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Thesis title:

Essays on Fiscal Policy

PhD in	Economics and Finance
Cycle	27
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Year of thesis defence	2017

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Abstract

In my PhD thesis, I am studying economic questions related to the fiscal austerity debate. I focus on understanding the size of fiscal multipliers, how their magnitude changes as the state of the economy changes and their relevant policy implications. I build on the existing literature by combining existing conjectures and by taking into account different types of asymmetries (e.g. country heterogeneity, the state of the economy and the level of debt).

In the first chapter, "Non-Linearities and Fiscal Policy", I contribute to the fiscal policy literature that points to non-linearities in the effects of fiscal policy in two ways. First, I have an economic contribution, where I study different types of non-linearities simultaneously (i.e. the state of the business cycle, the composition of fiscal consolidations and the level of debt). I add to the ongoing debate about the time-varying effect of fiscal shocks on the macroeconomy by adding a relevant component, debt. I propose a model that allows me to assess the dynamic role of public debt in the study of fiscal policy and its effects. I examine whether it is the "when" - the state of the cycle (recessions versus expansions), the "how" - the type of policy-stabilization (tax increases versus government spending cuts), or the "initial condition" - debt (high versus low), that is more important for the propagation mechanism of fiscal policy. I endogenously track the dynamics of debt together with the possible transition of the economy from one state to the other. My results suggest that there are heterogeneous implications when debt is high or low along different phases of the business cycle. Fiscal consolidations based on tax increases are in general self-defeating. Increasing taxes in periods of expansions have the most recessionary effect in the economy and fail to stabilize the debt ratio when debt is high. Cutting public expenditure has a less pronounced effect on the economic activity and is able to stabilize debt. The second contribution is methodological. Most of the recent literature on the topic adopts the local projections approach to derive the impulse response functions. I argue that the way the fiscal policy literature uses this method, when accounts for non-linearities, may be problematic and consequently affect policy conclusions.

In the second chapter, "The Country-heterogeneity of Fiscal Consolidation Plans: A Bayesian Approach", I exploit the attractive features of the Bayesian hierarchical modeling and the informational content of the narrative measures to provide country-specific estimates. Existing studies typically pool country data due to the lack of observed fiscal episodes per country. A Bayesian approach might a priori overcome this issue and provide country-specific results. As a first step, I provide some convergence diagnostics for my algorithm and I confirm that my Gibbs sampler converges. My results overall highlight that the transmission of fiscal policy highly depends on the economic environment.

The last chapter, "Fiscal Consolidation Plans in Recessions and Expansions", considers the fact that fiscal policy decisions are announced through multi-year plans. This chapter addresses the importance of accounting for both the intertemporal and the intratemporal component of the fiscal authority announcement, and different economic indicators that may affect the state of the economy.

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Acknowledgments

I am greatly indebted to my supervisor, Carlo Favero, for his guidance and continuous support over all my PhD years. Therefore, I would like to express my deep appreciation. I will forever be thankful, you have been a tremendous mentor for me!!! Thank you for encouraging my research and for allowing me to grow as a researcher.

I am grateful to Martin Dufwenberg, Francesco Giavazzi, Luigi Iovino, Tommaso Monacelli, Luca Sala, Dmitriy Sergeyev and Antonella Trigari. I truly benefited from your valuable comments, insightful discussions and advice. In addition, I would like to thank all the Bocconi faculty members and all the Bocconi society (Angela and Silvia, without you the Econ PhD would not exist). Most importantly, I would like to thank and wish best of luck to all my fellow PhDs. The encouragement among us and the interaction both at an academic and personal level, has been an essential ingredient for this journey. Of course in this journey, Alexey -you had a special seat. From day one, we travelled throughout this adventurous road together, as classmates, officemates, job market candidates, but above all as friends

I am incredibly thankful and I feel privileged to have been guided by Petros Dellaportas and Katerina Kyriazidou. Your consecutive insights, since my Bachelor and Master thesis, influenced my research decisions and helped me lay the first bricks in my research path.

Maristella Botticini and Massimo Marinacci, I honestly have no words to express my heartfelt gratitude. You are my guardian angels, and you are my role models

-as great scholars and as amazing human beings. Thank you for your wisdom, generous support and exemplary guidance - in all respects, during the PhD years and throughout the job market process!!!

To my family and Greek friends, thank you! Gianni, Roula, Niko, Simone, a special thank you for your patience, for the sacrifices you made on my behalf, for tolerating sleepless nights, for letting me release all my fears, anger, sadness and happiness arising from many psychological positive and negative shocks throughout these years. I have been immensely lucky to have you in my life, thank you for being YOU and being constantly by my side. You have always motivated me to strive towards my goal, my Ithaca.

Mom, Dad, this milestone is because of you and for you.

Chapter 1

Non-Linearities and Fiscal Policy

Abstract

Empirical evidence shows that fiscal multipliers depend on the state of the cycle, the nature of fiscal policy and the level of debt. In other words, evidence points to non-linearities in the effects of fiscal policy. This paper provides a framework to simultaneously assess the relevance of different sources of non-linearities. The empirical analysis, which uses a panel of 13 countries between 1980 and 2014, finds that fiscal consolidations based on tax increases are in general self-defeating, in that they result in an increase of the debt-to-GDP ratio. Increasing taxes in periods of expansion has the most recessionary effect on the economy. Cutting public expenditure has a less pronounced effect on economic activity and can stabilize debt. This paper also discusses the econometrics of non-linearities. Though the literature has often adopted the local projections approach to derive impulse response functions, I address the

potential pitfalls of this method both analytically and econometrically.

1.1 Introduction

The Global Financial Crisis and the Great Recession have triggered a renewed interest in the effects of fiscal policy. At the same time, discussions have increased regarding countries with high public debt under fiscal austerity programs. One of the main topics of policy debates relates to the implications that these fiscal austerity measures have for the macroeconomy, especially when a country is in an economic downturn. This paper assesses the role of the level of *public debt* in determining the size of fiscal multipliers, in a model that also accounts for the *state of the cycle* and the *type of fiscal stabilization* when mostly based on tax increases or on spending cuts.

Until recently, most of the literature estimated a single fiscal multiplier without taking into account the state of the economy. Recent work (Auerbach and Gorodnichenko (2012, 2013), Ramey and Zubairy (2016)) investigates whether estimates of fiscal multipliers differ depending on the state of the business cycle. However, there are few theoretical studies that link the size of the multiplier to economic downturns. A few exceptions are Michaillat (2014) on the labor market and Canzoneri, Collard, Dellas and Diba (2016), who make use of a costly financial intermediation as a financial friction and show that fiscal multipliers are state-dependent. Some New

Keynesian models, such as Christiano, Eichenbaum, and Rebelo (2011) and Woodford (2010), highlight the importance of the phase of the business cycle and study the multiplier effect when the economy is near the zero lower bound.

Alesina, Azzalini, Favero, Giavazzi and Miano (2016) shift the focus from the state of the cycle, arguing that it is not simply "when" a fiscal adjustment happens that matters (i.e. recessions versus expansions), but also "how" it happens (i.e. expenditure-based versus tax-based). Accounting for heterogeneous effects is critical, since the size of the multiplier can be more relevant in circumstances of economic downturns, even more so when a country has a high level of debt.

The main goal of this paper is to simultaneously study these non-linearities and contribute to the ongoing debate about the time-varying effect of fiscal shocks on the macroeconomy. Therefore, we propose a general model that provides enough flexibility to account for different non-linearities. In this paper, I focus on three non-linearities. The first arises from the state-of the economy, i.e. *recessions versus expansions*. The second is the composition of the fiscal consolidation, i.e. *tax-based versus expenditure-based*. The third non-linearity arises from the government's fiscal position, i.e. *high-debt ratio versus low-debt ratio.*

The recent literature on state-dependent multipliers (e.g. Auerbach and Gorodnichenko (2012) (AG in what follows)) uses the smooth transition vector autoregression (STVAR) model.[1] This is a regime-switching model, based on a logistic distri-

[1] In AG (2012) the identification of exogenous shifts in fiscal variables is obtained using the Blanchard-Perotti identification assumptions.

bution that controls for the transition from one regime to the other, with weights computed as a moving average of GDP growth. Nickel and Tudyka (2014) estimate fiscal multipliers taking into account countries' fiscal positions. They augment a panel vector autoregression model and introduce debt through an interaction term, the interacted panel vector autoregression. I propose a blend of these two models (STVAR and IPVAR) the ISTVAR. This model is a flexible way to condition endogenously on countries' government debt and examine the relevance of the instrument of stabilization that the government uses, taking into account the state of the economy. Differently from Nickel and Tudyka (2014), I endogenously track the dynamics of debt by explicitly modelling the evolution of the government debt-to-GDP as a function of the interest rate payments on the debt and the primary government deficit (Favero and Giavazzi (2007)). Therefore, I contribute to the state-dependent literature of fiscal policy not only by looking into the stabilization instrument that the fiscal authority uses, but by including debt itself.

I study cases of high and low debt as well as the potential of heterogeneous effects of tax- and expenditure-based fiscal consolidations implemented in bad and good times. My results indicate that there are heterogeneous implications at different stages of the business cycle when I condition on debt and account for the composition (expenditure-based, tax-based) of fiscal adjustments. The question is which heterogeneity is more relevant: Is it the *"how"* — the way the stabilization is performed? Is it the *"when"* —the phase of the cycle? Or is it the *"initial condition"* of the economy —namely, debt— that plays the most pivotal role and potentially constrains fiscal policy under all the different dimensions?

My findings indicate that, first of all, the initial level of debt and the composition of the fiscal adjustment are the most relevant non-linearities. Second, I find that the effects of tax-based adjustments are on average more recessionary when they are implemented during an economic upturn. The reason is that, when the economy is in recession, the probability of being in a recessionary regime is already close to 1. When debt is high, tax-based consolidations appear to be self-defeating. Instead of reducing the deficit, they deliver on average higher debt ratios because the negative effect on GDP growth is larger from the budget changes. Third, expenditure cuts, have a less pronounced effect on output. But, importantly, they are able to stabilize debt independently of the state of the cycle.

Existing empirical evidence (e.g. Favero and Giavazzi (2007)) shows that omitting debt can bias the evaluation of the output effects of fiscal policy. In my context, when the state of public finances is weak, this triggers a fiscal consolidation. On the one hand, this consolidation episode improves the primary balance of the government. On the other hand, it has a negative effect on the output growth. In addition, in future periods, this adjustment may constrain the future path of taxes and spending, since the government's budget constraint should eventually be respected. Including debt allows me to account precisely for these different channels and observe whether the fiscal authority succeeds to meet its objective (i.e. to shore up fiscal sustainability) depending upon the instrument of stabilization, the initial condition of debt and the state of the economy.

