal performance. In this regard Asatryan et al. (2012) find that greater sub-central autonomy leads to greater fiscal discipline in OECD countries. The international evidence on the effectiveness of fiscal rules in ensuring fiscal discipline is extensive. In the European context it is possible to mention the positive assessment of fiscal rules by Galí and Perotti (2003), Afonso and Hauptmeier (2009) and Nerlich and Reuter (2015), in addition to the above-mentioned results of Foremny (2014) dealing with sub-central governments. The analysis of Nerlich and Reuter (2015) is especially interesting concerning our focus on the cyclicality of public finances, as it is often claimed that fiscal rules lead to pro-cyclical behaviour (especially in bad times). The interaction of fiscal rules and fiscal space with the discretionary part of FP offers interesting results. Their findings suggest that fiscal rules foster greater fiscal space[21] while, at the same time, greater fiscal space is associated with a more pro-cyclical FP. Nevertheless, this greater pro-cyclicality may be mitigated by means of fiscal rules (especially expenditure rules). Therefore, in a low fiscal space environment such as Spanish ACs, a proper design, implementation and enforcement of fiscal rules may be particularly valuable in regaining room for manoeuvre and counteracting pro-cyclicality. However, as Foremny's (2014) findings suggest, it is necessary to strike the right balance between the stringency of fiscal rules and fiscal autonomy, bearing in mind the constitutional structure of the country concerned.

[19] As a robustness check we have built a fiscal rules index that takes into account only those rules related to regional governments and the main results hold in both specifications.

[20] It is important to take into account that the results of Argimon and Hernández de Cos (2012) relate to the 1984-2004 period.

[21] Their analysis of fiscal space relies on the contribution of Gosh et al. (2013). To be specific, estimates of fiscal space measure the distance of the debt-to-GDP ratio from the threshold from which the dynamics of debt become explosive.

Third, an index of per capita fiscal resources (regarding the autonomous financing system) is also included in the fiscal reaction function. This variable is significant (albeit with a moderate impact), indicating that more financial resources lead to a better primary balance. We should bear in mind that there has been great disparity in relative resources between ACs. A first disparity is between the *foral* and the common systems. In fact, "the Basque Country and Navarre obtain about 50% more per capita resources than the average common regime" (Zubiri, 2011, 112). There are also significant differences in per capita financing between the common regime ACs (see Vilalta, 2017). Empirical evidence by Barrios and Martínez (2013) and Leal Marcos and López Laborda (2015) also suggests that higher per capita revenues favour sound budget balances (the latter case favours compliance with regional budgetary targets).

Regarding political economy variables related to the incumbents, we find that the ideology of incumbents is not a significant factor behind primary balance determinants. In addition, we do not find robust evidence regarding the effect of political alignment on the primary balance of ACs. Lastly, we do find evidence of a negative effect of election years on fiscal performance, especially since the onset of the crisis. In this regard, it seems very likely that the regional elections held in 2011 delayed the unavoidable fiscal adjustment of ACs. The relevance of the electoral cycle on fiscal behaviour is also considered in Afonso and Hauptmeier (2009) and Leal Marcos and López Laborda (2015), obtaining the expected effect. This deficit bias in election years may be addressed by the proper implementation of fiscal rules.

4.2.2. *The response of the fiscal stance to cyclical conditions*

We turn now to the assessment of discretional FP. The correlation of ACs' FP with cyclical conditions is an issue of growing importance as fiscal decentralisation in Spain has led the ACs to be the first level of government regarding the expenditure side when we exclude financial expenditures (see Table 2.1). Our focus rests on the cyclically adjusted component of the primary budget balance[22], which captures the discretionary part of the ACs'

[22] In this paper, we use cyclically adjusted primary balances and structural balances as synonyms, although in a strict sense one should not include one-off and temporary measures in the latter (see Mourre et al., 2014).

FP. We exclude therefore the automatic response of fiscal variables to changes in the cyclical conditions (see equations (4) and (5)). Moreover, we assess the cyclicality of the FP of both the ACs and the general government.

Overall, ACs were pro-cyclical over the period 1987-2012, but since the outbreak of the crisis this pro-cyclical behaviour has sharpened (reflected in the negative estimates of our cyclical position variables in Table 2.7). Despite the fiscal stance of ACs being largely counter-cyclical in the early stage of the last crisis (see Figure 2.6), the assessment over the period 2008-2012 is unequivocally pro-cyclical. It is important to note that this shift in the cyclical properties of FP may not represent an improvement in welfare as ACs are responsible for stable expenditures such as health, education and social services. The general government's discretionary FP does not present any significant link with cyclical conditions in either of these periods[23]. Nevertheless, evidence for the European countries suggests that pro-cyclical discretionary policies are unfortunately not an exception (European Commission, 2006).

It is worth delving into the determinants of pro-cyclicality in order to place the results in context. There are factors that may play a role in bad times, others in good times, but there are also factors that are relevant throughout the cycle. The pro-cyclical behaviour of ACs in bad times may be explained by an unsound fiscal position, financial constraints and opportunistic behaviour by central governments (CGs). First, an unsound fiscal position may require sustainability needs to be given priority over cyclical stabilisation. Second, financial constraints may favour pro-cyclicality in bad times due to loss of confidence among investors[24]. Third, available evidence suggests that central governments are shifting the burden of consolidation towards lower tiers of government (Von Hagen and Foremny, 2013; Vammalle and Hulbert, 2013; Foremny et al., 2017). This evidence indicates that transfers from CGs are cut during consolidation periods, especially when the fiscal autonomy of SCGs is low. As matter of fact,

[23] We have used budgetary data in the analysis of both ACs and general government, in order to guarantee data homogeneity. Nevertheless, the assignment of responsibilities between levels of government makes this benchmark somewhat dubious.

[24] This is typically the case of middle income and developing countries (Alesina et al., 2008). Rodden and Wibbels (2010) also remark on this situation for sub-central governments, with the exception of Canada.

these three explanations fit into the evolution of ACs' public finances since 2010-2011.

Table 2.7. The response of the fiscal stance over the cycle: ACs and General Government

Dependent variable: Structural primary balance / Gross value added (first difference)

	ACs	ACs	General Government	General Government
	(17)	(18)	(19)	(20)
Constant term (x1000)	**4.06**	**2.88**	**4.62**	**2.31**
	(7.83)***	(5.46)***	(1.02)	(0.41)
Gross value added (% change)	**-0.15**	**-0.10**	**-0.11**	**-0.03**
	(-11.77)***	(-7.50)***	(-0.9)	(-0.2)
Gross value added (% change) * **dummy 2008-2012**		**-0.32** (-7.87)***		**-0.34** (-0.89)
Number of observations	442	442	25	25
Sample	1987-2012	1987-2012	1987-2012	1987-2012
Estimation method	OLS	OLS	OLS	OLS

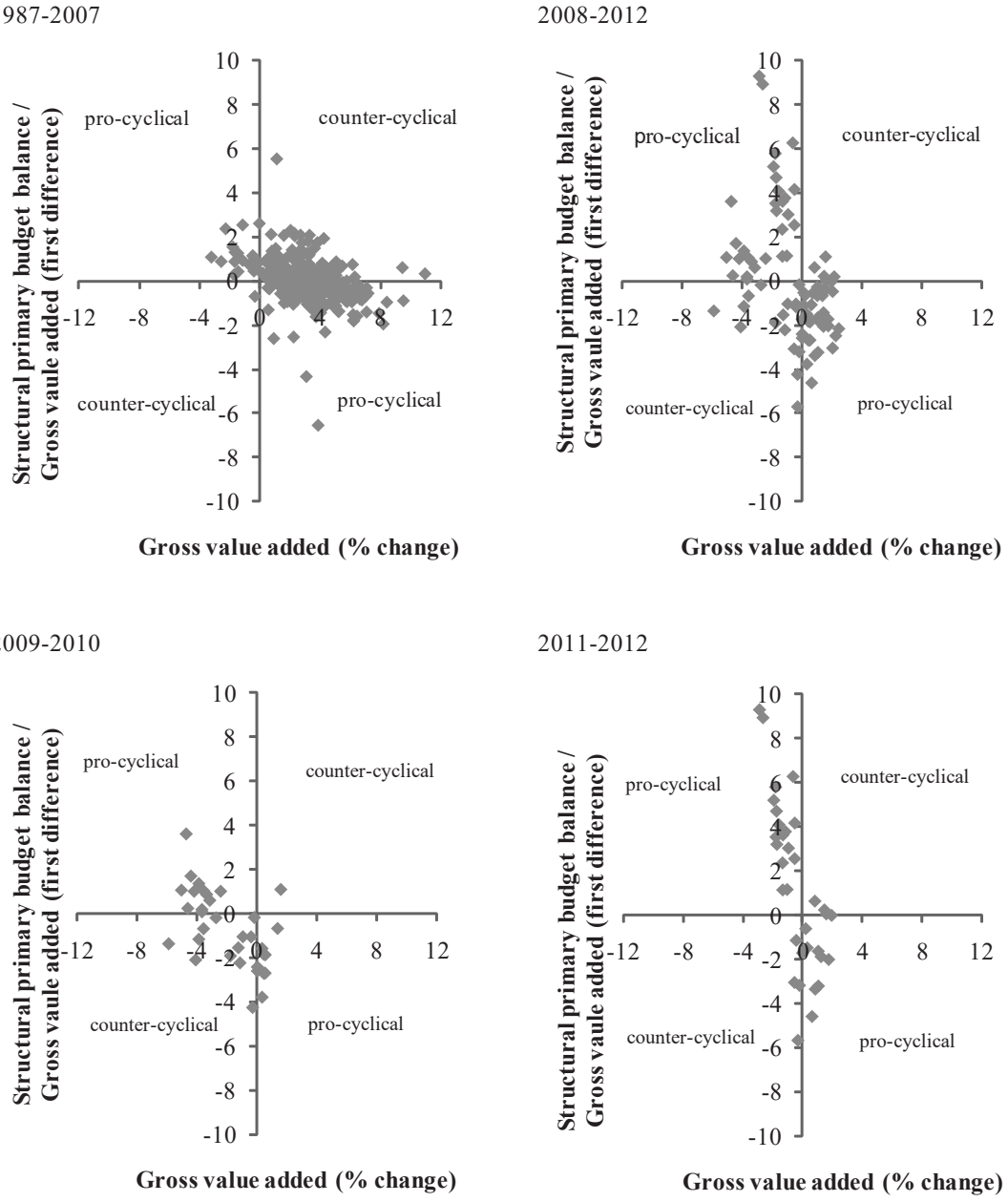
Notes: See Table 2.4. Regressions of ACs are estimated by panel EGLS (cross-section SUR weights). General Government regressions are estimated by robust Newey-West estimator.

The voracity effect (Tornell and Lane, 1999) and the interaction of democratic accountability and political corruption (Alesina et al., 2008) are factors related specifically to pro-cyclicality in good times. First, there may be a deficit bias as a result of there being powerful groups and weak institutional structures (common pool problems). Second, the interaction of democratic accountability and political corruption may end up in pressure from the electorate to benefit from budgetary windfalls. In this regard pro-cyclicality would be more pronounced in more corrupt democracies (Alesina et al., 2008).

Finally, other explanations may come into play over the cycle as a whole: the role of voter information (as a proxy for accountability) and measurement issues related to a) identification and implementation lags of FP, b) uncertainty in measuring cyclical conditions in real time and c) inaccuracy in budgetary forecasts[25].

[25] See a detailed explanation on the role of these measurement issues in European Commission (2006).

Figure 2.6. ACs' change in structural primary balance vs ACs' gross value added growth



Note: See Figure 2.5.

The role of voter information in the reaction of fiscal behaviour is explored by Solé-Ollé and Viladecans-Marsal (2017). Their work deals with local governments in Spain throughout the housing boom and bust (1995-2011). Less informed voters fostered overspending in boom times, while in bust times these voters delayed the unavoidable fiscal adjustment (as a result of

fiscal myopia). A lack of accountability may therefore result in pro-cyclicality and fiscal indiscipline. To some extent, the public finances of ACs present a similar pattern to that of Spanish local governments, as their revenues are also strongly related to the real estate cycle. Concerning measurement issues, it is worth paying attention to inaccuracy in budgetary forecasts (as a peculiarity of ACs). The advance payment system (concerning the financing system of ACs in the common regime) is at the core of remarkable distortions in the distribution of resources over the cycle. First, overestimates in 2008 and 2009 may have led to negative outcomes in terms of fiscal illusion, and next, underestimates from then on may have fostered pro-cyclicality[26].

Regarding regional asymmetries, not all ACs have the same response, as it is shown in Table 2.8[27]. All ACs present a clearly pro-cyclical fiscal stance in the period 1987-2012, with the exception of the Basque Country. Over the period 2008-2012, the Basque Country and the Valencian Community are the only ACs that exhibit a counter-cyclical fiscal stance (although the soundness of their public finances differs widely). In addition, there were 9 ACs that increased their pro-cyclicality after the onset of the crisis. In Figure 2.7 we provide a first attempt at identifying the determinants of the response of the fiscal stance to cyclical conditions in the Great Recession. Our descriptive analysis (which deserves further research) suggests that pro-cyclicality of the fiscal stance is a persistent behaviour and that initial debt level matters. In other words, the degree of pro-cyclicality during the crisis (2008-2012) is related to past fiscal behaviour (1987-2007). The negative correlation between initial debt level and counter-cyclicality may be related to the effects of a lower fiscal space. In fact, when ACs are close to the threshold of unsustainable debt, sustainability needs require corrective actions, thereby disregarding stabilisation measures (in bad times) and fostering pro-cyclicality.

[26] In Figure 7.1 of the Generalitat of Catalonia (2015, 77) one can appreciate the dynamics of advanced payments in relation to accrued revenues (that is, the resources which are finally settled two years later) over the period 2004-2015.

[27] Results are consistent regardless of the method of estimation. We have checked different weighting specifications as well as the introduction of fixed effects (which are redundant).

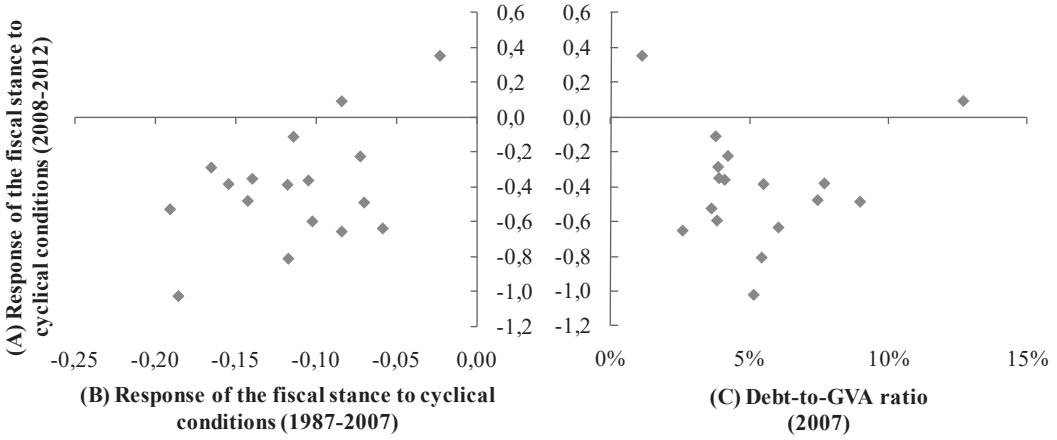
Table 2.8. The response of the fiscal stance over the cycle: differences across ACs

Dependent variable: Structural primary balance / Gross value added (first difference)

	(21)		(22)	
	Coefficient	t-Statistic	Coefficient	t-Statistic
Constant term (x1000)	3.29	(4.95)***	1.48	(2.02)**
Gross value added (% change) **Andalusia**	-0.15	(-3.93)***	-0.12	(-2.68)***
GVA (% change) **Aragon**	-0.18	(-6.69)***	-0.14	(-4.76)***
GVA (% change) **Asturias**	-0.25	(-7.45)***	-0.19	(-5.13)***
GVA (% change) **Balearic Islands**	-0.22	(-3.42)***	-0.16	(-2.35)**
GVA (% change) **Canary Islands**	-0.12	(-3.49)***	-0.07	(-2.19)**
GVA (% change) **Cantabria**	-0.14	(-3.03)***	-0.11	(-2.06)**
GVA (% change) **Catalonia**	-0.11	(-5.28)***	-0.07	(-3.14)***
GVA (% change) **Castile and León**	-0.19	(-7.55)***	-0.10	(-3.74)***
GVA (% change) **Castile–La Mancha**	-0.18	(-4.92)***	-0.12	(-3.2)***
GVA (% change) **Extremadura**	-0.26	(-6.62)***	-0.19	(-3.94)***
GVA (% change) **Galicia**	-0.19	(-8.28)***	-0.14	(-5.23)***
GVA (% change) **Madrid**	-0.11	(-4.89)***	-0.06	(-2.74)***
GVA (% change) **Murcia**	-0.14	(-3.73)***	-0.08	(-2.48)**
GVA (% change) **Navarre**	-0.16	(-2.39)**	-0.11	(-1.45)
GVA (% change) **Basque Country**	-0.05	(-1.1)	-0.02	(-0.52)
GVA (% change) **La Rioja**	-0.19	(-5.25)***	-0.17	(-4.31)***
GVA (% change) **Valencian Community**	-0.10	(-2.55)**	-0.08	(-2.03)**
dummy 2008-2012 * GVA (% change) **Andalusia**			-0.27	(-1.64)
dummy 2008-2012 * GVA (% change) **Aragon**			-0.21	(-1.77)*
dummy 2008-2012 * GVA (% change) **Asturias**			-0.33	(-3.38)***
dummy 2008-2012 * GVA (% change) **Balearic Islands**			-0.23	(-1.02)
dummy 2008-2012 * GVA (% change) **Canary Islands**			-0.15	(-1.12)
dummy 2008-2012 * GVA (% change) **Cantabria**			0.00	(0.01)
dummy 2008-2012 * GVA (% change) **Catalonia**			-0.42	(-4.33)***
dummy 2008-2012 * GVA (% change) **Castile and León**			-0.49	(-4.37)***
dummy 2008-2012 * GVA (% change) **Castile–La Mancha**			-0.69	(-5.17)***
dummy 2008-2012 * GVA (% change) **Extremadura**			-0.84	(-4.2)***
dummy 2008-2012 * GVA (% change) **Galicia**			-0.34	(-2.87)***
dummy 2008-2012 * GVA (% change) **Madrid**			-0.58	(-5.59)***
dummy 2008-2012 * GVA (% change) **Murcia**			-0.57	(-4.74)***
dummy 2008-2012 * GVA (% change) **Navarre**			-0.26	(-0.85)
dummy 2008-2012 * GVA (% change) **Basque Country**			0.38	(2.59)***
dummy 2008-2012 * GVA (% change) **La Rioja**			-0.12	(-0.8)
dummy 2008-2012 * GVA (% change) **Valencian Community**			0.18	(1.58)
Number of observations		442		442
Sample		1987-2012		1987-2012
Adjusted R^2		0.24		0.33
Redundant Fixed Effects Test		0.47		0.32
(p-value)		(0.96)		(0.99)
Estimation method		OLS		OLS

Note: See Table 2.4.

Figure 2.7. A first attempt at identifying the determinants of "the response of the fiscal stance to cyclical conditions in the Great Recession": the role of persistence and initial debt level



Notes: (1) To evaluate the response of the fiscal stance to cyclical conditions over 2008-2012, one should take the sum of the coefficient related to GVA growth and that of the interaction of GVA growth with the dummy variable for the period 2008-2012. These estimates correspond to specification (22) in Table 2.8. A positive response is indicative of a counter-cyclical fiscal stimulus.
(2) The correlation coefficient of (A) and (B) is 0.48, 0.46 excluding Valencia, and 0.16 excluding Valencia and the Basque Country.
(3) The correlation coefficient of (A) and (C) is 0.01, -0.40 excluding Valencia, and -0.10 excluding Valencia and the Basque Country.
Sources: Own compilation based on data from estimates in Table 2.8 and data from the Bank of Spain and INE.

Other sets of explanations (of these asymmetries) may be related to heterogeneity in preferences regarding the stabilization function, heterogeneity in regional business cycles (Bandrés and Gadea, 2013, provide evidence of such heterogeneity, although the Great Recession has led to greater regional synchronisation with the Spanish cycle), even to varying exposure to corruption (in this regard, see the contribution of Alesina et al. 2008, which states that pro-cyclicality is more pronounced in more corrupt democracies) or to different exposure to media information (Solé-Ollé and Viladecans-Marsal, 2017). These are interesting hypotheses that also deserve further research.

5. Conclusions

One of the main objectives of this chapter is to analyse the responsiveness of the FP of ACs (Autonomous Communities) to cyclical conditions. The analysis of ACs' discretionary FP reveals a pro-cyclical behaviour, which has sharpened since the last financial crisis. In Spain the lion's share of the welfare state is a regional responsibility. Pro-cyclical behaviour of this level of government does not seem to contribute positively to the welfare of its citizens, as it impacts on health, education and social services expenditures. However, this pro-cyclicality is not homogenous across ACs, and as a result the negative outcomes of this behaviour differ across ACs. In this context, a new institutional setting should be implemented to avoid these undesired results. The literature on Fiscal Federalism points to several features that may prevent pro-cyclical behaviour. Increasing revenue autonomy (e.g. that may include decreasing dependence on central government transfers and tax sharing schemes and increasing fiscal autonomy regarding tax collection and administration), modifying the tax basket (assigning less volatile tax sources to sub-central governments), guaranteeing a counter-cyclical influence from central government grants, fostering incentives to save during good times (that is, fostering rainy day funds) and increasing sub-central borrowing autonomy as far as possible are proposals from this angle (most of them drawn from Rodden and Wibbels, 2010).

Intergovernmental cooperation is a necessary asset to address large fiscal adjustments (and prevent pro-cyclical behaviours), but recent evidence suggests a worrisome trend. Central governments are not helping, but shifting the burden of consolidation towards lower tiers of government (Von Hagen and Foremny, 2013; Vammalle and Hulbert, 2013; Foremny et al., 2017).

Fighting corruption in the public sector and fostering accountability (e.g. greater government transparency and more informed voters) may also be a cornerstone in guaranteeing sustainable (and more counter-cyclical) FP. It is much easier for governments to be held accountable for revenue windfalls when voters are properly informed (Solé-Ollé and Viladecans-Marsal, 2017). Nevertheless, fighting against corruption is also crucial to avoiding "pressures" to benefit from these budgetary windfalls (Alesina *et al*., 2008).

The asymmetric response of the fiscal stance across ACs is also a serious concern, as it may be related to very different situations regarding fiscal space. In other words, highly indebted ACs are more likely to adopt a pro-cyclical fiscal stance when bad times come. In this regard, it is worth paying attention to the role of fiscal rules in creating more fiscal space. At the same time these rules (especially expenditure rules) may be an effective tool to mitigate pro-cyclicality in "higher fiscal space" environments (Nerlich and Reuter, 2015)[28]. Nevertheless, it is worth pointing out that the recentralising features of these rules in Spain have severely restricted the financial autonomy of ACs (Viver Pi-Sunyer and Martín, 2013).

The analysis of the determinants of the primary balance suggests an a-cyclical impulse from the public finances of ACs over the 1987-2012 period. This result is consistent with our findings on ACs' fiscal stance, as automatic stabilizers always play a counter-cyclical role. Our analysis is based on the estimation of fiscal reaction functions, which suggest that the public finances of ACs were sustainable. However, this sustainability has been weaker since 2009, as a result of an upward trend in regional government indebtedness. The analysis of this trend is one of the challenges that deserve further attention as some ACs may be approaching their debt limits, and thereby conditioning their forthcoming fiscal stances (especially in bad times).

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7. Appendix

7.1. Definition of variables and data sources

Alignment: =1 if the incumbent party (or the party leading the incumbent coalition) in the regional government is the same as the incumbent party in the central government (or the party leading the incumbent coalition). Source: own elaboration from http://www.argos.gva.es/ahe/indexv.html

Debt: debt-to-GVA ratio according to the Excessive Deficit Procedure. Source: Bank of Spain.

Electoral cycle: = 1 in election years. Source: Own elaboration from the Spanish Ministry for Home Affairs. http://www.infoelectoral.mir.es/

Employment: number of persons employed. Source: BDMORES and INE.

Foral: = 1 for Basque Country and Navarre and 0 otherwise.

Gross value added: in real terms. Source: BDMORES and INE.

Index of aggregate fiscal co-responsibility: percentage of own-source taxes as a share of total revenues. Source: Own elaboration based on definitive data of the ACs' Funding System. Spanish Ministry of Finance and Public Administrations

Index of expenditure responsibilities: index of relative expenditure decentralisation that proxies the increase in regional per capita expenditure spending needs due to the assignment of health care and education. It is measured in relation to the average per capita provision of public goods and services (other than health and education services). Source: Sorribas-Navarro (2011).

Index of fiscal rules: index of strength of fiscal rules of the European Commission. This index is built by adding together all fiscal rule strength indices in force in the respective Member States weighted by the coverage of the respective rule in general government finances. Source: European Commission.

Index of per capita fiscal resources: per capita index of resources of the autonomous financing system. Source: Own elaboration based on definitive

data of the ACs' funding system. Spanish Ministry of Finance and Public Administrations.

Left-wing / nationalist seats: percentage of seats corresponding to the concerned ideology. Source: Own elaboration based on http://www.argos.gva.es/ahe/indexv.html

Primary budget balance: primary balance-to-GVA ratio. The primary balance stands for government net borrowing or net lending excluding interest payments. Data adjusted for 2008 and 2009 negative settlements and outstanding payments to suppliers. Source: Budget Settlement of ACs and Autonomous Cities. Spanish Ministry of Finance and Public Administrations.

Unemployment rate: unemployed as a percentage of the labour force. Source: INE.

Uniprovincial$_{it}$: = 1 for single province ACs and 0 otherwise.

7.2. Descriptive Statistics

Table A2.1. Descriptive statistics
(Mean by AC, 1987-2012)

	Primary budget balance / Gross value added (%)	Gross value added (% change)	Employ-ment (% change)	Unemploy-ment rate (1st dif.)	Unemploy-ment rate (%)	Output gap EU5 (1st dif.)	Debt / Gross value added (%)	Foral	Unipro-vincial	Expendi-ture respon-sibility index	Aggregate fiscal correspon-sibility index	Per capita fiscal resources index	Fiscal rules index	% Nationa-list seats	% Left-wing seats	Electoral cycle	Align-ment
Andalusia	-0.42	2.6	1.8	0.22	24.2	-0.05	7.1	0	0	1.4	0.27	99.2	0.61	3.8	64.7	0.27	0.65
Aragon	-0.52	2.5	1.2	0.15	10.1	-0.05	4.9	0	0	0.7	0.27	116.1	0.61	23.5	46.8	0.27	0.46
Asturias	-0.43	1.6	0.3	0.19	14.0	-0.05	4.5	0	1	0.6	0.27	103.2	0.61	4.1	56.2	0.31	0.69
Balearic Islands	-0.61	2.4	2.8	0.36	11.8	-0.05	6.1	0	1	0.7	0.27	90.2	0.61	15.8	44.3	0.27	0.35
Canary Islands	-0.36	2.4	2.2	0.32	19.0	-0.05	4.7	0	0	1.2	0.27	106.6	0.61	37.8	35.4	0.27	0.12
Cantabria	-0.30	2.3	1.1	0.04	13.9	-0.05	5.2	0	1	0.7	0.27	111.9	0.61	26.4	32.5	0.27	0.38
Catalonia	-0.44	2.7	1.9	0.10	14.0	-0.05	9.6	0	0	1.4	0.27	96.6	0.61	57.2	45.9	0.31	0.00
Castile and León	-0.38	2.0	0.7	0.56	13.9	-0.05	4.0	0	0	0.6	0.27	121.9	0.61	2.3	39.1	0.27	0.35
Castile–La Mancha	-1.06	2.9	1.3	0.06	13.9	-0.05	5.6	0	0	0.6	0.27	111.6	0.61	0.0	56.0	0.27	0.65
Extremadura	-0.40	2.4	0.8	0.34	16.0	-0.05	6.0	0	0	0.6	0.27	123.3	0.61	1.2	58.3	0.27	0.65
Galicia	-0.36	2.3	0.1	0.31	20.9	-0.05	7.8	0	0	1.3	0.27	110.6	0.61	18.3	45.1	0.27	0.62
Madrid	-0.05	3.0	2.4	0.30	13.4	-0.05	5.1	0	1	0.7	0.27	86.0	0.61	0.0	47.7	0.27	0.65
Murcia	-0.41	2.7	2.1	0.05	11.8	-0.05	5.2	0	1	0.7	0.27	87.7	0.61	0.0	45.1	0.27	0.65
Navarre	0.07	2.9	1.7	0.34	16.6	-0.05	6.5	1	1	1.3	0.27	165.0	0.61	66.9	51.2	0.27	0.19
Basque Country	0.11	2.1	1.1	-0.05	9.5	-0.05	5.0	1	0	1.4	0.27	165.0	0.61	58.4	41.8	0.27	0.12
La Rioja	-0.50	2.6	1.2	0.18	9.6	-0.05	4.4	0	1	0.7	0.27	120.2	0.61	6.1	42.2	0.27	0.50
Valencian Community	-0.76	2.4	1.5	0.22	9.8	-0.05	10.3	0	0	1.4	0.27	88.5	0.61	10.8	51.9	0.27	0.65
Mean (unweighted)	-0.40	2.4	1.4	0.22	14.26	-0.05	6.0	0.12	0.41	0.9	0.27	112.0	0.61	19.6	47.3	0.27	0.45
Median	-0.04	2.7	2.2	-0.24	13.18	0.37	4.8	0.00	0.00	1.4	0.37	110.1	-0.30	10.2	46.0	0.00	0.00
Maximum	4.88	11.0	9.2	9.13	34.59	1.61	32.9	1.00	1.00	1.4	0.54	165.0	3.26	74.0	76.1	1.00	1.00
Minimum	-10.69	-5.9	-9.8	-4.91	4.54	-4.62	0.2	0.00	0.00	0.0	0.00	65.6	-0.30	0.0	17.9	0.00	0.00
Std. Dev.	1.56	2.5	3.4	2.25	6.08	1.33	4.6	0.32	0.49	0.6	0.22	23.8	1.11	22.4	10.0	0.45	0.50
Skewness	-2.18	-0.45	-0.63	1.05	0.75	-1.60	2.02	2.37	0.36	-0.7	-0.35	1.0	0.67	1.0	0.2	1.01	0.19
Kurtosis	11.73	3.88	3.03	4.59	3.21	6.18	9.40	6.63	1.13	1.6	1.29	3.5	2.09	2.7	3.0	2.03	1.04
Jarque-Bera	1752.3	28.7	29.4	127.2	42.3	374.0	1054.7	658.1	74.0	71.0	63.2	71.4	48.5	78.5	2.3	93.2	73.7
Probability	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	0.3	0.00	0.00

Chapter 3

Fiscal Responsiveness to Public Debt: an Analysis of Regional Debt Limit Uncertainty in Spain

1. Introduction

Concerns over fiscal sustainability in advanced economies have increased in recent years as a result of the widespread deterioration of public finances. The effects of the international financial crisis, but also population ageing and the stagnation of potential GDP, are elements that have put pressure on the public finances of these economies.

As a result of this context, the institutional framework has been modified, especially in Europe amid the Eurozone's sovereign debt crisis. More specifically, the system of fiscal governance in the euro zone has been changed, with the implementation of stricter fiscal rules and a greater emphasis on the sustainability of public debt. At the same time, there has been a remarkable fiscal consolidation process, amidst an unfavourable macroeconomic environment. In many countries, including Spain, one can identify a "fiscal fatigue" situation that starts in 2014 (AIREF, 2016) and leads towards a slightly expansive fiscal policy after four years of contraction.

The present chapter builds on the methodology of the fiscal reaction function (FRF), where the key element in ensuring debt sustainability is the response of the primary balance to the accumulation of debt (see the seminal contribution of Bohn, 1998). This author suggests that sustainability would be achieved if at least the primary balance could grow linearly with the debt-to-GDP ratio (especially for high levels of this ratio).

Other recent works have explored the implications for debt sustainability of a nonlinear relationship between both variables (see e.g. Gosh et al., 2013). In fact, an increasing or at least linear response of the primary balance cannot be ensured for any level of debt-to-GDP ratio. In this context, the concepts of "fiscal fatigue", "debt limit" and "fiscal space" take prominence, as we will see later on. "Fiscal fatigue" is indicative of situations where the response of the primary balance to the accumulation of debt would be to decrease, while "debt limit" indicates the threshold from which the dynamics of debt become explosive. Finally, "fiscal space" estimates the distance from the debt-to-GDP ratio to the above-mentioned debt limit.

The present analysis addresses the primary balance response to the debt of Spanish Autonomous Communities (ACs) from 1987 to 2015 and evaluates a potential nonlinear fitting between both variables. It also presents an empirical reflection on the concepts of fiscal space and debt limit for ACs as a whole, paying special attention to uncertainty issues. This robustness assessment of the debt limit is not common in the literature (one exception is Gosh et al., 2013), and seems appropriate when working with finite samples, especially when an asymmetric distribution lies behind the statistical relationship to be tested. In addition, to the best of our knowledge, the debate on the so-called debt limit hasn't been raised in the case of Spanish ACs as yet.

Overall, the results of this study provide evidence of a nonlinear relationship between the primary balance and the public debt of ACs, which points to a situation of fiscal fatigue. In 2015 this ratio stood at 26.8% of Gross Value Added (GVA), slightly above our lower estimate for the debt limit (24%) and well below the upper limit estimate (36%). These results have a backward-looking orientation, that is, fiscal reaction for the coming years is not necessarily determined by past behaviour. That being said, a reduced fiscal space in ACs calls for measures to ensure a sustainable debt trajectory and regain some room to deal with potential negative shocks (Gosh et al., 2013).

This chapter is divided into three sections. After the introduction, we present the analytical framework adopted to address the response of the primary balance to debt, based on Bohn's seminal work (1998) and the

latest contributions from Gosh et al. (2013). In the third section, we present an empirical application of the debt limit for the case of Spanish ACs. First, we estimate a FRF and then we assess the regional debt level in a stochastic setting. The assessment of uncertainty provides a brief reflection on inference by confidence intervals (in Appendix section 6.3). Finally, the analysis ends with a conclusion section.

2. Analytical framework: the primary balance's response to debt, the debt limit and the fiscal space

Until Bohn's seminal contribution (1998), the econometric approach to the sustainability of public debt was based on unit roots analysis of the debt-to-GDP ratio. However, the consistency of this analysis depends on a sufficient sample size and a proper specification of the deterministic component. As a matter of fact, an incorrect specification of the deterministic component, e.g. stemming from the existence of structural changes, can lead to inconsistent results (Perron, 1989).

Bohn (1998), however, addresses the sustainability of public debt from a new point of view and focuses on the response of the primary balance to changes in the ratio of public debt-to-GDP. This empirical strategy evaluates, through a FRF, the corrective actions in budgetary terms after an increase in the amount of debt[1]. If the response of the primary balance to an increase in the debt-to-GDP ratio is positive, one could conclude that the debt ratio is stationary and that would ensure the intertemporal budget constraint. In other words, sustainability would be achieved if the primary balance grows at least linearly with the debt-to-GDP ratio (and especially for high levels of this ratio). Bohn's work (1998) provides evidence of such corrective action for the US in the period 1916-1995. We now present a simple version of a FRF:

[1] The research field based on these FRFs is very wide and, according to Checherita-Westphal and Zdarek (2017), covers three research areas: (i) one addresses the contrasts of the sustainability of public debt; (ii) the estimation of fiscal policy rules based on the literature on monetary policy rules and, lastly (iii) the estimation of FRFs as an input for simulations within the Debt Sustainability Analysis of major international organizations (DSA) or as input for the calculation of the so-called debt limits. For a summary of the literature on FRFs see the work of these authors, Checherita-Westphal and Zdarek (2017), and that of Berti et al. (2016).

$$pb_t = \mu_t + f(d_{t-1}) + \varepsilon_t \quad (1)$$

where pb_t is the primary balance (as % of GDP), μ_t captures all the systematic determinants of the primary balance other than the lagged debt (i.e. the economic cycle, the election cycle, the institutional framework…), d_{t-1} stands for the lag of public debt (as % of GDP) and ε_t is the error term (which usually follows a white noise process).

This methodology doesn't require assumptions about interest rates and GDP growth, which implies an advantage over other sustainability assessments based on the standard debt accumulation equation, as discussed below. However, it should be noted that the methodology of FRF is a backward-looking approximation to sustainability, since it analyzes the past behaviour of fiscal policy[2].

Next, we present an extension of this strand of research (Abiad and Ostry, 2005), that combines the FRF framework with the standard debt accumulation equation, which includes an approach to the so-called "debt limit" and the concept of "fiscal space". Therefore, from the standard debt accumulation equation we have (for simplicity, stock-flow adjustments are not included):

$$D_t = (1+i)D_{t-1} - PB_t \quad (2)$$

$$d_t = \frac{1+r_t}{1+g_t} d_{t-1} - pb_t \quad (3)$$

where D_t is public debt, PB_t refers to the primary balance, i the nominal implicit interest rate, r the real implicit interest rate and g the real growth rate of GDP. Lower case letters indicate that the variable is expressed as % of GDP.

The expression of equation (3) in forward-looking terms, under the assumption of a constant trajectory for the primary balance, the real implicit interest rate and the rate of economic growth, leads to expressions (4) and

[2] The European Commission uses these FRF to evaluate the credibility of the stability and convergence programmes of Member States (see Berti et al., 2016). It assesses to what extent the fiscal position projected in these plans (namely, the changes in the structural primary balance) differs from the position arising from these FRFs.

(5) that allow us to calculate the debt limit (*DL*) and the fiscal space (FS_t)[3]:

$$DL = \frac{pb^{FRF}}{r - g} \tag{4}$$

The adjusted value of the primary balance is obtained from a FRF (pb_i^{FRF}) while the fiscal space measures the distance of the current level of debt to the debt limit (as a percentage of GDP).

$$FS_t = DL - d_t \tag{5}$$

The work of Gosh et al. (2013) is very similar to Abiad and Ostry (2005), although it increases the flexibility of the primary balance's response to debt by applying a polynomial of degree 3. This functional form allows the so-called fiscal fatigue behaviour to be incorporated, that is, a decreasing response of the primary balance from a certain debt threshold.

The approach to the debt limit in section 3 follows that of Gosh et al. (2013), as it considers a nonlinear relationship between the primary balance and debt, although it also introduces some differences. More specifically, we focus our attention on the polynomial containing the response of the primary balance to the accumulated debt, without applying the FRF to the standard debt accumulation equation (as in (4)). Thus, we avoid making assumptions on the differential between the implicit interest rate and the growth rate of GDP.

An essential point of this analysis is the uncertainty of these limits. In many of the studies disseminated by major international organizations, uncertainty is approached through a sensitivity analysis that considers different values for the differential (r-g). These studies often evaluate differentials from past sub-periods considered representative for the economy analysed. Overall, these limits are based on one-time estimates and therefore do not include information on their stochastic properties. An exception is the work of Gosh et al. (2013), which analyzes fiscal fatigue in a stochastic context. These authors provide the standard error of fiscal space estimates through the application of resampling techniques. Our analysis also provides a stochastic assessment of the debt limit by obtaining confidence intervals.

[3] See Abiad and Ostry (2005) for a demonstration of expression (4).