The second contribution of this paper is a discussion of the *econometrics* of non-linearities in fiscal policy. Most of the recent fiscal policy literature adopts the Jordà (2005) local projections approach to derive impulse response functions (IRFs). The main advantage of the local projections method is that it is a very simple, non-parametric way to estimate impulse responses. In addition, it is robust to misspecifications. It is also argued that this approach is flexible enough to accommodate non-linear specifications. In this paper, I argue that the way the fiscal policy literature uses this method to account for non-linearities may be problematic. When non-linearities are modelled through a logistic function, there is an endogenous feedback in the system, which makes the model history-dependent.[2] Therefore, the derivation of IRFs from local projections is not simply an extension of the linear case, which is history-independent. I discuss the potential pitfalls generated by the way this estimation method has been used in the presence of non-linearities. I do so both econometrically and analytically.

Econometrically, I use the STVAR model. Unlike AG (2013), I do not use the local projections approach.[3] Instead, I estimate a STVAR and use generalized impulse

[2]Not just a logistic function, but more in general a function of an endogenous variable.

[3]I mainly refer to Auerbach and Gorodnichenko (2013) who were the first to make use of this approach in fiscal policy. They claim that the IRFs calculated with the local projections method are equivalent to the ones derived from the conventional approach (STVAR). Going beyond this literature, this methodology has been applied recently also in the study of state-dependent monetary policy.

response functions, which allow for the endogenous transition of the economy from one state to the other. When AG derive their IRFs for each state, they assume that the economy always remains in the same state. I show evidence that the dynamics of the IRFs from the STVAR approach are different compared to the local projections approach. I run a Monte Carlo experiment to support my argument. Analytically, I prove, within a simple non-linear model, that the two approaches are not equivalent.

I also conduct out-of-sample simulations and evaluate the performance of the IRFs derived from my model. This allows me to compare the simulated to the actual effects of new episodes for the years 2009-2013, which were years of crisis. More precisely, I use data up to 2008 to estimate my models, and then I simulate them out-of-sample over the years 2009-2013. In this way, I am able to compare the actual realization of GDP growth to simulated outcomes, conditioning on the actual fiscal changes that were adopted. The out-of-sample simulations of my STVAR baseline model perform rather well.

To sum up, this paper contributes to the literature in two ways: First, I study relevant type non-linearities in a general regime-switching model that allows responses to vary with the state of the cycle, the composition of the fiscal adjustment and the degree of indebtness.[4] Second, I discuss the use of local projections in the state-dependent literature.

The paper is structured as follows: In the next section of the paper, I motivate

[4] My paper focuses on contractionary shocks, I do not study cases of fiscal stimulus. As Barnichon and Matthes (2015) point out, contractionary multipliers are different from expansionary multipliers, hence the sign matters.

my research and provide a literature review. In Section 3 I present a general model which portends what follows. Section 4 presents the data and discusses the three types of non-linearities. The proposed model specification is introduced in Section 5. The results are included in Section 6. Section 7, provides the discussion related to the derivation of the impulse response functions from the different methodologies together with the Monte Carlo experiment. Section 8 provides some robustness checks. Section 9 concludes.

1.2 Related Literature

The size of the fiscal multiplier has been broadly studied in the theoretical and empirical literature. Quantification is controversial. Answers vary and depend, to some extent, on the methodology, the nature of the shock, the identification scheme and the data.

There are two main strands of identification in the empirical literature: the structural VAR approach (e.g. Blanchard and Perotti (2002), Mountford and Uhlig (2009)) and the narrative approach (e.g. Ramey and Shapiro (1998), Romer and Romer (2010)). An issue of the standard structural identification (SVAR) approach is the problem of non-fundamentalness in the estimation of fiscal shocks since this approach relies on current and past shocks. This problem is related to the fiscal foresight phenomenon. In this approach the information of news shocks and their future changes is not embedded. Therefore, the sets of information held by the econometrician and economic agents are not aligned. On the other hand, the narrative approach allows for the direct identification of exogenous shocks from past budget accounts, fiscal changes that were announced as a response to past economic conditions. For this reason, the narrative approach provides a way to take into account the information that influences the expectations of economic agents.

Devries, Guajardo, Leigh, and Pescatori (2011) constructed an important dataset for 17 OECD countries for the period 1978-2009 of tax and spending changes, similar to the Romer and Romer (2010) approach. Their narrative record includes contemporaneous changes with the aim to reduce the budget deficit. These changes are considered exogenous because they are measures taken as a response to past economic conditions and not to prospective ones. Guajardo, Leigh, and Pescatori (2014) study the effects of these unanticipated narratively identified shocks on macroeconomic variables. Alesina, Favero and Giavazzi (2015) extend the Devries, Guajardo, Leigh, and Pescatori (2011) dataset and distinguish between expected and unexpected fiscal corrections. This allows them to study the impact of unanticipated and anticipated fiscal changes on the macroeconomy.

Until recently the literature, as the aforementioned papers, had focused on the effect of a single multiplier, and had not distinguished between the phases of the business cycle. Recent studies have relaxed the assumption of a homogeneous multiplier across different states of the economy and seek to study non-linearities of the multiplier in different regimes. AG (2012) employed a STVAR model to study the size of the fiscal multiplier in recessions and expansions in an SVAR (Blanchard and Perotti (2002)) identification context for the US economy. AG (2013) employ a similar methodology by using narrative data of OECD countries. They estimate their model with the local projections method (Jordà (2005)).[5] They discuss a simple linear model and show that the IRFs that one derives from the conventional approach are equivalent to the IRFs that one can get from the local projections method. They compute the local projections for each horizon as a separate regression. They claim that this permits them to construct IRF and accommodate non-linearities without imposing dynamic restrictions as is the case in other regime switching models. This is what motivates the methodological part of my contribution, in which I discuss more in depth the way AG use local projections. The conclusion in both papers (AG (2012, 2013)) is that the multipliers in different regimes differ. Ramey and Zubairy (2014, 2016) also adopt the local projections method in a state-dependent model to examine the possibility of a different response of government spending changes in periods of recessions compared to expansions. Ramey and Zubairys' results show that there is no evidence of heterogeneity. They both focus on government spending shocks. However, it is important to mention that while the state variable for Auerbach and Gorodnichenko is a function of an endogenous variable (moving average of GDP), for Ramey and Zubairy their state is a dummy variable (which is 1 if the unemployment

[5] I will provide a brief review of the paper and the methodology in Section 7.

rate is above a specific threshold, i.e. 6.5%). The importance of this point will be clear when we will discuss the use of the local projections method.

The above seminal papers have motivated many recent studies in this literature. Barnichon and Matthes (2016), for example, study whether the sign of a government spending shock matters. They find that an expansionary multiplier is below one, while the contractionary is above 1. Our paper contributes to the empirical literature of the study of fiscal multipliers by examining the potential for heterogeneous effects when one considers three dimensions of non-linearities related to "how", the "when" and the "initial condition" that an episode of fiscal adjustment is implemented. Several studies (e.g. Favero and Giavazzi (2007), Ilzetzki, Mendoza and Vegh (2013), Corsetti, Meier and Müller (2013)) have highlighted the importance of the government's fiscal position of a country. Omitting this dimension can bias the effects of fiscal shocks. Nickel and Tudyka (2014) estimate fiscal multipliers and take into account the countries' fiscal position. They use an interacted panel vector autoregression in a sample of European countries. Huidrom, Kose, Lim and Ohnsorge (2016) is a very recent paper that jointly accounts for the fiscal position and the business cycle, as we do. The main differences rely on the fact that I include debt endogenously in my model, and on the composition of the stabilization episodes. They use a Blanchard and Perotti (2002) identification scheme.

I use the idea of the IPVAR model into the STVAR model, which I call ISTVAR. The implementation of this model allows me to study the three different type of asymmetries (i.e. recessions and expansions, expenditure-based and tax-based, high-debt and low-debt) simultaneously. I track endogenously the dynamics of public debt-to-gdp ratio by explicitly including an equation of debt. I follow the paper of Favero and Giavazzi (2007) and model debt as a function of the average cost of debt and the primary deficit.

1.3 The General Model

My goal in this paper is to provide a general encompassing framework to simultaneously assess the relevance of different sources of non-linearities. To study non-linearities in the effects of fiscal policy I need a dynamic model which can account for:

1. The behavior of the macroeconomic variables of interest (Y_t) and

2. the behavior of the policy variables under study (P_t).

The macroeconomic variables (e.g. real gdp growth, consumption, etc.) are typically assumed to be a function of both their own past values, the past values of the policy variables and any exogenous adjustments or deviations of the fiscal authority from its rule. These functions can potentially be non-linear and depend on different economic conditions.

At the same time, the policy variables respond to the change of the fiscal authority rule, as well as through a potential feedback effect from the past policy decisions together with the effect arising from the response of the macroeconomic variables. A general framework that can describe the joint evolution of the two sets of variables is:

$$Y_t = f_1\left(Y_{t-1}, P_{t-1}, shock_t; \Phi_1\right) + u_{1t} \quad (1.1)$$

$$P_t = f_2\left(Y_{t-1}, P_{t-1}, shock_t; \Phi_2\right) + u_{2t}.$$

Y_t is a vector of macroeconomics variables for $t = 1, 2, ..T$ years, whereas P_t represents the set of policy variables. This, for example, can be a fiscal policy rule as a reaction function to a monetary policy shock. In my study the policy rule is the debt-to-gdp ratio. Φ_j, with $j = 1, 2$, are the parameters that we need to estimate. f_j, are functions that need to be defined according to the question under study, to account for either linear or non-linear responses. The choice of the functions clearly depends on the question of interest. At the same time, it depends on the policy rule and the number of macroeconomic variables included in the system (and vice-versa). The reason is that the scarcity of the data, especially when one uses a narrative record of identified shocks, puts some limits in the degrees of freedom and the number of parameters that can be estimated.

Once all the necessary components of the model are specified, one can proceed with the estimation of the model (e.g. via seemingly unrelated regression equations or maximum likelihood) and the derivation of impulse response functions. The derivation of the impulse response functions can be done through the generalized impulse response function, which I discuss in Section 5. The last step, concerns the calculation of fiscal multipliers as the ratio of the integral of the output response to the integral of the policy adjustment.

The above general encompassing model sets the base for the analysis that follows.

1.4 Data and Non-Linearities

1.4.1 Data

I make use of the narrative record initially constructed by Devries, Guajardo, Leigh, and Pescatori (2011) and extended by Alesina, Favero and Giavazzi (henceforth AFG). The dataset consists of a time series of fiscal consolidations of 17 OECD countries. The countries included in the initial data are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, Portugal, Spain, Sweden, United Kingdom, United States, for the period 1980 to 2014. Motivated by the literature of the narrative identification approach of Ramey and Shapiro (1998) and Romer and Romer (2010), AFG examine historical records available in official documents (Budget Reports, Budget Speeches, Central Banks Reports, Convergence and Stability Programs submitted by EU governments to European Commission, IMF Reports, OECD economic surveys) to identify the size, timing and principal motivation behind any fiscal action taken by each government. The fiscal alterations are measured as a percentage of GDP. As in Devries, Guajardo, Leigh, and Pescatori (2011), the focus is restricted to the identification of

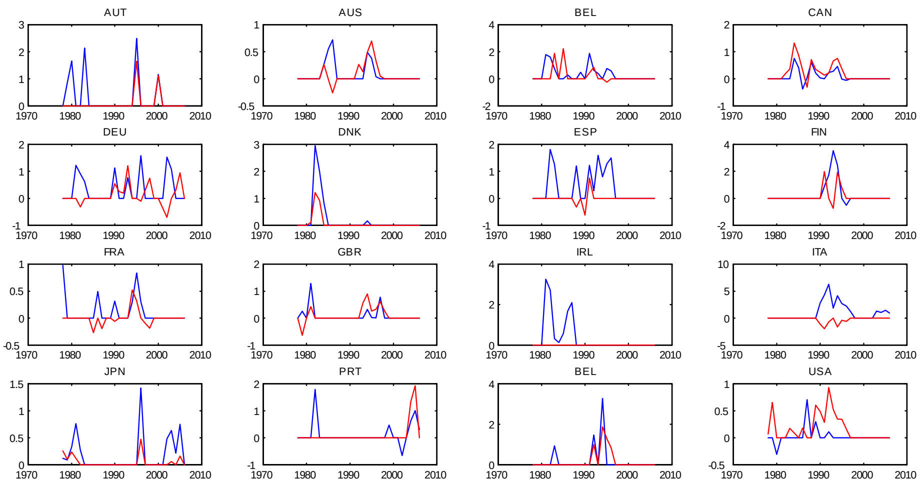

Figure 1.1: Country-specific narrative unanticipated (blue) and anticipated (red) fiscal adjustments.

fiscal changes that are exogenous to the economic cycle, as well as changes that are motivated by the willingness to reduce government deficit. This implies that a fiscal consolidation with the goal of restraining domestic demand or any other countercyclical policy is not included in the dataset. Figure 1 shows the aggregate narratively identified unanticipated and anticipated episodes for each country.

The classification of fiscal consolidations as tax-based (TB) or expenditure-based (EB) is based on the spirit of the work of Alesina, Favero and Giavazzi (2015) and is going to be discussed in the next section. The difference is that I do not include all the path of future announcements of fiscal adjustments. I consider just the unanticipated

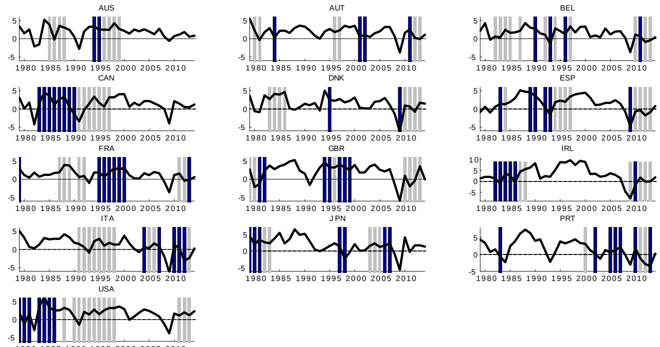

Figure 1.2: EB (blue) and TB (grey) episodes and the per capita GDP growth series (black line).

and anticipated legislative announcements that are implemented the same year.[6, 7] Figure 2 depicts the EB and TB fiscal narratively identified shocks together with the GDP growth. The initial sample consists of 17 countries, but after performing some exogeneity tests I drop 3 countries, Finland, Netherlands and Sweden. In addition, I drop Germany because data are available after 1991, because of the unification, and this restricts my analysis. My final sample includes a total of 74 episodes for taxes and 101 episodes for government spending. The main macroeconomic variables of interest in my baseline specification are real GDP, government spending, which is primary government spending (total government spending net of interest payments on debt), government revenues (current receipts), the average cost of debt and inflation. The frequency of observations is annual. My primary data source is the OECD.

[6]The challenge of the narrative data is that there is often lack of information. Governments do not make legislative announcements in a frequent basis, hence there are many "zeros" in the data. This phenomenon is even stronger when one accounts for the future implementation of fiscal changes. The exclusion of the future announcements does not create any bias. Notice that in general most of the plans of announcements have a one year horizon (on average TB plans last around 1.5 years, and EB plans 1.8 years), which is the information that I include in my sample.

[7]This is in line with the work of Devries, Guajardo, Leigh, and Pescatori (2011).

In my general model, public debt plays the role of the main policy variable. In the next subsection, I present the construction of this series. I use the general government debt as a percent of GDP from the WEO of the IMF as a reference series. The histogram of Figure 3 shows the distribution of the government debt data of my sample. In my analysis, those data serve as the initial values of the debt ratio.

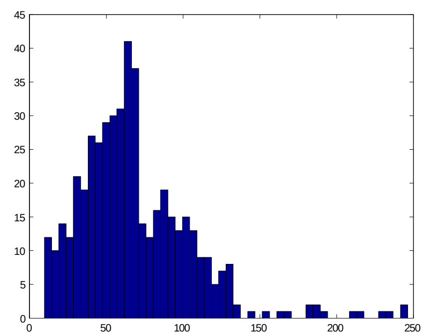

Figure 1.3: The distribution of fiscal position during the period 1980-2014. Debt-to-GDP ratio (x-axis), Frequency in % (y-axis).

1.4.2 Non-Linearities

State of the Economy

The first asymmetry of interest in my study arises from the state of the economy, namely if an economy is in recession or expansion. I follow Auerbach and Gorodnichenko (2012, 2013) and I use a regime indicator that is based on a logistic function, which I denote as $F(z_{it})$. $F(z_{it})$ indicates the probability of being in a recessionary regime. This is the key ingredient which allows me to smoothly endogenize in my model the possibility of the economy to move from one state to another and at the same time to track the feedback (as Caggiano, Castelnuovo, Colombo and Nodari (2015)) after a fiscal adjustment.

In my baseline specification the logistic function is a function of the two-years moving average of GDP growth and takes the following form

$$F(z_{it}) = \frac{\exp[-\gamma_i z_{it}]}{1+\exp[-\gamma_i z_{it}]}, \quad \gamma_i > 0. \tag{1.2}$$

Following Auerbach and Gorodnichenko, I denote by z the growth rate of output, as a moving average of two years, i.e. $z_{it} = \frac{\Delta y_{it-1}+\Delta y_{it-2}}{2}$, where Δy_{it} is GDP growth for country $\iota = 1,..,13$ at time $t = 1,...,35$. I use as an index of the business cycle the standardized measure of z_{it}.

γ is the parameter that controls the smoothness of the transitions from one regime to another. In general, large values are associated to immediate switches, while smaller ones imply a smoother transition. γ is calibrated in a way that matches the frequency and duration of recessions in an economy. The economy spends an $x\%$ of time in a recessionary regime according to the OECD dates. My goal is to calibrate γ to match this frequency. For example, for the US $\Pr((z_{it}) > 0.8 = 0.2)$, where I define an economy to be in a recession if $F(z_{it}) > 0.8$. Thus, this implies that I need to set $\gamma = 1.5$. Therefore, the magnitude of γ is in line with estimates of logit regressions of the OECD recession dates on the measure of z for all the countries in my sample.

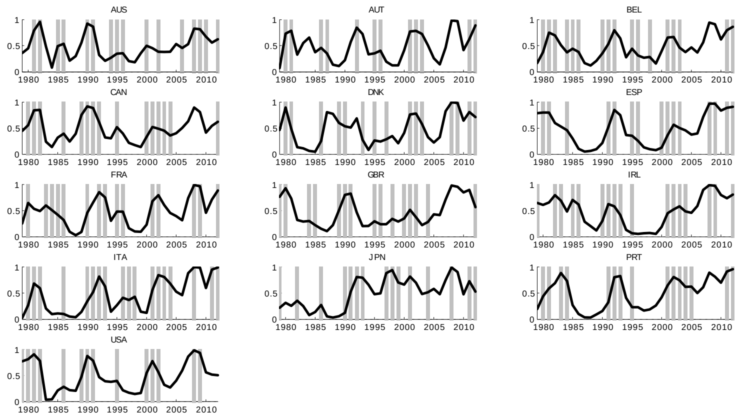

Figure 1.4: Recessions dates (shaded grey area) and the weight F(z) on the recession regime (black line).

The OECD dates are available from the Federal Reserve Bank of Saint Louis. These dates are based on the OECD Composite Leading Indicator (CLI). The series of the CLI is based on the growth cycle approach, where business cycles and turning points are identified through a deviation from the trend method. The recession dates are available in quarterly data, are not seasonally adjusted and are recorded as a dummy variable (1: for recession, 0: for expansion). I have yearly data on the narratively identified shocks, hence I translate the quarterly recession series of each country into a yearly recession series.

The general rule that I follow to calibrate γ_i for each country is that $\Pr\left((z_{it}) > 0.8 = x_i\right)$. Figure 4 shows the comparison of the constructed transition series to the OECD recession dates associated to the economic downturns of the 13 economies of the sample. The country-specific *gammas* are presented in Table 1.

Table 1: Calibration of smoothness parameter γ					
Country	Duration of Recessions	γ	Country	Duration of Recessions	γ
AUS	14%	1.14	GBR	19%	1.43
AUT	14%	1.53	IRL	14%	1.68
BEL	14%	1.13	ITA	22%	2.24
CAN	17%	1.09	JPN	17%	1.65
DNK	19%	1.72	PRT	22%	1.60
ESP	25%	1.70	USA	17%	1.56
FRA	14%	1.59			

Table 1.1: Time that a country spends at a recessionary regime and the calibration of the smoothness parameter γ.

Type of Fiscal Consolidation

The second asymmetry reflects the possible importance of the composition of the fiscal adjustment. Views about the relative effect of taxes or government spending differ among public debates and policymakers. Devries, Guajardo, Leigh, and Pescatori (2011) in their narrative record identify fiscal policy changes that are based either on taxes or government spending. Instead of directly including in my specification the tax and government spending adjustments I follow the Alesina, Favero and Giavazzi (2015) and take into account the fact that the different nature of changes may be correlated. Therefore, I take into account the entire fiscal adjustment (taxes and government spending together) and classify them as being tax-based if it is mainly based on tax increases, otherwise as expenditure-based.