3. An empirical exercise for Spanish Autonomous Communities

There is not much literature that has addressed the estimation of FRF at the regional level, and as far as we know, none of the previous works have considered a regional approach to the debt limit. In most of the research mentioned below for the Spanish case, the response of the primary balance to debt accumulation is linear or not significant, apart from the contribution of Esteller-Moré and Solé-Ollé (2004), who identify a nonlinear adjustment from a certain threshold (and in particular under the budget consolidation scenarios in place between 1992-2001). However, that contribution focused on the financial bailout hypothesis and the period of analysis was distant from the current situation. Argimón and Hernandez de Cos (2012) analysed the key factors of budget balance dynamics, that is, economic, political and institutional factors, for the period 1984-2004. In that case, the response of the PBB to the debt ratio was supposed to be linear, although the results were not significant. Mussons Olivella (2017) has presented a similar analysis for the period 1987-2012, although the impact of the economic cycle and the institutional framework were dealt with in greater depth. That work identifies a corrective action (in linear terms) of the primary budget balance to the accumulation of debt, although from 2009 onwards the fiscal performance of ACs is weaker. Hernández de Cos and Pérez (2013), in their analysis of regional debt dynamics, also included the impact of the institutional framework, but the variables that capture market discipline are the key determinants. These authors also identify (for the period 1995-2010) a corrective action (in linear terms) to the accumulation of debt. Fourthly, Molina-Parra and Martínez (2015) introduced the role of vertical interactions between tiers of government, and specifically the impact of the central government's budget balance on regional finances. Their specification suggests a linear adjustment to the relationship between the primary balance and debt accumulation, although the effect is not significant. The period analysed in this case was 1995-2010. Leal Marcos and López Laborda (2015) also used the FRF's analytical framework, not to examine the determinants of the budget balance or the change in ACs' debt, but the deviations of budget balances from budgetary targets set by the central government. The debt specification is linear, although the effect is not significant. The period covered is shorter but closer in time, that is from 2003 to 2012. Lastly, the recent works of Lago Peñas et al. (2017) and

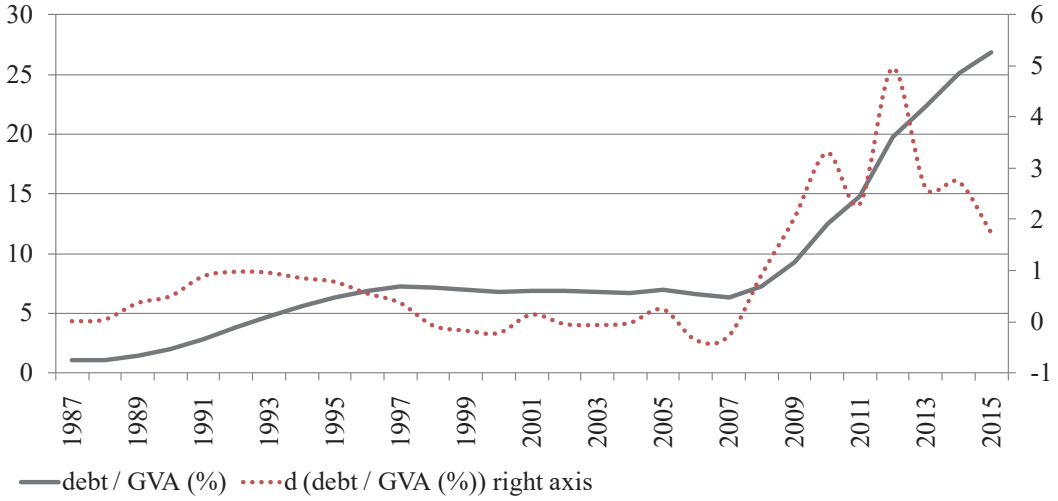
Delgado-Téllez et al. (2017a) also analyse the determinants of fiscal non-compliance, but without including the debt ratio as an explanatory variable. Both papers make use of implicit interest rates as a proxy to market-financing costs. The former obtains no statistically significant impact on fiscal compliance, whereas the latter provides significant evidence of the positive impact of regional financing costs on compliance margins (that is, the difference between fiscal outturns and targets).

Before turning to the estimation of the FRF and fiscal space of ACs, we show (in Figure 3.1) the evolution of regional debt since 1987, the first year of the so-called final stage of the financing system. In the previous period (the pre-autonomic stage and the subsequent transitional stage), ACs' debt played a marginal role; in fact, in 1987, the debt ratio stood at 1.1% of GVA. In the period 1987-1997, we see a significant growth in debt, which can be attributed in part to the unfolding of the "autonomic system"[4]. The decentralisation of responsibilities was based on a cost-effectiveness criterion, where the agreed amounts were updated according to the dynamics of the central government's tax revenues. However, Lago Peñas (2002) and Mussons Olivella (2009) provide cross-sectional evidence of the higher debt levels of those ACs that were the first to assume the responsibilities of health and education. Both works also indicate that the less indebted ACs were those receiving more funds[5]. The analysis of Lago Peñas (2002) covers the period 1984-1996, whereas that of Mussons Olivella (2009) refers to 1996-2006. Throughout the period 1997-2007 regional debt stabilized around 7% of GVA, thanks to the expansion phase related to the real estate cycle. The end of this growth model leads to a period where debt gets into an explosive trajectory, moving from 6.3% in 2007 to 19.8% in 2012. In the last stage, the period 2012-2015, regional debt continues to grow, but at a significantly slower pace thanks to the strengthening of fiscal consolidation. In 2015 debt reached 26.8% of GVA.

[4] This unfolding led to an asymmetric and gradual process of decentralisation of powers, where health and education stand out from the rest. Mussons Olivella (2009, 5) takes into consideration the years of transfer of these two major responsibilities, with substantial differences across ACs depending on the time they were devolved. In 2002, all ACs had assumed the responsibilities of health and education.

[5] Lago Peñas (2002) takes into account the development funds, whereas Mussons Olivella (2009) considers both the development funds and revenue from the regional financing system.

Figure 3.1. Evolution of ACs' debt (% of Gross Value Added)



Sources: Bank of Spain, BDMORES (Ministry of Economy and Finance) and INE.

In the following we provide an empirical exercise on regional debt limits in Spain. First, section 3.1 presents our estimates for the FRF, and then section 3.2. reports our approach to the fiscal space of ACs in a stochastic setting. In the Appendix section 6.3 we also provide a brief reflection on inference by confidence intervals, which can stem from either the estimator's asymptotic distribution or the empirical distribution.

3.1. Fiscal reaction function

The estimation of the FRF follows the empirical specification of Mussons Olivella (2017), which includes a detailed analysis of the impact of factors unrelated to the process of debt stabilization, especially those related to the economic cycle and the institutional framework. The empirical strategy involves a panel data analysis that reflects ACs' fiscal performance over the period 1987-2015. The estimation method deals with endogeneity problems by means of two-stage least squares. Our variable capturing the economic cycle is the variation in the unemployment rate and this is instrumented through the output gap of Spain's main trading partners, following a proposal by Galí and Perotti (2003). Our first stage results are reported in Table A3.1 (see Appendix section 6.2). The estimates also take into account the contemporary correlation of the disturbance terms by applying the SUR methodology (Zellner, 1962). In this regard, we do not model central

government behaviour, but we do control for common shocks to all ACs. For instance, we might expect that a central government measure that affects the primary budget balance in one AC would simultaneously affect the primary budget balance in other ACs as well. Note that these common shocks are captured by expression (7).

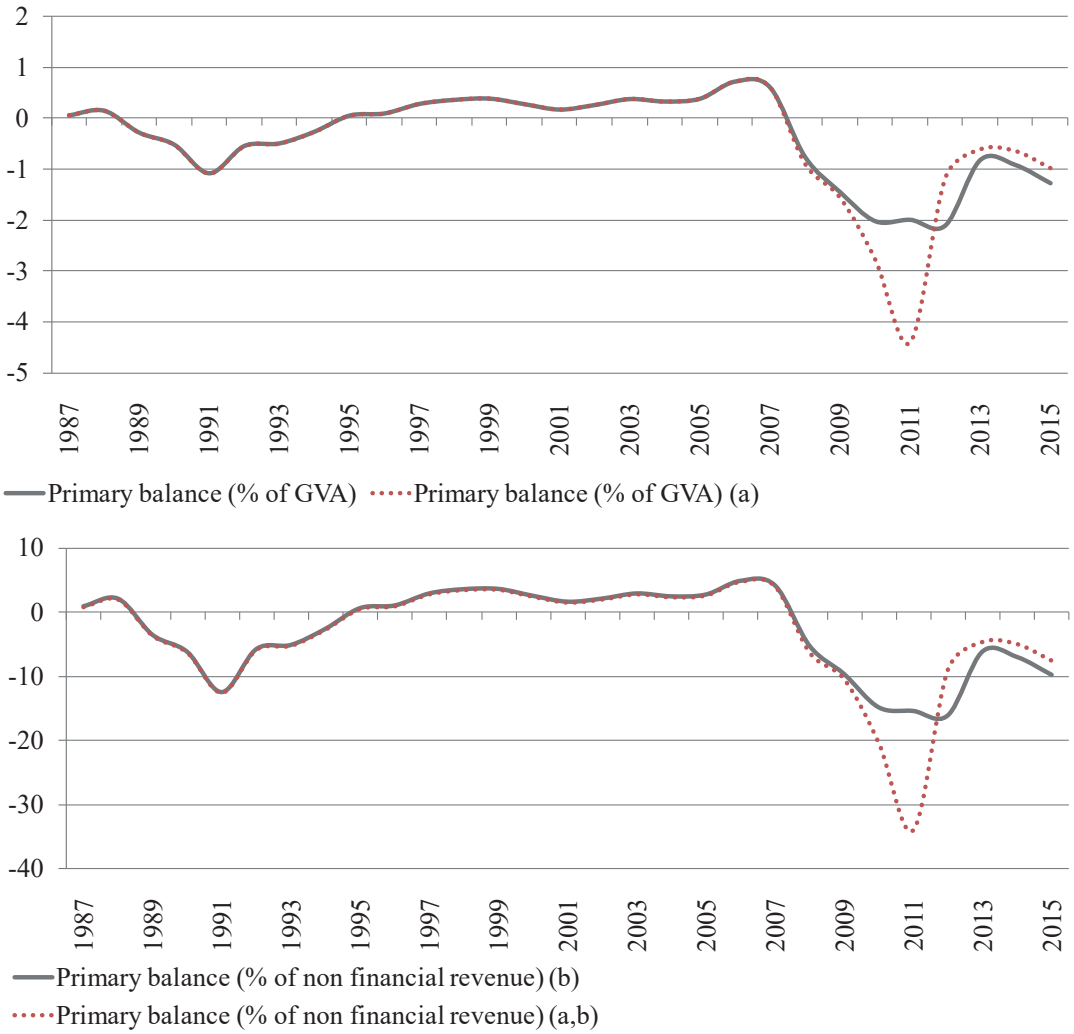
$$PBB_{it} = \gamma_1 + \gamma_2 \Delta UR_{it} + \gamma_3 PBB_{it-1} + \gamma_4 IRES_{it} + \gamma_5 ECYCLE_{it} + \gamma_6 DEBT_{it-1} + \gamma_7 DEBT_{it-1}^2 + u_{it} \quad (6)$$

$$E(u_{it}, u_{jt}) = \sigma_{ij} \text{ for all } t,\ E(u_{it}, u_{js}) = 0 \text{ for all } t \neq s \quad (7)$$

Our specification takes the **primary balance-to-GVA ratio**[6] of each AC (*PBB*) as the policy instrument and sets its target as a function of cyclical conditions (these being captured by the change in the unemployment rate, UR), the **lagged dependent variable**, the **lagged debt ratio** (*DEBT*) and its quadratic form ($DEBT^2$), an **index of expenditure responsibilities** (*IRES*) and an **electoral cycle variable** (*ECYCLE*). The index of expenditure responsibilities proxies the increase in regional per capita expenditure needs due to the assignment of health care and education (see Sorribas-Navarro, 2011), while the electoral cycle variable is a dummy for election years.

[6] The primary budget balance of each AC is computed according to budgetary criteria both regarding the institutional scope as well as the accounting rules. This data relates to all the public entities included in the consolidated budget of each AC. In addition, we adjust the dependent variable according to de la Fuente (2013) and Lago Peñas and Fernández Leiceaga (2013). On the one hand, we make corrections for the negative settlements from the funding system (for years 2008 and 2009), the payments for which were deferred. We regard these negative results as cancelled in 2010 and 2011 respectively (as provided for initially by law), and accordingly we do not apply revenue withholdings from then on (to return those deferred payments). On the other hand, we make adjustments related to outstanding payments to suppliers, which are captured by annual changes in accounts payable for accrued liabilities. After these adjustments our data are very close to national accounts criteria. Figure 3.2 displays the dynamics of our dependent variable, as well as the relevance of the above-mentioned corrections.

Figure 3.2. Evolution of ACs' primary budget balance



Notes: [a] Adjusted by 2008 and 2009 negative settlements and outstanding payments to suppliers.
[b] Adjusted by FEOGA and local funding revenue.
Sources: Spanish Ministry of Finance and Civil Service and INE.

Before moving to the debt limit issue, it is worth commenting briefly on the FRF's empirical estimates (Table 3.1). The PBB is not sensitive to the cyclical conditions of the whole sample, but before 2008 (see specifications (5) and (6) in Table 3.1) the reaction to changes in the unemployment rate was negative, and thereby counter-cyclical as a whole (i.e. considering the impact of both the cyclical and discretional component of fiscal policy)[7]. The results also point to a strong budgetary inertia, in accordance with the related literature. Our political and institutional variables also present the expected sign. The primary balance deteriorates in election years and as a result of the assumption of greater spending responsibilities. Last but not least, the response of the primary balance to lagged debt is non-significant in the whole sample, although the response previous to 2008 is positive, suggesting a corrective action to the accumulation of debt. We also provide a quadratic and cubic debt specification to enable more flexible responses. The quadratic specification (see specification (8)) is more robust, as the coefficient of the cubic term (see specification (9)) is only significant at the 10% level[8]. Therefore, the results point to a nonlinear response to be explored in the rest of the paper. A robustness check changing our dependent variable provides similar results (see Table A3.2 in Appendix section 6.2). In that case, the primary budget balance to non-financial revenue is our dependent variable, following a proposal by Lago Peñas and Fernández Leiceaga (2013)[9].

[7] See Mussons Olivella (2017) for an analysis of ACs' discretional fiscal policy. This paper indicates that ACs' fiscal stance has been pro-cyclical over the period 1987-2012. As a matter of fact, this pro-cyclicality has sharpened since the last crisis.

[8] The specification of the debt polynomial is an empirical issue, as has been reflected in the literature. For example, we can see that the seminal work of Bohn (1998) considers a quadratic form while the pioneering contribution from Gosh et al. (2013) identifies a cubic specification. A review of the literature can be found in Checherita-Westphal and Zdarek (2015) and Berti et al. (2016), including the details of the econometric specifications.

[9] We performed an additional robustness check regarding the inclusion of year fixed effects. Despite being significant from a statistical point of view, results did not bring important changes in the primary balance response to debt (and accordingly in the estimates of regional debt limit). In fact, changes in the unemployment rate, electoral cycle and our proxy to expenditure decentralisation capture most of the common dynamics across ACs.

Table 3.1. ACs' fiscal reaction functions: the response of the primary balance to debt

Dependent variable: Primary budget balance / Gross Value Added

	all ACs					
	(4)	(5)	(6)	(7)	(8)	(9)
Constant term (x1000)	**0.68**	**0.32**	**-4.00**	**-0.17**	**-0.70**	**-1.31**
	(1.40)	(0.51)	(-4.91)***	(-0.28)	(-0.98)	(-1.62)
Unemployment rate (first difference)	**-0.09**	**0.01**	**-0.14**	**-0.08**	**0.02**	**0.01**
	(-7.72)***	(0.21)	(-3.1)***	(-7.12)***	(0.53)	(0.43)
Unemployment rate (first difference) * **dummy 08-15**			**0.22**			
			(2.99)***			
Primary budget balance / Gross value added (-1)	**0.48**	**0.52**	**0.47**	**0.49**	**0.53**	**0.53**
	(12.62)***	(12.95)***	(13.28)***	(12.78)***	(13.61)***	(13.74)***
Index of expenditure responsibilities (x 1000)	**-0.89**	**-1.17**	**-2.94**	**-1.30**	**-1.47**	**-1.69**
	(-3.26)***	(-3.52)***	(-5.83)***	(-3.53)***	(-3.63)***	(-4.1)***
Electoral cycle dummy) (x1000)	**-2.53**	**-1.87**	**-2.36**	**-2.38**	**-1.79**	**-1.75**
	(-7.62)***	(-4.64)***	(-6.06)***	(-6.49)***	(-4.53)***	(-4.42)***
Debt / Gross value added (-1)	**-0.01**	**0.00**	**0.13**	**0.03**	**0.03**	**0.06**
	(-1.79)*	(0.07)	(10.44)***	(3.03)***	(3.66)***	(3.25)***
Debt / Gross value added (-1) * dummy 2008-15			**-0.12**			
			(-10.09)***			
(Debt / Gross value added (-1))^2				**-0.10**	**-0.10**	**-0.32**
				(-4.61)***	(-4.54)***	(-2.56)**
(Debt / Gross value added (-1))^3						**0.41**
						(1.83)*
Number of observations			493			
Sample			1987-2015			
Adjusted R^2	0.42	0.34	0.54	0.41	0.36	0.37
Estimation method	OLS	IV	IV	OLS	IV	IV
Hausman exogeneity test						
t-statistic / F-statistic		-4.00	26.56		-4.06	-4.03
(p-value)		(0.00)	(0.00)		(0.00)	(0.00)

Notes: All regressions are estimated by Panel EGLS (Cross-section SUR weights). *** ***, ** and * statistically significant at 99%, 95% and 90%. t-statistics within brackets. Changes in the output gap of the 5 biggest Spanish export markets - weighted by their export shares- are used as an instrument of ACs' cyclical position. The primary balance is adjusted for 2008 and 2009 negative settlements, and outstanding payments to suppliers. Hausman exogeneity tests based on artificial regressions.

3.2. Analysis of the regional debt limit uncertainty

This section analyses the implications of the primary balance's nonlinear response to the ACs' lagged debt. To take account of estimation uncertainty we provide confidence intervals based on the estimator's empirical distribution. The approximation to the regional debt limit is made through simulations of the primary balance's response to the accumulation of debt on the basis of the quadratic specification of the FRF (see specification (8) in Table 3.1):

$$\widehat{PBB}_{it} = \hat{\gamma}_1 + \hat{\gamma}_2 \Delta UR_{it} + \hat{\gamma}_3 PBB_{it-1} + \hat{\gamma}_4 IRES_{it} + \hat{\gamma}_5 ECYCLE_{it} + \hat{\gamma}_6 DEBT_{it-1} + \hat{\gamma}_7 DEBT_{it-1}^2 \quad (8)$$

Gosh et al. (2013) and Berti et al. (2016) take into account all the explanatory variables in obtaining the specific limit that makes debt unsustainable. However, other studies, such as that of Bohn (1998), pay attention exclusively to the primary balance's response to debt. In fact, the impact of budgetary inertia on our FRF plays a major role in the adjusted value of the primary balance (as the coefficient for the lagged dependent variable is 0.53). Therefore, for the purpose of calculating the debt limit one may exclude this inertia from the deficit (given the size of the budgetary imbalances in the aftermath of the crisis) and only analyze the primary balance's response to debt. This is our option (see below our equation (9)), and thereby these estimates are informative about ACs' public debt sustainability risks in a balanced budget setting.

$$\widehat{PBB}_{it} = \widehat{\beta_1} DEBT_{it-1} + \widehat{\beta_2} DEBT_{it-1}^2, \quad (9)$$

$$\text{where } \widehat{\beta_1} = \frac{\widehat{\gamma_6}}{(1-\widehat{\gamma_3})} \text{ and } \widehat{\beta_2} = \frac{\widehat{\gamma_7}}{(1-\widehat{\gamma_3})}$$

The inference by confidence intervals can stem from either the estimator's asymptotic distribution or the empirical distribution. However, it is shown in Appendix section 6.3 that the asymptotic distribution of the estimator may lead to a biased inference in finite samples, particularly when an asymmetric distribution lies behind the statistical relationship to be tested (e.g. the nonlinear relationship considered in our paper). In such cases it is best to proceed from an empirical distribution obtained through resampling techniques.

Thus, in order to capture the uncertainty of the response of the primary

balance to debt accumulation, we apply simulation techniques to obtain 1,000 vectors (Y) with the same distribution as $\hat{\beta}$. Accordingly, we define a random variable $\tilde{\beta}$ centred at $\hat{\beta}^0$, whose covariance matrix is $\widehat{cov(\hat{\beta})}^0$ (as we do not observe $cov(\hat{\beta})$) and where upper index ^{0} indicates a realization of the data generating process[10].

$$\tilde{\beta} \sim N\langle \hat{\beta}^0, \widehat{cov(\hat{\beta})}^0 \rangle \tag{10}$$

$$Y = PZ + \hat{\beta}^0, \tag{11}$$

$$\text{where } \widehat{cov(\hat{\beta})}^0 = PP' \text{ and } Z = P^{-1}(\tilde{\beta} - \hat{\beta}^0) \sim N\langle O, I \rangle$$

At this point, it can be shown that Y presents the same distribution as $\tilde{\beta}$:

$$E(Y) = E(PZ) + E\left(\hat{\beta}^0\right) = E\left(\hat{\beta}^0\right) = \hat{\beta}^0 \tag{12}$$

$$COV(Y) = E(Y-\mu)(Y-\mu)' = E(PZZ'P') = PE(ZZ')P' = PP' = \widehat{cov(\hat{\beta})}^0 \tag{13}$$

Therefore,

$$Y \sim N\langle \hat{\beta}^0, \widehat{cov(\hat{\beta})}^0 \rangle \tag{14}$$

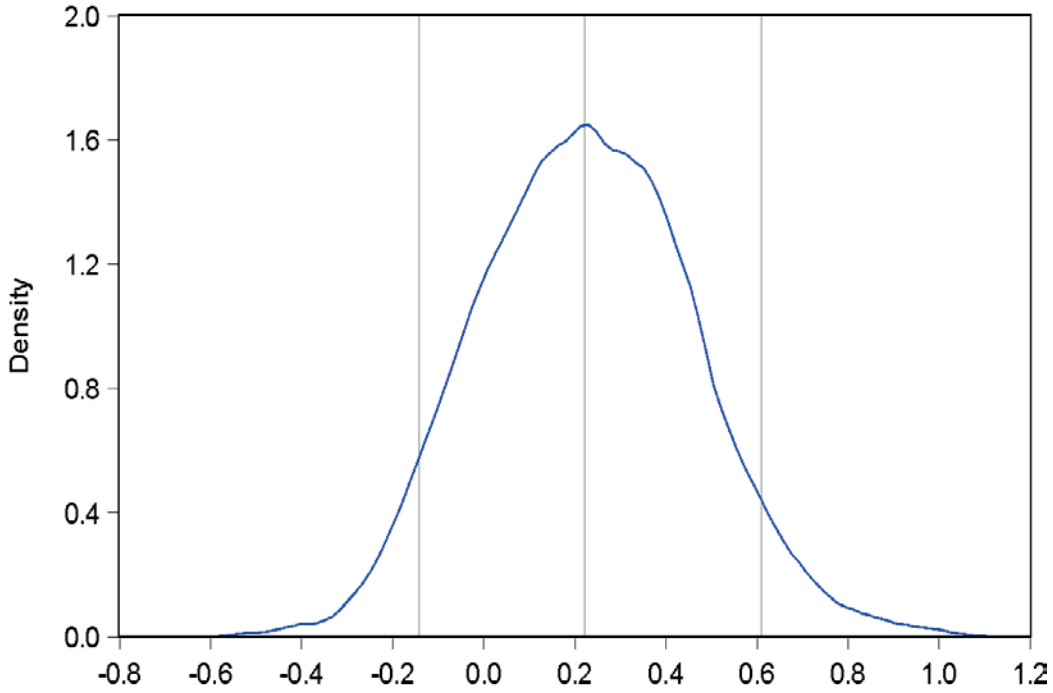
The results of the simulations performed are presented below. Figure 3.3 shows the density function of the simulations for the adjusted value of the primary balance. This function includes 1,000 responses to a debt ratio of 26.8%, which was the latest available data for all ACs at the time of performing this analysis (i.e. 2015). As for the midpoint of the confidence interval we assign the median simulation, as the density function is almost symmetrical[11]. Figure 3.4 displays the reaction of the primary balance for a realistic range of debt ratios (from 0 to 45% of GVA). The adjusted value of the primary balance, as shown, has a parabolic shape with positive values up to the debt limit. The 90% confidence interval of this debt limit is (24%, 31%, 36%), where these values refer to the lower, middle and upper limit respectively, putting the debt ratio in 2015 slightly higher than the lower limit. Consequently, in 2015, the fiscal space for all ACs is 0% for the lower limit simulation, 4% for the mid-point simulation and 9% for the

[10] Please note that $cov(\hat{\beta}) = \sigma^2(X'X)^{-1}$ in contrast to $\widehat{cov(\hat{\beta})} = \widehat{\sigma^2}(X'X)^{-1}$.

[11] If the density function displayed an asymmetric distribution, it could also be appropriate to use the statistical mode as the midpoint of the interval.

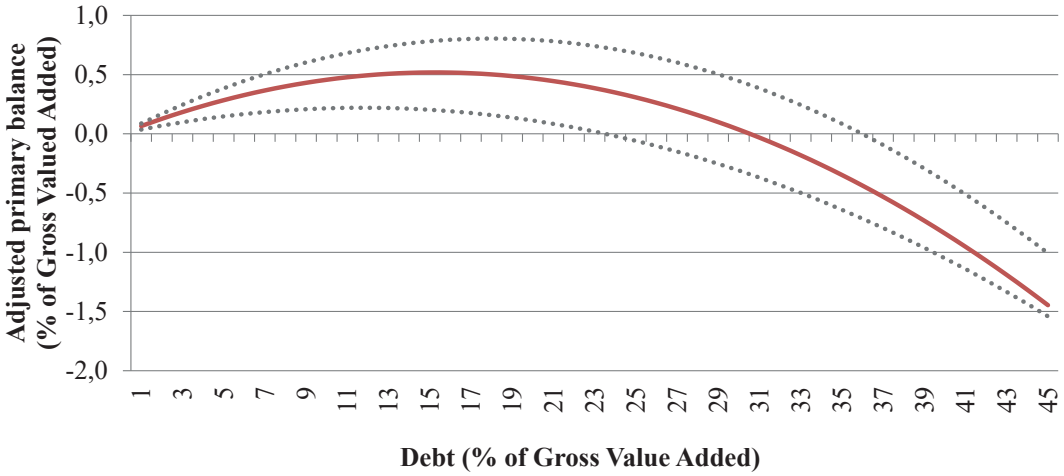
upper limit. Another interesting finding is that related to the "debt region" (i.e. the interval) where fiscal fatigue sets in, which is the region where the primary balance response follows a decreasing pattern. In this case, the 90% confidence interval of this fiscal fatigue threshold is (12%, 15%, 18%).

Figure 3.3. Density function of the response of the primary balance to the 2015 ACs' debt ratio



Note: The vertical bars indicate the midpoint and ends of the 90% confidence interval. This density function is based on 1,000 simulations drawn from specification (8) of Table 3.1. The simulations refer to the 2015 ACs' debt ratio.

Figure 3.4. Response of the primary balance of ACs to debt: a simulation with a quadratic functional specification



Notes: Simulations for a 90% confidence interval based on specification (8) of Table 3.1, where only primary balance to debt reaction is taken into account (i.e. we disregard the effects of the rest of the explanatory variables).

These results should be placed in context. First, one should not draw normative conclusions for specific ACs, although they call for measures to ensure both a sustainable debt trajectory and an appropriate fiscal responsiveness regarding plausible negative shocks (Gosh et al., 2013). Thus, this analysis contributes to the discussion regarding the debt sustainability of all ACs as a whole, but does not attempt to carry out simulations for specific ACs. To provide a disaggregated analysis, we would recommend enhancing the FRF with, inter alia, idiosyncratic factors such as specific debt and cycle reaction coefficients. It may also be worth considering some differences related to the institutional framework (e.g. the per capita resources provided by the ACs' financing system). In addition, we should take into account that these thresholds not only vary across ACs but over time.

Second, international evidence on fiscal space estimates should be taken into account, taking advantage of the contributions of Gosh et al. (2013) and Nerlich and Reuter (2015). The former provides evidence for 23 advanced economies over the 1970-2013 period, whereas the latter deals with EU27 countries over the 1985-2013 period. In general, Gosh et al. (2013) suggest a decline in the response of primary balance to lagged debt

as the debt ratio approaches 90-100% of GDP. This response would become negative around 150% of GDP. Estimates for the Spanish general government are close to this figure, as the projected debt limit stands at 153.9%. These results are similar to those of Nerlich and Reuter (2015).

Third, other approaches provide interesting insights for the Spanish case (not regarding ACs but the general government). In this regard it is worth mentioning the works of Andrés et al. (2017) and Domenech and González-Páramo (2017). The former explores the probability that the public debt exceeds a given threshold in connection with a market risk assessment. More specifically, this analysis builds on the VAR methodology to determine a threshold that maximizes the correlation between a measure of public debt risk and the sovereign spread. This measure of public debt risk is approached by the probability that public debt exceeds a given threshold over a certain time horizon. Thus, these results cannot be directly related to the notion of debt limit but to the region where risks to fiscal sustainability increase. Their findings suggest there has been a "prudent debt level" within the range of 50%-55% of GDP since 1999. The paper by Domenech and González-Páramo (2017) is based on the seminal contribution of Blanchard (1984), which takes into account the standard debt accumulation equation and an FRF to capture the convergence of the primary balance with its maximum level. This analysis does not provide a debt limit, but a combination of debt and primary balance positions ensuring fiscal sustainability. Estimates suggest that debt sustainability was "on a knife-edge" from 2009 to 2011 (in other words, Spain had no fiscal space during those years). It is also worth mentioning their evidence concerning high public debt outcomes. Their estimates point out that for each 10 percentage point increase in public debt, GDP falls 0.8%. In addition, their work also provides an interesting discussion on strategies to regain fiscal space. Their findings put structural reforms in place as an essential measure in restoring a prudent debt level. In this regard, a decrease of the structural unemployment rate in Spain from 15.5% to 7.5% would lead to a 6 percentage point improvement in the structural primary balance.

Fourth, we must also bring in the available evidence suggesting that central governments are shifting the burden of consolidation towards lower tiers of government (Von Hagen and Foremny, 2013; Vammalle and Hulbert, 2013; Foremny et al., 2017). This evidence indicates that transfers from CG are

cut during consolidation periods, especially when the fiscal autonomy of SCG is low. The Generalitat of Catalonia (2017) has provided evidence for the Spanish case on the deficit adjustment distribution over the period 2010 to 2016. ACs accounted for 46.5% of general government adjustment, local governments 23.5% and CG & Social Security 30%. This situation (that of shifting the burden of consolidation toward lower tiers of government) is especially worrisome as some ACs were very close to their debt limit, which may have contributed to the deterioration of welfare state services.

Fifth, we should examine our results in relation to Spanish budgetary stability regulations. The 2012 Budget Stability Law establishes a regional debt ceiling of 13% of GDP to be reached in 2020. According to our estimates, the above-mentioned threshold is close to the lower limit of our fiscal fatigue region, which suggests that the current ACs debt threshold is placed in a prudent area. A separate issue is the (in)feasibility of the debt target on the 2020 horizon. In fact, according to AIREF (2017) the fulfilment of this target is not expected before 2030 for most ACs.

Sixth, strictly speaking our approach (based on Bohn, 1998, and Gosh et al., 2013) is designed for general governments, namely for sovereign states. In our setting we should take into account that sometimes the central government may raise funds on the market when regional access to financial markets is limited or non-existent[12]. This intervention may have avoided the default of some ACs, as it is likely that some of them had been exceeding their debt limit previously.

[12] As a matter of fact, this was the case after 2012, when extraordinary liquidity support measures were put forward. First, the Fund for the Financing of Payments to Suppliers (FFPP) was created in March 2012 to pay off debt with suppliers. In other words, trade credits (included as total liabilities of general government debt) were replaced by EDP debt. Second, the Regional Government Liquidity Fund (FLA) was created in July 2012 to finance the repayment of outstanding regional government debt and its authorised net borrowing. Both funds were assumed by the Fund for the Financing of Regional Government in December 2014. Another source of debt is the one related to 2008 and 2009 negative settlements (0.7 pp and 2.3 pp of GDP respectively), which was supposed to be repaid in 2010 and 2011. However, those payments were deferred for 10 years. Overall, the percentage of regional government debt held by central government stood at 47.7% in 2015 (Delgado et al., 2017b). See Gordo et al. (2013) regarding debt developments in Spain since the start of the crisis, as well as more details on the debt relationship between tiers of government.

4. Conclusions

The primary balance's response to the accumulation of debt is the central question addressed in this chapter, with two notable contributions: evidence is provided on the state of fiscal fatigue of Spanish ACs using the FRF methodology as well as on the uncertainty of the thresholds that indicate fiscal fatigue and debt unsustainability. To the best of our knowledge, we are not aware of a similar approach in the Spanish regional context. In addition, the stochastic approach of these thresholds is not a common practice in the literature. As has been noted, this uncertainty assessment is particularly valuable when the FRF's parameters present robustness problems. In our case, these issues are caused by a nonlinear and finite sample setting.

The results suggest a limited fiscal space for ACs as a whole and are thus indicative of the relative need for fiscal consolidation (inversely proportional to the estimates of fiscal space). A prudent fiscal position advises a reduction of the debt-to-GVA ratio, in order to ensure a sustainable debt trajectory and to regain the capacity to respond to potential negative shocks (Ghosh et al., 2013). In this regard, it seems essential to (i) lay out and enforce reliable and feasible consolidation plans, (ii) enforce structural reforms to boost potential output (Domenech and González-Páramo, 2017), (iii) reform the regional financing system in order to ensure an appropriate distribution of resources that guarantees a sustainable balance between the principles of autonomy and equity, while leaving behind the preservation of the *statu quo,* and (iv) ensure vertical equity between tiers of government over time, that is a fair distribution of resources in connection with changes in expenditure needs (see a proposal by Castells et al. 2004). At this point, it is worth mentioning that the success of fiscal consolidation programs is not only about enforcing fiscal rules, but also about creating an equitable distribution of the burden of fiscal consolidation (Delgado-Téllez et al., 2017a) and striking the right balance between stabilisation and sustainability needs.[13] Moreover, the stringency of fiscal rules should be balanced against fiscal autonomy, bearing in mind the Spanish decentralised constitutional structure (Foremny, 2014).

[13] See a careful discussion in European Comission (2016b).

The debt limit debate is especially active in international bodies such as the IMF (Ghosh et al., 2013), the European Commission (Berti et al., 2016), and even in rating agencies (Zandi et al., 2011), which perform frequent assessments of the debt limit for the countries they monitor. The present analysis aims to bring the regional perspective to a country level debate. In any case, this analysis should be weighed with other approaches including the assessment of short-term risks and that of the standard debt accumulation equation. The latter would take into account the sustainability impact of the debt structure and the expectations around financial conditions and growth prospects[14].

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[14] In this regard it is worth noting the DSA framework of the EC in European Commission (2016a) and that of the ECB in Bouabdallah et al. (2017). AIREF (2017) provides an empirical implementation of this framework for ACs.

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6. Appendix

6.1. Definition of variables and data sources

Debt: debt-to-GVA ratio according to Excessive Deficit Procedure. Source: Bank of Spain.

Electoral cycle: = 1 in election years. Source: own elaboration from the Spanish Ministry for Home Affairs. http://www.infoelectoral.mir.es/

Gross value added: Source: BDMORES (Spanish Ministry of Finance and Civil Service) and INE.

Index of expenditure responsibilities: index of relative expenditure decentralisation that proxies the increase in regional per capita spending needs due to the assignment of health care and education. It is measured in relation to the average per capita provision of public goods and services (other than health and education services). Source: Sorribas-Navarro (2011).

Primary budget balance: primary balance-to-GVA ratio. The primary balance stands for the government net borrowing or net lending excluding interest payments. This data is adjusted for 2008 and 2009 negative settlements and outstanding payments to suppliers. Source: Budget Settlement of ACs and Autonomous Cities. Spanish Ministry of Finance and Civil Service.

Unemployment rate: unemployed as a % of the labour force. Source: INE.

6.2. First stage results and a robustness check

Table A3.1. First stage results: instrumenting our cyclical position variable

Dependent variable: Unemployment rate (first difference)

	all ACs		
	(1)	(2)	(3)
Constant term (x1000)	**0.30**	**-0.43**	**-1.37**
	(0.22)	(-0.29)	(-0.76)
Primary budget balance / Gross value added (-1)	**-0.59**	**-0.59**	**-0.59**
	(-12.12)***	(-11.8)***	(-11.83)***
Index of expenditure responsibilities (x 1000)	**4.51**	**3.99**	**3.70**
	(3.7)***	(3.04)***	(2.75)***
Electoral cycle (dummy) (x1000)	**-5.57**	**-5.49**	**-5.51**
	(-3.74)***	(-3.68)***	(-3.69)***
Debt / Gross value added (-1)	**-0.07**	**-0.04**	**13.78**
	(-5.68)***	(-1.14)	(0.23)
(Debt / Gross value added (-1))^2		**-0.10**	**-0.51**
		(-1.08)	(-1.18)
(Debt / Gross value added (-1))^3			**0.79**
			(0.97)
Output gap EU5 (first difference)	**-0.99**	**-0.99**	**-0.99**
	(-18.36)***	(-18.35)***	(-18.18)***
Number of observations	493	493	493
Sample	1987-2015	1987-2015	1987-2015
Adjusted R^2	0.57	0.57	0.57
Estimation method	OLS	OLS	OLS

Notes: ***, ** and * statistically significant at 99%, 95% and 90%. t-statistics within brackets. The primary budget balance is adjusted for 2008 and 2009 negative settlements, and outstanding payments to suppliers.

Table A3.2. ACs' fiscal reaction functions: the response of the primary balance to debt. A robustness check
Dependent variable: Primary budget balance / Non financial revenue

	all ACs		
	(10)	(11)	(12)
Constant term (x1000)	**1.51**	**-22.05**	**-22.50**
	(0.16)	(-2.22)**	(-2.08)**
Unemployment rate	**0.16**	**0.05**	**0.05**
(first difference)	(0.29)	(0.08)	(0.09)
Primary budget balance	**0.53**	**0.52**	**0.52**
/ Non financial revenue (-1)	(14.25)***	(13.82)***	(13.88)***
Index of expenditure responsibilities	**-7.89**	**-3.30**	**-3.27**
(x 1000)	(-2.11)**	(-0.82)	(-0.81)
Electoral cycle (dummy) (x1000)	**-14.31**	**-13.63**	**-13.54**
	(-3.49)***	(-3.46)***	(-3.49)***
Debt / Non financial revenues (-1)	**0.01**	**0.05**	**0.05**
	(1.4)	(5.79)***	(2.75)***
(Debt / Non financial revenues (-1))^2		**-0.02**	**-0.02**
		(-6.48)***	(-1.08)
(Debt / Non financial revenues (-1))^3			**0.00**
			(-0.01)
Number of observations		493	
Sample		1987-2015	
Adjusted R^2	0.33	0.39	0.39
Estimation method		IV	
Hausman exogeneity test	-3.43	-3.47	-3.47
t-statistic (p-value)	(0.00)	(0.00)	(0.00)

Note: See Table 3.1.

6.3. Confidence intervals: inference based on asymptotic vs empirical distributions

Inference by confidence intervals can be based on either the estimator's asymptotic distribution or the empirical distribution. It is shown below that the asymptotic distribution of the estimator may lead to a biased inference in finite samples, particularly when an asymmetric distribution lies behind the statistical relationship to be tested (e.g. the nonlinear relationship considered in our paper). In such cases it is best to proceed from an empirical distribution obtained through resampling techniques.

If we wish to obtain a confidence interval on the basis of the estimator's asymptotic distribution one could proceed from:

$$\hat{\theta} = f(\hat{\beta}) \approx f(\beta) + \frac{\partial f}{\partial \beta'}(\hat{\beta} - \beta) \rightarrow N\left[f(\beta), \frac{\partial f}{\partial \beta'} cov(\hat{\beta}) \frac{\partial f}{\partial \beta}\right], \quad (16)$$

where θ is any nonlinear combination of the β coefficients.