Government Debt

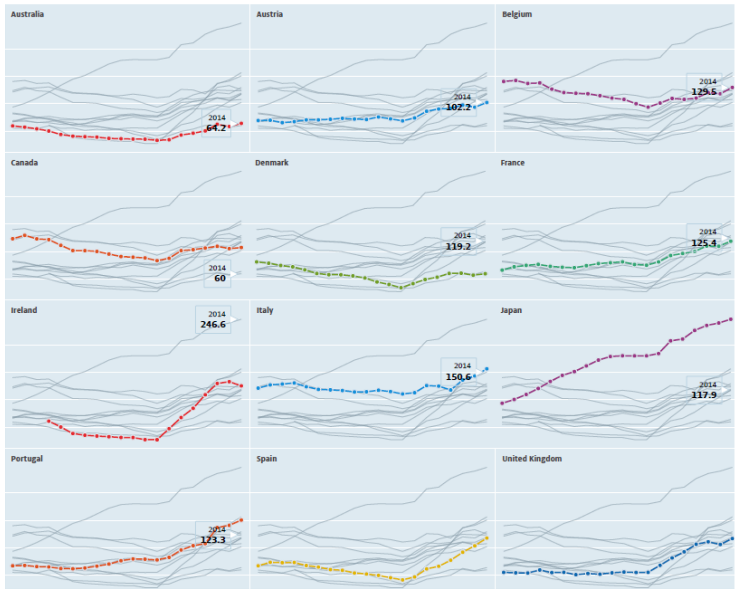

Figure 1.5: Debt-to-GDP ratio (Figure from the OECD website).

Figure 5 shows the government debt as a percent of GDP. From this figure it is possible to observe that countries like Belgium, Italy and Japan belong always in the group of countries with higher government debt. On the other hand, Portugal and the United States for example are cases that switch from being higher to lower (or vice versa). This means that it is not possible to fix exante the countries that would be classified as "higher-" or "lower-" debt. The ISTVAR, which is presented in Section 5.2, is a flexible way to endogenously model debt, without grouping countries into higher or lower debt.

I adopt the idea of Favero and Giavazzi (2007) to model debt in a way that mimics the government's budget constraint.

$$Debt_{it} = \frac{1 + i_{it}}{(1 + \pi_{it})(1 + \Delta y_{it})} Debt_{it-1} + (\exp(g_{it}) - \exp(\tau_{it})) . \tag{1.3}$$

i stands for the average cost of government debt, π is the inflation rate, g is government spending and τ is government revenues.[8] The debt-to-GDP ratio in this way is determined by the macroeconomic variables that are included in my specification. Figure 6 shows evidence that with the above equation (3) I manage to track well the debt-to-GDP ratio observed in the data. Differences may be due to presence of seigniorage, which is not considered in my framework, possible existence of stock-flow adjustments that lead to some measurement error, or due to approximation errors, since I use logarithms for the GDP growth rate and the inflation rate. For Australia, the fact that I combine different data sources to construct the series due to limited availability of data, may also explain why the implicit series does not match the observed series of the debt ratio.

[8] We take the exponential of the government to gdp and taxes to gdp ratios, because these variables are in logarithms.

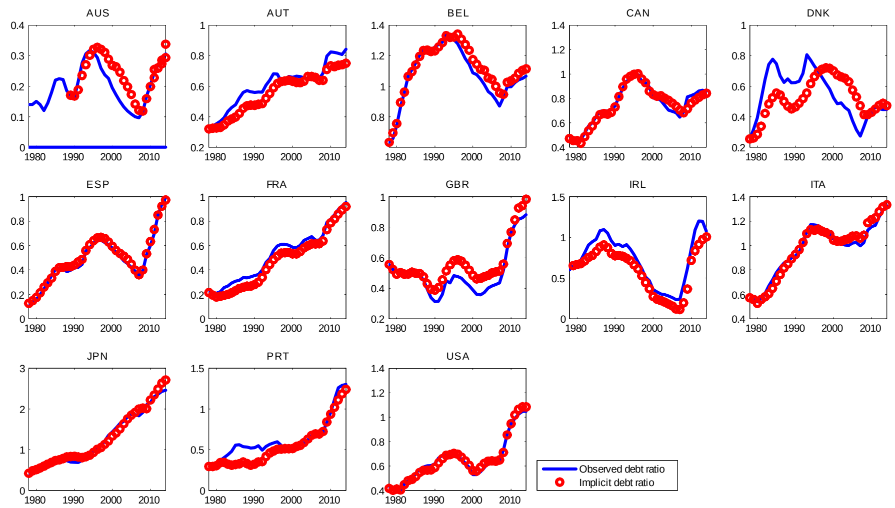

Figure 1.6: Observed Debt-to-GDP (data) versus the simulated series.

To understand better the insights of this identity I split (3) into two components: *a.* the so-called *snowball effect* ($\frac{1+i_{it}}{(1+\pi_{it})(1+\Delta y_{it})}Debt_{it-1}$) and *b.* the *primary balance effect*. Those represent the two channels that affect the evolution of debt following a consolidation episode. For example, suppose that the government reduces its expenditure by 1% of GDP. This implies a negative output effect and an increase of government spending. In terms of *a.*, the decrease of output growth, for a given past value of debt and a given i, implies an increase on the debt ratio. However, in terms of *b.*, the expenditure reduction has a direct impact on the primary balance, which improves, and reduces the debt-ratio.[9] Therefore, debt will increase or decrease

[9]The effect on output has a further indirect effect on the primary balance, that arises from the

depending on the synergy that eventually dominates.

1.5 Model Specification

1.5.1 The Fiscal Smooth Transition VAR with Debt

My aim is to account for the three non-linearities and study their relevance on the transmission of fiscal policy. To illustrate this, I adopt the general model that I presented in Section 3, where I introduce the non-linearities of interest (i.e. state of the economy, type of fiscal consolidation, government debt). To make model (1) functional I need to specify the different sets of variables and functional forms. My baseline framework with the three non-linearities reads as follows:

$$\begin{aligned} Y_{it} = (1 - F(z_{it})) \times \left[A_E Y_{it-1} + \Theta_E Debt_{it-1} + B_{1E} e_{i,t}^{EB} + B_{2E} e_{i,t}^{TB}\right] + \\ + F(z_{it}) \times \left[A_R Y_{it-1} + \Theta_R Debt_{it-1} + B_{1R} e_{i,t}^{EB} + B_{2R} e_{i,t}^{TB}\right] + \\ + \lambda_i + \chi_t + u_{it} \end{aligned} \tag{1.4}$$

$$Debt_{it} = \frac{1 + i_{it}}{(1 + \pi_{it})(1 + \Delta y_{it})} Debt_{it-1} + (\exp(g_{it}) - \exp(\tau_{it}))$$

$$F(z_{it}) = \frac{\exp[-\gamma z_{it}]}{1 + \exp[-\gamma z_{it}]}, \quad \gamma > 0.$$

automatic stabilizers. In addition, there is potentially, a third channel through the interest rate payment. In our discussion, we will focus on the main effects on *a.* and *b.*

Relating to model (1): Y includes the key macroeconomic variables $Y = [\Delta y \ \Delta\tau \ \Delta g \ i \ \pi]$, where Δy is GDP growth, $\Delta\tau$ is the change of government revenues, Δg is the change of government spending, i is the average cost of government debt and π is the inflation rate. λ_i and χ_t are country and time fixed effects respectively. $u_{it} \sim N(0, \Sigma_u)$, $i = 1, ..., N$ index countries and $t = 1, ..., T$ index time. The policy variable includes the Debt ratio and is specified by (3). For this policy variable, I do not include an error term, since as I discussed in the previous Section this is an identity.[10] e_{it}^{EB} and e_{it}^{TB} stand for the narratively identified shocks (defined as *shocks* in model (1)). My specification distinguishes between the instrument of stabilization, expenditure-based ($e_{i,t}^{EB} = e_{i,t}^{IMF} \cdot EB_{it}$) and tax-based ($e_{i,t}^{TB} = e_{i,t}^{IMF} \cdot TB_{it}$) narrative shocks, which are unanticipated and anticipated shocks implemented the same year.[11] In this model I assume that all the macroeconomic variables depend on the cycle, i.e. f_1 which in my case is the logistic function (2).[12] I estimate it as proposed by Granger and Terasvirta (1993).

Including debt in the study of fiscal consolidations is important. I remind my reader that the aim of the fiscal consolidations is to reduce public deficits. At the same time, the state of the public finances may not just trigger some episodes of fiscal adjustment but also have a direct impact on output growth through a different

[10]Of course, one could include an error term to account for measurement error, given the discrepencies that are observed in a couple of countries.

[11]$e_{i,t}^{IMF}$ stands for the the total adjustment, which includes tax and government spending changes. Whereas EB_{it} and TB_{it} are dummy variables for expenditure-based or tax-based cases respectively. An episode is recorded as expenditure-based (tax-based) when the total of expenditure-changes (tax-changes) dominate the total tax-changes (expenditure-changes).

[12]The linear model is a special case of STVAR for a value of $\gamma = 0$.

channel as I discussed in the introduction. Omitting debt may bias the magnitude of the consolidation effects.[13] The reason is that the short lags of $\Delta\tau$, Δg, i and π alone are incapable to trace the evolution of the debt ratio accurately enough. Favero and Giavazzi (2007), show that debt in (3) is the result of long and non-linear dynamics.[14] Since debt plays the role of the "initial condition" that the economy stands, the model dynamics are going to depend on it. This means that the initial value of the state of the economy and the initial value of the government's fiscal position matter for the purpose of studying the different dimensions of interest. I present results with initial values that make clear the dichotomies between a recessionary and expansionary regime (approximately 0.8 versus 0.2 as discussed in the previous section) and a high versus low debt ratio (0.3 and 0.9). It is important to stress that with this model I allow for the possible endogenous transition of the economy from one state to the other when a shock hits the economy, but also the endogenous feedback of debt. A flexible way that permits ME to actually account and track the transition of the economy and the debt dynamics is the use of the Generalized Impulse Response Functions.

My aim is to study the relevance of these non-linearities in the propagation of the fiscal adjustments.

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[13] I elaborate more on this argument in the appendix by discussing the econometrics.