If we assume (as an example) that $f(\beta) = \frac{1}{\beta}$, it is easy to check that:

$$\hat{\theta} \rightarrow N\left(\frac{1}{\beta}, \frac{\sigma^2}{\beta^4}\right)$$

Let's consider two simple examples to illustrate the differences in the inference of confidence intervals:

Example 1. $\beta \sim N(2,1)$

On the one hand, on the basis of the asymptotic distribution we obtain the 95% confidence interval, where the lower and upper bounds for *theta* are:

$\hat{\theta}$ = *0.50*
$\hat{\sigma}_{\hat{\theta}}$ = *0.25*
Upper limit = 0.50+0.50=1.00
Lower limit = 0.25-0.50=0.00

On the other hand, we may proceed from the empirical distribution:

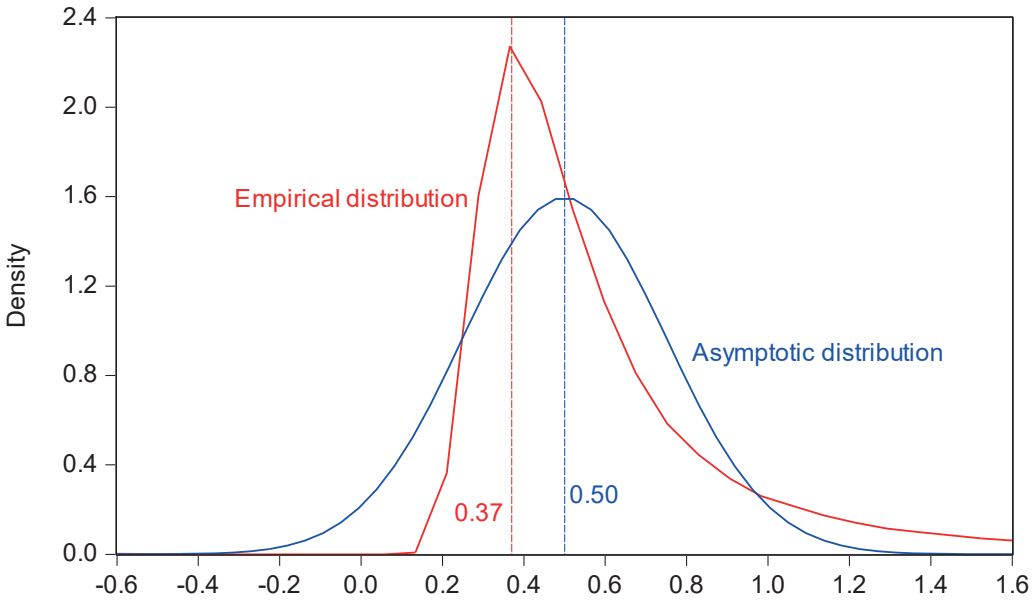
First, we generate a sample of 100,000 observations from $\beta \sim N(2,1)$
Second, we estimate 100,000 *thetas* from $\hat{\theta} = \frac{1}{\hat{\beta}}$

Third, the estimated *thetas* are ordered from the smallest to the largest. The lower bound is obtained as the *theta* value corresponding to observation 2,501 and the upper bound as the *theta* value corresponding to observation 97,500. The results obtained through simulation are:

Upper limit = 3.00
Lower limit = 0.19
$\hat{\theta}\ mode = 0.37$

Figure A3.1 displays the asymptotic and empirical distribution functions of *theta*. In this regard, recall that the latter has been obtained through simulation techniques.

Figure A3.1. Empirical and asymptotic distributions of "*theta*" ($\hat{\theta}$), example 1



Please note that the expected value of "theta" does not exist because it includes an expression that is the product of infinite and zero. That is to say:

$$E(\hat{\theta}) = \int \frac{1}{\hat{\beta}} p(\hat{\beta}) d\hat{\beta} = \infty * 0 = indeterminate \quad (17)$$

Therefore, we include the mode as being our preferred estimator (as it is the most likely value), instead of the expected value of "theta".

Example 2. $\beta \sim N(1,1)$

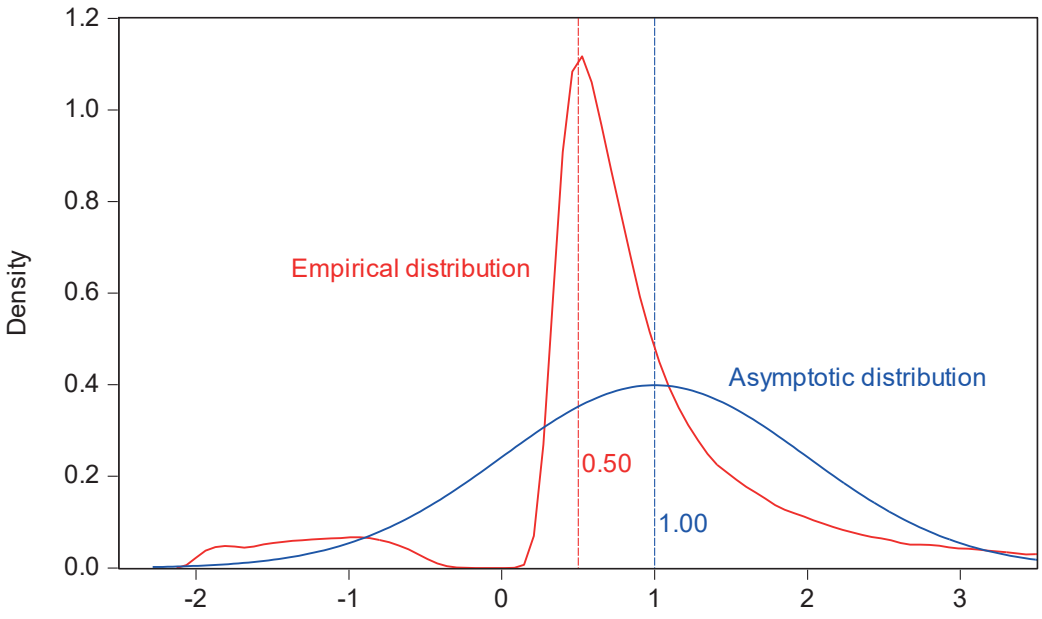
If we proceed as in the first example, the results (see Figure A3.2) highlight even more clearly the inadequacy of using the asymptotic distribution as a basis for inference. On the one hand, on the basis of the asymptotic distribution, we obtain the following statistics:

$\hat{\theta} = 1.00$
$\hat{\sigma}_{\hat{\theta}} = 1.00$
Upper limit = 3.0
Lower limit = -1.0

On the other hand, the empirical distribution provides the following statistics:

Upper limit = 10.07
Lower limit = -9.09
$\hat{\theta}\ mode = 0.50$

Figure A3.2. Empirical and asymptotic distributions of "*theta*" ($\hat{\theta}$), example 2



Thus, both examples illustrate the benefits of operating from an empirical distribution when we are interested in building confidence intervals in a nonlinear and finite sample setting.

Chapter 4

Dynamic Personal Income Tax Elasticities in Spanish Autonomous Communities

1. Introduction

The global financial crisis that started in 2008 led to a severe deterioration of Spanish public finances. This crisis has presented considerable challenges to fiscal policies, especially concerning Autonomous Communities (ACs). One of these challenges is the inaccuracy of fiscal forecasting (both in central and sub-central governments), where the analysis of tax elasticities plays an important role.

In this chapter we focus on the responsiveness of personal income tax (PIT) revenue to economic activity in Spanish common regime ACs (from here on, ACs refer to common regime ACs)[1]. The reliance of the regional financing system upon this tax has increased since 1994, to the extent that it has been the main the main source of revenue since 2009.

The measure of tax responsiveness to economic activity is captured by the concept of tax elasticity, which has been commonly used for forecasting and monitoring public finances (especially regarding the European fiscal surveillance framework), as well as for setting a tax-mix policy which considers both the growth potential and the cyclical variability of taxes (see e.g. Sobel and Holcombe, 1996). In the particular case of PIT, it is also useful to step back to the contribution of Musgrave and Thin (1948), who present this tax elasticity as a local measure of tax progression.

[1] Foral ACs are excluded for data availability reasons.

That being said, it is common practice to consider static relationships based on cross-sectional analysis when dealing with PIT elasticities. In fact, to the best of our knowledge there is no regional evidence in Spain for a dynamic pattern in these elasticities. The stability of personal income tax elasticities is assessed via an error-correction model that provides short and long-run elasticities. The analysis of potential asymmetries in the short-run dynamics and the discussion of dynamic adjustment between short and long-run elasticities are also noteworthy contributions of our work. Our results enable us to evaluate fiscal pressure outcomes, confirming the progressive nature of PIT.

In addition to the time variability of tax elasticities, we also pay attention to cross-sectional variability. The assessment of this variability is useful in both dimensions as tax elasticities play an important role in monitoring and forecasting regional public finances. Policymakers need reliable revenue forecasts in order to formulate suitable spending plans, and in particular to avoid unpleasant surprises on the revenue side. The literature so far has been particularly focused on the state level, disregarding the regional dimension. To our knowledge, only a few works have provided a regional analysis in the Spanish case, but from a different angle[2]. These contributions were based on cross-sectional data, whereas we use a time series analysis in our work. Regarding monitoring purposes, it is important to note the role of tax elasticities in the estimation of structural budget balances. The current Spanish regulations do not provide for either region-specific elasticities or region-specific cyclical positions. The former of the two is a strong assumption considering the results obtained in this chapter.

The chapter is structured as follows. Section 2 provides an empirical review of PIT elasticities with a special focus on Spain. Section 3 deals with data issues. In section 4 we turn to the econometric analysis of PIT elasticities, where we simulate some scenarios to explore the dynamic behaviour of tax elasticities and their influence on fiscal pressure. In this section we also explore forecasting accuracy in the presence of an endogenous relationship. To the best of our knowledge, this important issue has gone unnoticed in this strand of the literature. Section 5 concludes. The appendix includes data sources, first stage results, a more detailed discussion of estimation methods

[2] Sanz et al. (2016) is one of the finest examples of this strand of literature.

and forecast accuracy in the presence of endogeneity problems, and last but not least, an analysis of the role of fiscal autonomy on PIT revenue. In the latter case, the effective exercise of fiscal autonomy was limited to minor tax deductions and tax credits until the onset of the global financial crisis. ACs' budget constraints may be strengthening in the aftermath of this crisis, as PIT discretionary revenue increased in response to fiscal imbalances.

2. Personal income tax elasticities: an empirical review

The literature on tax elasticities starts with the seminal paper of Groves and Kahn (1952) and from then on there has been a continuous academic discussion that has contributed towards improving the measurement of these responses. The constant elasticity assumption is an issue commonly challenged in the recent literature. Sobel and Holcombe (1996) propose an error correction model to deal with the non-stationarity of tax revenue and its base. Bruce et al. (2006) consider asymmetric responses to the cycle based on the direction of the underlying equilibrium.

As Dye (2004, 136) points out "researchers face a choice of which tax measure to use in estimating elasticities: the tax base or tax revenue". On the one hand, data on tax revenue are much more available, although tax revenue depends on economic activity (our relationship of interest) and policy changes. Therefore it is essential to adjust revenue derived from policy changes that may be correlated to cyclical conditions. On the other hand, tax base data do not face this limitation, but are much less available. In this work we will analyse the elasticities of personal income tax revenue under the accrual basis.

In this section, we will focus on the literature that deals with personal income tax elasticities in the Spanish case. A distinction should be made between those works based on detailed information on tax law and codes and those based on a time series approach. The objectives of the former group are usually the measurement of structural budget balances as well as the analysis of fiscal reforms, while those of the latter group are closer to forecasting goals, but also cover the measurement of structural budget balances and tax-mix policy.

The first group includes most of the research of international organizations such as the OECD (Girouard and André, 2005; Price et al., 2014) or the

ECB (Bouthevillain et al., 2001). This approach takes advantage of microdata related to income distribution and information on tax law and codes. As Martínez-Mongay et al. (2007, 27) point out it is "a time and resource-consuming exercise", which makes it harder to update. This is an important issue if we are interested in forecasting performance. In this branch of research we should mention the works of Creedy and Sanz-Sanz (2010), Onrubia and Picos (2011) and Sanz-Sanz et al. (2016), which provide region-specific elasticities. The latter two studies found a decreasing pattern of personal income tax elasticities on a per capita income basis. This result is explored in greater depth in section 4.3.

The time series approach analyses tax revenue or tax base as a function of macroeconomic variables. The most common approach of this type is the error correction model, which is the empirical strategy used in our work. Regarding Spain we should mention the works of Martínez-Mongay et al. (2007), Zack et al. (2014) and Cuerpo and Losada (2015). In the international literature many articles have taken this approach after the work of Sobel and Holcome (1996) (for example, Bruce et al., 2006; Wolswijk, 2007; Poghosyan, 2011; Koester and Priesmeier, 2012; Koester and Priesmeier, 2017). State space models are another approach to addressing non-stationarity issues. Corrales et al. (2002) make use of this framework, although their main objective is not related to tax elasticities but to the measurement of structural budget balances.

In Table A4.1 (see Appendix section 7.2), we summarise the main results regarding tax elasticities in Spain as well as some specification issues. The range of personal income tax elasticities is from 0.9 to 2.1. Macroeconometric approaches are in the low band, in contrast to cross-sectional works. We do not take into account the works of Zack et al. (2014) and Cuerpo and Losada (2015) in this range of elasticities since they include other macroeconomic variables that would distort comparison.

Most of the works use tax revenue data, with the exception of Cuerpo and Losada (2015). In the time series approach, adjustment for tax reform effects is a common issue. The empirical strategies used in the works on Spain are the inclusion of dummies to capture the impact of specific tax reforms on PIT revenue (Martínez-Mongay et al., 2007) or the inclusion of

a variable to control for these reforms, such as the average rate of PIT (Zack et al., 2014).

Finally, we will focus on the proxy for the tax base. The literature deals with three main alternatives. The first proxy to the PIT base is a broad macroeconomic variable, such as GDP or gross value added (Martínez-Mongay et al., 2007), which is also our choice. The second option is the compensation of employees in its disaggregated form (employment * average compensation of employees). Finally, the third option relies on GDP and other macroeconomic variables (such as residential investment, Zack et al. 2014). In this latter approach, we should include the work of Cuerpo and Losada (2015), which present a detailed modelling of various tax bases (labour tax base, capital tax base and economic activity tax base) connected with many macroeconomic variables.

3. Data[3]

3.1. PIT revenue in the regional financing model

As we can see in Table 4.1, PIT revenue was the most important revenue source of ACs in 2012 (accounting for 33.4 % of regional financing system revenue). In addition, it should be highlighted that PIT is by far the largest fraction of potential fiscal autonomy in the hands of ACs. The next most significant source of fiscal autonomy is traditional ceded taxes, although their relevance is much less (13.0 % of regional financing system revenue). Therefore, it seems worthwhile to explore the fiscal autonomy determinants of personal income tax (in this regard, see a preliminary analysis in Appendix section 7.5).

[3] See Appendix section 7.1 for data sources.

Table 4.1. Regional revenue sources in Spain, 2012
(as a percentage of regional financing system revenue)

Personal income tax	33.4
Value added tax	25.2
Other indirect taxes	12.3
Traditional ceded taxes[1]	13.0
Tax revenue	84.0
Transfers[2]	16.1
Non-earmarked revenue (regional financing system)[2]	100.0

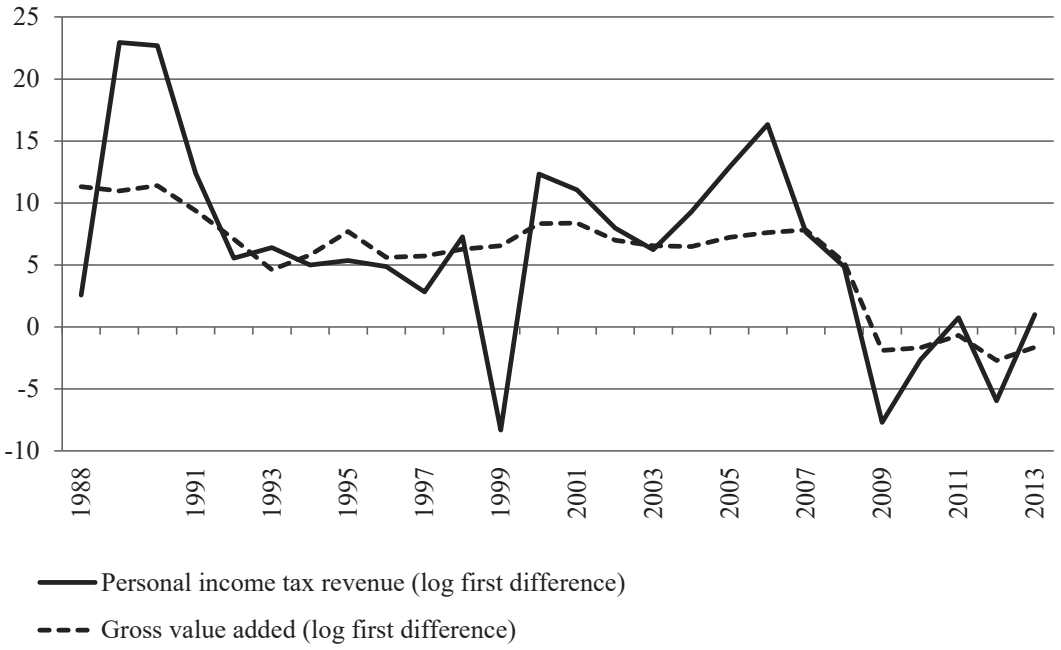
Notes: Tax revenue in normative terms.
[1] Traditional ceded taxes are assigned fully to ACs, and include inheritance and gift taxes, taxes on financial and capital transactions, recurrent taxes on net wealth and taxes on betting and gambling.
[2] Transfers and non-earmarked revenue include specific responsibilities.
Source: own elaboration from Generalitat of Catalonia.

3.2. Selecting the proxy for the tax base

Nominal Gross Value Added (GVA) has been selected as the proxy to our tax base. Our efforts will be addressed more to specification issues, than to a detailed modelling of different tax bases (e.g. Cuerpo and Losada, 2015). In addition, at regional level it is difficult to find enough data to implement such a disaggregated framework. Lastly, we use GVA rather than GDP, as the former does not include value added tax, which changed notably throughout our sample.

In Figure 4.1 we can appreciate the higher volatility of personal income tax revenue with respect to GVA. These differences suggest a complex pattern that may not be properly captured by the constant elasticity assumption.

Figure 4.1. Personal income tax revenue and gross value added



Sources: Spanish Tax Agency, Spanish Ministry of Finance and Public Administrations, BDMORES and INE.

3.3. Adjusting for tax reforms

As we have mentioned previously, we are interested in the relationship between PIT revenue (under the accrual basis) and changes in economic activity. Therefore we should control for tax reforms that may be correlated with the business cycle. We should be especially cautious with central government reforms (for instance, changes in tax rates, tax bases…) and there were also regional tax reforms, which should be adjusted for. Fortunately, policy-neutral data (both from central and regional governments measures) have been available since 2002, which turns our attention to the previous period[4].

We explored different strategies to deal with the effects of these tax reforms. One option is to include dummies to capture the impact of specific tax reforms on PIT revenue (see Martínez-Mongay 2007 for an implementation of this strategy). This approach may be suitable if there are

[4] See Gil et al. (2018) for an overview of legislated tax changes in Spain (Table A.I in the online appendix).

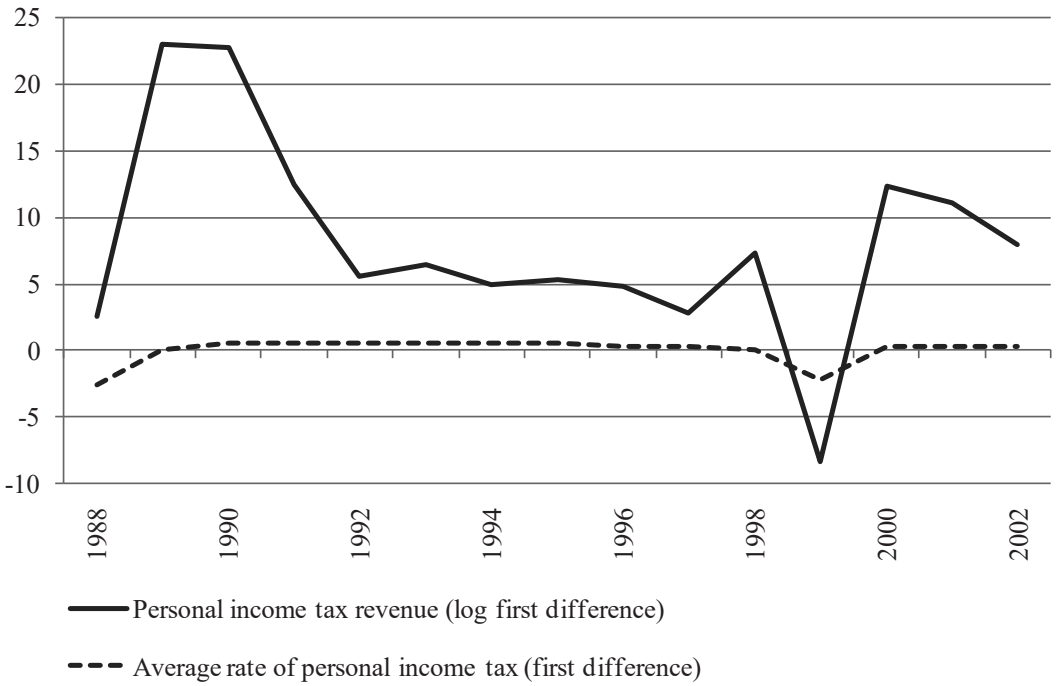
a limited number of relevant tax reforms, although including time dummies not only captures the effects of common tax reforms, but all the factors with a common pattern (the economic cycle as well). In other words, it is important not to partial out the effects of the economic cycle on tax revenue by including dummies, especially if we are interested in forecasting goals.

Another approach consists in controlling for these reforms by including a variable such as the average rate of personal income tax. Zack et al. (2014) include the PIT-to-GDP ratio, although this strategy may lead to biased estimates as a result of including an endogenous regressor. Our approach differs, since we take advantage of microsimulated average rates, which stem from the OECD's Taxing Wages report. To be specific, we make use of the average income tax rate of a single person with no child at 100% of average earnings. This average rate is expressed as a percentage of gross earnings (although before 1996 income tax revenue was normalized by gross wages) and refers to general government data. Thus, this indicator is our proxy to control for these discretionary measures before 2002. From then on we keep this variable constant as our data are policy neutral. In Figure 4.2 we show the connection between the evolution of personal income tax revenue and changes in the average rate of personal income tax. At first sight, it can be seen how this indicator allows us to capture the 1999 tax reform.

3.4. Available sample and PIT data

Before turning to the econometric analysis we point out that the available sample is 1987-2013. Our dependent variable (personal income tax revenue) is measured under the accrual basis since what is ceded to the regions in a given year is not really a fixed fraction of the collection of the fiscal period (i.e. under the cash basis) but the yield of the share of PIT, which is collected from two periods (the current one, through monthly withholdings, excluding that of December, and the following one, when the declarations of the tax settlement and withholdings corresponding to December are made). Despite the fact that PIT was not partially devolved until 1994, we found statistical information for each AC dating from 1987.

Figure 4.2. Personal income tax revenue and average rate of personal income tax



Notes: Personal income tax revenue of common regime ACs. Average rate of personal income tax refers to general government statistics.
Sources: Spanish Tax Agency, Spanish Ministry of Finance and Public Administrations, and OECD.

Homogeneous data on the share of PIT have been available since 2002. We found data for the period 1997-2001, although they are not homogeneous as that share depended on assumed responsibilities, which differed across common regime ACs. Therefore, we assumed the same levels of the share of PIT that have existed since 2009. We extended our data backwards to 2002 by adapting that share from 50% to 33%. Then, we extended our data for the period 1987-2001 by means of total PIT revenue under the accrual basis, that is, the sum of regional and central PIT revenue (data are extended using growth rates). These historical data are from the Spanish Tax Agency.

4. Econometric analysis of personal income tax elasticities

This section comprises both the empirical framework as well as the estimates of PIT elasticities. Our analysis is based on an error-correction model that deals with potential asymmetries in the short-run. First, we

provide the rationale for this approach distinguishing short and long-term estimates. Second, we lay out the strategy to take account of short-run potential asymmetries. Third, we provide a discussion of estimation methods (OLS vs IV), leading to some paradoxical results regarding forecasting performance[5]. We then move to our empirical estimates of PIT elasticities. In section 4.2 we provide further details of the dynamic adjustment between short and long-run elasticities. Finally, we also deal with cross-sectional variability in section 4.3, by means of region-specific tax elasticities in both the short and long-run.

4.1. Empirical framework and results: a dynamic approach to tax elasticities

The time series approach to PIT revenue elasticities consists of modelling tax revenue in function of macroeconomic proxies to capture tax base dynamics. In this modelling we may explore the presence of a cointegrated relationship between tax revenue and the tax base, namely the presence of a long-run relationship. If this is the case, "there exists an error-correction model that describes the short-run dynamics consistently with the long-run relationship, i.e. the Granger representation theorem which states that if a set of variables are integrated of the same order and cointegrated, then there exists a valid error-correction representation of the data" (Verbeek, 2004, 318)[6]. Our dataset rejected the null hypothesis of no cointegration[7]. Accordingly, we have adopted an error-correction representation of the data. As mentioned previously (in section 3.3), our empirical specification also deals with policy-driven measures. We include the average rate of PIT to take account of discretionary changes in revenue. It is important to note that we are not including the PIT-to-GDP ratio, that is to say an empirical

[5] In Appendix section 7.4, a short note is included demonstrating the superiority of OLS in terms of forecast accuracy with regard to IV, when endogeneity problems arise.

[6] Some authors refine their strategy by estimating the long–run elasticity using dynamic ordinary least squares (DOLS) as proposed by Stock and Watson (1993), which consist of adding leads and lags of the differenced regressors in order to adjust for possible endogeneity and autocorrelation. In this empirical strategy one should be careful about overparameterization.

[7] The results of the Kao residual panel cointegration test are available on request. However, an indirect form of testing for cointegration stems from the error correction model estimates. If we consider a simple error correction model, as follows:

$d(Y)=a\cdot d(X)+b\cdot ECM(-1) + u$

That is to say, if "b" is non-zero, this ECM coefficient may be obtained as a linear combination of stationary processes. Hence, a non-zero coefficient is an indirect way of testing for cointegration.

strategy which may lead to endogeneity problems, but the simulated average income tax rate for a single person with no children and average earnings.

At this point we turn to the empirical specification. Equation (1) and (2) are the long-run equations, where we include fixed effects (δ_i), our proxy to the tax base ($gross\ value\ added_{it}$) and the average rate of PIT ($average\ rate_t$) in its multiplicative and additive form respectively.

$$\ln(PIT_{it}) = \delta_i + \gamma_1 \ln(GVA_{it} * average\ rate_t) + \varepsilon_{it} \quad (1)$$

$$ln(PIT_{it}) = \delta_i + \gamma_1 \ln(GVA_{it}) + \gamma_2 \ln(average\ rate_t) + \varepsilon_{it} \quad (2)$$

Coefficient γ_1 denotes the long-run elasticity, that is how personal income tax revenue (PIT_{it}) varies as a result of one percentage change in gross valued added (GVA_{it}), our proxy to the tax base. Our data rejects the multiplicative form captured by equation (1), that is to say the hypothesis $\gamma_1 = \gamma_2$ in equation (2). Thus, henceforth we will only focus on this additive form. Equation (3) is our short-term symmetric specification, where α_1 denotes the short-run elasticity and λ the speed of adjustment, namely how fast PIT revenue converges to its long-run equilibrium.

$$\Delta(lnPIT_{it}) = \alpha_0 + \alpha_1 \Delta(\ln GVA_{it}) + \alpha_2 \Delta(\ln average\ rate_t) + \lambda \varepsilon_{it-1} + \upsilon_{it} \quad (3)$$

What are the main factors that determine long and short-run elasticities? Several authors point to different factors to bear in mind (Koester and Priesmeier, 2012; Belinga et al., 2014; Mourre and Princen, 2015; and Koester and Priesmeier, 2017). Long-run elasticities reflect the progressivity of PIT with respect to its base and other long-run trends such as the decline in labour-income share as well as the increase in inequality in the aftermath of the global crisis. We expect long-run elasticity to exceed one. Short-run elasticities capture the impact on PIT revenue of short-run fluctuations in the tax bases. In this regard, it is necessary to take labour market regulations into account as well as fiscal myopia, effects related to fiscal drag, tax compliance and the composition of growth[8]. First, a more protected and stable labour market should display less sensitivity to the economic cycle. Second, fiscal myopia regarding tax reforms may also

[8] Lags in tax collection should not play a role in accrual data (our case).

explain a divergence between short and long-run elasticities. Third, in a progressive tax system, nominal increases in earnings may lead to higher tax burdens, as a result of a tax system not indexed to inflation (e.g. some taxpayers may move into higher tax brackets while other taxpayers may not be eligible for mean-tested benefits). Thus, this fiscal drag effect may lead to higher elasticities. Fourth, tax compliance (and as a result tax revenue) may fall when households face liquidity constraints. Fifth, changes in the composition of growth may also play an important role. PIT elasticities are expected to be higher during demand-led growth than in export-led growth. Overall, as many factors come into play, an empirical assessment of those elasticities is particularly appealing.

The approach of the most recent literature to the short-run fluctuations of tax elasticities (since Bruce et al., 2006) also considers **potential asymmetries**. In this regard, results lead us to specify an asymmetry in the proxy to the tax base (and its lag), but not in the error correction term. A lag of our tax base variable is included to capture the dynamic relationship between tax revenue and economic activity. Equation (4) sets out our short-run asymmetric specification, where *F* is a dummy that takes 1 in below equilibrium years and 0 otherwise.

$$\begin{aligned}\Delta(lnPIT_{it}) = {} & \alpha_0 + \alpha_1 F\Delta(\ln GVA_{it}) + \alpha_2(1-F)\Delta(\ln GVA_{it}) \\ & + \alpha_3 F\Delta(\ln GVA_{it-1}) + \alpha_4(1-F)\Delta(\ln GVA_{it-1}) \\ & + \alpha_5\Delta(\ln average\ rate_t) + \lambda\varepsilon_{it-1} + \upsilon_{it}\end{aligned} \qquad (4)$$

The next step is to deal with estimation methods as our data suggest an endogenous relationship[9]. To deal with the endogeneity problem derived from the feedback between personal income tax and gross valued added, we instrument the latter with the EU-15 GDP[10]. This strategy is close to that of

[9] Please note the results of the Hausman test in Table 4.2, which rejects the null of exogeneity.

[10] First stage results are included in Appendix section 7.3 (Table A4.2). First, it is worth noting that we obtain the expected positive relationship between GVA growth and EU-15 GDP growth. Second, instrument relevance is checked and confirmed by means of the Shea partial R^2 (0.18). Third, we cannot test for instrument exogeneity as we only have one instrument. However, we have checked exogeneity in a shortened sample (2000-2013) by using an additional instrument, namely the lag in the rate of annulments, separations and divorces per 1,000 inhabitants. The Sargan test did not provide enough evidence to reject the null of exogeneity, that is, the overidentifying restriction (p-value=0.41). In this case, our IV estimates suggest a higher short-run elasticity (1.9). These results are available on request.

Galí and Perotti (2003) in their analysis of the discretionary policy in EMU countries, where the cyclical position of a country is instrumented by the cyclical position of its main trading partners.

At this point, it is worth paying attention to the implications of this endogenous relationship regarding forecasting performance. Despite the OLS estimator bias, Appendix section 7.4 shows the superiority of OLS in terms of forecast accuracy in comparison to the IV estimator. Before moving to our empirical estimates, we put forward a simple model to enable a better understanding of OLS and IV elasticities:

$$y = \beta x + u \tag{6}$$

$$u = x\tau + \varepsilon$$

Please note that the IV estimator attempts to capture the pure causal effect of *x* on *y*, that is:

$$E(\hat{\beta}^{IV}) = \beta \tag{7}$$

By contrast, the OLS estimator not only captures this pure causal effect but also the effect of x on u, that is:

$$E(\hat{\beta}^{OLS}) = E\left(\frac{\partial y}{\partial x}\right) = \beta + E\left(\frac{\partial u}{\partial x}\right) = \beta + \tau \tag{8}$$

Paradoxically, as a result of this bias, if we are interested in the prediction of y conditioned by x, the OLS estimator is an unbiased predictor, because E(u/x) is different from zero.

Now we move on to our empirical estimates. To start with, we will discuss our **symmetric elasticities** (regression (i) and (iii) in Table 4.2 regarding OLS and IV estimates respectively), which can be compared to those obtained in the Spanish empirical literature (see Table A4.1). Our OLS estimates are in the low-band (1.18[11] and 1.07 concerning the short and long-run respectively), very close to Martínez-Mongay et al. (2007) who also used GVA as a proxy to the tax base. By contrast, our short-run IV estimates (1.58) are closer to microdata studies, such as Onrubia and Picos

[11] That is, the sum of the contemporaneous and the lagged coefficient.

(2011), Price et al. (2014) and Sanz Sanz et al. (2016)[12]. This divergence may be related to the above-mentioned discussion on estimation methods. In Appendix section 7.4 (see Table A4.3 and Table A4.4), we provide common measurements of forecast accuracy over different time horizons (namely, the root mean squared error and the mean absolute error statistics), which reveal the expected superiority of OLS in relation to IV[13].

Asymmetric estimates of regional PIT elasticities are raised in regression (ii). In this case, we evaluate potential asymmetries concerning all explanatory variables, but our data suggest only considering this asymmetric behaviour in our proxy to the tax base variable (and its lag). A first check on fiscal forecasting performance in Table 4.3 indicates that the asymmetric specification does not systematically outperform its symmetric rival over the last recession. In fact, the latter generally presents better forecasting performance, even though the differences in MAE (mean absolute error) and RMSE (root mean squared error) statistics may not be significant. However, this comparison is not intended to compare models, but forecasts. It should be borne in mind that comparing models by means of pseudo-out-of-sample forecasts may be suboptimal, as suggested by Diebold (2015). We therefore consider both approaches to be useful, although the dynamics that lies behind the asymmetric specification is far more complex. Thus, we provide in section 4.2 some simulations to assess the significance of our results.

[12] Please note that long-run elasticities are the same both for OLS and IV estimates. When a cointegrated relationship is present, endogeneity does not lead to biased estimates.
[13] Due to our limited sample size, we do not provide a formal test comparing predictive accuracy (such as the proposal of Diebold and Mariano, 1995).

Table 4.2. Symmetric and asymmetric modelling of regional personal income tax elasticities

	(i)	(ii)	(iii)
Long run. Dependent variable = Personal income tax revenue			
Constant	-5.04	-5.04	-5.04
	(-33.06)***	(-33.06)***	(-33.06)***
Gross value added (GVA)	1.07	1.07	1.07
	(109.12)***	(109.12)***	(109.12)***
Average rate of personal income tax	0.38	0.38	0.38
	(5.66)***	(5.66)***	(5.66)***
Short run. Dependent variable = Δ Personal income tax revenue			
Constant	0.00	0.00	-0.02
	(-0.24)	(-0.34)	(-3.48)***
Δ GVA	1.02		1.58
	(23.97)***		(15.12)***
Δ GVA * F		0.80	
		(14.37)***	
Δ GVA * (1-F)		1.14	
		(22.73)***	
Δ GVA (-1)	0.16		
	(3.77)***		
Δ GVA (-1) * F		0.02	
		(0.31)	
Δ GVA (-1) * (1-F)		0.27	
		(5.39)***	
Δ Average rate of PIT	0.83	0.71	0.84
	(12.41)***	(13.24)***	(11.55)***
Error correction term	0.30	0.49	0.28
	(11.51)***	(16.61)***	(10.14)***
Method of estimation	OLS	OLS	IV
Short run statistics			
Number of observations	390	390	390
Sample	1988-2013	1988-2013	1988-2013
Adjusted R^2	0.72	0.78	0.64
Hausman exogeneity test			-3.94
t-statistic (p-value)			(0.00)
Shea partial R^2			0.18

Notes: Short-run regressions are estimated by Panel EGLS (Cross-section SUR weights). *** significance at 99% & ** 95% & * 90%. t-statistics are reported between parentheses. Long-run regressions are estimated by Panel Least Squares including Fixed Effects. F is a dummy that signals a below equilibrium scenario. Error correction term = long-run value of PIT revenue (t-1) - PIT revenue (t-1).

Table 4.3. Comparing forecast accuracy of symmetric and asymmetric specifications

Symmetric specification

OLS estimator conditional on X (ACs GVA)

Estimation sample	forecast horizon: one year ahead		forecast horizon: two years ahead		forecast horizon three years ahead	
	RMSE	MAE	RMSE	MAE	RMSE	MAE
1988-2007	0.032	0.025	0.034	0.029	0.049	0.040
1989-2008	0.031	0.022				
1990-2009	0.037	0.034	0.066	0.058		
1991-2010	0.034	0.031			0.043	0.034
1992-2011	0.027	0.024	0.031	0.027		
1993-2012	0.046	0.043				
Mean	0.035	0.030	0.044	0.038	0.046	0.037

Asymmetric specification

OLS estimator conditional on X (ACs GVA)

Estimation sample	forecast horizon: one year ahead		forecast horizon: two years ahead		forecast horizon three years ahead	
	RMSE	MAE	RMSE	MAE	RMSE	MAE
1988-2007	0.031	0.024	0.034	0.028	0.045	0.035
1989-2008	0.031	0.025				
1990-2009	0.04	0.033	0.056	0.047		
1991-2010	0.042	0.035			0.053	0.044
1992-2011	0.031	0.025	0.045	0.037		
1993-2012	0.059	0.051				
Mean	0.039	0.032	0.045	0.037	0.049	0.040

Notes: Own elaboration based on regressions (i) and (ii) in Table 4.2. *RMSE* stands for root mean squared error and *MAE* for mean absolute error.

4.2. Dynamic adjustment between short-run and long-run elasticities: simulated elasticities and fiscal pressure scenarios

The empirical literature on Spanish PIT elasticities deals with either short or long-run elasticities. To our knowledge, there is no discussion of the dynamic adjustment between the two. In fact, it is not a common practice in the international literature, with the exception of Koester and Priesmeier (2012) in the German case and Koester and Priesmeier (2017) in euro area countries. Both papers provide evidence for dynamic elasticities, that is, revenue not only reacts contemporaneously to changes in income but also afterwards. In fact, the latter work indicates strong evidence for dynamic

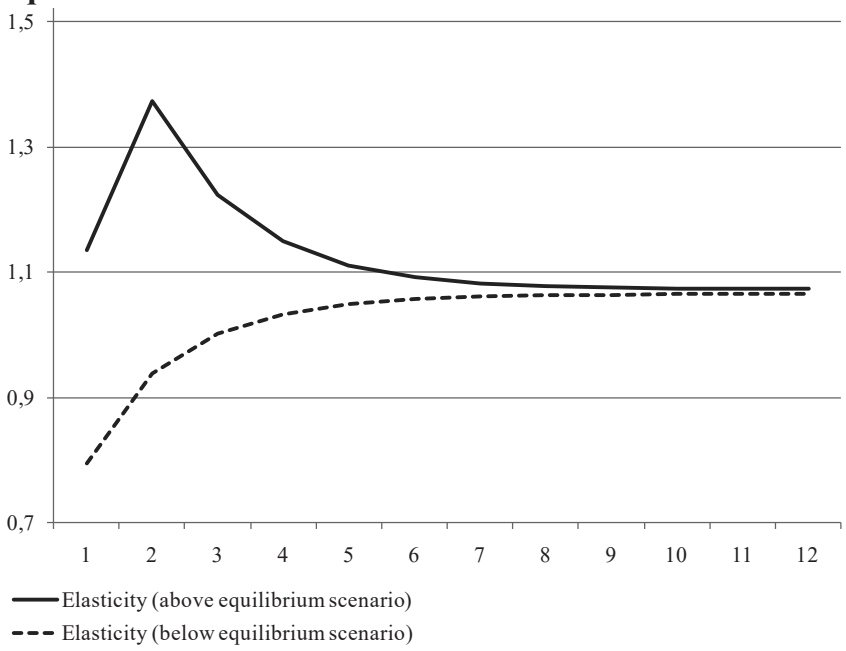
elasticities in Spain. The result is also noteworthy regarding the degree of volatility of the Spanish tax system, captured by the difference between short and long-run elasticities. Their evidence indicates that Spain's tax system is the most volatile in the euro area. The adjustment pattern between short and long-run suggests an overshooting revenue response concerning the tax system as a whole.

Our symmetric estimates suggest a slight difference between short and long-run PIT elasticities (1.2 vs 1.1 respectively), but greater differences arise when considering asymmetric responses[14]. As mentioned previously, to assess the dynamics of the asymmetric specification (regression (ii) in Table 4.2), it is convenient to provide some simulations as it is very hard to derive their properties analytically. Two groups of simulations are provided. To start with, we assess the dynamic adjustment between short-run and long-run elasticities when we are above or below the long-run equilibrium. We have simulated the impact of a 10% increase and a 10% decrease of GVA on PIT revenue and the results are displayed in Figure 4.3. When PIT revenue is above the long-run equilibrium the impact leads to an overreaction effect that gets corrected until the long-run value is reached. When PIT revenue is below, a typical error correction model response is obtained, with a mean lag of 0.49[15]. The ratio of PIT revenue-to-GVA (see Figure 4.4) shows the implications in terms of fiscal pressure. In this regard it is interesting to note the progressive nature of PIT. The fiscal pressure increases or decreases depending on the sign of the shock.

[14] However, an important difference with regard to Koester and Priesmeier (2017) arises from using accrual data in our study, which most likely entails lower volatility as revenue is not affected by lags in tax collection.

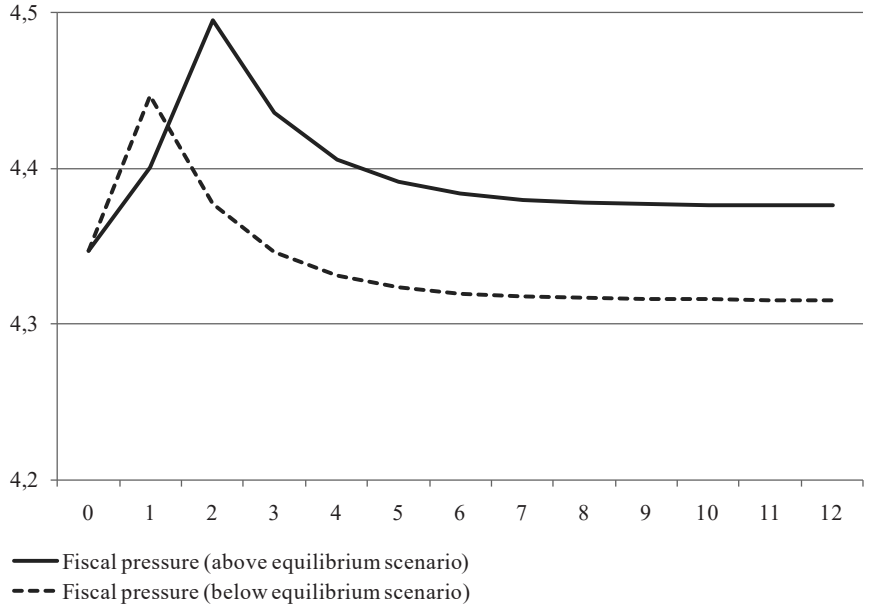
[15] The mean lag is obtained as the weighted average of the lag in question by the share of adjustment occurring at that lag.

Figure 4.3. Simulated elasticities. Above and below equilibrium scenarios



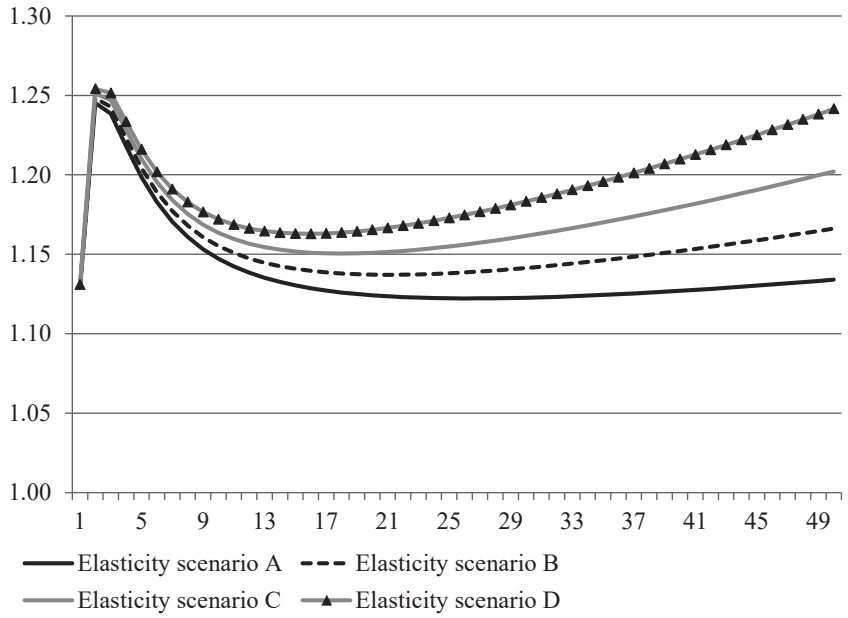
Notes: Above equilibrium scenario: a 10 percent increase in gross value added. Below equilibrium scenario: a 10 percent decline in gross value added. Simulated elasticities are based on regression (ii) of Table 4.2.

Figure 4.4. Simulated fiscal pressure. Above and below equilibrium scenarios



Notes: Idem as Figure 4.3.
Fiscal pressure: PIT revenue as a percentage of gross value added.

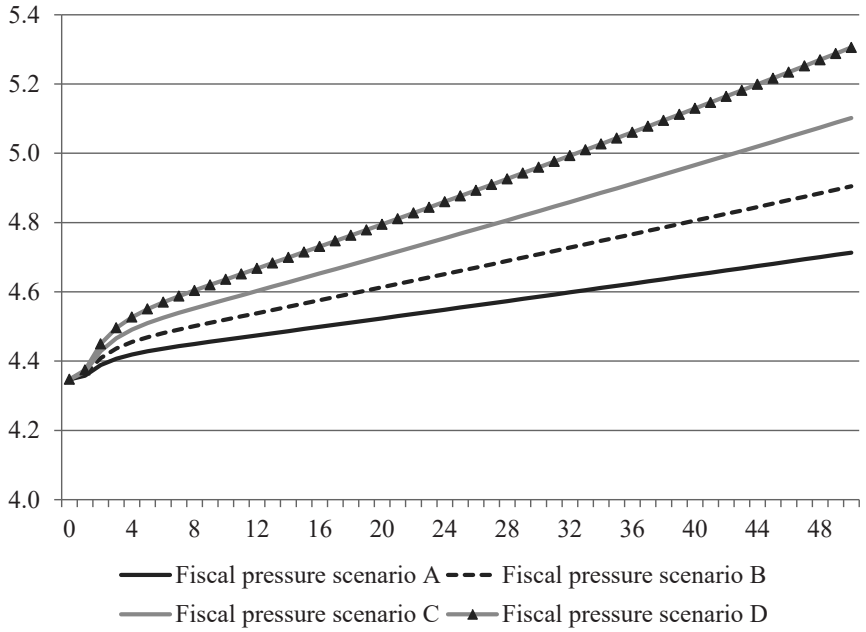
Figure 4.5. Simulated elasticities in a sustained economic Growth environment. Above equilibrium scenarios



Notes: Scenario A: 2 % growth of gross value added (GVA). Scenario B: 3 % growth in GVA. Scenario C: 4 % growth in GVA. Scenario D: 5 % growth in GVA. Simulated elasticities are based on regression (ii) of Table 4.3.

The second group of simulations only considers the above equilibrium scenarios. We provide several scenarios to evaluate the outcomes of these overreaction effects on simulated elasticities and fiscal pressure. These scenarios consist of sustained trajectories of GVA growth of 2%, 3%, 4% and 5% respectively. Long-term simulated elasticities increase with higher sustained GVA growth rates (see Figure 4.5). One possible explanation for this behaviour is the tax overreaction in the above equilibrium situation. The overreaction with respect to the first GVA growth is added to the overreaction with respect to the second GVA growth, and so forth, and since the income is always increasing, the dynamic elasticity is finally above the static elasticity obtained from the long-term equilibrium solution. Nevertheless, these findings should be interpreted with caution as we are not considering changes in individual elasticities, which could in fact lead to a decrease in PIT elasticities. In the next section we provide an extended discussion on this issue.

Figure 4.6. Simulated fiscal pressure in a sustained economic growth environment. Above equilibrium scenarios



Notes: Idem as the previous Figure.
Fiscal pressure: PIT revenue as a percentage of gross value added.

4.3. Regional heterogeneity in personal income tax elasticities

In this section, the cross-sectional dimension of PIT elasticities is considered. First, we lay out the empirical strategy, which enables the identification of region-specific tax elasticities. Our results suggest a decreasing pattern with regard to per capita income, both in the long and short-run. Then, we connect our results to previous cross-sectional studies based on microdata. These results may give rise to some debate on the estimation of structural budget balances. The current Spanish regulation on budgetary stability does not provide for either region-specific elasticities or region-specific cyclical positions. Considering our results this is a strong assumption.

In order to take into account cross-sectional variability, we assess the equality constraint for short and long-run elasticities as well as the redundancy of fixed effects. Our data suggest taking region-specific tax elasticities into account both in the short and the long-run, as well as fixed effects in the long-run. Equations (9) and (12) deal with long and short-run

region-specific tax elasticities respectively[16]. Figure 4.7 displays our region-specific estimates, both for short and long-run estimates, which suggest a decreasing pattern of regional tax elasticities with respect to per capita income, especially in the long-run. Thus, we allowed our tax base parameter to depend on income per capita. Equations (9), (10) and (11) deal with the long-run case, while short-run dynamics are represented by equations (12) and (13). Regression estimates in Table 4.4 and Table 4.5 confirm this "income per capita" dependency (see regressions (v) and (vii) respectively).

$$lnPIT_{it} = \delta_i + \gamma_i \ln(GVA_{it}) + \beta \ln(average\ rate_t) + \varepsilon_{it} \quad (9)$$

$$lnPIT_{it} = \delta_i + \gamma_r \ln(GVA_{it}) + \beta \ln(average\ rate_t) + \varepsilon_{it} \quad (10)$$

$$\text{where } \gamma_r = \gamma_0 + \gamma_1 \ln\left(\frac{GVA_{it}}{POP_{it}}\right)$$

$$lnPIT_{it} = \delta_i + \gamma_0 \ln(GVA_{it}) + \gamma_1 \ln(GVA_{it}) * \ln\left(\frac{GVA_{it}}{POP_{it}}\right) + \beta \ln(average\ rate_t) + \varepsilon_{it} \quad (11)$$

$$\Delta(lnPIT_{it}) = \psi + \alpha_i \Delta(\ln GVA_{it}) + \beta \Delta(\ln average\ rate_t) + \lambda \varepsilon_{it-1} + \upsilon_{it} \quad (12)$$

$$\Delta(lnPIT_{it}) = \psi + \alpha_r \Delta(\ln GVA_{it}) + \beta \Delta(\ln average\ rate_t) + \lambda \varepsilon_{it-1} + \upsilon_{it} \quad (13)$$

$$\text{where } \alpha_r = \alpha_0 + \alpha_1 \ln\left(\frac{GVA_{it}}{POP_{it}}\right)$$

This decreasing pattern of PIT elasticities on a per capita income basis is in line with the previous literature. On the one hand, it is worth exploring the role of individual revenue elasticities and their aggregation. In this connection, it is convenient to express "the revenue elasticity with regard to GVA" as the product of two elasticities[17]: "the revenue (*R*) elasticity with regard to taxable income (*TI*)" and "that of taxable income to GVA".

[16] We did not include a lag in the tax base variable to avoid overparameterization.

[17] This is a proposal by Lambert (1993, as cited in López Laborda and Onrubia Fernández, 2014).

$$\varepsilon_{R,GVA} = \frac{\Delta R/_{\Delta TI}}{R/_{TI}} * \frac{\Delta TI/_{TI}}{\Delta GVA/_{GVA}} = \frac{marginal\ rate}{average\ rate} * \frac{\Delta TI/_{TI}}{\Delta GVA/_{GVA}} \quad (14)$$

The first component follows a decreasing pattern in individual terms, as the marginal tax rate and the average tax rate are an increasing function of per capita income, but the latter rises more strongly than the former. Thus, as shown in for example Sanz-Sanz et al. (2016), individual elasticities are much higher in the lower part of income distribution[18]. The aggregation of individual elasticities finally follows a similar pattern, as poorer ACs have greater concentrations of lower-income individuals. The second component, the taxable income elasticity with regard to GVA, depends on several factors that make it difficult to determine its incidence. Changes in regional productive structure, avoidance or fraud practices, labour income share and inequality dynamics are factors which may condition this elasticity. It is outside the scope of this thesis to determine the incidence of these factors but the aggregate results by González-Parámo (1997), Creedy and Sanz-Sanz (2010) and Sanz-Sanz et al. (2016) suggest the dominance of the first component.

On the other hand, we pay attention to empirical contributions that appeared in the late nineties, due to the potential regressive effect of the partial devolution of PIT. To be specific, Alcalá-Agulló and Carles-Carrasco (1999) and González-Parámo (1997), and subsequently Onrubia and Picos (2011), explored the relationship between revenue increases and per capita income (which is not an elasticity, but a somewhat related issue). These works provide analytical expressions that connect this relationship to per capita income convergence and the income elasticity of fiscal pressure. Their empirical results reveal a decreasing pattern of PIT revenue dynamics with regard to per capita income, which did not reinforce the regressive concerns mentioned previously.

[18] In fact, Musgrave and Thin (1948) already provided evidence in the US case of this decreasing relationship.

Hence, our evidence on regional PIT elasticities is in line with previous contributions, although we also contribute with dynamic elasticities.

Table 4.4. Long-run regional personal income tax elasticities

	(iv)	(v)
Dependent variable = Personal income tax revenue		
Constant	-5.04 -35.23)***	-6.86 (-11.48)***
Nominal Gross Value Added (GVA)		1.45 (11.99)***
GVA * (GVA per capita)		-0.02 (-3.14)***
Average rate of personal income tax	0.37 (5.97)***	0.39 (5.91)***
GVA		
Andalusia	1.10 (35.53)***	
Aragon	1.00 (30.81)***	
Asturias	1.09 (28.92)***	
Balearic Islands	1.03 (36.6)***	
Canary Islands	1.00 (33.42)***	
Cantabria	1.07 (32.21)***	
Catalonia	1.00 (32.67)***	
Castile and León	1.09 (30.17)***	
Castile–La Mancha	1.18 (38.7)***	
Extremadura	1.16 (35.36)***	
Galicia	1.10 (32.9)***	
Madrid	0.96 (34.13)***	
Murcia	1.15 (39.58)***	
La Rioja	1.09 (34.67)***	
Valencian Community	1.11 (35.46)***	
Long run statistics		
Number of observations	405	405
Sample	1987-2013	1987-2013
Adjusted R2	0.99	0.99

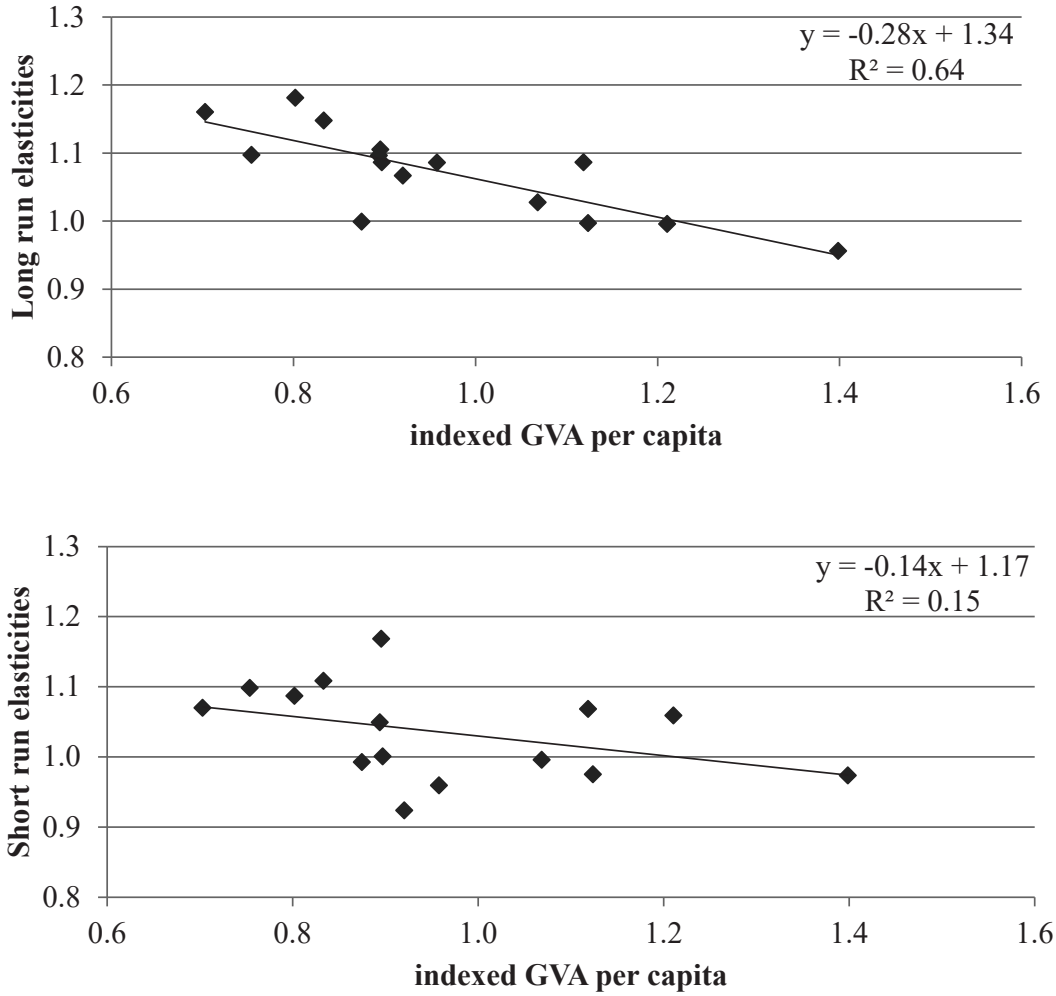
Notes: Long-run regressions are estimated by Panel Least Squares including Fixed Effects. *** significance at 99% & ** 95% & * 90%. t-statistics are reported between parentheses.

Table 4.5. Short-run regional personal income tax elasticities

	(vi)	(vii)	(viii)	(ix)
Dependent variable = Δ Personal income tax revenue				
Constant	-0.01 (-1.54)	0.00 (0.28)	-0.02 (-3.58)***	-0.02 (-3.85)***
Δ GVA		3.24 (7.14)***		3.30 (5.95)***
Δ GVA * (GVA per capita)		-0.23 (-4.74)***		-0.19 (-3.25)***
Δ Average rate of PIT	0.83 12.53)***	0.89 15.05)***	0.85 12.09)***	0.91 15.24)***
Error correction term	0.39 11.58)***	0.41 12.05)***	0.36 10.81)***	0.38 11.52)***
Δ GVA				
Andalusia	1.10 19.44)***		1.57 11.28)***	
Aragon	0.97 14.66)***		1.49 10.01)***	
Asturias	1.00 14.82)***		1.61 (9.48)***	
Balearic Islands	1.00 14.32)***		1.39 10.16)***	
Canary Islands	0.99 15.63)***		1.42 10.13)***	
Cantabria	0.92 14.33)***		1.47 (9.32)***	
Catalonia	1.06 19.68)***		1.53 11.86)***	
Castile and León	0.96 12.64)***		1.68 (8.27)***	
Castile–La Mancha	1.09 14.18)***		1.63 (9.85)***	
Extremadura	1.07 13.43)***		1.61 (9.53)***	
Galicia	1.05 16.08)***		1.59 10.35)***	
Madrid	0.97 13.97)***		1.49 10.35)***	
Murcia	1.11 14.66)***		1.61 (10.1)***	
La Rioja	1.07 11.21)***		1.51 (9.34)***	
Valencian Community	1.17 16.07)***		1.61 11.08)***	
Short run statistics				
Method of estimation	OLS	OLS	IV	IV
Number of observations	390	390	390	390
Sample	1988-2013	1988-2013	1988-2013	1988-2013
Adjusted R^2	0.70	0.73	0.65	0.69

Notes: All regressions are estimated by Panel EGLS (Cross-section SUR weights). *** significance at 99% & ** 95% & * 90%. t-statistics are reported between parentheses. Error correction term = long-run value of PIT revenue (t-1) - PIT revenue (t-1). See long-run estimates in Table 4.4.

Figure 4.7. A decreasing pattern of regional personal income tax elasticities on a per capita income basis



Notes: Short and long-run estimates from Table 4.4 and 4.5 Indexed gross valued added per capita (common regime ACs =1.00)

5. Conclusions

The instability of public finances since the onset of the last global crisis has directed more attention to tax elasticities as a tool for guiding revenue forecasting. PIT is the most important revenue source of ACs and it could in fact gain in importance in the next reform of the regional financing model, as some authors (e.g. Cuenca, 2014; Lago Peñas and Martínez Vázquez, 2015) have argued for a full devolution of PIT.

Our results provide evidence for a dynamic reaction pattern concerning regional PIT, taking into account potential asymmetries. In fact, to the best of our knowledge there is no regional evidence in Spain for a dynamic pattern of tax elasticities, but for a static relationship based on cross-sectional analysis. It is important to identify the relative position with respect to long-run trajectories as different dynamic processes drive PIT revenue behaviour. The dynamic adjustment between short and long-run elasticities illustrates the different patterns involved in above and below equilibrium environments. Thus, these results suggest not relying only on static elasticities when dealing with forecasting, monitoring and policy design objectives. In addition, our results allow the progressive nature of PIT to be confirmed in different scenarios.

The constant PIT elasticity assumption is also challenged when considering the regional dimension. Our analysis identifies a decreasing pattern of short and especially long-run elasticities with respect to per capita income. Thus, this cross-sectional variability may be valuable for tax revenue forecasting. Furthermore, it may be worth considering these region-specific elasticities when measuring structural budget balances.

Without pretending to reach a definitive conclusion, we provide a first check of predictive accuracy over the last recession. We perform a pseudo-out-of-sample model comparison that suggests similar predictive accuracy between the symmetric and the asymmetric specification, although the former outperforms the latter slightly in most cases. Despite this comparison, we should bear in mind that comparing models by means of pseudo-out-of-sample forecasts may be suboptimal, as suggested by Diebold (2015).

Finally, another noteworthy contribution is the analysis of forecasting performance in the presence of an endogenous relationship. Despite the OLS estimator bias, the superiority of OLS is shown, both analytically and empirically, in terms of forecasting accuracy in comparison to the IV estimator. That is to say, in terms of forecasting capacity, the IV estimator is suitable if we are interested in a forecast conditioned by knowledge of the instrumental variables, while OLS is suitable if the forecast is carried out conditional to knowledge of the variables included on the right hand of the equation. In connection with the Spanish literature on PIT elasticities, our

OLS short-run estimates (1.2) are close to those elasticities based on a time series approach, whereas our IV short-run elasticity estimates (1.6) are closer to those obtained in cross-sectional studies. These findings may be related to the statistical properties of OLS and IV estimators in the presence of endogenous regressors.

6. References

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7. Appendix

7.1. Data sources

Average rate of personal income tax: OECD. Taxing Wages.

Personal income tax discretionary revenue / PIT revenue: Spanish Ministry of Finance and Public Administrations.

Electoral cycle: Own elaboration from the Spanish Ministry for Home Affairs.
http://www.infoelectoral.mir.es/

EU 15 GDP: Eurostat.

Gross value added and population: BDMORES for the period 1987-2000 (Spanish Ministry of Finance and Public Administrations) and INE for the period 2000-2014.

Left-wing seats: Own elaboration based on
http://www.argos.gva.es/ahe/indexv.html

Personal income tax revenue: Spanish Tax Agency and Budget Settlement of ACs and Autonomous Cities. Spanish Ministry of Finance and Public Administrations.

Primary budget balance / non-financial revenue: Budget Settlement of ACs and Autonomous Cities. Spanish Ministry of Finance and Public Administrations.

7.2. Personal income tax elasticities in Spain: a summary of the empirical literature

Table A4.1. Empirical works on personal income tax elasticities in Spain

	Dataset	Dependent variable	Adjustment for tax reform effects	Method	Proxy to tax base	Elasticity	
						Short-term	Long-term
González-Páramo (1997)	1987-1995	Nominal tax revenue per capita		OLS (fixed effects)	GVA per capita	0.8-1.9	-
Bouthevillain et al. (2001)	1970-1998	Nominal tax revenue (labour component)	Dummies	OLS & ECM & tax law and detailed revenue data	Employment private sector, compensation per private sector worker	1.0 1.5	-
Corrales et al. (2002)	1970-2001	Nominal direct taxation (deviation from potential values)		Unobserved components model	Output gap	1.5	-
Girouard & André (2005)	2003	Nominal tax revenue (labour component)		Tax law and detailed revenue data	Gross income	2.1	-
Martínez-Mongay et al. (2007)	1975-2006	Nominal direct tax revenue	Dummies	ECM	GVA GDP	1.3 1.4	1.3 1.3
Creedy & Sanz-Sanz (2010)	2002 (2007 tax law)	Nominal tax revenue		Tax law and detailed revenue data	Gross income	1.3	-
Onrubia & Picos (2011)	1999-2007	Nominal tax revenue		Tax law and detailed revenue data	Taxable income	1.3	-
Price et al. (2014)	2010	Nominal tax revenue		Tax law and detailed revenue data	Gross income	1.9	-
Zack et al. (2014)	1986-2010	Nominal tax revenue	Inclusion of average tax rate	ECM & Dynamic OLS	Gross disposable household income, average tax rate, nominal residential investment	0.43 0.18 0.20	0.90 0.14 0.14
Cuerpo & Losada (2015)	1995-2013	Labour tax base, capital tax base and economic activity tax base		ECM Detailed modelization	Macroeconomic variables	-	-
Sanz Sanz et al. (2016)	2008	Nominal tax revenue		Tax law and detailed revenue data	Gross income	1.5	-

7.3. First stage results

Table A4.2. First stage results: instrumenting ACs GVA growth

	(x)
Dependent variable = Δ ACs gross value added	
Constant	0.02
	(8.10)***
Δ EU15 GDP	0.83
	(16.64)***
Δ Average rate of personal income tax	-0.01
	(-0.24)
Error correction term	0.04
	(2.14)**
Number of observations	390
Sample	1988-2013
Adjusted R2	0.44

Notes: *** significance at 99% & ** 95% & * 90%. t-statistics are reported between parentheses. Error correction term = long-run value of PIT revenue (t-1) - PIT revenue (t-1).

7.4. Biased estimator but unbiased predictor: a paradoxical result when endogeneity arises

In the presence of an endogeneity problem, it is known that the OLS estimator is biased and inconsistent. The antidote is to apply IV. However, if there are reliable projections for the explanatory variables *X*, and as a result it is desirable to perform conditional inference on *X*, it is much less known that the OLS predictor is unbiased whereas the IV predictor is biased. We will consider this result in more detail.

1) Obtaining the expected value of the error term conditional on explanatory variables in the presence of endogeneity:

$$y = X\beta + u$$

$$u = X\tau + \varepsilon$$

$$X'u = X'X\tau + X'\varepsilon$$

$$\Sigma_{Xu} = \Sigma_{XX}\tau$$

$$\tau = \Sigma_{XX}^{-1}\Sigma_{Xu}$$

$$E(u/X) = X\tau = X\Sigma_{XX}^{-1}\Sigma_{Xu} \quad \text{(A1)}$$

2) Obtaining the expected value for the dependent variable conditional on the observed value of the explanatory variables:

$$E(y/X) = X\beta + E(u/X) = X\beta + X\Sigma_{XX}^{-1}\Sigma_{Xu} \quad \text{(A2)}$$

3) Obtaining the expected value for the OLS predictor:

$$\hat{y} = X\hat{\beta}$$

$$E(\hat{y}/X) = XE(\hat{\beta})$$

$$\beta = (X'X)^{-1}X'y = \beta + (X'X)^{-1}X'u$$

$$E(\hat{\beta}) = \beta + \Sigma_{XX}^{-1}\Sigma_{Xu}$$

$$E(\hat{y}/X) = XE(\hat{\beta}) = X(\beta + \Sigma_{XX}^{-1}\Sigma_{Xu}) = E(y/X) \quad \text{(A3)}$$

4) Unbiasedness property of the OLS predictor

As it is verified that:

$$E(\hat{y}/X) = E(y/X) \quad \text{(A4)}$$

It is established that the OLS predictor, conditional on knowledge of the explanatory variables *X*, is unbiased. By contrast,

$$E(y/X) = X\beta + E(u/X) \neq X\beta \quad \text{(A5)}$$

Thus, any predictor based on an unbiased estimator of β will be biased, as it is not taking into consideration that:

$$E(u/X) = X\tau = X\Sigma_{XX}^{-1}\Sigma_{Xu} \neq 0$$

5) Variance of the OLS predictor error term conditional on *X*:

Since our baseline equations are:

$$y = X\beta + u$$

$$u = X\tau + \varepsilon$$

when making a conditional inference on *X*, we take:

$$y = X(\beta + \tau) + \varepsilon$$

and our estimator of the population parameter is not β but $(\beta + \tau)$, while the estimator of the variance of the error term is not σ_u^2 but σ_ε^2.

That is to say, we note that:

$$y/X = X(\beta + \tau) + \varepsilon$$

$$E(y/X) = X(\beta + \tau)$$

$$y/X\text{-}E(y/X) = \varepsilon$$

Hence, as for out-of-sample period $T+l$ we find that:

$$Y_{T+l}/X'_{T+l} = X'_{T+l}(\beta + \tau) + \varepsilon_{T+l}$$

$$E(Y_{T+l}/X'_{T+l}) = X'_{T+l}(\beta + \tau)$$

$$e_T(l) = \varepsilon_{T+l}$$

$$E[e_T(l)]^2 = \sigma_\varepsilon^2 \qquad \text{(A6)}$$

That is, the OLS variance of the error term tends to σ_ε^2. In addition, when $\tau \neq 0 \Longrightarrow \sigma_u^2 > \sigma_\varepsilon^2$ given that:

$$u'u = \tau'X'X\tau + \varepsilon'\varepsilon + 2\varepsilon'X\tau$$

$$N\sigma_u^2 = \tau'\Sigma_{XX}\tau + N\sigma_\varepsilon^2$$

$$\sigma_u^2 - \sigma_\varepsilon^2 = \frac{1}{N}\tau'\Sigma_{XX}\tau > 0 \text{ if } \tau \neq 0$$

6) Variance of the IV predictor conditional on the matrix of instruments *Z*:

In this case, our baseline equations are:

$$y = X\beta + u$$

$$u = X\tau + \varepsilon$$

$$X = Z\Pi + V$$

Then, we note that:

$y=(Z\Pi+V)\beta+u=Z\Pi\beta+(V\beta+u)$

$y/Z=Z\Pi\beta+(V\beta+u)$

$E(y/Z)=Z\Pi\beta$

$y/Z-E(y/Z)=(V\beta+u)$

As for out-of-sample period $T+l$ we find that:

$Y_{T+l}/Z'_{T+l}=Z'_{T+l}\Pi\beta+(V'_{T+l}\beta+u_{T+l})$

$E(Y_{T+l}/Z'_{T+l})=Z'_{T+l}\Pi\beta$

$e_T(l)=V'_{T+l}\beta+u_{T+l}$

$[e_T(l)]^2=\beta' V_{T+l}V'_{T+l}\beta+(u_{T+l})^2+2\beta' V_{T+l}u_{T+l}$

Therefore, the IV variance of the error term tends to:

$$E[e_T(l)]^2=\beta'\Sigma_{VV}\beta+\sigma_u^2 \quad \text{(A7)}$$

Hence, we can consider the following difference:

(IV variance of the error term)-(OLS variance of the error term)⟶ $\beta'\Sigma_{VV}\beta+(\sigma_u^2-\sigma_\varepsilon^2)$ (A8)

Thus, two components stand out when explaining the higher variance of the IV predictor with regard to the OLS predictor:

- $(\sigma_u^2-\sigma_\varepsilon^2)>0$ as long as $\tau\neq 0$.
- $\beta'\Sigma_{VV}\beta\geq 0$ since Σ_{VV} is a positive semi-definite matrix. This second component is capturing the prediction error as a result of predicting the explanatory variables *X* from the matrix of instruments *Z*.

Next, we provide empirical evidence that verifies our findings. In Table A4.3 and Table A4.4 we compare the forecast accuracy of the OLS and IV estimator over different time horizons by means of the symmetric specification for PIT tax elasticities. We do so by providing the root mean squared error (RMSE) and the mean absolute error (MAE) statistics, which reveal the expected superiority of the OLS predictor (conditional on *X*)

relative to the IV predictor (conditional on *Z*). As an example, OLS (conditional on *X*) one-year ahead forecasts give a 3% MAE (as our data is expressed in logs), whereas IV (conditional on *Z*) one-year ahead forecasts gives a 6.9% MAE. In fact, forecast statistics from OLS (conditional on *X*) are at least more than twice as accurate as those of IV (conditional on *Z*).

Table A4.3. Comparing forecast accuracy of OLS and IV estimators with the symmetric specification (I out of II)

OLS estimator conditional on X (ACs GVA)

	forecast horizon: one year ahead		forecast horizon: two years ahead		forecast horizon three years ahead	
	RMSE	MAE	RMSE	MAE	RMSE	MAE
1988-2007	0.032	0.025	0.034	0.029	0.049	0.040
1989-2008	0.031	0.022				
1990-2009	0.037	0.034	0.066	0.058		
1991-2010	0.034	0.031			0.043	0.034
1992-2011	0.027	0.024	0.031	0.027		
1993-2012	0.046	0.043				
Mean	0.035	0.030	0.044	0.038	0.046	0.037

OLS estimator conditional on Z (EU15 GDP)

	forecast horizon: one year ahead		forecast horizon: two years ahead		forecast horizon three years ahead	
	RMSE	MAE	RMSE	MAE	RMSE	MAE
1988-2007	0.085	0.077	0.084	0.079	0.076	0.066
1989-2008	0.033	0.027				
1990-2009	0.045	0.041	0.056	0.051		
1991-2010	0.035	0.033			0.091	0.081
1992-2011	0.093	0.093	0.088	0.085		
1993-2012	0.026	0.019				
Mean	0.053	0.048	0.076	0.072	0.084	0.074

Notes: Own elaboration based on regression (i) in Table 4.2. *RMSE* stands for root mean squared error and *MAE* for mean absolute error.

Table A4.4. Comparing forecast accuracy of OLS and IV estimators with the symmetric specification (II out of II)

Instrumental variables estimator conditional on X (ACs GVA)

	forecast horizon: one year ahead		forecast horizon: two years ahead		forecast horizon three years ahead	
	RMSE	MAE	RMSE	MAE	RMSE	MAE
1988-2007	0.051	0.045	0.098	0.084	0.140	0.120
1989-2008	0.060	0.056				
1990-2009	0.032	0.027	0.058	0.050		
1991-2010	0.049	0.046			0.071	0.062
1992-2011	0.016	0.013	0.054	0.041		
1993-2012	0.062	0.057				
Mean	0.045	0.041	0.070	0.058	0.106	0.091

Instrumental variables estimator conditional on Z (EU15 GDP)

	forecast horizon: one year ahead		forecast horizon: two years ahead		forecast horizon three years ahead	
	RMSE	MAE	RMSE	MAE	RMSE	MAE
1988-2007	0.141	0.138	0.175	0.169	0.154	0.141
1989-2008	0.068	0.061				
1990-2009	0.078	0.077	0.055	0.038		
1991-2010	0.033	0.031			0.085	0.075
1992-2011	0.092	0.091	0.086	0.083		
1993-2012	0.024	0.018				
Mean	0.073	0.069	0.105	0.097	0.120	0.108

Notes: Own elaboration based on regression (iii) in Table 4.2. *RMSE* stands for root mean squared error and *MAE* for mean absolute error.

7.5. Evaluation of fiscal autonomy in regional personal income tax

Another challenge in Spanish public finances is the incentives regarding fiscal decentralisation, a process which has moved ahead rapidly in the past 30 years. The decentralisation of spending responsibilities has moved faster than the decentralisation of revenue. This partial decentralisation process may have softened regional budget constraints and may have undermined fiscal accountability (Rodden, 2002; Lago Peñas and Martínez-Vázquez, 2015). Despite the fact that regional tax powers have increased notably since 1997, ACs were generally passive in tax matters before 2010 (Solé-Ollé, 2013).

In this section, we examine the role of fiscal autonomy in PIT and its determinants. In our opinion, these issues are essential in assessing the incentives of the Spanish decentralised structure (in particular if ACs are facing hard budget constraints). We will analyse several factors that could lie behind the discretionary part of PIT: in particular, the response to the electoral-cycle, to the cyclical conditions as well as to the budget balance situation. As far as we know, the literature has taken only a descriptive approach on this issue (see, e.g., Duran and Esteller, 2004; Lago, 2007; Solé-Ollé, 2013; Cuenca, 2014; López Laborda and Zabalza, 2015).

7.5.1. *Descriptive analysis*

Since 1997 ACs have been able to change elements of PIT, although the effective exercise was limited to minor tax deductions and tax credits until the onset of the global crisis. However, since 2011 ACs have been particularly active in modifying the PIT schedule. In Box A4.1 we present the evolution of fiscal autonomy concerning PIT, while Figure A4.1 summarizes the main discretionary changes in PIT regional rates.

Box A4.1. Tax autonomy of regional governments concerning personal income tax

Before 1994: no tax autonomy in PIT.

1994 -1996: no tax autonomy in PIT. Tax sharing of 15%.

1997-2001: Increase in tax autonomy (power over tax credits, tax deductions and tax rates). ACs were entitled to 30% of PIT when education responsibilities were transferred, but they were only able to modify 15% (although some ACs did not accept this new agreement).

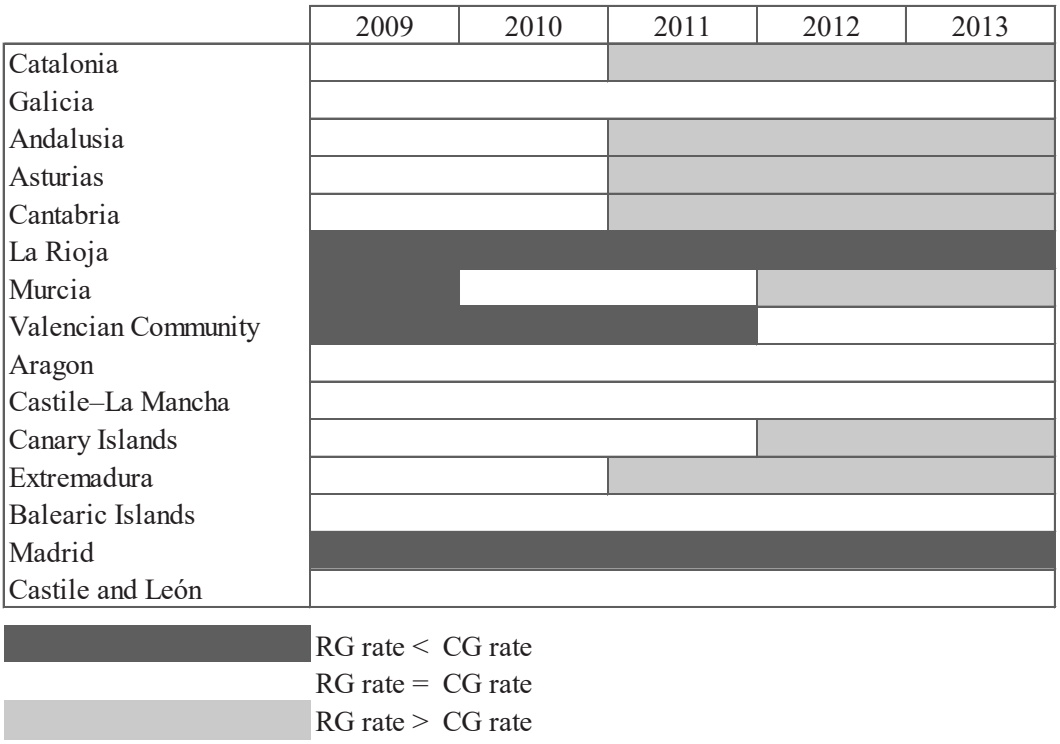
2002-2008: Increase in tax autonomy. The share of PIT rises to 33%.

2009: Increase in tax autonomy (more power over tax rates, personal and family allowances within +- 10% band). The share of PIT rises from 33% to 50%.

According to PIT rates we can group ACs into those with a lower rate than the central government (La Rioja and Madrid), those which have always applied the central government rate (Galicia, Aragon, Castile-La Mancha,

Balearic Islands, and Castile and Leon) and those that have increased their rates. In fact, most of the increases have taken place since 2011.