[14] More precisely, they show that:

$$\begin{aligned} Debt_{it} &= \sum_{j=0}^{K} \left(\exp(g_{i,t-j}) - \exp(\tau_{i,t-j})\right)^{j} \prod_{j=0}^{K} \left(\frac{1+i_{i,t-j}}{(1+\pi_{i,t-j})\,(1+\Delta y_{i,t-j})} \right) + \\ &\quad + \prod_{j=0}^{K} \left(\frac{1+i_{i,t-j}}{(1+\pi_{i,t-j})\,(1+\Delta y_{i,t-j})} \right) Debt_{i,t-j-1} \end{aligned}$$

1.5.2 The Interacted Smooth Transition VAR

As a further extension of (4), I assume that the fiscal shocks depend on the level of debt, in that I explicitly interact the government budget constraint, the identity (3), with the identified consolidations. I employ a model which I call Interacted Smooth Transition Vector Autoregression (ISTVAR):

$$Y_{it} = (1 - F(z_{it})) \times \left[A_E Y_{it-1} + \Theta_E Debt_{it-1} + B_{1E} e_{i,t}^{EB} + B_{2E} e_{i,t}^{TB}\right] + \tag{1.5}$$

$$+F(z_{it}) \times \left[A_R Y_{it-1} + \Theta_R Debt_{it-1} + B_{1R} e_{i,t}^{EB} + B_{2R} e_{i,t}^{TB}\right] +$$

$$+\lambda_i + \chi_t + u_{it}$$

$$B_{jS} = B_0^S + B_1^S \cdot Debt_{it-1}, \quad \text{for } S = E, R \text{ and } j = 1, 2,$$

$$Debt_{it} = \frac{1 + i_{it}}{(1 + \pi_{it})(1 + \Delta y_{it})} Debt_{it-1} + (\exp(g_{it}) - \exp(\tau_{it}))$$

$$F(z_{it}) = \frac{\exp[-\gamma z_{it}]}{1 + \exp[-\gamma z_{it}]}, \quad \gamma > 0.$$

This model makes the non-linearity that is introduced through debt stronger, since the effect from a fiscal adjustment in this case depends also on the interaction with debt. I expect that this additional component can allow for a better evaluation of the implications of adjustments in the study of high and low debt. Some additional justification behind this specification is the following:

The economic motivation that the aim of the fiscal adjustments is to decrease the public deficit, is a good argument to justify the choice of interacting these adjustments and debt.

An "ideal" specification would account for the interaction of both the set of macroeconomic variables and the set of the shocks. However, this clearly translates into a larger number of parameters to be estimated. There is where the so-called "curse of dimensionality" hits. Especially, because of the scarcity of the narrative data.

1.5.3 Generalized Impulse Response Functions

I now turn to the derivation of the impulse response functions, which in a non-linear environment may deem complicated. The derivation of impulse responses of the variables in Y_{it} to innovations is different from the case of a standard VAR, due to the presence of the logistic function and of the budget constraint. In my setting (model (1)), I compute the response of the output growth (or the rest of the economic aggregates) to fiscal shocks via generalized impulse response functions (Koop, Pesaran and Potter 1996), which allow to endogenize the transition from one regime to the other and to track the feedback between debt and the regime.

$$GIRF_{\Delta y}\left(h, \Omega_{t-1,} shock_t\right) = E\left(\Delta y_{t+h} | \Omega_{t-1,} shock_t = 1\right) - E\left(\Delta y_{t+h} | \Omega_{t-1,} shock_t = 0\right),$$

where Ω_{t-1} accounts for the history, $h = 0, 1, 2..., H$ are the horizons and $shock_t$ represents the shock of interest, which is either the tax-based or the expenditure-based narrative identified shock . I rely on the equation above to derive the impulse response functions.[15] The steps I follow are:

Step 1. First, assume that the structural shock of interest (i.e. EB/ TB) hits the economy, which is equal to one, while the rest of the shocks are equal to zero, and simulate the system forward.

Step 2. Then generate dynamically forward, an alternative simulation for all variables, by assuming, differently from *Step 1*, that all the shocks are equal to zero.

Step 3. To compute the impulse responses, take the difference between the above simulated values of *Steps (1. - 2.)*.

Step 4. In addition, run a correlated bootstrap method for the calculation of the confidence intervals, where I report the 16-84% confidence intervals.[16]

I repeat the above 4 steps for all the 2^3 combinations of interest.[17] This methodology produces impulse responses that allow for the feedback and dynamics of both the state variable $F(z)$ and $Debt$.

[15] Applying this methodology in a VAR would produce standard impulse responses.

[16] For my bootstrap, I re-sample the residuals of the estimated non-linear VAR (e.g. model 4) allowing for the correlation between the residuals of the different countries. This generates a set of observations for $Y, F(z), Debt$, which allows me to re-estimate my model and derive the GIRFs. I rely on 1000 iterations.

[17] The combinations are: TB shock in recession ($F(z) = 0.8$) when debt is high (0.9); EB shock in recession ($F(z) = 0.8$) when debt is high (0.9); TB shock in expansion ($F(z) = 0.2$) when debt is high (0.9); EB shock in expansion ($F(z) = 0.2$) when debt is high (0.9); TB shock in recession ($F(z) = 0.8$) when debt is low (0.9); EB shock in recession ($F(z) = 0.8$) when debt is low (0.3); TB shock in expansion ($F(z) = 0.2$) when debt is low (0.3); TB shock in expansion($F(z) = 0.2$) when debt is low (0.3). I set for each case the initial values for debt, the regime indicator, and all the related initial parameters.

1.5.4 Fiscal Multipliers

The last part of the analysis involves the computation of the fiscal multipliers. I calculate the dynamic cumulative multipliers. Following Uhlig (2012), I take the integral of the generalized impulse response of output divided by the integral of the generalized impulse response of the fiscal policy variable of interest (revenues or expenditures) given the adjustment under study.[18] Basically, for the case of the government revenues this is the ratio of the changes of $\sum_{h=1}^{H} \Delta y_h / \sum_{h=1}^{H} \Delta \tau_h$, while $\sum_{h=1}^{H} \Delta y_h / \sum_{h=1}^{H} \Delta g_h$ is for the government expenditures.[19] I rescale these changes into currency equivalents, by using the ratio of the sample mean ratio of the expectation of output over taxes or government spending.[20,21]

1.6 Results

1.6.1 The Fiscal STVAR with Debt (Model 4)

In Section 4 (Figure 3), we saw how the government debt-to-GDP ratio is distributed along the different percentiles.[22] My econometric specification allows me to

[18] Uhlig discounts those integrals, which I do not. This does not change my results.

[19] This implies that the available number of multipliers that one can compute is 2^3, given the different nonlinearities.

[20] Recall that the variables of interest are in logarithms and in real terms.

[21] Ramey and Zubairy (2016) are concerned with such a rescaling, especially for the case of the US and when they study a long historical dataset. I take into account their point, but I see that my results are robust.

[22] We drop Japan from our study, since it is the only country in our sample with such high debt-ratios.

examine the size of the effects of the coefficients at specific values of the fiscal position from the percentiles of the sample. Initial conditions matter for the dynamics of the generalized impulse response functions. I present the impulse response functions together with the endogenous response of debt and the transition of the state for model (4).[23,24] In the Appendix I report the estimated coefficients (with their standard errors) for the equations of output growth, taxes and spending.

In Figure 7 and 8 I illustrate the cumulative impulse response functions of the main macroeconomic variables. I focus on the response of the output growth, for scenarios of low and high debt respectively.[25] In addition, the innovative feature of my model is that I can track the endogenous feedback of the debt-ratio, as well as, the endogenous response of the state indicator. Debt is low at a value of 30%, whereas debt is high at the value of 90%.[26] My results represent the behavior of the average country in my sample. When debt is low, Figure 7 shows that the fiscal effects on output growth generated through increases in taxes are state-dependent. Adjustments that are mainly composed through taxes and are implemented in boom periods have the most recessionary effect. This is statistically different from the same

[23]We do not depict he confidence intervals of the response of Fz and debt. The reason is that they are pretty narrow and we prefer to keep the picture of the graph more clear given that there are many curves presented together.

[24]Differently from AG, we allow for the endogenous transition from one regime to the other ($F(z)$). As it has been already stressed from Caggiano, Castelnuovo, Colombo and Nodari (2015), this is an important point to highlight. Therefore, we document the response of $F(z)$ starting in recession versus the one starting in expansion.

[25]I present the results for output, since later I present also the multipliers.

[26]One reason that we choose to present results for these values, is that these values are associated with the point of the tails of our sample distribution as depicted in Figure 3. In addition, the 90% value reflects the discussion of Reinhart and Rogoff (2010) that provide evidence of a negative impact of growth when the level of debt ratio is above this threshold.

type of consolidations when implemented in periods of recessions, which appear to be less recessionary. It appears that in bad times, when the economy underperforms and things go bad, they cannot go much worse. The state of the cycle seems to matter also when stabilizations are mainly implemented through increases in government spending. In this case, in period of expansions the effect on output is almost negligible. In terms of the endogenous response of the transition variable, for all the cases convergence to the assumed probability "target" is observed, which is that the economy spends on average 20% of the time in a recessionary regime. This is not the case when we turn to high debt, where the economy converges in a more recessionary target where the "target" indicates a probability of being 50-60% in a recessionary regime.

In Figure 8, when the debt-ratio is high and the phase of the cycle is low, tax changes are self-defeating on average. They bring the debt-ratio to higher levels and the economy converges in a recessionary regime. Output growth falls on impact, and even if there is a sign of recovery after one year, it remains in a recessionary regime. Interestingly, on the other hand, government spending adjustments have a stabilizing feedback to debt. Especially, when an expenditure-based fiscal consolidation is implemented during good periods, this leads on average into a negligible response of the output growth. At the same time, it reduces the debt ratio. Therefore, there is a stabilizing feedback on the economic system.

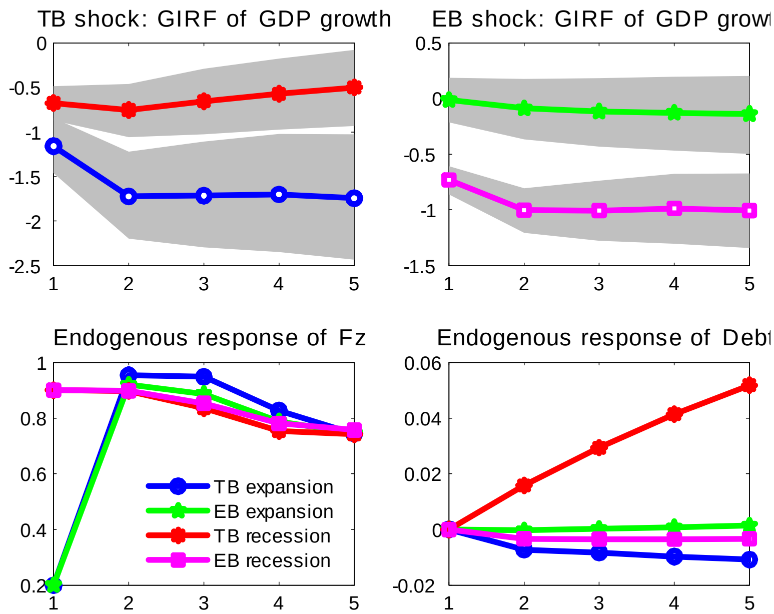

Figure 1.7: Cumulative GIRFs for the Fiscal STVAR with LOW Debt: The output growth response on a tax-based shock or an expenditute-based shock in recessions or expansions when the Debt ratio is low.