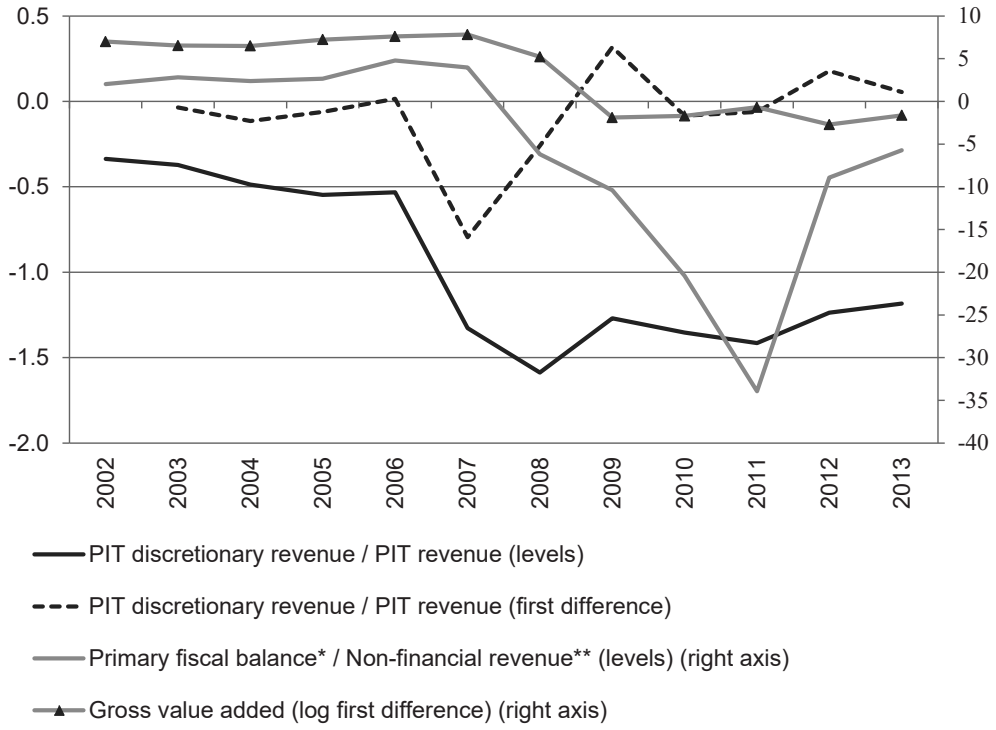
Figure A4.1. Discretionary changes in regional personal income tax rates



Notes: CG (RG) stands for central (regional) government.
Source: Generalitat of Catalonia (2014).

PIT discretionary revenue has always been negative, although before 2009 regional governments presented a looser fiscal policy (see Figure A4.2). Since 2009 ACs partly reduced the fiscal benefits given in good times, to the extent that some of them have increased their tax rate. At first sight, from Figure A4.2, it seems that the PIT policy of ACs has contributed to the sustainability of public finances but at the cost of being pro-cyclical. The following econometric analysis tries to identify these issues.

Figure A4.2. PIT discretionary revenue / PIT revenue, gross value added and primary fiscal balance* / non-financial revenue**



Notes: * Adjusted for 2008 and 2009 negative settlements and outstanding payments to suppliers. ** Adjusted for FEOGA revenues and local funding revenues.
Sources: Spanish Tax Agency, Spanish Ministry of Finance and Public Administrations, BDMORES and INE.

7.5.2. *An econometric approach to the determinants of discretionary personal income tax revenue: some results and limitations*

The following outlines our modelling of PIT discretionary behaviour. Our approach is in the spirit of a fiscal reaction function framework (see e.g. Galí and Perotti, 2003), where a policy instrument is regressed against variables capturing cyclical conditions, the budgetary and financial situation, and the institutional framework. To be more specific, equation A9 relates the change in the ratio of PIT discretionary revenue-to-PIT revenue ($\Delta DR\_PIT/PIT$) to gross value added growth ($\Delta lnGVA$), the lagged primary budget balance (PBB_{t-1}), the electoral-cycle (*ECYCLE*, a dummy

that takes value 1 in election years and zero otherwise) and the government ideology (LEFT, the percentage of left-wing seats)[19].

$$\Delta \frac{DR\_PIT_{it}}{PIT_{it}} = \gamma_1 + \gamma_2 \Delta(lnGVA_{it}) + \gamma_3 PBB_{it-1} + \gamma_4 ECYCLE_{it} + \gamma_5 LEFT_{it} + u_{it} \quad \text{(A9)}$$

The results are displayed in Table A4.5. The estimated model presents a low R^2 value (0.08) and only the response to the primary budget balance situation is significant. This weak evidence reflects a short-sample (2003-2013), but more importantly a lack of variability in our dependent variable. In fact, fiscal activism in personal income taxation starts with the onset of the crisis, and in particular for fiscal consolidation purposes. In fact, this is what the estimated model reflects. Nevertheless, all the variables take the expected sign as we expected the pro-cyclical behaviour of PIT discretionary revenue, a negative reaction to the lagged primary budget balance and to the electoral cycle, and a positive response to left-wing representation in parliament.

[19] The primary budget balance of each AC is computed according to budgetary criteria both regarding the institutional range covered as well as the accounting rules, with adjustments following de la Fuente (2013) and Lago Peñas and Fernández Leiceaga (2013). On the one hand, we make corrections for the negative settlements from the funding system (for years 2008 and 2009), the payments for which were deferred. We regard these negative results as cancelled in 2010 and 2011 respectively (as provided for initially by law), and accordingly we do not apply revenue withholdings from then on (to return those deferred payments). On the other hand, we make adjustments related to outstanding invoices (misplaced public expenditure), which are captured by annual changes in accounts payable for accrued liabilities. After these adjustments our data are very close to national accounts criteria. In addition, as in Lago Peñas and Fernández Leiceaga (2013), we have considered the primary budget balance normalized by non-financial revenue (adjusted for FEOGA revenue and local fund revenue).

Table A4.5. Determinants of discretionary PIT revenue
Dependent variable: Δ (Personal income tax discretionary revenue / Personal income tax revenue)

	(xi)
Constant term (x1000)	-0.57
	(-0.59)
Δ Nominal gross value added (x1000)	-6.38
	(-1.18)
Primary budget balance / Non-financial revenue (-1) (x1000)	-3.75
	(-2.04)**
Electoral cycle (dummy) (x1000)	-0.21
	(-0.58)
% of left-wings seats (x1000)	1.20
	(0.66)
Number of observations	165
Sample	2003-2013
Adjusted R2	0.08
F-statistic (p-value)	4.60 (0.00)

Notes: Regressions are estimated by Panel EGLS (Cross-section weights). *** significance at 99% & ** 95% & * 90%. t-statistics are reported in brackets.

Chapter 5

Estimating Potential Output at Regional Level with the European Commission's Methodology. An Assessment of the Fiscal Stance of the Generalitat of Catalonia*

1. Introduction

The estimation of potential GDP, that is, the ability to grow without generating inflationary pressures[1], provides an analysis of the sources of economic growth. These source factors are, labour, capital and total factor productivity (from now on, TFP). In turn, the distance between actual and potential GDP, also known as the output gap (OG), offers an indicator of the cyclical position and, therefore, the possibility of evaluating the suitability of economic policies.

The measurement of structural budget balances is one of the main applications of the OG, which is the budget balance adjusted for cyclical effects net of one-off and temporary measures. Since 2005 the structural balance is the cornerstone of the EU's fiscal surveillance framework. In turn,

* This work is an enlarged and updated version of Mussons Olivella (2015), especially regarding the analysis of FP stance and the approach by means of unobserved components models.

[1] This assumption (the stability of prices in the estimation of potential GDP) has been questioned in the literature, since the relation between inflation and unemployment has weakened lately. Moreover, in the latest expansive stage inflation has not been indicative of other imbalances, neither externally (as the deficit for current account) nor domestically (as the expansion of credit or the growth of asset prices), and thereby, has ceased to be a relevant indicator of imbalances in the economy as a whole. See the groundbreaking work of Borio et al. (2013), and Alberola et al. (2014) for a specific application to the Spanish economy.

the budgetary stability framework in Spain has set its medium term objectives in structural terms since 2012.

Potential GDP and structural budget balances are instruments for guiding economic policy, widespread at state level but much less so at regional level. In this regard, the main contribution of this chapter is the estimation of potential GDP and OG for Catalonia, following the methodology of the European Commission (EC) (Havik *et al*., 2014). To the best of our knowledge, it is the first approach at regional level using the EC's methodology. The measurement of the cyclical position enables us to make an appraisal of the Catalan fiscal stance since the year 2004.

In short, the results show that since the mid-1990s the Catalan economy has evolved from an expansive phase, in which potential GDP grew almost at an annual rate of 3%, to a phase where the capacity for growth decreased severely. This reduction in the capacity for growth is not unique to the Catalan economy, but has also occurred in the rest of the advanced economies.

The imbalances accumulated in the last expansive phase and some long-term trends are factors that push this capacity for growth in the advanced economies downward. These trends point to the ageing of the population, the slowdown in technological growth, a higher demand for secure assets and the increase of income inequality (Hernando *et al*., 2015).

The outbreak of the crisis in 2008 was a turning point in the pattern of growth of the Catalan economy. The contribution of the capital stock to potential growth stalled, that of the labour factor reached negative values and only that of the TFP pushed potential growth forward. The recovery since 2014 is mainly based on the TFP contribution, whereas the labour and capital stock contributions are far from those of the previous expansion. In this context, the design of economic policy faces great challenges in reinforcing the capacity for growth of the Catalan economy. Job creation and the improvement of human capital are principal, in connection with measures that favour investment as well as the processes of innovation and internationalization of the economy.

As has been mentioned previously, measuring the OG enables us to appraise the fiscal policy (FP) stance. In short, the Generalitat of

Catalonia's FP has been pro-cyclical since the year 2004, except for the first budgetary response to the crisis and the recovery period beginning in the second half of 2013. In coming years, the available fiscal space (in terms of debt) can condition the fiscal stance.

This chapter is structured into 7 sections. The EC's methodology is explained in the second section as well as its main limitations. The third section deals with the estimation of potential GDP and OG for the Catalan economy, while the fourth turns to the estimation of the Generalitat of Catalonia's structural budget balance. Section 5 concludes and Section 6 is devoted to bibliography. Lastly, the appendix includes a more detailed treatment of the EC's methodology, the medium-term macroeconomic scenarios and alternative estimates of Catalan potential GDP based on Unobserved Components (UC) models. The assessment of these alternative estimates suggests that further research is needed in order to improve their robustness at regional level. Nevertheless, it raises doubts about the reliability of pseudo-real-time OG estimates, especially regarding the uncertainty inherent in recursive computation (that is, parameter instability). It also points to the lack of usefulness of OG estimates for inflation forecasting, but a limited usefulness for GDP forecasting. Overall, these preliminary results are in line with the related literature (see e.g. Marcellino and Musso, 2011).

2. Methodology

2.1. Potential GDP: main estimation methods

Potential GDP is a non-observable magnitude approached in the literature by a variety of methods. Without pretending to be exhaustive, we can distinguish statistical, semi-structural and structural methods (see Table 5.1). Our baseline estimation relies on the production function methodology, which is a structural method commonly used by the main international organizations such as the EC or the OECD. Before turning to this method, we describe the main features of the above-mentioned approaches.

Statistical methods do not take into account the relationships postulated by economic theory. These methods depend on strictly statistical techniques to approach potential GDP. The filter of Hodrick and Prescott (1997) is a

paramount example. In general, the main positive characteristic of these methods is their ease of calculation, whereas the end-of-sample bias and bias as a result of structural changes are the main drawbacks (Bouthevillain *et al*., 2001). The filter of Hodrick and Prescott is a symmetrical moving average, so that bias may arise at the ends of the sample. To minimize this limitation it is advisable to extend the series by means of univariant forecasts, although this strategy entails a new bias related with forecast accuracy. For Catalonia, we can highlight the work of Jorba (2007), which analyses potential GDP over the 1980-2007 period.

Table 5.1. Advantages and disadvantages of the main estimation methods of potential GDP

	Avantages	Disadvantages
Statistical methods (e.g. Hodrick and Prescott)	• Ease of calculation	• End-of-sample bias and the bias as a result of structural changes
Semi-structural methods (e.g. UC models based on macroeconomic relationships)	• Real time performance	• Complex modelling
Structural methods (e.g. production function)	• Reference method by the EC • Interpretation based on economic theory • Macroeconomic and demographic scenarios may be evaluated	• Intensive information requirements • Complex modelling of non observable variables

Source: Own compilation.

The result of combining statistical methods with economic theory leads us to the semi-structural approaches. These methods make use of economic theory relationships, such as the Phillips curve (Kuttner, 1994) or Okun's law (Apel and Jansson, 1999), to identify potential GDP. Real-time adjustment is one of its main strengths, although state-space modelling[2] is complex, and therefore these estimations are more difficult to replicate.

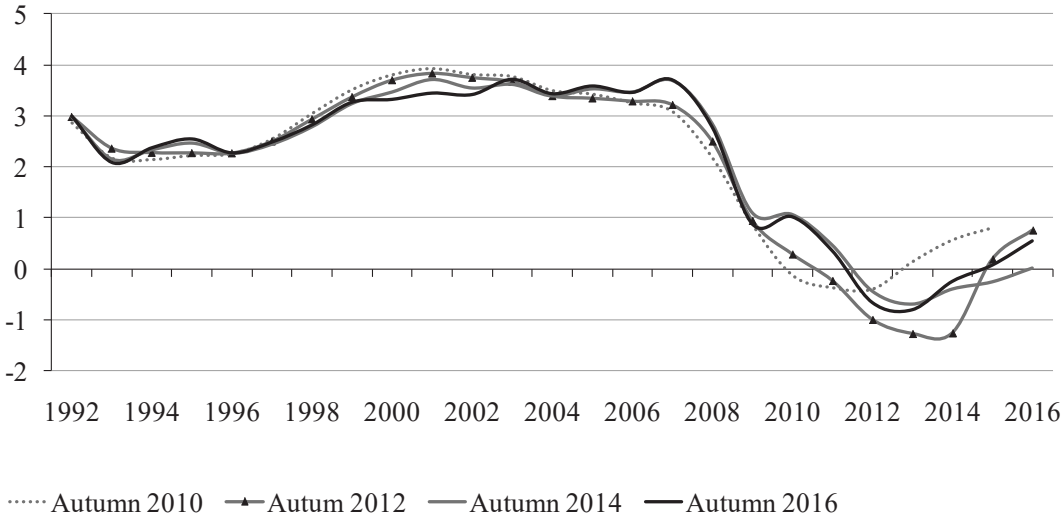
[2] A model in state-space represents a dynamic system as a set of input, output, and state variables, related by a system of first order differential equations. The use of these models was widespread in the field of engineering throughout the 60s, on the basis of Kalman contributions.

Finally, the structural methods are mainly based on relationships that stem from economic theory. In particular, the production function method as well as dynamic stochastic general equilibrium models (Galí *et al*., 2007) should be mentioned. In the latter strand of literature, potential GDP is defined as the level of output that can be attained if prices and wages are flexible. For Catalonia, we can highlight the estimations of Correa-López and Mingorance-Arnáiz (2012), based on the production function methodology. Their approach differs substantially from the EC's, as the structural unemployment rate and the structural TFP are obtained by means of the Hodrick and Prescott filter. By contrast, the EC addresses these key variables with UC models.

Despite the advantages of structural methods, especially regarding the interpretation of results and ease of communication, their estimates also suffer from uncertainty. These methods depend partially on strictly statistical and semi-structural approaches, in addition to macroeconomic and demographic forecasts[3]. As a matter of fact, the downward revision of potential GDP growth rates in the main advanced economies, as a result of the effects of the crisis, is a good example of this uncertainty in recent years. Figure 5.1 reveals recent revisions of Spanish potential output by the EC.

[3] The work of Domenech *et al*. (2007) is a good example of the application of different univariate and multivariate methods to the cyclical position of the Spanish economy. In that case the results provided similar cyclical position estimates.

Figure 5.1. Selected vintages of Spanish potential GDP
(annual % change)



Source: EC.

2.2. European Commission methodology for calculating potential GDP

The estimation of Catalan potential GDP is based on the EC's methodology, which builds on a production function[4]. The main features of this method are described below (see Figure 5.2).

A Cobb-Douglas production function is used to represent GDP by means of the endowments of production factors - capital stock (*K*) and labour (*L*) - and the indicator of technical efficiency, that is, total factor productivity *(TFP)*.

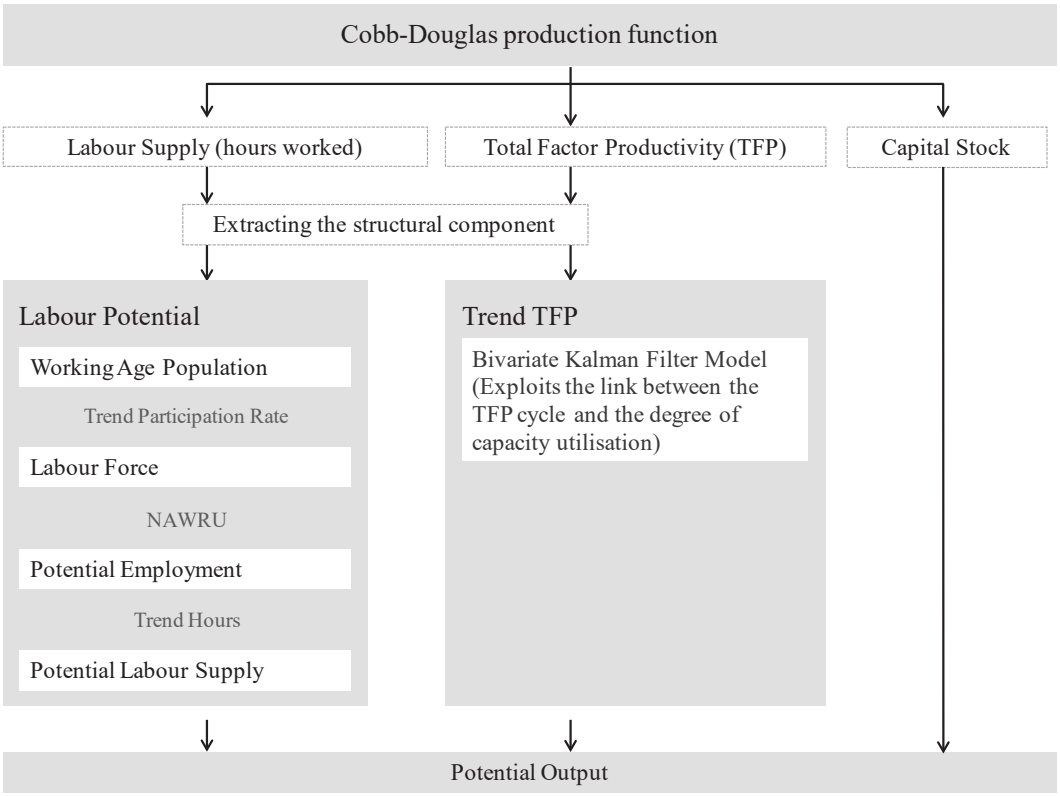
$$Y = L^{\alpha}\mathrm{K}^{1-\alpha} * TFP \qquad (1)$$

The α parameter refers to the output elasticity of labour, that is, a unitary increase of the labour factor leads to an increase of α in GDP. Under perfect competition and constant returns to scale assumptions, the output elasticity of each production factor is equal to its factor income share. The EC assumes the same factor income share for all member states: 0.65 for the

[4] The EC provides all data, programs and estimates related to the estimation of potential GDP, structural unemployment rate and structural TFP in:
https://circabc.europa.eu
Once on the website, go to: European Commission > Economic and Financial Affairs > OGs.

labour factor and 0.35 for capital stock. We are maintaining the same assumption in this analysis. In Appendix section 7.2 we include the full specification of the production function, which also takes into account the degree of utilisation of factor inputs as well as their level of efficiency.

Figure 5.2. European Commission methodology for estimating potential GDP



Source: Own compilation based on Havik et al. (2014).

Potential GDP (Y_{pot}) can be represented by the potential factor use of inputs as well as the trend level of efficiency, while OG is obtained as the difference between actual GDP and potential GDP (in logarithmic terms).

$$Ypot = L_{pot}^{\alpha} K_{pot}^{1-\alpha} * TFP_{pot} \quad (2)$$

$$OG = Y/Y_{pot} - 1 \quad (3)$$

Next, we define potential labour supply, capital stock as well as the trend level of efficiency, that is, structural TFP.

2.2.1. *The labour factor*

The potential labour input is estimated in terms of the potential number of hours worked (L_{pot}), from the following variables: the population of working age (POP)[5], the smoothed participation rate ($PART_{trend}$), the structural unemployment rate ($NAWRU$) and the trend of average hours worked per year and employee ($HOURS_{trend}$).

$$L_{POT} = POP * PART_{trend} * (1 - NAWRU) * HOURS_{trend} \qquad (4)$$

The participation rate and the average hours worked per employee are smoothed by means of a Hodrick and Prescott filter (λ=10).

The approach to the potential value of employment is more complex, since it depends on the structural unemployment rate consistent with stable inflation[6]. Until the spring of 2014 the EC used a Phillips curve, which postulates a negative relationship between the acceleration of nominal unit labour cost (ULC) and the cyclical component of unemployment. Some Member States questioned this empirical strategy, especially Spain, because of a marked pro-cyclicality in estimates of the Spanish structural unemployment rate. To deal with this issue the EC adapted the methodology, for most countries, using a new Keynesian Phillips curve (which postulates a negative relationship between real ULC growth and the cyclical component of unemployment). In this new version, price rigidities are taken into account more specifically. At times, real ULC growth may indicate greater moderation than change in nominal ULC, as in the case of Spain in recent years (see EC, 2014). In both approaches the estimation is carried out by maximum likelihood using the Kalman filter. A more detailed explanation is given in the Appendix section 7.1.

2.2.2 The capital factor

As for the potential capital input, the EC assumes actual capital stock as potential estimates. Estimation of capital stock is based on the perpetual inventory method, which establishes capital stock at time t (K_t) as the result

[5] In the case of population, the EC has foreseen the possibility of smoothing its migratory component. However, this initiative has not made any headway, as some Member States do not provide official statistics for this area.
[6] See footnote 1.

of adding investment made at time t (I_t) to capital stock at time *t*-1 (K_{t-1}), taking the depreciation rate (d_t) into account.

$$K_t = I_t + (1 - d_t)K_{t-1} \tag{5}$$

2.2.3. *Total Factor Productivity (TFP)*

TFP measures the changes in output that are due neither to labour nor to capital, such as technological improvements, organizational innovations or a sectoral reallocation of resources. From a statistical point of view, the TFP is approached as the ratio of output growth in relation to the growth of inputs, which are weighted by their share in the national income.

$$TFP = Y/(L^{\alpha}K^{1-\alpha}) \tag{6}$$

The potential value of TFP is obtained by means of a bivariate UC model (similarly to Kuttner, 1994), where the cyclical part of TFP is related to the degree of capacity utilisation in the economy. The estimation of the potential value of TFP is also carried out by maximum likelihood using the Kalman filter. A more detailed explanation is given in the Appendix section 7.2.

2.3. Limitations of the EC methodology for calculating potential GDP

In this section we point out some shortcomings in the EC's methodology. First, as mentioned earlier, the increasing dependence of the PF approach on UC models, which are used to obtain the potential value of labour and TFP, raises some issues. In this regard, it is worth exploring the economic meaning of the state-space models used by the EC. The EC modelling considers two unit roots for the permanent component of the unemployment rate and a damped trend model for the permanent component of TFP[7]. This approach may provide a valid approximation during a certain period of time, but its economic meaning is very dubious as there is an increasing impact of shocks as we go further in time. A short demonstration is given below.

The permanent component of the unemployment rate (p_t) is modelled as:

[7] The damped trend model yields an integrated trend which is somewhere between order 1 and 2. See Appendix section 7.2.

$$p_t = \alpha_t + p_{t-1} + \varepsilon_{pt} \tag{7}$$

$$\alpha_t = \alpha_{t-1} + \varepsilon_{\alpha t} \tag{8}$$

Therefore:

$$\Delta p_t = \frac{1}{(1-L)}\varepsilon_{\alpha t} + \varepsilon_{pt} \tag{9}$$

$$(1-L)^2 p_t = \varepsilon_{\alpha t} + \Delta\varepsilon_{pt} = \gamma_t \tag{10}$$

This data generating process, as captured by (10), may be expressed as:

$$(1-L)p_t = \sum_{-\infty}^{0}\gamma_t + \sum_{1}^{t}\gamma_t = p_0 + \gamma_t + \gamma_{t-1} + \gamma_{t-2} + \cdots \tag{11}$$

And also as:

$$p_t = \sum_{-\infty}^{t}(p_0 + \gamma_t + \gamma_{t-1} + \gamma_{t-2} + \cdots) = \tag{12}$$

$$= \sum_{-\infty}^{0}(p_0 + \gamma_t + \gamma_{t-1} + \gamma_{t-2} + \cdots) + \sum_{1}^{t}(p_0 + \gamma_t + \gamma_{t-1} + \gamma_{t-2} + \cdots) =$$

$$= p_0^* + tp_0 + \gamma_t + 2\gamma_{t-1} + 3\gamma_{t-2} + 4\gamma_{t-3} + \cdots + t\gamma_1$$

Thus, expression (12) indicates an increasing impact of shocks as we go further on in time.

Second, the EC's methodology depends on subjective constraints over the hyperparameters (the variances governing the state-space model), which differ from country to country. The choice of these constraints impacts greatly on the degree of smoothness finally obtained.

Third, NAWRU and structural TPF are forecast dependent, which introduces uncertainty, as Darvas and Simon (2015) remark. If the forecasts turn out to be accurate this strategy would reduce end-point uncertainty, but it could be the opposite (as has occurred since the onset of the global financial crisis).

Fourth, as a result of these limitations a disparity of official estimates can be found even when using the same method, as well as substantial revisions (see Darvas and Simon (2015) for a European analysis)[8].

The results of Darvas and Simon (2015) suggest that the size of revisions is related to the variability in the current account balance. "One reason for the inability of the EU's methodology to correctly identify the economic cycle in real time is that it focuses only on the relationship between the OG and labour market tensions via the NAWRU. While in a large and closed economy such a relationship may describe the impact of the OG reasonably well, it is certainly insufficient for small open economies. In the latter economies, much of the excess demand (i.e. positive OG) is absorbed by the trade balance and this has indeed happened in Greece, Ireland, Latvia and Spain: before the crisis, the trade balance in these countries deteriorated rapidly" (Darvas, 2013, 9).

Fifth, the assumption of identical (and constant) elasticity with respect to productive factors across all Member States may introduce some bias, as it may not be suitable for some countries.

Sixth, the inclusion of the 65-74 age-range as labour potential is dubious. This group is not generally accepted as being of working age by current laws and regulations and may result in an overestimation of the potential output of countries with an ageing population.

Seventh, the assumption of no cyclicality in the working age population is not reliable, but the EC (d'Auria et al., 2010) claims that there is no homogenous data for all Member States to replace this population with a smoothed alternative. In addition, it may be especially suitable to consider these cyclical movements in countries like Spain, where immigration has had a noticeable impact on population growth in recent times.

[8] In the Spanish case, we can also find a disparity of official estimates. Since the onset of the real estate and financial crisis, the EC's and the Bank of Spain's OG estimates are persistently more optimistic than those of the Spanish Ministry of Finance and Public Administrations. The main difference lies behind NAWRU estimates, which are higher in the former case, and thereby cyclical conditions point to more optimistic values. In turn, more optimistic values for OG lead to greater structural deficits, which call for further fiscal adjustment.

Eight, all capital stock is assumed to be productive. As pointed out by Darvas (2013, 4) "some of the capacities built before the crisis should not be taken into account when estimating production factors at their long-term sustainable levels". In this regard, it is also questionable to assume all housing assets are productive.

Despite all these caveats the PF approach is valuable as it is suitable for story-telling, which is an important part of most organizations dealing with forecasting and stabilisation policy advice (Hjlem and Jönsson, 2010). In addition, this method facilitates the comparability of Catalan OG estimates with those of other advanced economies, as it is used by most international organizations.

2.4. Measuring the fiscal effort

The budget balance can be broken down into a cyclical and a structural component. The distinction is very important since the structural part represents the discretionary component of FP, that is, the fiscal effort that can be attributed to the action of governments. This measurement of fiscal effort is, as a matter of fact, a cornerstone in the European system of fiscal governance since 2005.

There are two main approaches to the measurement of fiscal effort: on the one hand, the change in the primary structural balance, which is also called fiscal stance (a top-down approach*)* and, on the other hand, an approach based on narrative methods (a bottom-up approach). The primary structural balance is the budget balance adjusted for cyclical effects, interest expenditures and one-off measures. The bottom-up approach is obtained as the sum of the budgetary impact from each of the discretionary measures (see e.g. Barrios and Fargnoli, 2010, and Princen et al., 2013). Before turning to the methodology of the structural balance, which is the option chosen in this work to appraise the orientation of FP, we deal with the main shortcomings of both approaches.

The primary structural balance has two important limitations. First, its dependence on uncertain OG estimates, and second, the extraordinary revenue and expenditure changes not captured by average elasticities. These are the so-called windfalls or shortfalls (mainly regarding the revenue side). In fact, Carnot and de Castro (2015) note some biases related to this

approach. In good times the orientation of FP is optimistic, which leads to fiscal effort being overstated, and conversely there is a pessimistic orientation in bad times. In the Catalan economy we should highlight noticeable windfalls and shortfalls in revenues as a result of changes in the composition of economic growth and changes in real estate prices.

The narrative approach overcomes the above-mentioned limitations, although other shortcomings arise. First, information requirements regarding budgetary issues are more extensive, since an appraisal of the impact of each discretionary measure is necessary. This information may suffer from biases (as it is commonly only provided by the same government that is being analysed) and most of the time it is not exhaustive. Second, the absence of discretionary expenditure measures does not necessarily lead to a neutral fiscal effort[9].

The EC considers both approaches when appraising the fiscal effort of EU Member States although, as has been mentioned previously, the structural balance is the cornerstone of FP surveillance. In the present analysis, we provide an approach to the fiscal effort of the Generalitat of Catalonia by means of the structural balance approach. In further research, it would be interesting to assess our results with the narrative method, as well as with the proposal of Carnot and de Castro (2015), which combines both methods.

The Spanish Budgetary Stability regulations broadly follow European guidelines, but also present some noteworthy singularities (see the Ministerial Order ECC/2741/2012, of 20th December, developing the methodology of Organic Law 2/2012, of 27th April, on Budget Stability and Financial Sustainability). Before commenting on these singularities, we present the methodology for calculating primary structural balances (see Mourre et al., 2014, for a more detailed discussion).

$$\frac{SPB_t}{\mathrm{Ypot}_t} = \left(NFR_t - NFE_t + E_{int,t} - one\ off_t\right)/\mathrm{Y}_t - \varepsilon * OG_t \qquad (13)$$

$$\varepsilon = \left[\left(\sum\nolimits_1^4 \eta_{NFR,i}\frac{NFR_i}{NFR} - 1\right)\frac{NFR}{Y}\right] - \left[\left(\eta_{E_{unempl.}}\frac{E_{unempl.}}{NFE} - 1\right)\frac{NFE}{Y}\right] \qquad (14)$$

[9] See Carnot and de Castro (2015) for a more detailed explanation of these limitations.

, where *SPB/Ypot* is the primary structural balance (as a percentage of potential GDP)[10], *NFR* and *NFE* are the non-financial revenue and expenditure respectively, E_{int} the interest expenditure, *one off* the one-off measures, *Y* the GDP, ε the semi-elasticity of the budget balance-to-GDP ratio with respect to the OG, *OG* the output gap, $\eta_{NFR,i}$ the elasticity of revenue category *"i"* with respect to the OG and $\eta_{E_{unempl.}}$ the elasticity of expenditure on unemployment benefits ($E_{unempl.}$) with respect to the OG.

As we can appreciate in the expression above, semi-elasticity ε captures the difference between the semi-elasticity of revenues and that of expenses. The elasticity of each category of revenue and expenditure is weighted by its share in total non-financial revenue and expenditure respectively. These elasticities are based on the work of Mourre et al. (2014) and the Spanish Ministerial Order ECC/2741/2012. The current regulations contemplate the following revenue categories (and elasticities): Personal Income Tax (1.84), indirect taxes (1.00), transfers from the regional financing system (1.42) and other income categories (0.00). As for expenditure, the only category sensitive to the economic cycle is unemployment benefits (-5.83), although this responsibility is not assigned to ACs. Thus, the calculation of the semi-elasticity for ACs can be simplified:

$$\varepsilon = \left[\left(\sum_{1}^{4} \eta_{NFR,i} \frac{NFR_i}{NFR} - 1 \right) \frac{NFR}{Y} \right] + \frac{NFE}{Y} \qquad (15)$$

The Spanish regulations on budgetary stability (the above-mentioned Ministerial Order) assume the same elasticities and cyclical position at the central, regional and local tiers of government. Therefore, the cyclical sensitivity only differs as a result of revenue and expenditure structures as well as differences in the revenue and expenditure ratio (as a percentage of GDP). However, this assumption should deserve further attention, since Bandrés and Gadea (2013) provide evidence of significant differences between regional economic cycles.

The estimation of the primary structural balance of the Generalitat, shown in section 4, is based on budgetary data in national accounts terms, the

[10] Mourre et al. (2014) provide a demonstration of expression (13) and (14). Appendix section 7.5 contains a demonstration of expression (14) as well as an empirical implementation for the Generalitat of Catalonia.

cyclical position of the Catalan economy (which stems from the present work) and a specific semi-elasticity estimated for Catalonia (see Table A5.6 in Appendix section 7.5).

3. Estimation of potential GDP and output gap for the Catalan economy

In this section we describe the estimation of potential GDP and OG for the Catalan economy. First, we approach the potential value of each of the components shaping GDP: labour, capital and total factor productivity (TFP). Next we deal with the aggregated results, that is, the potential GDP and the OG.

The data sources that feed the analysis of the Catalan case have been selected to allow for a homogenous comparison with AMECO (the annual macroeconomic database of the EC).

GDP and employment data come from Spanish Regional Accounts (INE). For the period before 2000, Idescat provides retrospective estimations of the average number of hours worked per year and employee and the number of employees. Unemployment data are based on the Economically Active Population Survey (EPA) and population data on Idescat projections. Idescat also provides the degree of capacity utilisation in the economy as a whole. That estimation is carried out according to the EC's methodology. Capital stock data come from the BBVA-Ivie while macroeconomic and demographic scenarios are included in the Appendix section 7.3. These scenarios depend on projections by the Ministry of the Vice-presidency and Economy and Finance of the Generalitat and Idescat respectively.

3.1. The labour factor

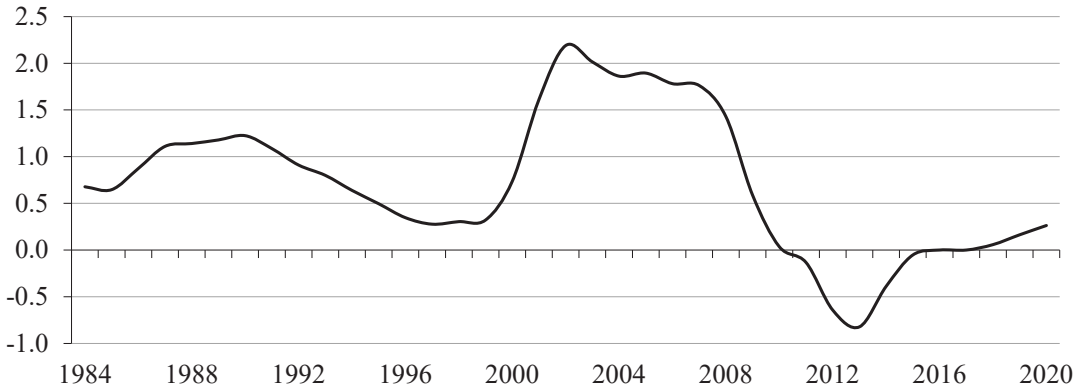
As indicated previously, the potential value of the labour factor is obtained from the population of working age, the smoothed participation rate, the structural unemployment rate and the trend of average hours worked per year and employee.

As for population dynamics, there have been three distinct stages in Catalonia since the eighties (Amarelo, 2013). A certain demographic stagnation took place in the eighties and nineties, as a result of embracing a

low fecundity pattern similar to other advanced economies, which entailed a progressive trend towards population ageing.

From the end of the nineties until the beginning of the last crisis, there was very intense growth in the population of working age, especially in relation to the migratory cycle. This growth slowed down after 2008 and has registered negative values since 2011. Idescat's population projections (2014) suggest negative growth until 2017, that reflects a very low natural growth, with negative values since 2016, and a negative migratory growth until 2017. These low rates of natural growth result from the decline in the number of women of childbearing age. In the case of the population of working age (see Figure 5.3) these projections also indicate negative growth until 2017. In this regard, it should be pointed out that the EC's methodology considers the population from 15 to 74 years old to be the population of working age.

Figure 5.3. Growth of the population of working age (15 to 74 years)
(annual % change)

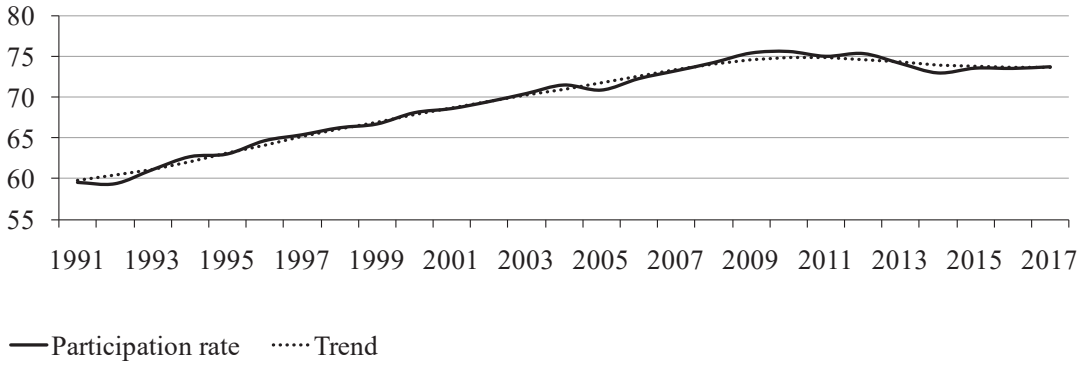


Note: Population estimates until 2014 and population projections since 2015.
Source: Idescat.

Labour force participation is also a key factor concerning the potential value of the labour factor. As a matter of fact, the participation of women in the labour force has increased drastically over the last 30 years and migratory phenomena have further pushed the participation rate upward, leaving the Catalan participation rate above the EU average. There was a break in this trend in 2012, when the participation rate levelled off, and

even decreased slightly (see Figure 5.4)[11]. However, currently the participation rate in Catalonia is still above the EU average.

Figure 5.4. Participation rate and its trend (%)

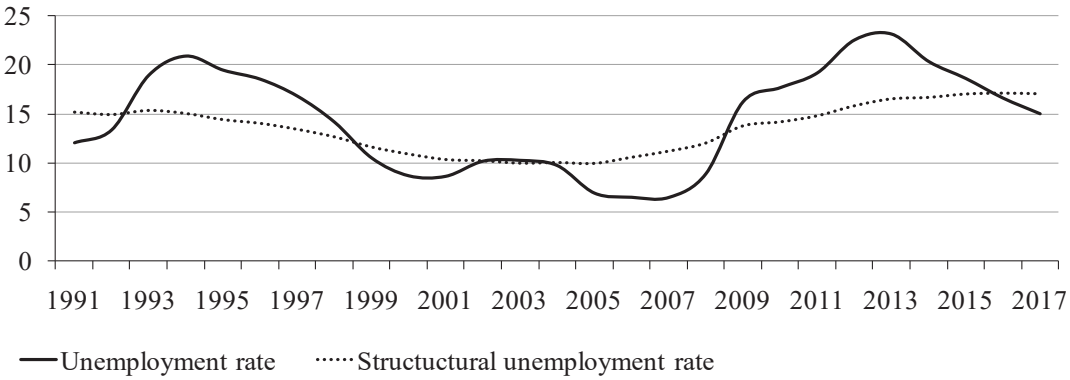


Note: Ratio between active population (based on EPA) and population of 15 to 74 years (based on population estimates).
Source: Own compilation based on data from INE and Idescat.

The structural unemployment rate of the Catalan economy has stood at around 16%-17% since 2013. This estimation is based on the New Keynesian Phillips curve, as in the case of Spain. The results obtained suggest that the unemployment gap closed in 2016. This situation stands out in contrast to the real estate boom, when the structural unemployment rate fell to its minimum, around 10% (see Figure 5.5). The increase in the structural unemployment rate is the outcome of a protracted period of crisis and, especially, the increase in long-term unemployment (those unemployed who have been looking for work for more than a year). This group accounted for 59.6% of total unemployment in 2015.

[11] In this regard, BBVA Research (2015a) provides an analysis for the Spanish economy. There are several factors that are pushing the participation rate downwards, in particular, the ageing population as well as the increase in the years of education of young people. Moreover, the slowdown in the growth of the female participation rate has led to smaller upward contributions to the participation rate. The results of this analysis suggest that it is very likely that the participation rate will not increase, as long as the participation of young people and those over 54 years old do not increase.

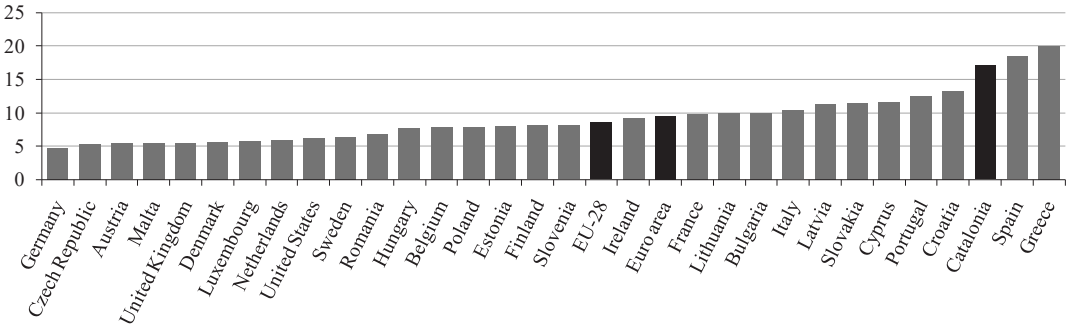
Figure 5.5. Unemployment rate and structural unemployment rate (as a percentage of active population)



Source: Own compilation based on data from INE.

From a European comparative perspective, only Greece and Spain surpassed the structural unemployment rate of Catalonia in 2015. In contrast, Germany and the Czech Republic register the lowest rates at around 5% (see Figure 5.6). The figures for Catalonia should however be interpreted with caution, as the participation rate of Catalonia is much higher than in most EU countries. From another angle, the difference in terms of employment rates between Catalonia and the euro area, at the time of analysis, is almost non-existent (Generalitat of Catalonia, 2016c).

Figure 5.6. Structural unemployment rate of Catalonia and selected countries. 2015 (as a percentage of active population)



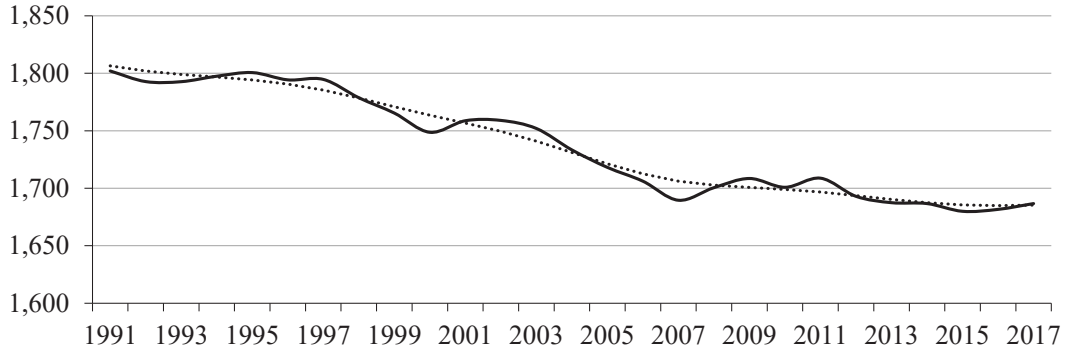
Source: Own compilation based on data from EC and INE.

The EC (Orlandi, 2012) provides an alternative estimate for structural unemployment rates, which does not question official estimates, but is a complement to them. This new indicator is the part of the NAWRU that is

explained by institutional factors, and as a result presents lower frequency dynamics. In Spain non-institutional factors account for 5 percentage points of the current structural unemployment rate. At this point, it is worth highlighting the key institutional factors that determine the structural unemployment rate: the unemployment benefits replacement rate, the labour tax wedge, the degree of union density and expenditure on active labour market policy. The Spanish economy particularly stands out because of the negative difference in expenditure on an active labour market policy and the positive difference in the unemployment benefits replacement rate. This last indicator expresses unemployment benefit levels as a percentage of previous earnings, over a 5 years horizon, although it must be stressed that the calculations rely on the 2005-2007 period. Spain is characterized by relatively high generosity in the first year that then decreases during the following years. These results have to be interpreted with caution, since the latest legislative changes after the onset of the crisis have reduced the replacement rate. In addition and in parallel there has been a sharp decline in unemployment benefit coverage rates. At the same time it is necessary to take into account that the 2005-2007 period was not representative of the post-crisis context when there was a high probability of outflow from unemployment. Despite these caveats, the OECD (2014) still considers that the Spanish system remains relatively generous, and it is important to highlight its emphasis on the lack of conditionality in passive labour market policy.

The trend of average hours worked per year and employee is the last necessary factor in estimating potential labour input. This trend has followed a downward trajectory over the last three decades, showing decreasing potential labour input (see Figure 5.7) as it does in most advanced economies. The growth of the service sector and the increasing importance of part-time employment are expected to put downward pressure on the average hours worked per year and employee.

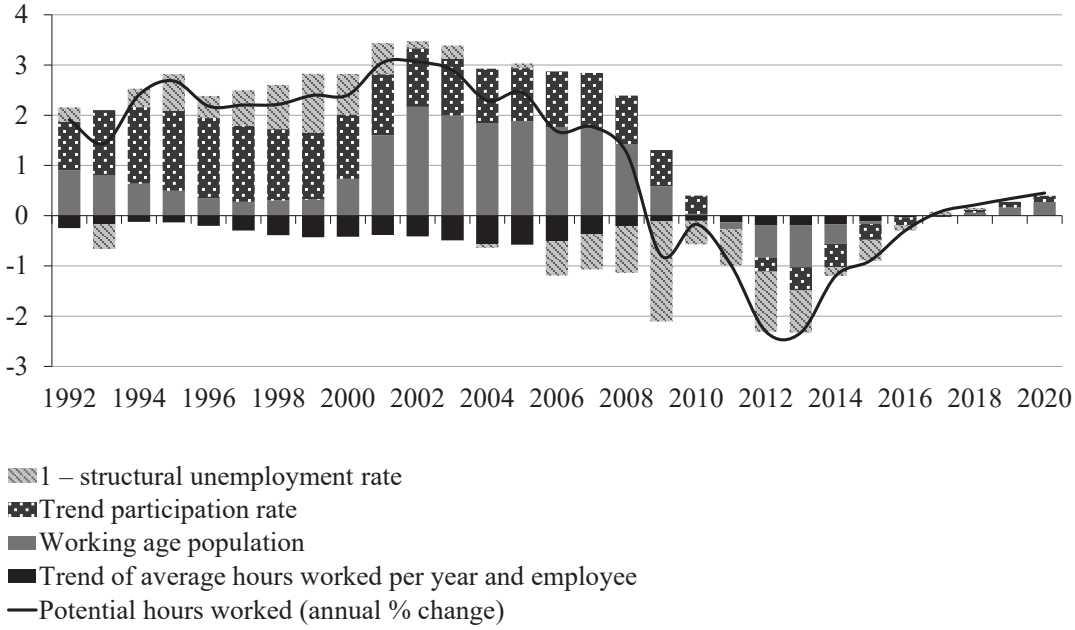
Figure 5.7. Average hours worked per year and employee and the trend



Source: Own compilation based on data from INE.

Potential labour input is measured as total number of hours worked (see Figure 5.8). The results suggest considering three distinct stages since the beginning of the nineties. The first stage is characterized by intense growth in potential labour input until the year 2000, as a result of an increase in the participation rate, a decrease in the structural unemployment rate and a moderate increase in the population of working age. From then to the year 2008, the growth of the potential labour factor is also very remarkable, although its contribution to potential GDP diminished. During this stage, there was a notable increase in the population of working age, despite a slowdown in growth throughout the period. The structural unemployment rate also presented a positive contribution, but smaller in magnitude. Over the 2003-2005 period this rate fell to its minimum. Finally, in the stage that started with the onset of the crisis, the potential growth of labour input got into negative territory. The structural unemployment rate is the factor that led the decline during the first years after the crisis; afterwards, it is the population of working age. In addition, there was a noticeable stagnation of the positive contribution of the participation rate and a slighter fall in the average of hours worked per year and employee.

Figure 5.8. Potential growth of the labour factor and the contribution of its key factors (percentage points, except potential hours as annual % change)



Source: Own compilation based on data from INE and Idescat.

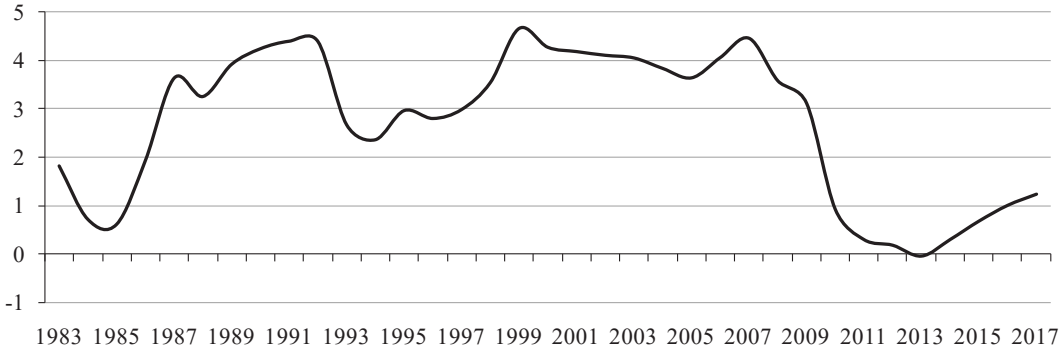
3.2. The capital factor

The process of capital accumulation was especially intense in the Catalan economy from the nineties until the bursting of the real estate bubble and the financial crisis (see Figure 5.9). This accumulation was a key source of growth during those years. In this regard, it is also worth mentioning that capital deepening leads to higher labour productivity, which in turn boosts growth, as long as investment is well-targeted.

There are two periods when the process of accumulation was particularly outstanding: 1987-1992 and 1999-2007, with average rates of around 4%. In the middle of these two periods, there was a slowdown in the growth of capital stock that reflected the crisis of the early nineties and the fiscal consolidation process prior to entry into the euro area. The arrival of the euro was conducive to an environment of stability and low interest rates, which boosted the process of capitalization until the onset of the financial and real estate crisis. Since 2010 this process has stagnated, even showing negative values in 2012 and 2013. In other words, gross fixed capital formation did not make up for the depreciation of assets. The collapse of

investment at that time, both public and private, is explained by funding difficulties, excess capacity in some sectors and the severity of the fiscal consolidation process.

Figure 5.9. Growth of capital stock (annual % change)



Note: Capital stock is projected since 2013 by means of the perpetual inventory method, in accordance with the macroeconomic scenarios in Appendix section 7.3.
Source: Own compilation based on data from BBVA-Ivie Foundation and Idescat.

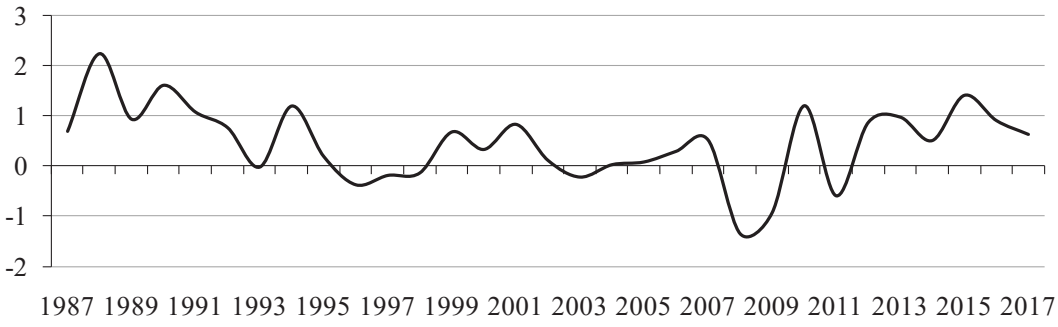
3.3. Total factor productivity (TFP)

The TFP, as has been mentioned previously, measures changes in GDP that are due neither to labour nor capital such as technological improvements, organizational innovations or the sectoral reallocation of resources.

The impact of the crisis on TFP, a priori may have led to positive or negative outcomes (Hernando, *et al*. 2015). On the one hand, on the negative side, first we have the fall in investment in R&D, second, difficulties in restructuring the financial sector, which led to financial constraints on the economy as a whole, and third, the increasing importance of low productivity activities in the service sector.

On the other hand, the Schumpeterian process of creation and destruction may have had a positive outcome on TFP. It is likely that exiting companies had lower productivity than those that continued, whereas new companies were related to innovative and more productive activities. In fact, the European Central Bank (2011) and the Banco de España (2015) provide evidence of this Schumpeterian process regarding selected euro area countries and Spain respectively.

Figure 5.10. Contribution of TFP to GDP growth (percentage points)



Source: Own compilation based on data from INE, BBVA-Ivie Foundation and Idescat.

TFP dynamics (see Figure 5.10) were at a standstill throughout the nineties and during the real estate boom. This stagnation was most likely capturing the expansion of low-productivity sectors, which rely to a great extent on the accumulation of production factors (labour and capital). Then TFP fell drastically with the outbreak of the crisis, but afterwards, since 2010, has recovered strongly.

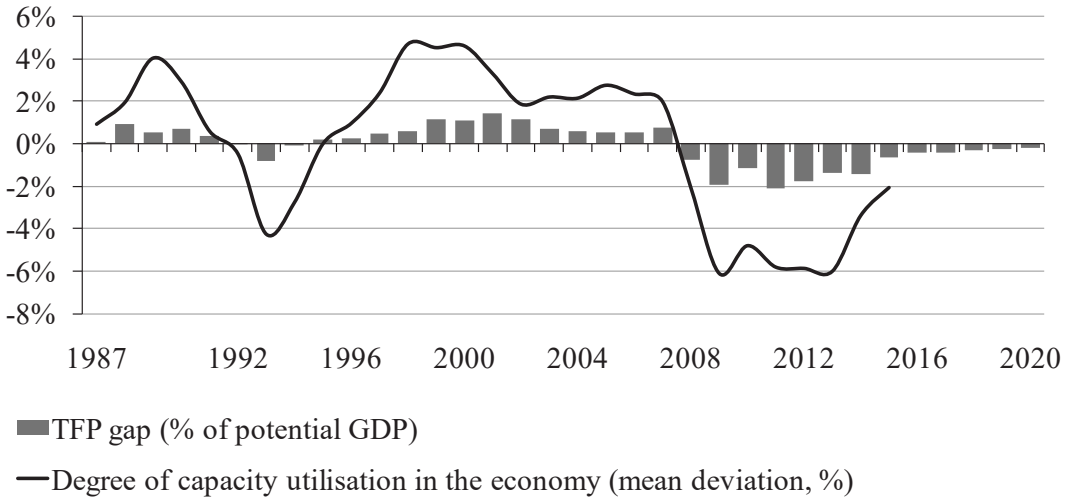
The degree of capacity utilisation in the economy enables the identification of the cyclical part of TFP. The capacity utilisation rate for Catalonia was produced by Idescat, following the EC's methodology[12]. Its construction is based on a direct measurement of the capacity utilisation of the industrial sector and two business climate indicators: one for the service sector and another for the construction sector. Industry data comes from the Business Climate Survey of the Spanish Ministry of Industry, Energy and Tourism (*Encuesta de Coyuntura Industrial*), while data on the construction and service sectors come from Idescat's and the Barcelona Chamber of Commerce's Business Climate Survey (*Enquesta de Clima Empresarial*).

The results (see Figure 5.11) indicate a positive correlation between the cyclical part of the TFP and the degree of capacity utilisation in the economy (the latter is expressed as deviation from the average). These deviations took positive values in the last expansive period (1994-2007) and negative values afterwards. In 2012 the degree of capacity utilisation in the

[12] The EC's methodology for building "the degree of capacity utilisation in the economy" as well as its latest estimates may be consulted at the EC's website related to OGs (see footnote 4).

economy fell to its minimum (6 percentage points below the average), while the TFP gap stood at -1.4% of potential GDP. Our medium-term projections suggest a gradual closure of this gap.

Figure 5.11. TFP gap and degree of capacity utilisation in the economy



Source: Own compilation based on data from INE, BBVA-Ivie Foundation and Idescat.

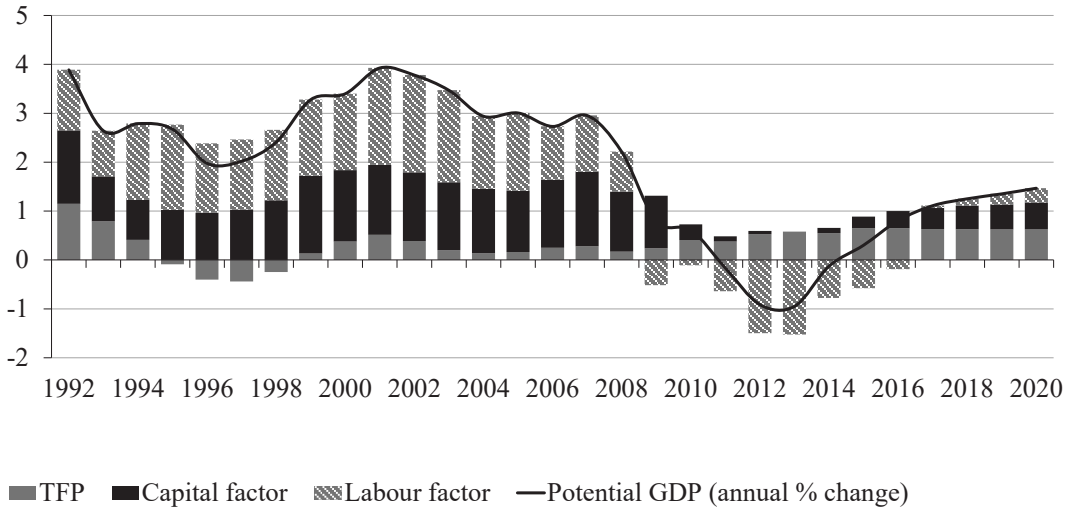
3.4. Potential GDP and the output gap

In this section we present the aggregated result regarding potential GDP and its deviation from actual GDP, that is, the OG. The potential GDP has passed through two distinct stages since the nineties. In the first stage, up to 2008, the potential GDP growth of the Catalan economy remained strong, almost at 3%. Afterwards, the growth of potential GDP slowed down, in accordance with the situation in other advanced economies.

The potential growth that took place during the expansive stage is explained mainly by the production factors (labour and capital). The role of TFP is almost residual. However the outbreak of the crisis marks a turning point after which the growth pattern of the Catalan economy greatly altered. The contribution of capital stock to potential GDP stagnated, that of the labour factor became negative whereas TFP partly offset these trends. Overall, the growth of potential GDP has weakened since 2001, falling to a minimum in 2013. After that, a gradual recovery took place, and it turned positive in 2016 (see Figure 5.12).

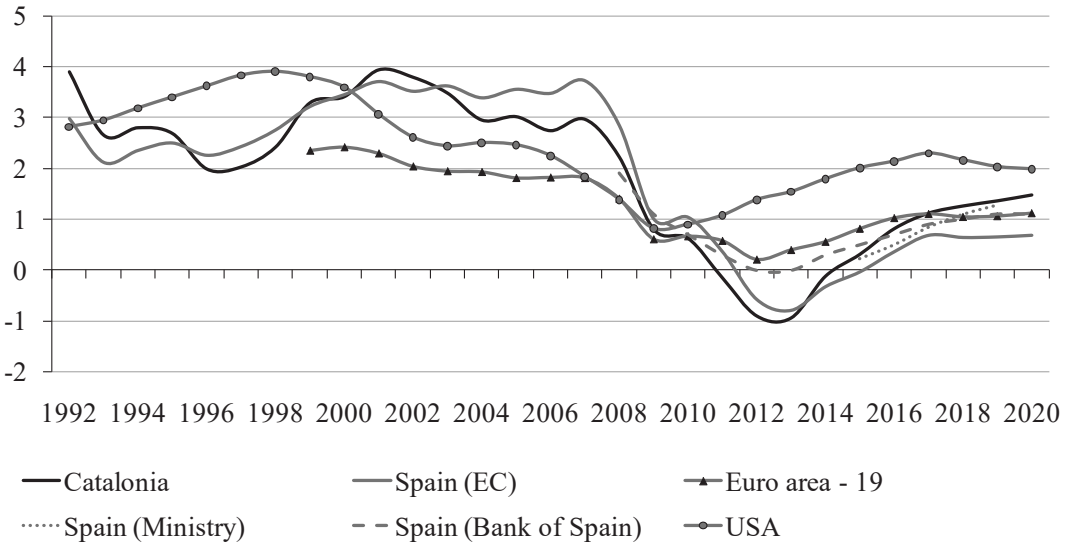
The potential growth slowdown in the Catalan economy is stronger than that of the euro area. However, potential growth prospects for the euro area are also weak, not above the 1% threshold. These trends are in stark contrast with the US recovery. In fact, in 2015 US potential growth stands at the same rate as that of the pre-crisis period (see Figure 5.13).

Figure 5.12. Potential GDP growth and contribution of its key factors (percentage points, except potential GDP as annual % change)



Source: Own compilation based on data from INE, BBVA-Ivie Foundation and Idescat.

Figure 5.13. Growth of potential GDP in Catalonia, Spain, the Euro area and the USA (annual % change)



Source: Own compilation based on data from EC, INE, BBVA-Ivie Foundation and Idescat.

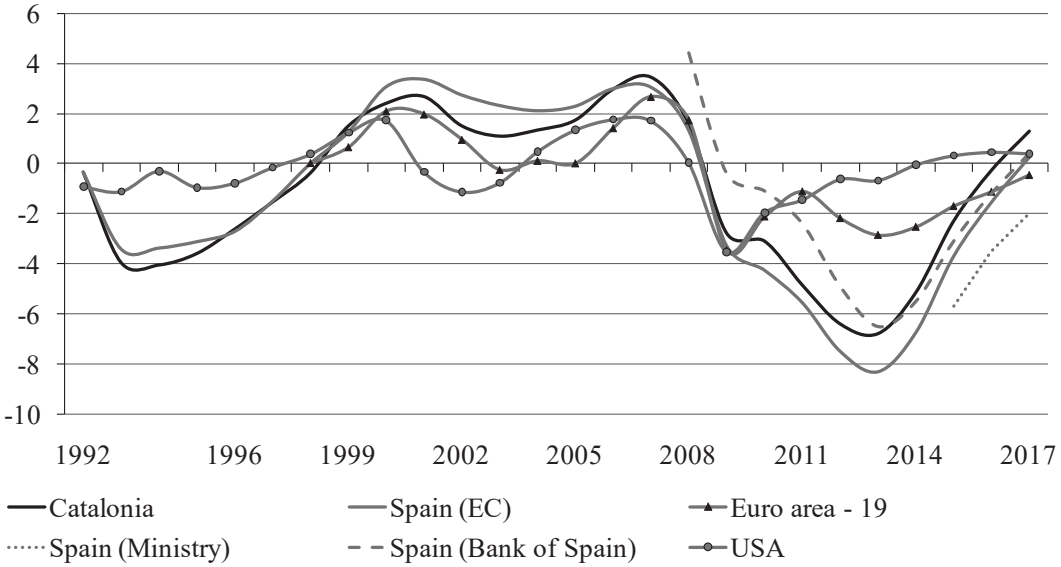
Regarding the cyclical position, three main stages in the Catalan economy stand out since 1995. The first stage, of expansion, covers the period from 1995 to 2007, with the exception of the years 2001, 2002 and 2003. The OG presents a positive stance, even though a set of macroeconomic imbalances build up during this period; in particular, an increase in private indebtedness, a loss of competitiveness and an accumulation of unsustainable current account deficits as well as oversized real estate and financial sectors. The unfolding of the crisis and the unwinding of previous macroeconomic imbalances has proved very costly in terms of potential output. The OG has run into negative values since 2009, with a minimum reached in 2013 (-6.8%). Afterwards, the Catalan economy moved on to a recovery stage, which allowed for a gradual closing of the OG.

The trajectory of the Catalan OG is very similar to that of other advanced economies, and especially to that of Spain (see Figure 5.14)[13], although there are statistically significant differences between the cyclical positions of Spain and Catalonia. Compared with the euro area OG, two main differences arise. First, as expected, cyclical conditions are more variable in Catalonia, and second, there was a markedly different profile in the last crisis; during 2010 and 2011 the cyclical position of the Catalan economy worsened, while that of the euro zone recovered.

According to the macroeconomic and demographic scenarios for the coming years (see Appendix section 7.3), the Catalan OG is expected to be close to equilibrium, in line with the euro area. Nevertheless, this new equilibrium presents noticeable challenges to be faced with, in particular the high structural unemployment rate. This labour market imbalance may dampen economic growth in addition to having adverse effects on poverty, social inclusion and equal opportunities for young people.

[13] As mentioned previously (see footnote 8), the EC's estimates for Spain do not always coincide with those of the Spanish Ministry of Economy and Competitiveness, even though both organizations are using the same methodology. To be specific, in the 2016 Stability Programme the OG of the Spanish economy stood at -5.6% in 2015, whereas the EC's spring estimates (European Commission, 2016) pointed to -3.7%. The results of our analysis are comparable to the above-mentioned vintage of the EC.

Figure 5.14. OG in Catalonia, Spain and the Euro area
(as a percentage of potential GDP)



Source: Own compilation based on data from EC, INE, BBVA-Ivie Foundation and Idescat.

4. Estimation of the structural balance of the Generalitat of Catalonia

Change in the primary structural balance, as mentioned in section 2.4, is an approach to the fiscal effort of governments. This approach, in conjunction with the estimation of the cyclical position of the Catalan economy, allows an appraisal of the orientation of the Generalitat of Catalonia's FP. Nevertheless, it should be noted that the fiscal stance of SCGs is not comparable to that of general governments. In the following, we discuss several reasons that make this comparison inappropriate in the Spanish case.

First, the capacity to respond of SCGs over the economic cycle is less than that of CG. Fiscal autonomy on the revenue side is less than that of CG, which conditions SCGs' responsiveness over the cycle. In addition to lower taxing power than the CG, the advance payment system (concerning the common regime AC's financing system) is at the core of remarkable distortions in the distribution of resources over the cycle, with negative outcomes in terms of fiscal illusion and fiscal autonomy (see a more detailed discussion in Cuenca, 2015), which may limit the appropriateness of SCGs' fiscal stance over the cycle. Cyclical sensitivity regarding the expenditure side also differs greatly between tiers of government, as SCGs'

responsibilities are mainly unrelated to the cycle (as their focus lies on health, education and social services). Thus, a pro-cyclical fiscal stance on the part of an SCG may be particularly damaging. Second, the orientation of ACs' FP is conditioned by the CG's discretionary allocation of budget targets between tiers of government, the observance of which allows access to the regional liquidity mechanism provided by the CG. Therefore the discretionary nature of the regional budget balance in bad times may be somewhat dubious, as ACs' fiscal performance is greatly conditioned by the CG. Despite the above-mentioned constraints, it is worth exploring the fiscal stance of regional governments, as regional spending accounts for 1/3 of non-financial public expenditure in Spain. Moreover, this sort of analysis is justified by legal imperatives as well as by the fiscal autonomy of ACs that still remains.

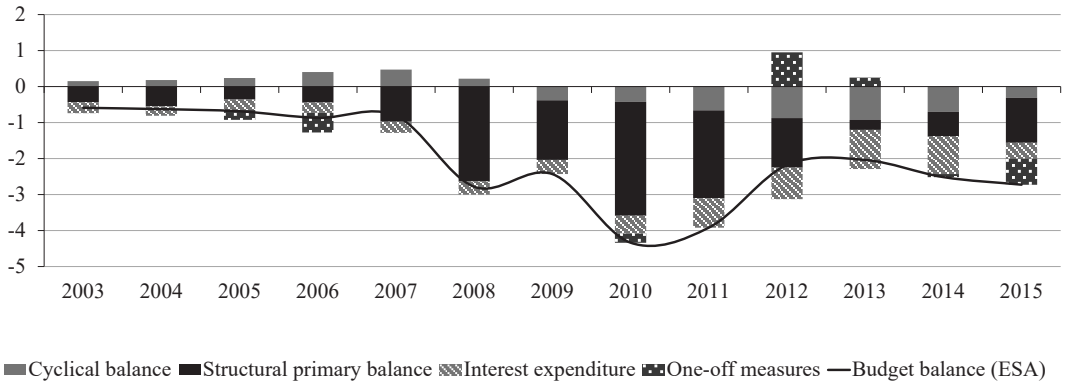
In this section, after indicating the statistical sources used in the analysis, we provide a decomposition of the Generalitat of Catalonia's budgetary balance in accordance with section 2.4, and an appraisal of the Generalitat's fiscal stance bearing cyclical conditions and debt dynamics in mind.

The estimation of the primary structural balance is based on the Generalitat of Catalonia's budgetary data (in accrual terms), the cyclical position of the Catalan economy (which depends on the results in section 3) and a specific semi-elasticity for the AC of Catalonia (see Table A5.6 in Appendix section 7.5). Our estimates suggest a semi-elasticity of 0.14, whereas official estimates for the Spanish general government stand at 0.48 (Mourre et al., 2014). These results are to be expected when considering the size of the public sector and the composition of revenue and expenditure.

Figure 5.15 reveals a deficit position over the period under analysis (2003-2015). The primary structural balance is the main determinant of the budget balance dynamics, especially after 2007. The contribution of this component lost ground after 2010, even though it has regained its importance since 2014; this trend reflects the beginning of the fiscal consolidation process in 2010 and its slowdown in 2014. The cyclical part of the budget balance plays a secondary role throughout the period analysed, although in some years its role is notable, i.e. from 2012 to 2014. The more negative contributions are registered in those years when OG yields more negative values.

It is also necessary to highlight the increasing role of interest expenditure since 2010, except for 2015 when the financial conditions of the liquidity mechanisms offered by the CG improved substantially. These liquidity mechanisms (that have been in force since 2012) have allowed for significant reductions in the cost of new debt issuances, which are connected to the dynamics of CG's interest rates (see Generalitat of Catalonia, 2016b). However, these mechanisms come at a cost of strengthened fiscal conditionality and budgetary surveillance (see Viver Pi-Sunyer and Martín, 2013). Finally, the role of one-off and other temporary measures should also be considered. Their role has been limited, but not negligible in some years, especially since 2012.

Figure 5.15. The evolution of the budget balance of the Generalitat of Catalonia and the contribution of its key factors (as a percentage of GDP, except cyclical balance and primary structural balance as a percentage of potential GDP)

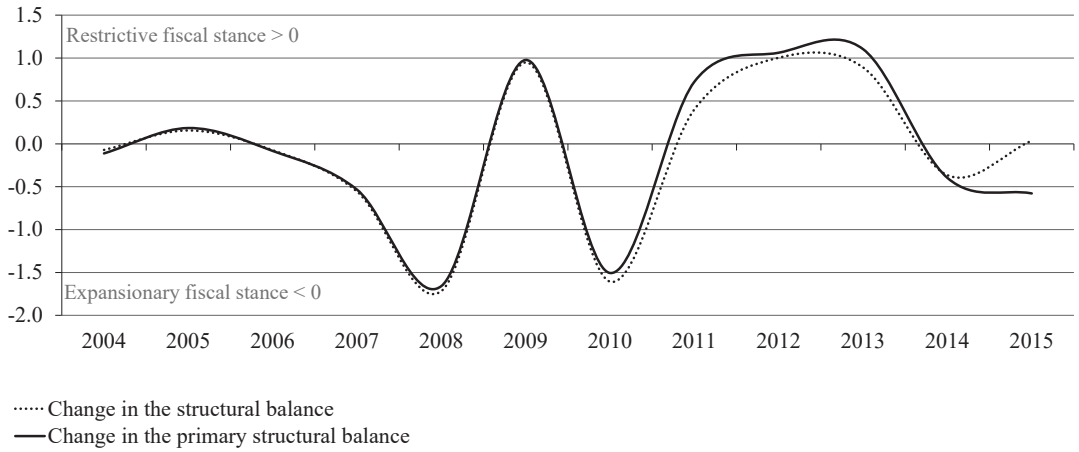


Source: Own compilation based on data from Idescat and Ministry of the Vice-presidency and of the Economy and Finance.

In general it can be stated that the FP stance of the Generalitat of Catalonia has been pro-cyclical since the year 2004, except for the first budgetary response to the crisis and the recovery period beginning in the second half of 2013 (see Figures 5.16 and 5.17). In a first stage, until 2008, an expansionary and increasingly pro-cyclical fiscal stance was adopted. It should be pointed out that the increase in expenditure stood at 13.6% in 2008 (see Generalitat of Catalonia, 2016a), although it was the first year in which the cyclical position worsened. In addition, it was also when the first fall in revenue occurred, with drastic falls in that of the totally ceded taxes of 25.5% in both 2008 and 2009. The 2009 improvement in primary

structural balance is an outlier, explained by forecast inaccuracy regarding the advance payment system and additional resources related to the regional financing system approved in that year. In 2010, the FP turned into a markedly expansive and counter-cyclical fiscal stance. The fall in regional financing system revenue (-14.2%) and spending stability led to a worsening of the primary structural balance. Then, from 2011 through 2013, the fiscal consolidation process gained in strength, thereby shifting to a pro-cyclical fiscal stance again. At this point it is worth noting that the fiscal adjustment was more reliant on expenditure cuts than on tax increases[14]. Finally, in 2014 and 2015 there was a loosening of the fiscal stance, especially when not taking interest expenditure into account.

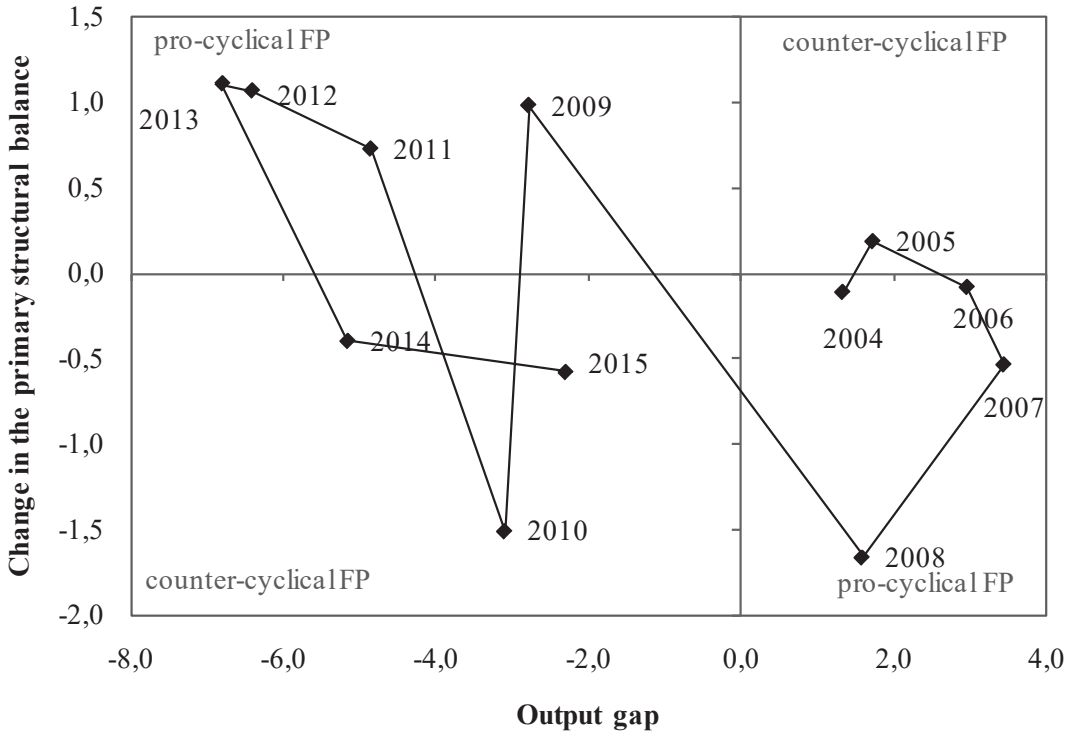
Figure 5.16. Orientation of the FP of the Generalitat of Catalonia (I out of III). Change in the structural balance and in the primary structural balance (as a percentage of potential GDP)



Source: Own compilation based on data from Idescat and Ministry of the Vice-presidency and of the Economy and Finance.

[14] Revenue-raising reforms from 2012 to 2014 represent in cumulative terms 2.1% of GDP, whereas expenditure adjustments attain 3.2% of GDP from 2011 to 2014 (see Generalitat of Catalonia, 2016a).

Figure 5.17. Orientation of the FP of the Generalitat of Catalonia (II out of III). Cyclical position and change in the primary structural balance (as a percentage of potential GDP)



Source: Own compilation based on data from Idescat and Ministry of the Vice-presidency and of the Economy and Finance.

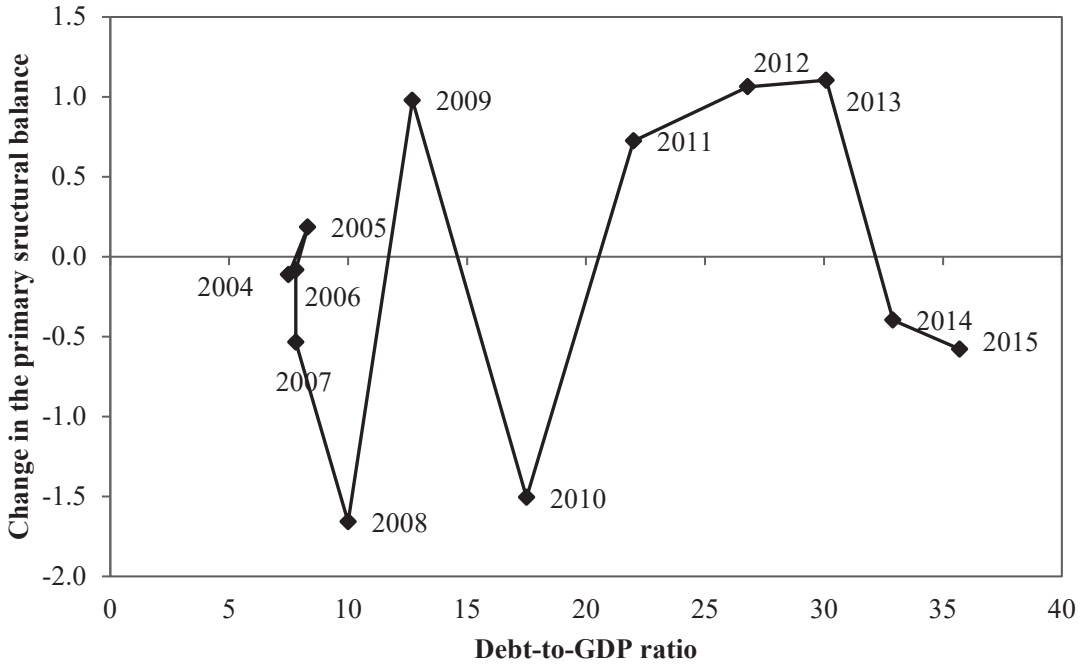
The orientation of the FP, however, has also to be considered together with the sustainability requirements of public finances. Thus, it is convenient to appraise the fiscal stance along with the evolution of the debt of the Generalitat of Catalonia. The debt-to-GDP ratio presents a sharp increase after 2008, which slows down two years later. At the time of writing this analysis, the last available data is related to the third quarter of 2016, when the debt ratio stood at 35.6% of GDP. In this analysis, we take advantage of the fiscal space literature to assess the sustainability requirements of the Generalitat[15]. In the third chapter of this thesis we provide evidence of a nonlinear relationship between the primary balance and the public debt of ACs as a whole, which points to a fiscal fatigue situation for high levels of the debt ratio. We estimate a confidence interval that places the debt limit

[15] We define fiscal space following the proposal of Gosh et al. (2013), that is, the distance from the debt ratio to the debt limit. This limit indicates the threshold from which the dynamics of debt become explosive.

between 24% and 36% of GVA. Despite these being estimates for ACs as a whole, and as such they do not allow any specific inferences to be made, we can state that the fiscal space of the Generalitat has been reduced severely. The perennial deficit of the Generalitat throughout the period analysed and especially the budgetary impact of the last financial and real estate crisis are the main reasons that lie behind this trend.

In short, the increase in the indebtedness of the Generalitat in the last 10 years has clearly reduced its fiscal space, and thus in coming years a prudent fiscal position is advisable to ensure a sustainable debt trajectory and to regain the capacity for response to potential negative shocks (Gosh et al., 2013). There are several ways, not mutually exclusive, of tackling the lack of fiscal space of the Generalitat, apart from fiscal consolidation. The following proposals are not only for the Generalitat, but also for all Spanish regional level governments. First, particular attention must be given to the vertical and horizontal distribution of resources. In this regard, it is necessary to review the regional financing system in due time, as is established by law, though, this has not been implemented by the CG since 2014. Second, it is also necessary to strengthen the budgetary constraints of the ACs. In addition to enforcing reliable fiscal rules, it is essential to reinforce both fiscal and financial autonomy. Among other proposals, the reform of the advance payment system and a gradual reduction of dependence on the central government's liquidity mechanisms are pressing needs, concerning fiscal and financial autonomy respectively. Third, when regional public finances become sounder, it would be interesting to assess the appropriateness of regional rainy-day funds (see e.g. Cuenca, 2015, and Hernández de Cos and Pérez, 2015), a proposal that may contribute to both the sustainability and stabilisation of these finances. Finally, it is also crucial to boost potential output by means of structural reforms (Domenech and González-Páramo, 2017).