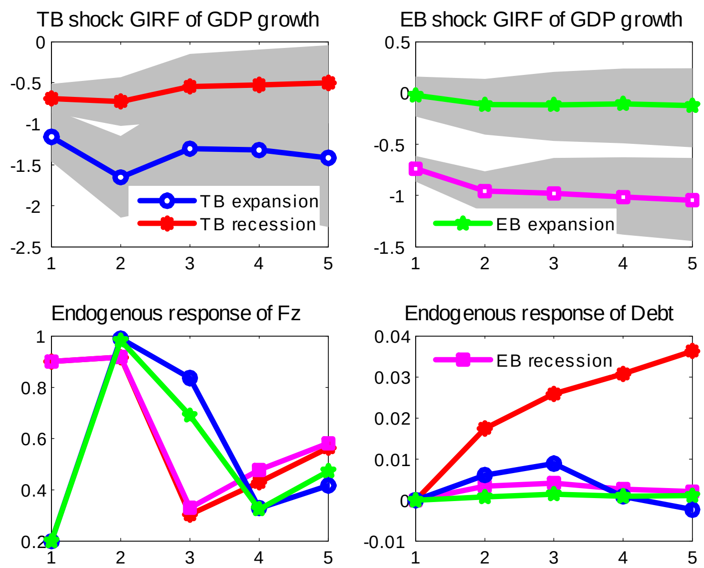

Figure 1.8: Cumulative GIRFs for the Fiscal STVAR with HIGH Debt: The output growth response on a tax-based shock or an expenditute-based shock in recessions or expansions when the Debt ratio is high.

The Cumulative Fiscal Multipliers

Figure 9 reports the dynamic response of the cumulative fiscal multipliers. The multipliers obtained when debt is low or high differ, with the government spending multipliers ranging between $[-0.5, -0.24]$, while the tax multipliers between $[-1, 0.8]$. A one percentage-point decline in government spending as a ratio to GDP is associated with an output of contraction. When debt is low the size of the contractionary effect appears to be larger. On the other hand, the tax multiplier is associated with a decrease of output on impact, which then starts to increase. This is not the case when a tax increase occurs when debt is low and when the economy is in economic upturns, where we observe a cumulative negative multiplier. In the Appendix I report the relevant cumulative multipliers with their confidence intervals. The multipliers account for both the response of GDP growth together with the response of taxes and government spending on the shock of interest, which can give a sense of the synergies that propagate back to our economic system and affect debt and output.

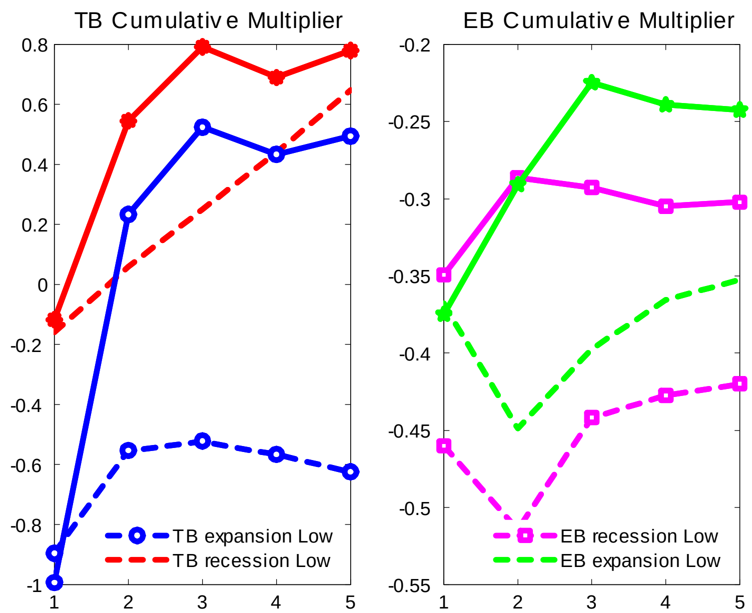

Figure 1.9: The Fiscal STVAR with Debt: Dynamic cumulative multipliers for H=5 horizons. Solid lines refer to cases of high debt, dashed lines refer to cases of low debt (for TB: blue in expansion, red in recession; for EB: green in expansion, magenta in recession).

1.6.2 The Interacted-STVAR (Model 5)

In this subsection I present the results for the ISTVAR model (5), in which when an adjustment is implemented is interacted also with the level of debt. When debt is low, from Figure 10, the fiscal effects on output growth generated through increases in taxes are state-dependent, as before. However, this is not the case for expenditure-based consolidations.When debt is high (Figure 11), compared to the previous results,

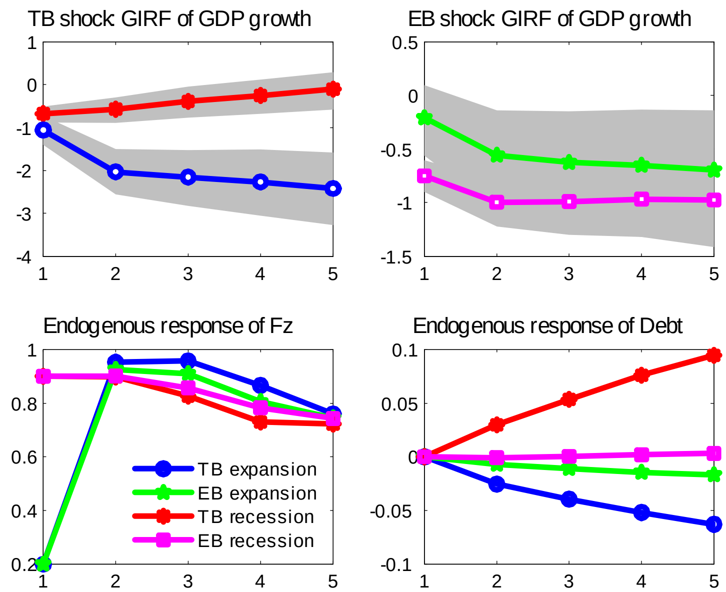

Figure 1.10: Cumulative GIRFS for the ISTVAR with LOW Debt: The output growth response on a tax-based shock or an expenditute-based shock in recessions or expansions when the Debt ratio is low.

it is interesting one to observe that now also an increase of taxes in periods of expansions is self-defeating. The tax shock increases public debt, which remains on an upward trajectory in the subsequent horizons.

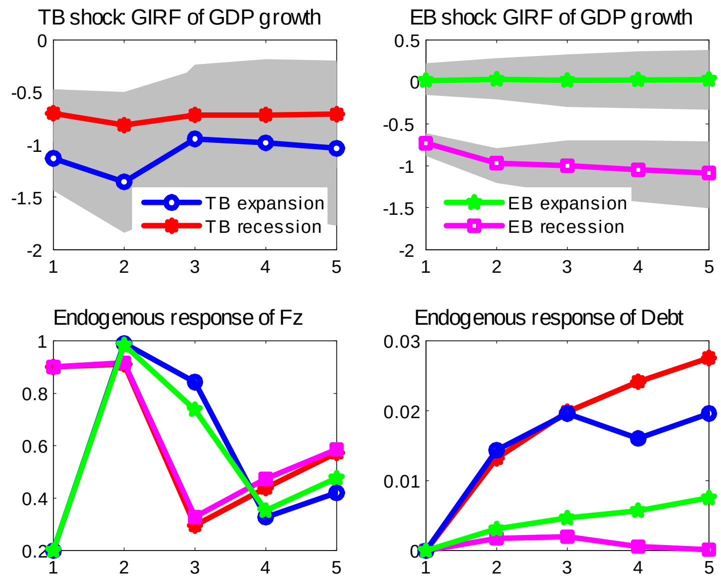

Figure 1.11: Cumulative GIRFS for the ISTVAR with HIGH Debt: The output growth response on a tax-based shock or an expenditute-based shock in recessions or expansions when the Debt ratio is high.

To sum up, policies implemented through expenditure-based adjustments seem to harm the economy less and are effective regarding their objective. They are able to stabilize, and even reduce debt. The picture is different when ones looks into a composition of policies based in tax increases. The distortionary flavour that taxes have, generate an opposite effect from the one that a government of a country would desire. Two factors can explain the increase in public debt, especially in periods of recessions: 1) the negative effect on the output growth and 2) the contemporaneous increase of government spending, which offsets the positive effect of higher revenues on the primary balance. This can be better understood by looking into the debt accumulation equation (3).

In general, the government can engage in decreasing the stock of public debt either by increasing its revenue, by the use of distortionary income taxation, or by reducing its expenditures, for example services that operate as a substitute for private consumption. In terms of policy implications, cutting expenditure seems to be more advisable, since it is less harmful for the economy. A cut in expenditure may reduce the distortion of taxes, since this may imply a decrease of taxation. This can be interpreted as a demand shock in the economy, and for this reason the effect on gdp growth is less pronounced.[27]

[27] Government spending is often wasteful. In this case this channel would be even stronger.

1.7 State-Dependent IRFs and Local Projections

In this section I discuss the potential pitfalls of the use of local projections in the state-dependent fiscal policy literature. For the purpose of this discussion I will work with a simplified model (STVAR), which accounts for two non-linearities (e.g. the state of the cycle and the type of fiscal consolidation). The goal of this section is to compare the performance of the local projections method to the GIRFS. Given this objective, I restrict our focus on the simplified model, both because it is more pedagogical and because this is the model generally used in the recent literature.

1.7.1 The Smooth Transition VAR

Given the objective of this section I simply assess the heterogeneity of the fiscal adjustments through state-dependence and composition. I make use of a tri-variate smooth transition vector autoregressive model (for an extensive presentation see Granger and Terasvitra (1993)).

$$Y_{it} = (1 - F(z_{it})) \times \left[A_E Y_{it-1} + B_{1E} e^{EB}_{i,t} + B_{2E} e^{TB}_{i,t}\right] +$$

$$+F(z_{it}) \times \left[A_R Y_{it-1} + B_{1R} e^{EB}_{i,t} + B_{2R} e^{TB}_{i,t}\right] +$$

$$+\lambda_i + \chi_t + u_{it}$$

$$F(z_{it}) = \frac{\exp[-\gamma_i z_{it}]}{1+\exp[-\gamma_i z_{it}]}, \quad \gamma > 0$$

where Y_{it} includes: Δy, the GDP growth, $\Delta\tau$, the change of government revenues, Δg, the change of government spending.[28] This model specification is still distinguishing between EB and TB narrative shocks.[29]

Following the previous discussion, I estimate the response of the output growth (or the rest of the economic aggregates) to fiscal shocks with the method of the generalized impulse response functions, which allow to endogenize the transition from one regime to the other.