Figure 5.18. Orientation of the FP of the Generalitat of Catalonia (III out of III). Fiscal stance (as a percentage of potential GDP) **and debt-to-GDP ratio** (%)



Source: Own compilation based on data from Idescat, Ministry of the Vice-presidency and of the Economy and Finance, and the Bank of Spain.

5. Conclusions

This chapter has provided an estimation of the potential GDP and OG of the Catalan economy, as well as an assessment of the fiscal stance of the Generalitat of Catalonia. Our estimates are based on the EC methodology, which facilitates comparison with other European economies. However, estimates of the cyclical position as well as the fiscal effort of the Generalitat are subject to several limitations which suggest taking the results with due caution, including those surrounding macroeconomic and demographic scenarios. In addition, the literature (see e.g. Marcellino and Musso, 2011, and Darvas, 2016) casts doubts on the reliability of these measurements in real time, as there are noticeable sources of uncertainty (in particular, those related to potential parameter instability). In the Appendix section 7.6 we provide a preliminary assessment of alternative estimates of Catalan OG based on UC models, which point to similar findings.

As regards potential GDP, our results suggest that since 1995 the Catalan economy has moved from an expansive stage, in which potential GDP grew at a rate of almost 3%, to a stage in which the capacity for growth decreased. This slowdown of potential GDP is not a phenomenon exclusive to the Catalan economy but also to be found in the rest of the advanced economies.

Since the onset of the real estate and financial crisis, the accumulation of productive factors (labour and capital) has no longer been the main driver of Catalan economic growth, but has been replaced by TFP. However, the contribution of TFP during most years has only partially offset the stagnation of capital stock as well as the fall in the potential labour supply. Therefore, measures to foster innovation and internationalization, as well as the enhancement of human capital are essential to reinforce this capacity for growth over the coming years (BBVA Research, 2015*b)*, in addition to an appropriate regulatory environment (Gual et al. 2006). This area for improvement (regarding TFP) is conspicuous in the Catalan economy, as TFP is not playing the same role as in leading economies such as the US[16].

Investment efforts are also essential to reinforce the recovery of the Catalan economy, although these efforts should be better targeted than during the last expansive stage. In this sense, the improvement of financial conditions for the private sector in peripheral euro area countries, a more gradual fiscal consolidation and advances in non-banking funding sources could favour an environment more attractive to investment.

Since the outbreak of the crisis, potential labour supply has been pushed downward by a high structural unemployment rate as well as working age population dynamics. In this regard, policies dealing with active labour market measures, human capital, innovation and competition are crucial to tackling structural unemployment. The role of the working age population is also extremely important. In this case, it is important to tackle declining natural growth and migration policies. Overall, the Catalan economy faces great challenges against a backdrop of recovery, which calls for measures to ensure medium and long-term potential growth.

[16] Serrano et al. (2017) provide an estimate for the relative TFP of the Spanish economy (with respect to the US); in 2015 Spanish TFP remained 44 percentage points below.

Estimates of potential GDP provide an indicator for inferring the cyclical position, the so-called OG. A positive OG can be identified in the pre-crisis period, attaining its peak in 2007. After the outbreak of the crisis, the Catalan economy developed a widening negative gap that continues until 2013. From that time forward, there has been a gradual correction of this gap, in connection with the medium-term macroeconomic and demographic scenarios. Our estimates indicate the closure of the OG in approximately 2016 and 2017.

Against this backdrop, the appropriateness of the fiscal stance of the Generalitat of Catalonia is assessed, revealing that there has been a pro-cyclical stance since 2004, except for the period of the first budgetary response to the crisis and the recovery period beginning in the second half of 2013. This pro-cyclical behaviour is worrisome since the Generalitat is responsible for principal areas of the welfare state (education, health and social services). This pro-cyclical character of FP is a widespread situation at state level in the euro area (see García Perea and Gordo, 2016, p.58). However the orientation of SCGs' FP is not comparable to that of states for several reasons. First, fiscal autonomy on the revenue side is less than that of CG, which conditions SCGs' responsiveness over the cycle. Second, cyclical sensitivity regarding expenditure differs greatly between tiers of government, as SCGs' responsibilities are mainly unrelated to the cycle. Thus, a pro-cyclical fiscal stance on the part of SCGs may be particularly damaging. Third, the orientation of ACs' FP is conditioned by the CG's discretionary allocation of budget targets between tiers of government, the observance of which allows access to regional liquidity mechanisms provided by the CG. Therefore the discretionary nature of regional budget balances in bad times may be somewhat dubious.

In the years to come, available fiscal space may condition FP stance. It is necessary to regain some room to deal with potential negative shocks, such as the worsening of financial conditions. Our OG estimates point to closure in 2016-2017, which would call for a neutral fiscal stance. Later on, if the Catalan economy progresses towards an expansive phase, a more restrictive fiscal stance would be advisable, in order to dampen the economic cycle as well as to restore the above-mentioned fiscal space.

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7. Appendix

7.1. Analytical framework for the structural unemployment rate

In this section we deal with the theoretical foundations of the Phillips curve and the state-space modelling of the structural unemployment rate.

7.1.1. *Traditional Phillips curve*

The Phillips curve postulates a negative relationship between the unemployment gap (C_t) and the expected growth of real unit labour costs ($\Delta RULC_t^e$).

$$\Delta RULC_t^e = -\gamma C_t \qquad \text{(A1)}$$

Inflation expectations are a core element in the specification of this relationship. The Traditional Phillips curve assumes static expectations (that is, $\Delta P_t^e = \Delta P_{t-1}$) or adaptive expectations about inflation (that is, $P_t^e = P_{t-1}^e + \lambda(P_{t-1} - P_{t-1}^e)$. The result of this set of assumptions leads to the standard Phillips curve, that is to say, in terms of the acceleration of nominal unit labour costs ($\Delta^2 NULC_t$).

$$\Delta^2 NULC_t = -\gamma C_t \qquad \text{(A2)}$$

If adaptive expectations are assumed, this Traditional Phillips curve can be formulated with more lags and other exogenous variables, especially labour productivity (LP_t) and terms of trade (TOT_t). This specification was employed by the EC in all countries until the spring of 2014 and is actually still in use for Austria, Belgium, Germany, Italy, Luxembourg, Malta, the Netherlands and the United States.

$$\Delta^2 NULC_t = \sum\nolimits_{\mathrm{i}} \rho_i \Delta LP_{t-i} + \sum\nolimits_{\mathrm{i}} \omega_i \Delta TOT_{t-i} - \sum\nolimits_{\mathrm{i}} \gamma_i C_{t-i} \qquad \text{(A3)}$$

7.1.2. *New Keynesian Phillips curve*

Since the spring of 2014, the EC has used the New Keynesian Phillips curve in the countries in which the structural unemployment rate is more pro-cyclical. The formation of expectations is the main difference with respect to the traditional curve. Rational expectations are introduced as well as several assumptions regarding the time when wages are fixed (in the middle of the year rather than at the beginning). However, the

macroeconomic literature considers that a strictly forward-looking specification is not realistic (Galí and Gertler, 1999). Thus, empirical studies often use a hybrid formulation, which enables a combination of a backward-looking behaviour with a forward-looking one:

$$\Delta RULC_t = \beta(s\Delta RULC^e_{t+1} + (1-s) * \Delta RULC_{t-1}) - \gamma C_t \qquad \text{(A4)}$$
where $\beta \leq 1$ i $0 \leq s \leq 1$

, where *s* indicates the share of forward-looking wage setters while β the discount factor. In fact, this specification corresponds with a traditional Phillips curve when *s* = 0 (no forward-looking behaviour) and $\beta = 1$.

When a second order autoregressive process is assumed for the unemployment gap, the previous specification can be expressed in the following terms (this is the empirical specification used by the EC regarding the NAWRU):

$$\Delta RULC_t = \varphi\Delta RULC_{t-1} - \gamma_1 C_t + \gamma_2 C_{t-1} + u_t \qquad \text{(A5)}$$

7.1.3. *State-space modelling*

The methodology of the EC for estimating the structural unemployment rate relies on the state-space approach, where the unemployment gap is identified by means of a Phillips curve.

The state-space modelling of the New Keynesian Phillips curve is as follows (see Havik *et al*., 2014, for more analytical details):

$$U_t = P_t + C_t \qquad \text{(A6)}$$

$$\Delta RULC_t = \varphi\Delta RULC_{t-1} - \gamma_1 C_t + \gamma_2 C_{t-1} + u_t \qquad \text{(A7)}$$

$$u_t = \sum_i \theta_i \epsilon_{t-i} \qquad \text{(A8)}$$

$$C_t = \delta_{c1} C_{t-1} + \delta_{c2} C_{t-2} + v_t \qquad \text{(A9)}$$

$$P_t = \mu_t + P_{t-1} + z_t \qquad \text{(A10)}$$

$$\mu_t = \mu_{t-1} + a_t \qquad \text{(A11)}$$

That is, it encompasses two measurement equations, the unemployment rate (U_t) and the growth rate of real unit labour costs ($\Delta RULC_t$), and four equations containing the state transitions. The unemployment rate is expressed as the sum of a permanent component (P_t) and a cyclical component (C_t), while the growth of real unit labour costs is determined by the Phillips curve framework. Regarding the states, the error term of the Phillips curve follows a moving average process; the cyclical component of the unemployment rate an $AR(2)$ process; the permanent component of the unemployment rate, a random walk with a drift (μ_t), and this drift, a random walk. Finally, a white noise error term (v_t, z_t and a_t) is included for the cyclical and permanent component of the unemployment rate as well as for the above-mentioned drift.

Table A5.1. Estimation of the structural unemployment rate

Parameters and selected statistics

	Coefficient	Statistic t
Phillips curve		
ϕ	0.42	(2.68)***
γ_1	-0.04	(-2.56)**
γ_2	0.02	na[1]
Cyclical component of the unemployment rate		
δ_{c1}	1.36	(9.53)***
δ_{c2}	-0.64	(-5.25)***
Residual independence		
Ljung-Box statistic Phillips curve (p-value = 0.22)		
Ljung-Box statistic unemployment gap (p-value = 0.57)		
Sample		1990-2017

Note: [1] Not available. Fixed parameter.

7.2. Analytical framework for the structural TFP

As mentioned previously, TFP captures the portion of GDP growth not explained by the contribution of production factors. The EC uses a Cobb-Douglas production function to represent GDP (Y) by means of the endowments of production factors -capital stock (K) and labour (L)- and the indicator of technical efficiency, that is, TFP. Both factors of production are corrected by the degree of utilisation (U_L and U_K), as well as for the efficiency of the utilisation of these factors (E_L and E_K).

$$Y = (U_L LE_L)^{\alpha}(U_K KE_K)^{1-\alpha} = L^{\alpha}K^{1-\alpha} * TFP \quad \text{(A12)}$$

$$TFP = \left({E_L}^{\alpha}{E_K}^{1-\alpha}\right)\left({U_L}^{\alpha}{U_K}^{1-\alpha}\right) = \frac{Y}{L^{\alpha}K^{1-\alpha}} \quad \text{(A13)}$$

The EC methodology for estimating structural TFP is very similar to that of the structural unemployment rate. In this case the cyclical component is identified from the degree of capacity utilisation in the economy (see Havik *et al*., 2014, for more analytical details). The state-space modelling of structural TFP is as follows:

$$TPF_t = P_t + C_t \quad \text{(A14)}$$

$$CUBS_t = \alpha + \beta C_t + u_t \quad \text{(A15)}$$

$$u_t = \sum_i \theta_i \epsilon_{t-i} \quad \text{(A16)}$$

$$C_t = \delta_{c1} C_{t-1} + \delta_{c2} C_{t-2} + v_t \quad \text{(A17)}$$

$$P_t = \mu_t + P_{t-1} + z_t \quad \text{(A18)}$$

$$\mu_t = \gamma \mu_{t-1} + a_t \quad \text{(A19)}$$

That is, it encompasses two measurement equations, the TFP and the degree of capacity utilisation in the economy ($CUBS_t$), and four equations containing the state transitions. The TFP can be expressed as the sum of a permanent component (P_t) and a cyclical component (C_t), while the degree of capacity utilisation in the economy is related to the cyclical component of TFP. Regarding the states, the error term in the Phillips curve is approximated by a moving average process; the cyclical component of the TFP, by an *AR*(2); the permanent component of the TFP, by a random walk with a drift (μ_t), and this drift, by an *AR*(1). Finally, a white noise error term (v_t, z_t and a_t) is included for the cyclical and permanent component of TFP as well as for the above-mentioned drift.

Table A5.2. Estimation of the structural TFP

Parameters and selected statistics

	Coefficient	Statistic t
Phillips curve (CUBS vs TFP cyclical component)		
β	3.15	(5.62)***
TFP cyclical component		
δ_{c1}	0.81	(3.93)***
δ_{c2}	0	0
TFP structural component		
μ	0.0061	(2.18)**
γ	0.87	(10.70)***
Residual independence Ljung-Box statistic Phillips curve (p-value = 0.00) Ljung-Box statistic TFP gap (p-value = 0.41)		
Sample		1986-2017

7.3. Medium-term macroeconomic scenario

Table A5.3. Medium-term macroeconomic scenario

(annual % change, unless otherwise indicated)	2015	2016	2017
GDP (2010 base)			
Real GDP	3.3	2.9	2.7
Nominal GDP	3.9	3.9	4.0
Total factor productivity[1]	1.4	0.9	0.6
Gross capital formation	6.2	5.5	4.3
Labour market			
Employed population	2.9	2.4	2.2
Average hours worked per employee	-0.4	0.1	0.3
Compensation of employees	0.6	0.9	1.4
Unemployment rate[2]	18.6	16.6	15.0
Prices			
GDP deflator	0.5	1.0	1.3
Private consumption deflator	-0.2	-0.1	1.2

Notes: [1] Contribution to real GDP growth (in percentage points).
[2] Population in unemployment / active population) x 100.
Source: Ministry of the Vice-presidency and of the Economy and Finance.

7.4. Comparative results

Table A5.4. Comparative results (I out of II)

	GDP (annual % change)			Potential GDP (annual % change)			Output gap (%)		
	Catalonia	Spain	Euro area	Catalonia	Spain	Euro area	Catalonia	Spain	Euro area
1992	1.4	0.9	-	3.9	3.0	-	-0.3	-0.3	
1993	-1.0	-1.0	-	2.6	2.1	-	-4.0	-3.4	
1994	2.7	2.4	-	2.8	2.3	-	-4.1	-3.4	
1995	3.2	2.8	-	2.7	2.5	-	-3.6	-3.1	
1996	3.0	2.7	-	2.0	2.2	-	-2.6	-2.7	
1997	3.2	3.7	-	2.0	2.4	-	-1.5	-1.5	
1998	3.6	4.3	3.0	2.4	2.7	-	-0.4	0.0	0.0
1999	5.3	4.5	3.0	3.3	3.2	2.3	1.5	1.2	0.7
2000	4.4	5.3	3.9	3.4	3.4	2.4	2.4	3.1	2.1
2001	4.3	4.0	2.2	3.9	3.7	2.3	2.7	3.4	2.0
2002	2.7	2.9	1.0	3.8	3.5	2.0	1.5	2.7	0.9
2003	3.1	3.2	0.7	3.5	3.6	1.9	1.1	2.3	-0.2
2004	3.2	3.2	2.3	2.9	3.4	1.9	1.3	2.1	0.1
2005	3.5	3.7	1.7	3.0	3.5	1.8	1.7	2.3	0.0
2006	4.0	4.2	3.2	2.7	3.5	1.8	3.0	3.0	1.4
2007	3.5	3.8	3.1	3.0	3.7	1.8	3.5	3.0	2.7
2008	0.4	1.1	0.5	2.2	2.8	1.4	1.6	1.3	1.7
2009	-3.5	-3.6	-4.5	0.8	1.0	0.6	-2.8	-3.3	-3.5
2010	0.3	0.0	2.1	0.6	1.0	0.7	-3.1	-4.2	-2.1
2011	-2.0	-1.0	1.6	-0.2	0.4	0.6	-4.9	-5.5	-1.1
2012	-2.5	-2.6	-0.9	-0.9	-0.6	0.2	-6.4	-7.5	-2.2
2013	-1.4	-1.7	-0.3	-0.9	-0.8	0.4	-6.8	-8.3	-2.8
2014	1.6	1.4	0.9	-0.1	-0.3	0.5	-5.1	-6.7	-2.5
2015	3.3	3.2	1.7	0.3	-0.0	0.8	-2.3	-3.7	-1.7
2016	2.9	2.6	1.6	0.8	0.4	1.0	-0.3	-1.5	-1.1
2017	2.7	2.5	1.8	1.1	0.7	1.1	1.3	0.3	-0.5

Sources: Ministry of the Vice-presidency and of the Economy and Finance, INE and EC (Spring 2016 vintage).

Table A5.5. Comparative results (II out of II)

	Unemployment rate (%)			Structural unemployment rate (%)		
	Catalonia	Spain	Euro area	Catalonia	Spain	Euro area
1992	13.4	17.0	-	14.9	17.2	-
1993	18.9	20.8	-	15.4	17.5	-
1994	20.9	22.0	-	15.0	17.1	-
1995	19.4	20.7	-	14.4	16.5	-
1996	18.5	19.9	-	14.0	16.0	-
1997	16.8	18.4	-	13.4	15.3	-
1998	14.1	16.4	10.4	12.7	14.6	9.3
1999	10.5	13.6	9.7	11.7	13.7	9.2
2000	8.7	11.9	8.9	10.9	13.1	9.1
2001	8.6	10.6	8.3	10.4	12.5	9.0
2002	10.2	11.5	8.6	10.3	12.5	8.9
2003	10.3	11.5	9.1	10.0	12.4	9.0
2004	9.7	11.0	9.3	10.1	12.4	9.0
2005	6.9	9.2	9.1	10.0	12.4	9.0
2006	6.5	8.5	8.4	10.6	12.8	9.0
2007	6.5	8.2	7.5	11.2	13.1	8.9
2008	8.9	11.3	7.6	12.1	14.0	9.1
2009	16.2	17.9	9.6	13.8	15.5	9.4
2010	17.7	19.9	10.2	14.2	16.0	9.4
2011	19.2	21.4	10.2	14.8	16.6	9.4
2012	22.5	24.8	11.4	15.8	17.5	9.6
2013	23.1	26.1	12.0	16.5	18.2	9.7
2014	20.3	24.5	11.6	16.7	18.3	9.7
2015	18.6	22.1	10.9	17.0	18.4	9.6
2016	16.6	20.0	10.3	17.1	18.4	9.6
2017	15.0	18.2	10.0	17.0	18.3	9.6

Sources: Ministry of the Vice-presidency and of the Economy and Finance, INE and EC (Spring 2016 vintage).

7.5. Budgetary semi-elasticity to OG

Budgetary semi-elasticity (ε) measures the reaction of the budget balance ratio to the relative variation of the OG. Following Mourre et al. (2014):

$$\varepsilon = \frac{d\left(\frac{B}{Y}\right)}{\frac{dY}{Y}} = \frac{d\left(\frac{R}{Y}\right)}{\frac{dY}{Y}} - \frac{d\left(\frac{E}{Y}\right)}{\frac{dY}{Y}} = \left[\frac{\frac{dR}{dY}Y - R\frac{dY}{dY}}{\frac{Y^2}{Y}}\right] - \left[\frac{\frac{dE}{dY}Y - E\frac{dY}{dY}}{\frac{Y^2}{Y}}\right] =$$

$$= \left[\frac{\frac{dR}{R}}{\frac{dY}{Y}} - 1\right]\frac{R}{Y} - \left[\frac{\frac{dE}{E}}{\frac{dY}{Y}} - 1\right]\frac{E}{Y} = (\eta_R - 1)\frac{R}{Y} - (\eta_E - 1)\frac{E}{Y} \quad \text{(A20)}$$

, where B, R, E, Y, η_R and η_E stand for budget balance, revenue, expenditure, GDP, revenue elasticity and expenditure elasticity respectively. In Table A5.6 we obtain this semi-elasticity for the Generalitat of Catalonia[17].

Table A5.6. Budgetary semi-elasticity: the case of Generalitat of Catalonia

	(A)	(B)	(C)=(A)*(B)	(D)=(C)-1	(E)	(F)=(D)*(E)
	Elasticities	Shares of revenue categories (% of total revenue) and expenditure categories (% of total expenditure)			Total revenue and expenditure (% of GDP)	Revenue, expenditure and budget balance semi-elasticity
Personal income tax	1.84	29.6	0.54			
Indirect taxes	1.00	34.4	0.34			
Regional financing system transfers from central government	1.42	0.5	0.01			
Other revenue	0	35.5	0.00			
TOTAL revenue		100	0.89	-0.1	12.6	-0.01
TOTAL expenditure	0	100	0	-1.0	15.0	-0.15
Budget balance						0.14

Notes and sources: Individual elasticities based on Mourre et al. (2014) and Spanish Ministry of Economy and Competitiveness (2016). Budgetary data covers the period 2012-2015. Total revenue and expenditure refer to non-financial revenue and expenditure respectively, which are based on national accounts data of the IGAE (Spanish Ministry of Finance and Civil Service). Shares of revenue categories are based on budgetary data of the Generalitat of Catalonia.

[17] Díaz Mendoza et al. (2015) also estimate this semi-elasticity for all ACs, obtaining 0.15 semi-elasticity for Catalonia. It is worth mentioning that their estimates are based on the 2012-2014 period while individual elasticities are based on previous OECD estimates.

7.6. Modelling of Catalan potential GDP based on unobserved components models

A natural approach to estimating a latent variable, i.e. potential GDP, is to formulate a UC model that relates this unobserved variable to observables such as unemployment, inflation, investment, credit growth or residential price growth. UC models are widely used at state level whereas there are very few contributions at regional level. In this section we provide a preliminary analysis of the Catalan cyclical position based on UC models. This analysis includes alternative estimates as well as an assessment based on its reliability and usefulness for inflation and GDP growth forecasting performance.

7.6.1. *Empirical framework and estimation results*

There are two main types of UC models for estimating potential GDP, one based on the statistical properties of the series under consideration and another based on macroeconomic relationships (Hjlem and Jönsson, 2010). In the first group, we are going to explore some of the seminal contributions to the field, that is, the work of Watson (1986) and that of Clark (1987). In the second group we will explore, on the one hand, a Phillips curve model of price adjustment, following the seminal work of Kuttner (1994), and on the other hand, a system which is built upon an Okun's law relationship. The state-space representation is quite similar to the one by Domenech (2013), although employment is used instead of the unemployment rate.

As regards data sources, GDP and employment data are drawn from Spanish Regional Accounts (INE). Retrospective estimations (for the period previous to 1980 for GDP and 1986 for employment) are drawn from de la Fuente (2010). Unemployment data comes from the INE, investment from BBVA-Ivie, while Idescat provides the degree of capacity utilisation in the economy.

The purpose of our work is to evaluate the cyclical position of the Catalan economy, by separating the permanent (yp_t) and cyclical component (yc_t) of real output (y_t).

$$y_t = yp_t + yc_t \tag{A21}$$

Before turning to the econometric results, a summary of the estimated UC models is listed below. The state-space representation of the models covered is presented according to RATS conventions (for further details, refer to chapter 10 in Estima, 2012):

$$Y_t = \mu_t + C_t' X_t + V_t \tag{A22}$$

$$X_t = A_t X_{t-1} + Z_t + F_t W_t \tag{A23}$$

,where Y_t are the observable data, μ_t the exogenous shift in the observables, X_t are the unobservable or state variables, C_t the loadings from those states to observables, V_t the measurement errors, A_t the transitional matrices, Z_t the exogenous shift in the states, F_t the loadings from those shocks to states and W_t the shocks to the states.

The optimum estimator for all these models is the Kalman filter, which is an algorithm for solving state-space models in the linear case, where the parameters of the models are usually estimated by maximum likelihood methods. First, a summary of the estimated UC models is listed below, and after we present the results of our estimates.

7.6.1.1. *Model 1. Watson (1986)*

Watson (1986) uses a UC model that consists of the sum of a non-stationary trend model and a stationary cycle model. The trend is a local trend with fixed rate while the cycle is modelled as a stationary AR(2) process.

$$y_t = yp_t + yc_t \tag{A24}$$

$$yp_t = \alpha_{yp} + yp_{t-1} + \varepsilon_{ypt} \tag{A25}$$

$$yc_t = \gamma_1 yc_{t-1} + \gamma_2 yc_{t-2} + \varepsilon_{yct} \tag{A26}$$

, where ε_{ypt} and ε_{yct} are the shocks.

The state-space form of the modelled system (according to RATS conventions):

$Y_t = y_t = \ln(gdp_t)$; $X_t = (yp_t, yc_t, yc_{t-1})'$

$C_t' = (1,1,0)$; $Z_t = (\alpha_{yp}, 0,0)'$

$$A_t = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \gamma_1 & \gamma_2 \\ 0 & 1 & 0 \end{pmatrix}; F_t = \begin{pmatrix} 1 & 0 \\ 0 & 1 \\ 0 & 0 \end{pmatrix}; W_t = \begin{pmatrix} \varepsilon_{ypt} & 0 \\ 0 & \varepsilon_{yct} \end{pmatrix}$$

7.6.1.2. *Model 2. Clark (1987)*

Clark (1987) builds a model based on Watson (1986), with a varying local trend rate. The model has two unit roots and two stationary roots. This model introduces more flexibility, but its economic interpretation is more dubious (see an assessment in section 2.3).

$$y_t = yp_t + yc_t \tag{A27}$$

$$yp_t = \alpha_t + yp_{t-1} + \varepsilon_{ypt} \tag{A28}$$

$$\alpha_{t+1} = \alpha_t + \varepsilon_{\alpha t} \tag{A29}$$

$$yc_t = \gamma_1 yc_{t-1} + \gamma_2 yc_{t-2} + \varepsilon_{yct} \tag{A30}$$

, where $\varepsilon_{ypt}, \varepsilon_{\alpha t}$ and ε_{yct} are the shocks.

The state-space form of the modelled system (according to RATS conventions):

$Y_t = y_t = \ln(gdp_t)$;

$X_t = (yp_t, \alpha_{t+1}, yc_t, yc_{t-1})'$

$C_t' = (1,0,1,0)$

$$A_t = \begin{pmatrix} 1 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & \gamma_1 & \gamma_2 \\ 0 & 0 & 1 & 0 \end{pmatrix}; F_t = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{pmatrix}; W_t = \begin{pmatrix} \varepsilon_{ypt} & 0 & 0 \\ 0 & \varepsilon_{\alpha t} & 0 \\ 0 & 0 & \varepsilon_{yct} \end{pmatrix}$$

7.6.1.3. *Model 3. Kuttner (1994)*

Kuttner (1994) was the first to estimate potential output as a latent variable using a Phillips curve model of price adjustment, where the level of output is systematically related to inflation; in particular, the output cycle (yc_t) is related to changes in inflation ($\Delta\pi_t$). It is worth noting that the error term in the Phillips curve is approximated by a moving average process.

$$y_t = yp_t + yc_t \tag{A31}$$

$$\Delta\pi_t = \alpha_\pi + \beta yc_t + z_t + \theta_1 z_{t-1} \tag{A32}$$

$$yp_t = \alpha_P + yp_{t-1} + \varepsilon_{ypt} \tag{A33}$$

$$yc_t = \gamma_1 yc_{t-1} + \gamma_2 yc_{t-2} + \varepsilon_{yct} \tag{A34}$$

, where ε_{ypt}, ε_{zt} and ε_{yct} are the shocks.

The state-space form of the modelled system (according to RATS conventions):

$$Y_t = (\ln(gdp_t), \Delta\pi_t)'; X_t = (p_t, c_t, c_{t-1}, z_t, z_{t-1})'; \mu_t = (0, \alpha_\pi)'$$

$$C_t{}' = \begin{pmatrix} 1 & 1 & 0 & 0 & 0 \\ 0 & \beta & 0 & 1 & \theta_1 \end{pmatrix}; Z_t = (\alpha_P \quad 0 \quad 0 \quad 0 \quad 0)'$$

$$A_t = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & \gamma_1 & \gamma_2 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \end{pmatrix}; F_t = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{pmatrix}; W_t = \begin{pmatrix} \varepsilon_{ypt} & 0 & 0 \\ 0 & \varepsilon_{yct} & 0 \\ 0 & 0 & \varepsilon_{zt} \end{pmatrix}$$

7.6.1.4. *Model 4. GDP and employment*

We have also attempted to add more structure to the Watson model by introducing an equation that relates the employment cycle (ec_t) with the output cycle (yc_t). The specification used for the employment cycle equation is taken from Domenech (2013). In fact, it is quite similar to an Okun's Law relationship but employment data is used instead of the

unemployment rate. This choice was made for data availability reasons, as we have had regional employment data since 1955 whereas unemployment rate data has only been available since 1978.

$$y_t = yp_t + yc_t \tag{A35}$$

$$e_t = ep_t + ec_t \tag{A36}$$

$$yp_t = \alpha + yp_{t-1} + \varepsilon_{ypt} \tag{A37}$$

$$yc_t = \gamma_1 yc_{t-1} + \gamma_2 yc_{t-2} + \varepsilon_{yct} \tag{A38}$$

$$ep_t = \omega + ep_{t-1} + \varepsilon_{ept} \tag{A39}$$

$$ec_t = \delta ec_{t-1} + \beta\gamma_1 yc_{t-1} + \beta\gamma_2 yc_{t-2} + \beta\varepsilon_{yct} + \varepsilon_{ect} \tag{A40}$$

, where ε_{ypt}, ε_{yct}, ε_{ept} and ε_{ect} are the shocks.

The state-space form of the modelled system (according to RATS conventions):

$Y_t = (y_t, e_t) = \big(\ln(gdp_t), \ln(employment_t)\big)'$

$X_t = (yp_t, yc_t, yc_{t-1}, ep_t, ec_t)'$

$$C_t{}' = \begin{pmatrix} 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 \end{pmatrix}$$

$$Z_t = (\alpha \quad 0 \quad 0 \quad \omega \quad 0)'$$

$$A_t = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & \gamma_1 & \gamma_2 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & \beta\gamma_1 & \beta\gamma_2 & 0 & \delta \end{pmatrix}$$

$$F_t = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & \beta & 0 & 1 \end{pmatrix}; W_t = \begin{pmatrix} \varepsilon_{ypt} & 0 & 0 & 0 \\ 0 & \varepsilon_{yct} & 0 & 0 \\ 0 & 0 & \varepsilon_{ept} & 0 \\ 0 & 0 & 0 & \varepsilon_{ect} \end{pmatrix}$$

7.6.1.5. *System estimates*

In the Table A5.7 we present parameter estimates for the proposed models[18]. We have considered two samples as a major structural break affects our data in the mid-seventies. In this period the Catalan economy went through three major changes: a) the exhaustion of an economic model that had begun in the sixties, with the end of Spanish autarky; b) the international oil crisis; c) the arrival of democracy. In the full sample estimates (1955-2014) a dummy is introduced in the GDP trend component (which takes the value 1 for the period 1975-2014) to capture the new environment that affected the Catalan economy[19,20]. Estimates for the 1980-2014 period are also interesting as they are not affected by the above-mentioned structural break. In general terms reasonable parameter estimates are obtained, although some caveats should be made.

Naive results have been obtained for the trend output in models 1, 2 and 3: a linear trend is identified in models 1 and 3, and a parabola in model 2. The linear and parabola results are related to the non-significant estimate for the variance of the permanent GDP component (*e_yp*). The differences between the linear and the parabola results may be due to the fixed trend rate specified in Watson and Kuttner's model, whereas in Clark's model the GDP trend follows a local trend model.

When considering employment data (model 4) the smoothed states look more reasonable but are still far from being reliable. In this regard, GDP and the employment trend still look too linear. In fact, the variance for the employment cycle (e_ec) is not significant and neither is the variance for the employment trend (e_ep) in the 1955-2014 period. These results suggest that sometimes the GDP cycle can be chosen to help fit both series (GDP and employment). Some restrictions on the trend such as pegging relative variance may be needed to avoid this situation. In fact, this is how the EC

[18] Estimates were done with RATS 8.2. A program containing RATS code for UC models is available on request. Initial guess values were obtained from OLS estimates of the equations that had been put forward, where cycle and trend components were proxied using the HP filter.

[19] This break was confirmed by the Lumsdaine-Papell unit root test (1997), which is available on request.

[20] The parameter estimates are not reasonable when these models are estimated without the mentioned dummy, with the exception of the Clark model which takes the GDP trend as an I(2) process.

approach works but in our opinion these subjective constraints are neither a transparent nor satisfactory empirical strategy.

Table A5.7. System estimates for UC models

	Model 1 Watson (1986)		Model 2 Clark (1987)		Model 3 Kuttner (1987)		Model 4 GDP & Employment	
GDP Cyclical fluctuations								
γ_1	1.37	1.60	1.43	1.61	1.37	1.60	1.61	1.66
	(24.95)***	(30.94)***	(16.72)***	(23.91)***	(25.06)***	(33.93)***	(57.11)***	(33.59)***
γ_2	-0.52	-0.72	-0.49	-0.71	-0.54	-0.72	-0.68	-0.79
	(-9.35)***	(-13.42)***	(-6.76)***	(-9.69)***	(-9.47)***	(-14.76)***	(-23.99)***	(-15.36)***
GDP / Employment Trend component								
α (gdp trend)	0.06	0.02			0.06	0.02	0.06	0.02
	(68.98)***	(11.45)***			(80.07)***	(12.67)***	(24.75)***	(14.14)***
dummy_1975	-0.04				-0.04		-0.04	
	(-33.32)***				(-38.1)***		(-12.45)***	
Ω (employment trend)							0.01	0.02
							(9.1)***	(9.64)***
Standard deviations								
ε_yp	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(10.86)***	(5.84)***
ε_yc	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01
	(10.86)***	(8.25)***	(10.08)***	(8.12)***	(10.9)***	(8.31)***	(10.86)***	(7.14)***
ε_α			0.01	0.00				
			(1.92)*	(0.00)				
ε_π					0.02	0.01		
					(10.77)***	(8.11)***		
ε_ep							0.00	0.01
							(0.00)	(3.43)***
ε_ec							0.00	0.00
							(0.00)	(0.00)
Okun's Law								
δ							0.08	0.06
							(0.86)	(0.77)
β							1.35	1.24
							(13.24)***	(13.37)***
Phillips curve								
α					0.00	0.00		
					(-0.51)	(-3.55)***		
β					0.08	0.03		
					(1.78)*	(1.57)		
θ					-0.18	-0.64		
					(-1.33)	(-3.43)***		
Sample	1955-2014	1980-2014	1955-2014	1980-2014	1955-2014	1980-2014	1955-2014	1980-2014
Independence (Ljung-Box statistic p-value)	0.19	0.25	0.36	0.47	0.00	0.00	0.00	0.00
Homoscedasticity (Goldfeld-Quandt heterocedasticity test p-value)	0.00	0.92	0.00	0.25	0.00	0.85	0.00	0.98
Normality p-value	0.06	0.74	0.01	0.80	0.07	0.76	0.01	0.59
Log-Likelihood	142.0	88.6	130.5	83.4	281.5	184.2	307.30	189.70

Notes: *** significance at 99% & ** 95% & * 90%. t-statistics are reported within brackets.

Despite the foregoing, the parameter estimates look reasonable. We obtain stationary roots for the GDP cycle (note that the stationarity condition requires $\gamma_1 + \gamma_2 < 1$). The estimates for the fixed trend rate in the case of GDP and employment also look reasonable. For instance, in model 1 (sample 1980-2014) the 0.02 estimate indicates an average growth of the

GDP trend of 2%. Moreover, we should highlight that the coefficient that relates the GDP cycle to change in inflation (in the Phillips curve) and that which relates GDP cycle to the employment cycle (Okun's Law) also look plausible. Both are significant and have the expected signs, with the exception of the Phillips curve in the 1980-2014 sample. Nevertheless, the latter result is in line with recent literature (Borio et al., 2013), as inflation has in recent times become less indicative of macroeconomic imbalances.

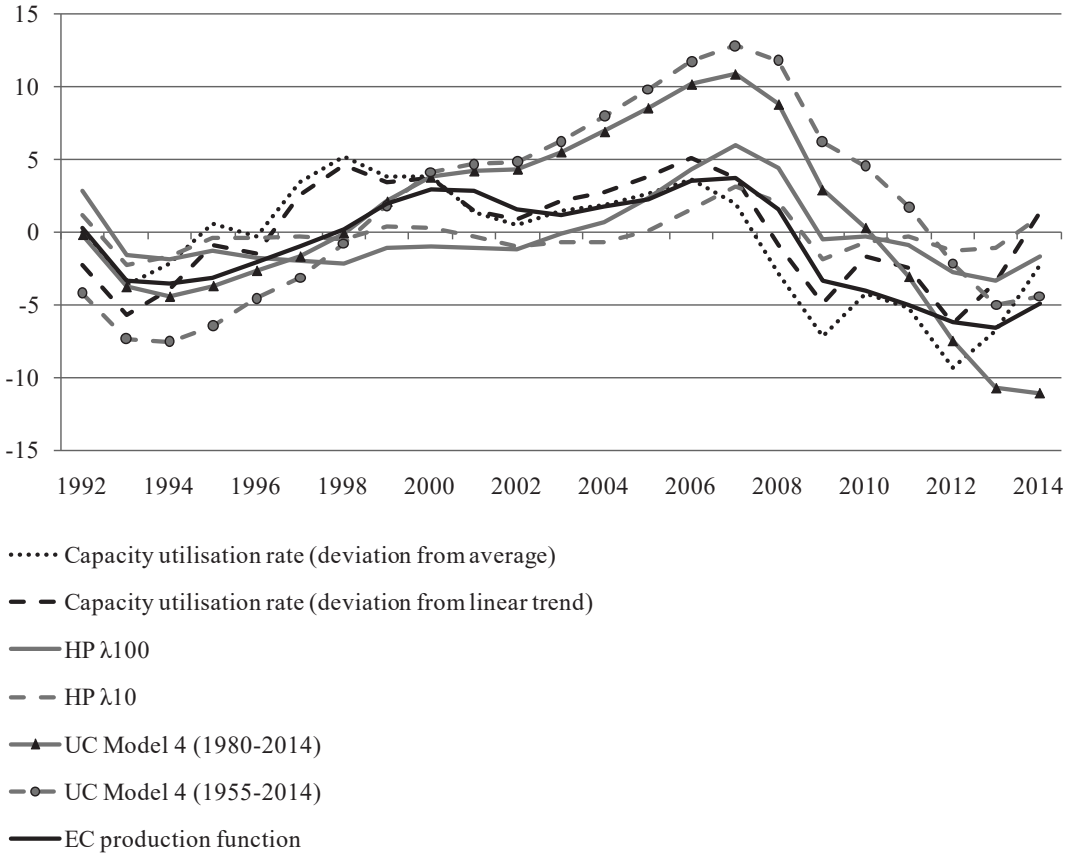
In further research, it would be interesting to explore more complex specifications that use more than one macroeconomic relationship, which may enable us to narrow down the uncertainty of parameter estimates. In this connection, Apel and Jansson (1999) build a system of equations that is comprised of a Phillips curve and an Okun's law relationship. Domenech and Gómez (2005) take into account the information content of the unemployment and investment rates to build a state-space representation for the Spanish economy. And Borio et al. (2013) include information about the financing cycle, in particular credit and property prices, as it is important to bear in mind the extent to which financial conditions foster or constrain economic activity.

7.6.2. *Assessment of results*

The assessment of our OG estimates is based on their correlation with standard measures of slack, the uncertainty of these estimates and their usefulness for inflation and GDP growth forecasting performance. This strategy is based on the seminal work of Orphanides and van Norden (2002), which was applied to the euro area by Marcellino and Musso (2011).

In order to assess our OG estimates (those of the EC production function approach and UC models), we also provide alternative estimates that cover the HP filter and measurements based on capacity utilisation rates (deviation from the average and deviation from a linear trend). As regards UC models, we only evaluate "model 4" estimates, since measurements based on Watson (1986), Clark (1987) and Kuttner (1994) provide naive results, namely a linear trend or a parabola for trend output.

Figure A5.1. Final estimates of Catalan OG and other slack indicators (%)



Source: Idescat and own estimates.

First, we evaluate our OG estimates by means of their correlation with standard measures of slack (such as the capacity utilisation rate or the unemployment rate) as well as other cyclical indicators (investment-to-GDP ratio, GDP growth, GDP deflator growth). The OG estimates are expected to be correlated with these measures.

A first inspection of these correlations in Table A5.8 indicates that estimates based on EC PF methodology present a strong association with standard measures of economic slack. However the PF approach has a head start as these variables are taken into account in this method. Correlations with the OG estimates of UC models differ according to the sample considered. Estimates for the 1955-2014 sample present unexpected correlations, whereas correlations with estimates for the 1980-2014 sample behave as expected. In both cases we can highlight a weak correlation with GDP but a strong association with the investment-to-GDP ratio as well as

the unemployment rate. Hodrick and Prescott estimates also provide the expected association although less intensely. Finally, it is worth highlighting the intense correlation of capacity utilisation rate measurements with other cyclical indicators as well as other OG estimates, in particular when measured as deviation from the average.

Table A5.8. Correlation between OG final estimates and other cyclical indicators

	HP λ10	HP λ100	EC production function	UC Model 4 (1955-2014)	UC Model 4 (1980-2014)	Capacity utilisation rate (deviation from average)	Capacity utilisation rate (deviation from linear trend)
Output gap estimates and other slack indicators							
HP λ10	1.00						
HP λ100	0.78	1.00					
EC production function	0.55	0.63	1.00				
UC Model 4 (1955-2014)	0.52	0.73	0.69	1.00			
UC Model 4 (1980-2014)	0.48	0.77	0.88	0.89	1.00		
Capacity utilisation rate (deviation from average)	0.41	0.29	0.80	0.27	0.54	1.00	
Capacity utilisation rate (deviation from linear trend)	0.57	0.38	0.78	0.53	0.59	0.89	1.00
Other cyclical indicators							
GDP deflator (% change)	0.16	0.33	0.59	-0.01	0.41	0.60	0.27
GDP (% change)	0.37	0.20	0.67	0.22	0.41	0.88	0.83
Investment rate (% of GDP)	0.37	0.62	0.85	0.80	0.92	0.50	0.52
Unemployment rate (%)	-0.58	-0.72	-0.97	-0.82	-0.93	-0.69	-0.75

Note: Sample period is 1992 to 2014 in all cases (23 observations).

7.6.2.1. *Uncertainty of the OG estimates and other slack indicators*

The proposal of Marcellino and Musso (2011) suggests evaluating the uncertainty surrounding OG estimates by means of an analysis covering the following dimensions: model uncertainty, parameter uncertainty, parameter instability and data uncertainty. First, model uncertainty is related to the lack of consensus on the method for obtaining OG estimates. Therefore, it is convenient to present alternative estimates. Second, parameter uncertainty is related to the estimation of the parameters, which (at the end of the day) will provide our OG estimates. This uncertainty may be captured by confidence bands. Third, recursive estimation is another source of changes in OG estimates as it may induce parameter instability. Finally, changes in data vintages may also introduce uncertainty in our OG estimates. In this section we will cover the above-mentioned sources of

uncertainty, with the exception of the data dimension as we do not have a real time dataset.

Alternative OG estimates are provided in Figure A5.1, the final estimates of which are summarised in Table A5.9. Gaps based on UC models deviate most from zero, in particular when taking into account the 1955-2014 sample. This deviation is not a desirable outcome, as the mean is expected to be zero, but this result may be explained by the short sample considered in the assessment (that is, from 1992 to 2014). UC models also present a higher variability in OG estimates, in contrast to HP estimates. The EC PF approach and capacity utilisation measurements are somewhere in the middle, but closer to HP estimates in terms of variability. It is also worth highlighting the greater persistence in UC models and EC PF approach, where first order autoregressive coefficient of final estimates is above 0.9.

Table A5.9. Final estimates of Catalan OG and other slack indicators. Summary statistics

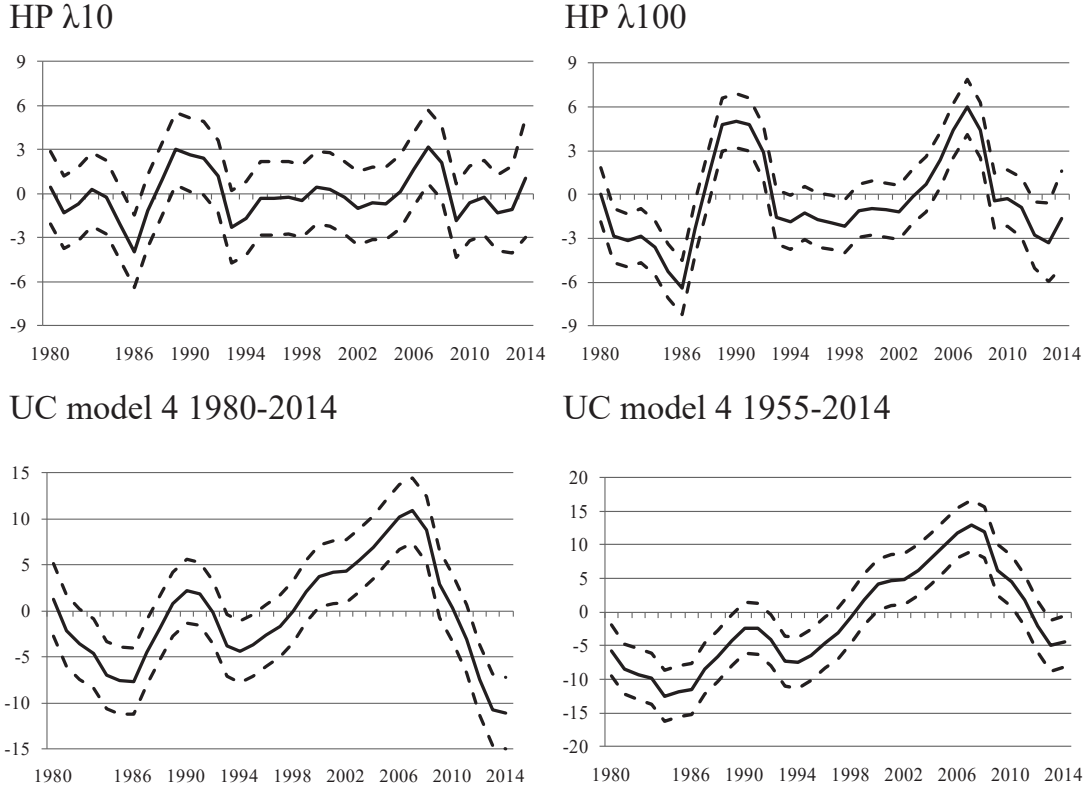
	Mean	Standard deviation	Minimum value	Maximum value	AR(1)
Capacity utilisation rate (deviation from average)	-0.6	3.9	-9.3	5.3	0.80
Capacity utilisation rate (deviation from linear trend)	0.1	3.2	-6.3	5.1	0.71
HP λ10	-0.1	1.5	-2.3	3.2	0.37
HP λ100	-0.2	2.8	-3.3	6.0	0.73
UC Model 4 (1955-2014)	1.9	6.5	-8.4	12.9	0.94
UC Model 4 (1980-2014)	0.9	5.8	-11.1	10.9	1.00
EC production function	-0.8	3.3	-6.5	3.8	0.92

Note: Sample period is 1992 to 2014 in all cases (23 observations).

All these models require the estimation of parameters, which are subject to uncertainty. In this regard, providing confidence bands for OG estimates is a useful approach to the extent of parameter uncertainty, which is especially worrisome around turning points (in particular when dealing with real-time estimates). In Figure A5.2 confidence bands for HP and UC model based

gaps are provided[21]. It is worth noting the sign uncertainty in HP OGs at the end of the sample.

Figure A5.2. Confidence bands for OG final estimates based on UC models



Note: We have only considered the stochastic nature of GDP potential.

Next, we deal with parameter instability by means of an analysis of final vs pseudo-real-time estimates (that is, rolling estimates over the final

[21] To this end, the HP filter may be represented as a UC model, in particular as a local trend model (see e.g. Doan, 2010):

$$y_t = yp_t + \varepsilon_{yt} \quad \text{(A41)}$$

$$yp_t = yp_{t-1} + \alpha_{t-1} \quad \text{(A42)}$$

$$\alpha_t = \alpha_{t-1} + \varepsilon_{\alpha t} \quad \text{(A43)}$$

$$\sigma^2_{\varepsilon_y} / \sigma^2_{\varepsilon_\alpha} = \lambda \quad \text{(A44)}$$

, where y_t *and* yp_t are real and permanent output respectively, α_t is the local trend rate, ε_{yt} and $\varepsilon_{\alpha t}$ are the shocks, and λ is a restriction between the measurement variance to the trend rate variance. This ratio is usually 100 x P^2, where P is the number of periods per year.

dataset)[22]. This exercise is provided for HP, UC models and measurements based on the degree of capacity utilisation in the economy. Pseudo-real-time data analysis based on the EC PF approach is out of the scope of the thesis[23].

These recursive computations (Table A5.10 and Figure A5.3) reveal sizeable revisions, especially regarding UC model based gaps (including HP)[24]. By contrast, revisions of measurements based on capacity utilisation rates are milder (in particular when measured as deviations from the average). In the latter case, the average revision stands at 1 percentage point. The correlation between "final estimates" and "pseudo-real-time estimates" also indicates similar results, although the UC model 4 ranks much better. It can also be seen that more than 80% of the time the level of "final estimates" and "pseudo-real-time estimates" present the same sign.

Table A5.10. Pseudo-real-time estimates of Catalan OG and other slack indicators. Summary statistics

		Mean	Standard deviation	Minimum value	Maximum value	AR(1)	Correlation (Pseudo RT, Final)	Correlation (Pseudo RT, Revision)	Sign
Capacity utilisation rate (deviation from average)	Pseudo RT	-4.0	4.0	-9.7	1.9	0.9	1.0	0.6	100
	Revision	1.0	0.7	0.0	1.8	0.9			
Capacity utilisation rate (dev. from linear trend)	Pseudo RT	-2.6	3.1	-7.2	1.4	0.7	0.9	0.3	90
	Revision	2.0	1.6	-0.2	4.1	0.9			
HP λ10	Pseudo RT	-0.9	1.5	-4.0	1.1	0.7	0.5	-0.4	80
	Revision	1.2	1.6	-0.8	4.0	0.8			
HP λ100	Pseudo RT	-2.7	2.8	-6.2	1.1	0.9	0.7	-0.2	90
	Revision	3.4	2.3	0.0	6.7	0.9			
UC Model 4 (1955-2014)	Pseudo RT	-0.5	5.8	-6.3	9.9	0.1	0.3	-0.5	60
	Revision	5.2	7.5	-3.6	19.1	0.6			
UC Model 4 (1980-2014)	Pseudo RT	-3.4	5.7	-11.1	3.8	1.0	0.9	0.6	80
	Revision	4.3	3.8	-2.1	7.8	0.9			

Notes: Sample period is 2005 to 2014 in all cases (10 observations). "Revision" refers to the difference between final estimates and pseudo-real-time estimates. "Sign" reports the percentage of times that the level of pseudo-real-time estimates is the same as that of final estimates.

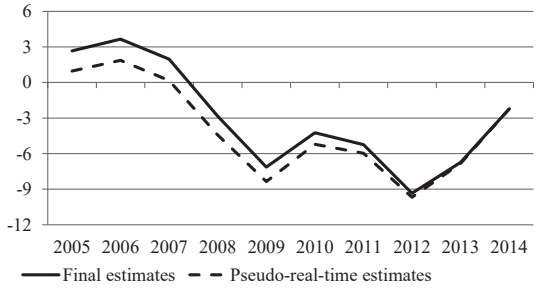
[22] "Final dataset" does not mean it is final data, but the last available data at the time of performing the current analysis.

[23] Nevertheless, Mc Morrow et al. (2015) offer a real-time evaluation of OG estimates based on the EC PF approach. Their results suggest a better performance of this "commonly agreed" reference method than HP filter gaps and the equivalent OECD and IMF methods. This analysis also points out noticeable OG errors in the pre-crisis period.

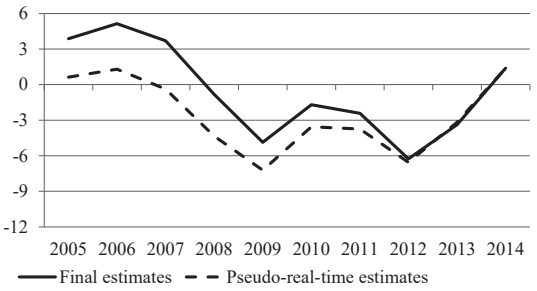
[24] Pseudo-real-time estimates for the UC model 4 based on the 1955-2014 period are not provided, due to convergence problems in the estimation for some years.

Figure A5.3. Final and pseudo-real-time estimates of Catalan OG and other slack indicators

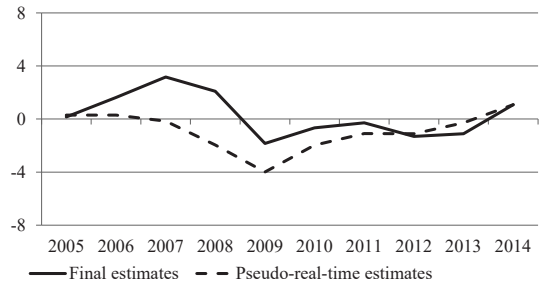
Capacity utilisation rate (deviation from the average)



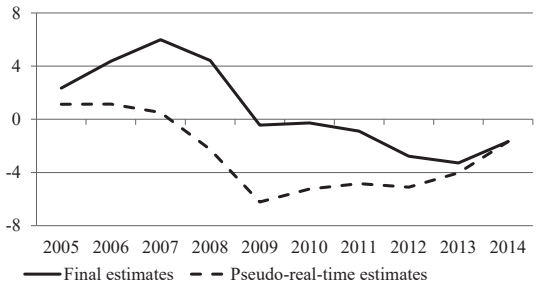
Capacity utilisation rate (deviation from a linear trend)



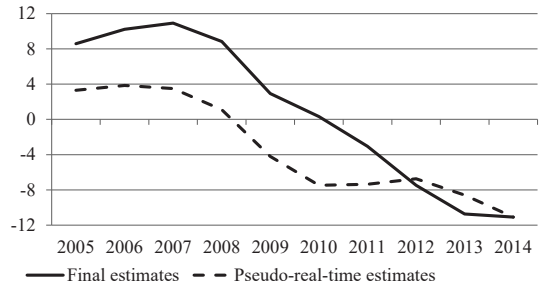
HP λ10



HP λ100



UC model 4 (1980-2014)



7.6.2.2. *GDP growth and inflation forecasting performance based on OG estimates and other slack indicators*[25]

Inflation and GDP growth forecasting performance are both needed as policy institutions often use OG estimates as a guide for macroeconomic policy. As Hjlem and Jönsson (2010) indicate the goal of this exercise is not to find the best forecasting model but to evaluate the relative merits of our OG estimates. Root mean squared error (RMSE) is used for measuring forecast errors. We present a relative RMSE, which is a ratio between the RMSE of the model in question and the RMSE of the benchmark model. When this relative RMSE statistic is lower than 1 our OG model outperforms the benchmark AR model. Our OG models consist of including OG estimates into the benchmark specification both in levels and first difference. The inclusion of the change in OG should capture the speed-limit effects (e.g. Fuhrer, 1995). The evaluation periods are 2006-2007 and 2013-2014 in order to analyse pre-crisis and post-crisis performance. Nevertheless, we should be cautious as pre-crisis evaluation is based on only 13 observations. In the box below we present common sample estimates to evaluate its R^2 in-sample statistic as well.

$$\pi_t = \alpha + \beta\pi_{t-1} + \varepsilon_t \tag{A45}$$

$$\pi_t = \alpha + \beta\pi_{t-1} + \gamma_1 OG_t + \gamma_2 \Delta OG_t + \varepsilon_t \tag{A46}$$

Equation estimates for the forecasting performance exercise (see Tables A5.11 and A5.12) reveal that the change in cyclical position is more relevant (in terms of explaining the GDP growth or the change in the GDP deflator) than the cyclical position itself. This result is interesting in itself as there is more uncertainty in the level of the OG than in the change of the OG (Darvas and Simon, 2015).

In the GDP growth forecasting contest, UC model 4 for the 1980-2014 sample ranks first, both in the post-crisis and pre-crisis period, and outperforms the naive model. The performance of measurements based on capacity utilisation rates when measured as deviation from the average is also notable, also outperforming the naive model. The PF model presents a slightly inferior forecasting performance than the naive specification,

[25] This assessment is based on OG final estimates. An interesting extension consists of performing the same evaluation by means of pseudo-real-time estimates.

whereas HP models are even worse, especially the HP λ10 model. Finally, R^2 in-sample statistics also indicate better results for UC models.

Table A5.11. Real GDP growth forecasting performance based on OG final estimates and other slack indicators

Dependent variable: GDP $_t$ (% change)

		Output gap model						
	Naive	HP λ10	HP λ100	EC production function	UC Model 4 (1955-2014)	UC Model 4 (1980-2014)	Capacity utilisation rate (dev. from average)	Capacity utilisation rate (dev. from linear trend)
constant	0.01	0.00	0.01	0.02	0.02	0.03	0.02	0.01
	(1.37)	(1.02)	(4.19)***	(5.24)***	(8.27)***	(13.77)***	(3.48)***	(1.93)*
GDP $_{t-1}$ (% change)	0.62	0.77	0.46	0.00	-0.09	-0.19	0.21	0.48
	(3.53)***	(8.31)***	(4.72)***	(-0.02)	(-0.83)	(-2.37)**	(0.99)	(2.36)**
OG $_t$		-0.83	-0.22	0.32	0.02	0.03	0.36	0.22
		(-4.09)***	(-2.34)**	(2.85)**	(0.8)	(1.37)	(2.9)***	(1.53)
Δ OG $_t$		1.41	1.02	0.93	1.01	1.06	0.27	0.40
		(8.85)***	(8.35)***	(6.82)***	(10.56)***	(15.97)***	(2.13)**	(2.84)**
Sample	1993-2014							
Estimation method	OLS							
Adjusted R^2	0.35	0.87	0.85	0.83	0.90	0.95	0.81	0.75
DW	1.81	1.59	0.94	0.87	1.51	1.32	1.94	1.97
RMSE / RMSE Naive [1]	1.00	1.23	2.35	1.04	0.90	0.46	0.75	2.24
RMSE / RMSE Naive [2]	1.00	4.18	0.99	1.28	1.13	0.46	0.60	0.65

Notes: *** significance at 99% & ** 95% & * 90%. t-statistics are reported within brackets.

[1] RMSE relative to the benchmark model (Naive). Estimation sample 1993-2012. Ex-post forecast 2013-2014.

[2] RMSE relative to the benchmark model (Naive). Estimation sample 1993-2005. Ex-post forecast 2006-2007.

Lastly, in the GDP deflator growth forecasting contest, none of the models considered outperforms the naive model. That is to say, these results suggest that a simple AR(1) model would be less biased than more complex models. This is surprising as the PF methodology takes price dynamics into account in its estimation. However, these results also reveal the lower sensitivity of inflation to economic activity, in line with the findings of Borio et al. (2013)[26]. Disregarding the predictive power of the naive estimation, the PF approach ranks first in the pre-crisis period and third in the post-crisis period. UC models provide similar results to the PF methodology, while measurements based on capacity utilisation rates provide mixed results. In the latter case, when measured as deviation from

[26] See footnote 1. Nevertheless, Cuadrado and Moral-Benito (2016) provide interesting insights for the Spanish case, indicating a nonlinear relationship between inflation and economic activity. Their evidence points to a lower sensitivity in periods of moderate growth or mild contraction, whereas this sensitivity is higher when the slack is especially large.

the average, they rank first in the post-crisis period and fourth in the pre-crisis period. By contrast, when measured as deviation from a linear trend, they rank fifth in the post-crisis period and third in the pre-crisis period. Finally, we do not appreciate marked differences in R^2 in-sample statistics.

Table A5.12. GDP deflator growth forecasting performance based on OG final estimates and other slack indicators

Dependent variable: GDP deflator $_t$ (% change)

		Output gap model						
	Naive	HP λ10	HP λ100	EC production function	UC Model 4 (1955-2014)	UC Model 4 (1980-2014)	Capacity utilisation rate (dev. from average)	Capacity utilisation rate (dev. from linear trend)
constant	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00
	-0.48	(-0.26)	(0.22)	(1.2)	(1.61)	(2.15)**	(1.62)	(0.62)
GDP deflator $_{t-1}$	0.84	0.92	0.89	0.79	0.72	0.70	0.70	0.82
(% change)	(7.72)***	(9.31)***	(9.73)***	(7.44)***	(7.62)***	(7.11)***	(5.71)***	(7.57)***
OG $_t$		-0.10	-0.06	0.07	0.00	0.01	0.12	0.10
		(-0.67)	(-0.92)	(1.24)	(0.05)	(0.23)	(2.34)**	(1.81)*
Δ OG $_t$		0.37	0.32	0.24	0.24	0.24	0.00	0.03
		(2.7)**	(3.58)***	(2.46)**	(3.4)***	(3.44)***	(0.04)	(0.44)
Sample				1993-2014				
Estimation method				OLS				
Adjusted R^2	0.74	0.80	0.83	0.82	0.82	0.83	0.79	0.77
DW	1.55	1.64	1.86	1.67	1.61	1.70	1.60	1.60
RMSE / RMSE Naive [1]	1.00	1.55	1.66	1.25	1.22	1.33	1.05	1.42
RMSE / RMSE Naive [2]	1.00	1.80	2.91	1.07	1.29	1.07	1.39	1.10

Notes: *** significance at 99% & ** 95% & * 90%. t-statistics are reported within brackets.

[1] RMSE relative to the benchmark model (Naive). Estimation sample 1993-2012. Ex-post forecast 2013-2014.

[2] RMSE relative to the benchmark model (Naive). Estimation sample 1993-2005. Ex-post forecast 2006-2007.

7.6.3. *Conclusions*

In short, we have dealt with the capabilities of state-space models for estimating the Catalan OG. Seminal contributions to the field were assessed (Watson 1986; Clark 1987; Kuttner 1994) as well as that of Domenech (2013). The assessment of these alternative OG estimates raises doubts about their reliability in pseudo-real-time, especially regarding the uncertainty that comes from recursive computation (that is, parameter instability). It also points to the lack of usefulness of OG estimates for inflation forecasting, whereas it notes a limited usefulness for GDP forecasting. Overall, these preliminary results are in line with the related literature (see e.g. Marcellino and Musso, 2011), but further research is needed in order to improve their robustness at regional level.

In the near future, it would be interesting to embed other macroeconomic relationships. In this connection it would be worth exploring the link between the GDP cycle and the current account balance (Darvas and Simon, 2015) or between the GDP cycle and financial conditions (Borio, 2013). Other avenues of research consist in exploring models based on quarterly data and structural VAR models with long-run restrictions to estimate the OG, in particular the seminal work of Blanchard and Quah (1989), and that of Enders and Hurn (2007), which considers an explicit international linkage and which could be very appealing as Catalonia is a small open economy. Also of interest is the model of Afonso and Claeys (2008), which establishes short and long-run restrictions on the effects of FP, one of the fields where indicators of the cyclical position make the most sense.

Chapter 6

Conclusions

Concerns over sustainability and the cyclical pattern of public finances have been especially great since the onset of the global financial crisis. This thesis aims to examine those concerns with regard to the Spanish ACs. Our analysis is to be seen in an evolving context in which we summarize the latest developments in Europe and in Spain, and in particular those concerning Spanish ACs. It is in this setting that we make our main contributions, connect them with the literature, and examine their policy implications as well as their limitations. Finally, we outline potential avenues of further research, mostly connected with the limitations we find.

In the European context both objectives, sustainability and the stabilising function of the public sector, were reinforced in the aftermath of the Great Recession. First, sustainability was reinforced by means of the reforms that took place during that time (the Six-Pack in 2011, the Fiscal Compact in 2012 and the Two-Pack in 2013). The focus on fiscal discipline was reflected, inter alia, in the balanced budget rule, the mechanism that has established a gradual convergence of the debt ratio towards the debt target of 60% of GDP, as well as in strengthened budgetary surveillance. Afterwards, attention was given to the cyclical pattern of FP in the 2015 reform and the proposals in the 2015 Five President's Report. The former laid out principles for a modulation of fiscal effort over the economic cycle under the preventive arm of the Stability and Growth Pact, whereas the latter contributed to the debate about a euro area macroeconomic stabilisation function (where options such as an investment protection

mechanism, an unemployment reinsurance fund and rainy day funds are being considered)[1].

Spain also shows the above-mentioned European trends, but more intensely. At first, after the Great Recession began, sustainability was a pressing concern, as the Spanish general government was on the edge of a fiscal cliff in the years 2009-2011 (Domenech and González-Páramo, 2017). Afterwards, the Spanish economy was in great need of stabilisation in a context with very limited fiscal space. In fact, the unemployment rate and the public debt ratio peaked in 2013 (26.1%) and 2014 (100.4%) respectively.

In the case of Spanish ACs the debate was focused mainly on sustainability issues, with recentralising trends that were revealed in the allocation of stability targets by the CG, the conditionality attached to the extraordinary liquidity mechanisms and the non-observance of the reform of the regional financing system (legally envisaged to be in force by 2014). The new budgetary regulation introduced in 2012 was inspired by European reforms. Medium targets were established in structural terms, although the allocation of stability targets took only headline deficits into account. In addition, individual targets were almost always set equal to the target established by the regional subsector. In this context, a new independent fiscal institution (AIREF) was established in 2013, focusing on the implementation of fiscal rules.

In the following, we locate our research within this background. First, we deal with our fiscal reaction function (FRF) analysis (Chapters 2 and 3). Then we move on to tax elasticities (Chapter 4) and finally, to the EU's approach to cyclical position and fiscal effort (Chapter 5).

Stabilisation and sustainability concerns were confirmed by our analysis based on fiscal reaction functions. Discretionary fiscal behaviour has been pro-cyclical, in a context of very limited fiscal space. This situation is especially worrisome as health, education and social services expenditures are within regional responsibilities.

[1] See an overview of the future evolution of EU's fiscal framework in European Fiscal Board (2017).

The cyclical response of FP and the primary balance reaction to debt accumulation are issues explored in great detail at international level (regarding general governments). In the literature that explores the FRF of Spanish ACs these issues are most of the time taken into account as control variables in order to test other hypotheses. Esteller-Moré and Solé-Ollé (2004) are concerned with sustainability but from a different angle, the bailout hypothesis. Argimón and Hernández de Cos (2012) propose a set of economic, political and institutional factors to explain the primary balance. In this case, as mentioned below, some attention is given to cyclicality. Barrios and Martínez (2013) explore the link between fiscal discipline and regional development differentials. Hernández de Cos and Pérez (2013) tackle regional debt dynamics, with special attention to the variables that capture market discipline. Molina-Parra and Martínez (2015) deal with vertical interactions across levels of government, while other studies are centered on the deviation of budget balances from budgetary targets, in particular Leal Marcos and López Laborda (2015), Lago Peñas et al. (2017) and Delgado Téllez et al. (2017).

As an innovation, in Chapter 2, we analyse not only the response of ACs' fiscal impulse (that is, the change in the primary balance) but also the response of the ACs' fiscal stance (that is, the change in the primary structural balance). The response of the former suggests counter-cyclicality over the period 1987-2008, but an a-cyclical impulse over the whole sample 1987-2012. Foral ACs stand out from other ACs, as their response is much more counter-cyclical, in line with the findings of Argimón and Hernández de Cos (2012). From an international perspective, the empirical evidence of the cyclical pattern of sub-central public finances is mixed. Rodden and Wibbels (2010) identify a pro-cyclical FP, whereas Von Hagen and Foremny (2013) identify counter-cyclical behaviour[2]. Our findings regarding the discretionary part of FP suggest pro-cyclical behaviour in line with the international evidence (see European Commission, 2006). This pro-cyclicality has sharpened since the last crisis and it differs across ACs.

In Chapter 3 we focus on the sustainability of regional public finances. The literature based on FRF for the Spanish case suggests a linear reaction (of

[2] From a different angle, Lago et al. (2018) analyse the effects of decentralisation on fiscal stability performance (regarding general governments). Their analysis suggests that decentralisation does not lead to macroeconomic instability.

primary balance to debt accumulation) or no reaction, with the exception of Esteller-Moré and Solé-Ollé (2004). We provide evidence of a nonlinear relationship between the primary balance and debt, which points to a situation of fiscal fatigue and reduced fiscal space. A noteworthy contribution is also the analysis of regional debt limit uncertainty, in connection with the approach of Gosh et al. (2013). In 2015 the regional debt ratio stood at 26.8% of Gross Value Added, slightly above our lower estimate for the debt limit (24%) and well below the upper estimate (36%). However, institutional factors cannot be detached from this debate, as shown in Chapter 2. The electoral cycle, expenditure decentralisation and per capita fiscal resources also play a role regarding sub-central fiscal performance.

Overall, these results suggest some policy implications for any effort to guarantee the fiscal stability and fiscal sustainability of regional governments. To start with, it is important to notice that stabilisation and sustainability outcomes are intertwined. In fact, a pro-cyclical FP in good times may lead to a deficit bias if it means providing demand support in bad times. By contrast, the creation of fiscal buffers in good times may contain debt increases in bad times that arise as a result of a counter-cyclical FP stance. At times, it is not possible to satisfy stabilisation and sustainability objectives simultaneously and it is thus important to strike the right balance between both (see European Commission, 2016). However, achieving both aims is not only about a technical trade-off but also about taking fiscal institutions into account, as can be seen in the proposals below.

Several proposals may foster the stabilisation of regional public finances: i) increasing revenue autonomy to cope with unexpected shocks and thereby avoiding bail out expectations (in particular, reducing the dependence on central government (CG) transfers and tax-sharing schemes and reforming the advanced payment system in order to reduce the lag between fiscal autonomy decisions and budgetary outcomes in cash terms), ii) modifying the tax basket, that is, assigning less volatile tax sources to ACs, iii) dealing with coordination failures between levels of governments (in particular dealing with the opportunistic behaviour of the CG in bad times; see e.g. Foremny et al., 2017), iv) establishing rainy day funds, in line with practices in other countries such as the US, v) increasing sub-central borrowing autonomy, as long as hard budget constraints can be ensured (in

this connection it is important to ensure a smooth return to financial markets for the most indebted ACs), vi) fighting against corruption and fostering fiscal accountability (it is much easier for governments to be held accountable for the use of revenue windfalls when voters are properly informed; see Solé-Ollé and Viladecans-Marsal, 2017) and vii) enforcing simple fiscal rules that do take into account credible and region-specific targets, as suggested in certain years by the Spanish independent fiscal institution (see e.g. AIREF, 2015).

Some of the above-mentioned proposals also have a direct influence on the sustainability of regional public finances. However, we cannot disregard additional strategies to restore fiscal space: i) the reform of the regional financing system in order to ensure an appropriate distribution of resources that guarantees a sustainable balance between the principles of autonomy and equity, while leaving behind the preservation of the status quo, (ii) ensuring vertical equity between tiers of government over time, that is a fair distribution of resources in connection with changes in expenditure needs (see a proposal by Castells et al. 2004), iii) enforcing simple, flexible and credible fiscal rules (Beetsma and Debrun, 2018), iv) enforcing structural reforms to boost potential output (Domenech and González-Parámo, 2017) and v) creating a clear crisis resolution system, in contrast to the emergency liquidity assistance provided by the CG since 2012 (Hernández de Cos and Pérez, 2015). In addition, it is worth mentioning some elements that may contribute to the effectiveness of fiscal rules in a decentralised setting: i) ensuring that consolidation programs create an equitable distribution of burden between tiers of government (Delgado Téllez et al., 2017), ii) fostering the complementary role between fiscal rules and independent fiscal councils (Wyplosz, 2018), iii) striking the right balance between the stringency of fiscal rules and fiscal autonomy (Foremny, 2014) and iv) avoiding excessive vertical fiscal imbalances (Kotia and Duarte Lledó, 2016).

Our FRF approach suffers from several limitations that point to several areas for further research. First, this analysis is based on a backward looking approach, that is, fiscal reaction for the coming years is not necessarily determined by past behaviour. In this sense it would be interesting to compare our results with the DSA framework in order to take into account the sustainability impact of the debt structure and expectations

around financial conditions and growth prospects (AIREF, 2017, provides an empirical implementation of this framework). Second, our cyclical conditions indicators are a proxy to the regional cyclical position, which could be evaluated with alternative measures such as the proposals of Borio et al. (2013) for the cyclical position, and Corrales et al. (2002) for the structural budget balance. Both proposals are based on UC models, a promising avenue of research, though especially challenging when considering data availability at a regional level. Third, another line of research consists of comparing ex-post with real-time assessments, in line with Golinelli and Momigliano (2009). This is an important area of research as policy is made in real-time environments. Fourth, some identification problems arose when evaluating the effect of fiscal autonomy (we obtain a non-significant effect over the 1987-2008 period and a negative effect when considering the whole sample). This result could be due to an insufficient degree of fiscal autonomy to cope with the huge imbalances caused by the crisis as well as the caveats regarding the fiscal autonomy indicator (as it is especially correlated with the dynamics of devolved taxes, which shrank much more than transfers throughout the crisis). In this regard, a comparative analysis of fiscal autonomy may be especially valuable (see an interesting contribution of Foremny, 2014). Moreover, in the years to come, in the specific case of Spanish ACs, it would also be very interesting to analyse the effects that dependency on the CG's extraordinary financial mechanisms may have on fiscal performance. Fifth, the role of fiscal rules is not explored in detail in this thesis. It would be interesting in coming years to explore the effectiveness of the fiscal rules implemented post-crisis in more detail, as well as the role of independent fiscal institutions (as more time is needed for a proper evaluation). Sixth, the role of fiscal coordination is not explored explicitly, although our estimation strategy allows for the capture of common shocks to all ACs (by means of the SUR estimation). In this regard, the opportunistic behaviour of the CG opens up interesting areas for further research (such as the contribution of Foremny et al., 2017).

Complexity in the cyclical pattern of tax revenue: dynamic elasticities, asymmetric responses over the cycle and regional heterogeneity on a per capita income basis. When endogeneity arises, conditioned by the observed values of the explanatory variables, OLS is a biased estimator but an unbiased predictor.

In Chapter 4 we provide an analysis of personal income tax elasticities. In contrast to previous contributions for Spanish ACs we explore dynamic elasticities. This has been a widespread practice in the latest contributions for general governments since the seminal works of Sobel and Holcombe (1996) and Bruce et al. (2006). We identify short and long-term elasticities as well as the adjustment pattern between both elasticities. A tax overreaction is identified when PIT revenue is above the long-run equilibrium while a typical error correction model response is obtained when PIT revenue is below it. Discussion of the dynamic adjustment is not a common practice in the international literature, with the exception of Koester and Priesmeier (2012) for Germany and Koester and Priesmeier (2017) for euro area countries. Both papers provide evidence of dynamic elasticities, that is, revenue not only reacts contemporaneously to changes in income but also afterwards. In fact, the latter work indicates strong evidence for dynamic elasticities in Spain. Some findings regarding cross-sectional variability should also be noted: short and especially long-run elasticities decrease with respect to per capita income. This pattern is in line with the previous literature based on cross-sectional data (Sanz-Sanz et al., 2016, is one of the finest examples). Another noteworthy contribution is the analysis of forecasting performance in the presence of an endogeneity relationship. Despite the OLS estimator bias, the superiority of OLS is shown, both analytically and empirically in terms of forecasting accuracy, in comparison to the IV estimator.

The accuracy of tax revenue forecasting is an important policy area, especially around turning points. In the Spanish case, tax revenue forecasting inaccuracy by the CG did not favour prudent behaviour on the part of ACs in the early stages of the crisis, in particular concerning the advance payments of the regional financing system. The first implication is that the notion of tax elasticity should be more flexible: both in the temporal and geographic dimension. However, we obtained very similar results between symmetric and asymmetric models when checking forecasting performance during the last recession. Second, it is important to notice the advisability of using OLS when our projections are based on knowledge of the explanatory variables X. Third, these results are not only valuable in terms of forecasting but also concerning cyclical adjustment methods and tax-mix policy.

The main limitations of this research arise first from only comparing forecasting performance over a crisis period (due to our sample availability). Therefore, despite comparing the forecasting performance of the symmetric and asymmetric models, we cannot be conclusive. It would be useful to compare forecasting performance over both crisis and expansion periods. Second, the difference between comparing forecasting and comparing models is important. We should bear in mind that comparing models by means of pseudo-out-of-sample forecasts may be suboptimal, as suggested by Diebold (2015). Third, our proxy to fiscal reforms is a simplifying assumption made to capture the main changes. Thus, it may be interesting to compare the effects of adjusting tax reforms following a narrative approach such as that of Gil et al. (2018).

Other potential areas for further research stem from comparing forecasts based on real-time and ex-post information (see e.g. Koester and Priesmeier, 2017). These authors suggest that dynamic models do not always outperform static models in real-time environments. Second, in connection to the tax mix policy (see e.g. Sobel and Holcombe, 1996) it would be especially valuable to obtain dynamic elasticities for other taxes, in particular those specific to SCGs. Third, another area of research is that related to the determinants of regional advance payments where political economy factors play an important role (electoral cycle, opportunistic behaviour of CGs, inter alia). We have explored tax elasticities under the accrual basis but it may also be very interesting to delve into the dynamics of these advance payments. Fourth, it may also be interesting to examine the dynamic nature of tax elasticities by means of a time-varying coefficients model. These models are based on UC models (see a proposal by Doan, 2010). Fifth, it may be worth exploring the link between tax elasticities and income inequality suggested by Creedy and Sanz-Sanz (2010). The simulations of these authors (based on a cross-section analysis) suggest that revenue elasticity increases with income inequality.

Fiscal stance and cyclical position are assessed at regional level by means of the EU's methodology. In short, the fiscal policy of the Generalitat of Catalonia has been pro-cyclical, except for the first budgetary response to the crisis and the recovery period beginning in the second half of 2013. Alternative pseudo-real time estimates of the output gap raise reliability concerns.

In Chapter 5 we apply for the first time (to the best of our knowledge) the EU's commonly agreed production function methodology at regional level. The measurement of the Catalan cyclical position allows for an assessment of the Generalitat of Catalonia's fiscal stance (also according to the EU's methodology)[3]. Our main results suggest that the cyclical position of the Catalan economy differs from that of Spain. Pro-cyclical behaviour is found in accordance with Chapter 2. However, this pro-cyclicality was not present during the first budgetary response to the crisis and the recovery period beginning in the second half of 2013. Another noteworthy contribution is related to some limitations of the EC methodology, in particular that of considering I(2) processes and that of relying on subjective restrictions of the hyperparameters. Alternative estimates of Catalan potential GDP based on unobserved components models are presented, which suggest shortcomings in their reliability and usefulness for inflation forecasting performance. These results are in line with Marcellino and Musso (2011).

The policy lessons from this analysis suggest considering region-specific targets according to sustainability and stabilisation needs, as opposed to the implementation of the Spanish budgetary stability framework. As for the case of the Generalitat of Catalonia, it is advisable to restore fiscal space in order to avoid pro-cyclical behaviour when bad times come again. In addition, the analysis of these methodologies suggests there is an increasing complexity in the EU's fiscal rules, which contrasts to relying on simple, flexible and enforceable rules as recommended by Beetsma and Debrun (2018).

The limitations of our approach are very much related to those of the EU methodology that have been emphasised in section 2.3 and 2.4 of Chapter 5. In this connection, it is worth pointing out the possibility of embedding other macroeconomic imbalances when measuring cyclical position, such as those derived from the financial cycle, external accounts and investment. Some promising approaches are the proposals of Borio et al (2013), Darvas and Simon (2015) and Doménech and Gómez (2005) respectively. Second, it should be pointed out that our analysis has not evaluated the reliability of EU estimates in pseudo-real time, as this is beyond the scope of our thesis. Nevertheless, Mc Morrow et al. (2015) offer a real-time evaluation of OG

[3] Both methodologies are explained in Havik et al. (2014) and Mourre et al. (2014) respectively.

estimates based on the EC production function approach. Their results suggest this "commonly agreed" reference method performs better than HP filter gaps and the equivalent OECD and IMF methods.

Other further research related to the cyclical position could include UC models based on quarterly data, as our analysis is based entirely on annual data, and structural VAR models with long-run restrictions to estimate the OG (in particular the proposals by Blanchard and Quah (1989), Enders and Hurn (2007), and Afonso and Claeys (2008)). Finally, as for structural budget balances, it may be worth considering specific elasticities for indirect taxation at regional level (as an input to calculate revenue semi-elasticity). It could also be of interest to explore UC models for estimating structural budget balances at regional level (see e.g. Corrales et al., 2002).

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