1.7.2 Local Projections Method

In this subsection I first present the local projections approach proposed by Oscar Jordà (2005) to derive the impulse responses. This requires to run a series of

[28]

$$\begin{aligned}
\begin{bmatrix} \Delta y_{it} \\ \Delta\tau_{it} \\ \Delta g_{it} \end{bmatrix} &= [1-F(z_{it})] \begin{bmatrix} \alpha_{11}^E & \alpha_{12}^E & \alpha_{13}^E \\ \alpha_{21}^E & \alpha_{22}^E & \alpha_{23}^E \\ \alpha_{31}^E & \alpha_{32}^E & \alpha_{33}^E \end{bmatrix} \begin{bmatrix} \Delta y_{it-1} \\ \Delta\tau_{it-1} \\ \Delta g_{it-1} \end{bmatrix} + [1-F(z_{it})] \begin{bmatrix} \beta_1^E \\ \beta_2^E \\ \beta_3^E \end{bmatrix} e_{it}^{IMF} + \\
&+ [F(z_{it})] \begin{bmatrix} \alpha_{11}^R & \alpha_{12}^R & \alpha_{13}^R \\ \alpha_{21}^R & \alpha_{22}^R & \alpha_{23}^R \\ \alpha_{31}^R & \alpha_{32}^R & \alpha_{33}^R \end{bmatrix} \begin{bmatrix} \Delta y_{it-1} \\ \Delta\tau_{it-1} \\ \Delta g_{it-1} \end{bmatrix} + [F(z_{it})] \begin{bmatrix} \beta_1^R \\ \beta_2^R \\ \beta_3^R \end{bmatrix} e_{it}^{IMF} + \\
&+ \lambda_i + \chi_t + \begin{bmatrix} u_{it}^y \\ u_{it}^\tau \\ u_{it}^g \end{bmatrix}
\end{aligned}$$

[29]However, as a matter of ease and compactness for the discussion in the next section, I will keep notation simple and I will denote just the aggregate fiscal shock (for the disaggregate case, the extension is straightforward).

regressions for each horizon. The advantage of the local projections method lies on the fact that it does not constrain the shape of the IRF. I will first briefly present this approach as was introduced by Oscar Jordà for linear specifications. Along with this brief presentation I will refer to the limitations of the approach, already pointed out originally by the author, in the case of a non-linear specification. Then, I will move to the discussion of the state-dependent case as was first used in the fiscal policy literature by Auerbach and Gorodnichenko (2013).

The simplicity of this methodology has attracted many supporters, including researchers in fiscal policy and monetary policy. It is a flexible, model-free methodology, robust to misspecifications, from which one easily can derive the IRFs by running a series of regressions. In the linear case the model is

$$y_{it+h} = a_h x_{it-1} + \beta_h e_{i,t}^{IMF} + \lambda_i + \chi_t + \varepsilon_{it+h},$$

for $h = 0, 1, 2, ...$ horizons, where y is the variable of interest, x is a vector that includes the one lag of the growth of GDP, taxes and government spending. $e_{i,t}^{IMF}$ stands for the identified narrative shock (EB/ TB). The set of regressions in the above linear specification imply that the IRFs for this case are the collections of the β coefficients of each period.

AG allow for state-dependence in a straightforward way. In this case, the model becomes

$$\begin{aligned}\Delta y_{it+h} &= (1-F(z_{it}))\left[a_{E,h}x_{it-1}+\beta_{E,h}e_{i,t}^{IMF}\right]+ \\ &+F(z_{it})\left[a_{R,h}x_{it-1}+\beta_{R,h}e_{i,t}^{IMF}\right]+ \\ &+\lambda_i+\chi_t+\varepsilon_{it+h}.\end{aligned}$$

AG (2013) advocate that the local projections representation is equivalent to a moving average representation. This is the point of our potential criticism. The authors discuss the linear case both mathematically and graphically. They show that the IRFs that one recovers from the local projections approach are similar to the IRFs of the conventional approach for the linear case. Then they assume that the same should hold true for the non-linear case, and directly apply their version of local projections for their non-linear model. Basically, theirs IRFs are derived again as a sequence of the β_h's, estimated in a series of single regressions for each horizon. The IRFs for AG when a shock hits the economy in periods of recessions is the collection of the estimated $\beta_{R,h}$ and for expansions is $\beta_{E,h}$.

1.7.3 The Moving Average Representation

To compute the IRFs one typically proceeds by constructing first the moving average representation. Recently, it has been assumed in this literature (starting from AG) that the local projections approach is equivalent to the moving average representation of the series.

In this section I prove that the IRFs of a simple non-linear AR(1) differ from the IRFs recovered from the local projections approach.

Let me assume a non-linear model, of a similar spirit as my baseline model.

$$y_t = \alpha_t y_{t-1} + u_t \qquad \forall t \in \mathbb{N}_0. \tag{1.6}$$

In particular, one can have

$$\alpha_t = \frac{e^{-\frac{\gamma}{2}(y_{t-1}+y_{t-2})}}{1+e^{-\frac{\gamma}{2}(y_{t-1}+y_{t-2})}} A_1 + \frac{1}{1+e^{-\frac{\gamma}{2}(y_{t-1}+y_{t-2})}} A_2 \qquad \forall t \in \mathbb{N}_0.$$

Lemma 1 *For each* $t \in \mathbb{N}_0$

$$y_t = \sum_{\tau=0}^{t} \phi_{\tau,t} u_\tau + \phi_{-1,t} y_{-1}$$

where

$$\phi_{\tau,t} = \prod_{s=\tau+1}^{t} \alpha_s \qquad \forall \tau \in \{-1, 0, ..., t\}.$$

By convention, I assume that $\prod_{s=\tau+1}^{t} \alpha_s = 1$, if $\tau + 1 > t$. In particular, $\phi_{t,t} = 1$.

Assume now that

$$y_t = \alpha_t y_{t-1} + \beta_t e_t^{IMF} + u_t \qquad \forall t \in \mathbb{N}_0. \tag{1.7}$$

In particular, one can have

$$\begin{aligned} \alpha_t &= \frac{e^{-\frac{\gamma}{2}(y_{t-1}+y_{t-2})}}{1+e^{-\frac{\gamma}{2}(y_{t-1}+y_{t-2})}} A_1 + \frac{1}{1+e^{-\frac{\gamma}{2}(y_{t-1}+y_{t-2})}} A_2 \\ \beta_t &= \frac{e^{-\frac{\gamma}{2}(y_{t-1}+y_{t-2})}}{1+e^{-\frac{\gamma}{2}(y_{t-1}+y_{t-2})}} B_1 + \frac{1}{1+e^{-\frac{\gamma}{2}(y_{t-1}+y_{t-2})}} B_2 \forall t \in \mathbb{N}_0. \end{aligned}$$

Lemma 2 *For each $t \in \mathbb{N}_0$*

$$y_t = \sum_{\tau=0}^{t} \phi_{\tau,t} u_\tau + \sum_{\tau=0}^{t} \beta_\tau \phi_{\tau,t} e_\tau^{IMF} + \phi_{-1,t} y_{-1}$$

where

$$\phi_{\tau,t} = \prod_{s=\tau+1}^{t} \alpha_s \qquad \forall \tau \in \{-1, 0, ..., t\}.$$

By convention, I assume that $\prod_{s=\tau+1}^{t} \alpha_s = 1$, if $\tau + 1 > t$. In particular, I have that $\gamma_{t,t} = 1$.

The proofs are provided in the appendix.

What is important to realize from the above result is that the computation of the IRFs in the conventional approach depends on the time-varying coefficients which are functions of the lags of the left-hand-side variable. The IRFs are history-dependent. This is different from the linear case, where in the above setting would imply that $\phi_{\tau,t} = \prod_{s=\tau+1}^{t} \alpha$.[30] Therefore, in the non-linear setting the local projections method as has been widely used in the literature is not equivalent to the moving average representation, which means that the IRFs are not equivalent. This is easy to observe if one derives the IRFs that correspond to the local projections approach à la AG.

[30]It may be easier for the reader to notice that in the linear case if one starts from the baseline model, by substituting, one would have:
$y_0 = \alpha y_{-1} + \beta e_0^{IMF} + u_0$
$y_1 = \alpha y_0 + \beta e_1^{IMF} + u_1 = \alpha^2 y_{-1} + \alpha\beta e_0^{IMF} + \alpha u_0 + \beta_1 e_1^{IMF} + u_1$
$y_2 = \alpha y_1 + \beta e_2^{IMF} + u_2 = \alpha^3 y_{-1} + \alpha^2 \beta e_0^{IMF} + \alpha^2 u_0 + \alpha\beta e_1^{IMF} + \alpha u_1 + \beta e_2^{IMF} + u_2$ etc., whereas in the state-dependent case:
$y_0 = \alpha_0 y_{-1} + \beta_0 e_0^{IMF} + u_0$
$y_1 = \alpha_1 y_0 + \beta_1 e_1^{IMF} + u_1 = \alpha_1 \alpha_0 y_{-1} + \alpha_1 \beta_0 e_0^{IMF} + \alpha_1 u_0 + \beta_1 e_1^{IMF} + u_1$
$y_2 = \alpha_2 y_1 + \beta_2 e_2^{IMF} + u_2 = \alpha_2 \alpha_1 \alpha_0 y_{-1} + \alpha_2 \alpha_1 \beta_0 e_0^{IMF} + \alpha_2 \alpha_1 u_0 + \alpha_2 \beta_1 e_1^{IMF} + \alpha_2 u_1 + \beta_2 e_2^{IMF} + u_2$

I write the baseline model specification in a simpler way. More precisely, I drop the i subscript, the country and time dummies, and I just include the lag just of the output growth.

$$\begin{aligned}\Delta y_{t+h} &= (1-F(z_t))\left[a_{E,h}\Delta y_{t-1}+\beta_{E,h}e_t^{IMF}\right]+ \\ &+F(z_t)\left[a_{R,h}\Delta y_{t-1}+\beta_{R,h}e_t^{IMF}\right]+ \\ &+\varepsilon_{t+h}.\end{aligned}$$

1.7.4 IRFs à la Auerbach and Gorodnichenko

$$\Delta y_t = (1-F(z_t))\left[a_{E,0}\Delta y_{t-1}+\beta_{E,0}e_t^{IMF}\right]+F(z_t)\left[a_{R,0}\Delta y_{t-1}+\beta_{R,0}e_t^{IMF}\right]+\varepsilon_t$$

$$\Delta y_{t+1} = (1-F(z_t))\left[a_{E,1}\Delta y_{t-1}+\beta_{E,1}e_t^{IMF}\right]+F(z_t)\left[a_{R,1}\Delta y_{t-1}+\beta_{R,1}e_t^{IMF}\right]+\varepsilon_{t+1}$$

.

.

.

$$\Delta y_{t+h} = (1-F(z_t))\left[a_{E,h}\Delta y_{t-1}+\beta_{E,h}e_t^{IMF}\right]+F(z_t)\left[a_{R,h}\Delta y_{t-1}+\beta_{R,h}e_t^{IMF}\right]+\varepsilon_{t+h}.$$

Following AG this implies that the impulse response function of a fiscal consolidation in recession is $IRF^{\Delta y,R} = \left\{\beta_{R,h}\right\}_{h=0}^{H}$ with $H = 5$. Similarly in expansion is $IRF^{\Delta y,E} = \left\{\beta_{E,h}\right\}_{h=0}^{H}$. In this case, the impulse responses depend just on the first two initial lags of the LHS variable. They do not take into account both the change of the dependent variable and the possibility of the endogenous transition from one state to the other. The correct way of constructing the impulse response functions thinking the moving average representation would be for $h = 1$:

$$\begin{aligned}
\Delta y_{t+1} &= (1 - F(z_{t+1}))(1 - F(z_t))\beta_{E,1}e_t^{IMF} + (1 - F(z_{t+1}))F(z_t)\beta_{ER1,1}e_t^{IMF} + \\
&+F(z_{t+1})(1 - F(z_t))\beta_{R,1}e_t^{IMF} + (1 - F(z_t))F(z_{t+1})\beta_{ER2,1}e_t^{IMF} + \\
&+\alpha_1\alpha_0\Delta y_{t-1} + \varepsilon_{t+1}.
\end{aligned}$$

Hence, one can conclude that in the non-linear case the local projections do not recover the same IRFs as the conventional approach.

1.7.5 Monte Carlo Experiment

The goal in this subsection is to conduct a Monte Carlo experiment. The reason is that I would like to compare the IRFs derived by the STVAR versus the IRFs from the local projections method as has been used in the literature. First, I assume that the STVAR baseline model is the true model (data generating process DGP). This means that I estimate the model and use the fitted values of the STVAR to generate data. Then I proceed by applying the local projections method on the generated data.

The algorithm for the Monte Carlo experiment is the following:

Step 1. I first draw an error $\sim N(0, \Sigma)$.

Step 2. For time t , from the DGP I generate $\begin{bmatrix} \Delta y_{it} \\ \Delta \tau_{it} \\ \Delta g_{it} \end{bmatrix}$, by taking $t-1$ and $t-2$ as given.

Step 3. I get the new $F(z_{it})$.

Step 4. Repeat 1-3.

In the first round in *Step 2*, I take the initial two lags as given. The reason is that the lags of the dependent variable are included both in the controls and in the regime indicator.

Next, I apply the local projections approach in the data generated to derive the impulse responses of the variable of interest (e.g. output growth).

Recall that when the impulse responses are estimated by the local projections method, they depict the average behavior of the economy for each sample from t to $t+h$ depending on the shock and the initial state.

1.7.6 IRFs from the STVAR versus Local Projections

Before moving to the main findings of this discussion, I report the results that I get from the estimation of a linear VAR. The IRF for the output growth (Figure 17 in the Appendix) show that a 1% fiscal shock has a recessionary effect, with the fiscal adjustments based mainly on spending cuts being less costly in terms of short-run output losses. I get similar results if we use the local projections method, the IRFs from the two different methods are not statistically different. This is in line with what Auerbach and Gorodnichenko (2013) have discussed.

Moving to the STVAR model, first, I discuss the results that I acquire by using the local projections approach on the data. Then, I will look into the results drawn from the Monte Carlo experiment. To derive the IRFs with the local projections method, one need to account for the serial correlation generated in the regressions from $h > 0$ and correct the standard errors. Following Ramey and Zubairy(2016), I use the Newey-West standard errors.

The results for the non-linear model, where I consider just the non-linearities that arise from the state of the business cycle together with the different composition of fiscal shocks (see Figure 18 in the Appendix), indicate that the shocks occurring during economic downturns seem to be statistically different compared to the fiscal shocks implemented during periods of economic upturns. When a tax-based fiscal consolidation hits the economy during "good" times, the immediate effect is more recessionary compared to the case of "bad" times. Fiscal adjustments based upon taxes when implemented in periods of expansion have overall on average the most recessionary effect. The tax-based adjustments implemented in periods of recessions are less recessionary, which is in accordance with my previous findings. In the case of adjustments composed mainly from taxes, I find evidence of state-dependency. On the other hand, expenditure-based fiscal consolidations implemented in different periods are not statistically different. This last result is in line with the findings of Ramey and Zubairy (2016).

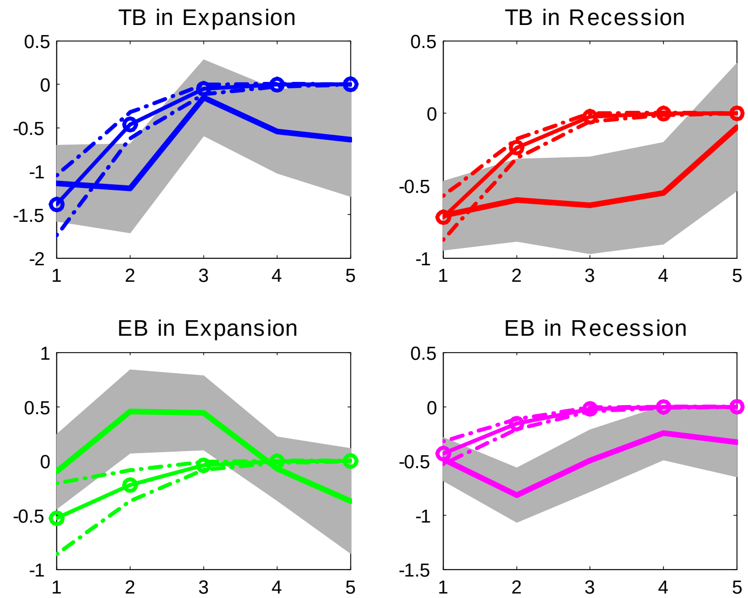

Figure 1.12: Data: IRFS with local projections (solid line with grey shaded area) versus STVAR.

From Figure 12 I observe that the IRFs derived from the two different methods differ. There is evidence that the two curves are statistically different. This is not the case just for the tax-based consolidations in expansions. The initial effects are identical, which is in line with what I discussed about the moving average representation and the fact that for $h = 0$ the initial effects should be the same. The response of the output growth with the local projections method is more erratic in general compared to the conventional approach. This is reasonable since the impulse responses with the local projections method are based on the estimated coefficient of the corresponding period. It important to mention, that irrespectively of the econometric discussion in a theoretical basis, the conclusions from the two different methods differ. In fact, one can notice from Figure 19 (in the Appendix) that the state-dependent evidence that I get from the GIRFs is now reversed.

Finally, I conduct out-of-sample simulations and compare the actual realization of GDP growth for the years 2009-2013 to the simulated ones derived from the STVAR and the local projections.[31]

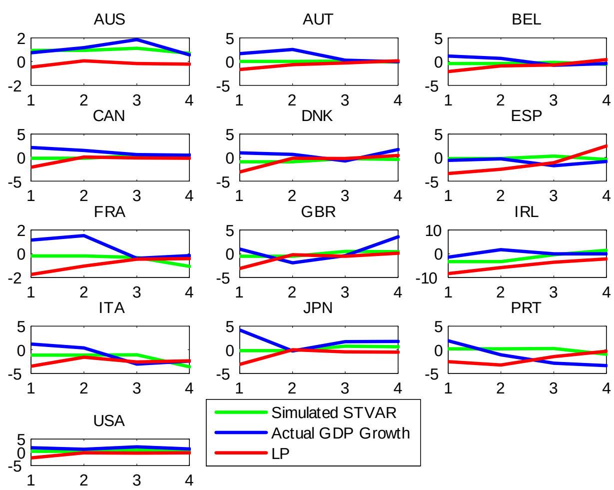

Figure 1.13: Out-of-sample simulation.

[31]Local projections are not used in general for forecasting. I still believe that it is a reasonable way to compare the fit of the two methods.

1.7.7 Monte Carlo Experiment

The underline assumption is that the STVAR is the true model, which I use as the data generating process. In Figure 14, I present just the confidence intervals of the STVAR, since this is the uncertainty of the true model. The size of the initial effects is comparable to the STVAR. The derived IRFs in this case are not statistically different and the dynamics also seem not to differ much. One reason may be that the non-linearity introduced is not that strong, since the GDP growth after a shock does not change much from one year to the other.[32,33]

[32] For this reason, as a simple exercise I consider conducting the same experiment in the ISTVAR framework. In this case the non-linearity that arises from the government debt dynamics is stronger, so it could be interesting to see the difference to the existing findings.

[33] Further tests for the difference of the IRFs include the one of Olivei and Tenreyro (2010).

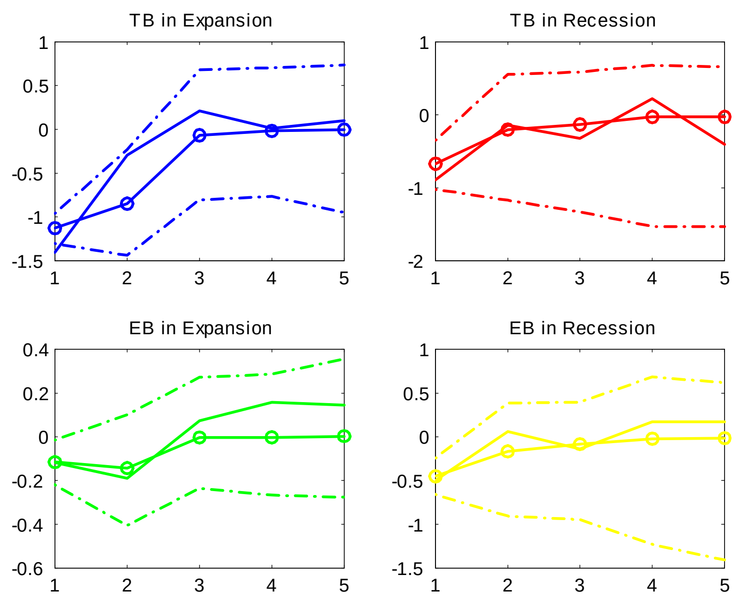

Figure 1.14: Monte Carlo Experiment: The solid line with the circles depicts the IRFs derived from the true model (the DGP, i.e. the STVAR) and the true confidence intervals, while the solid line depicts the IRFS derived with the local projections method.

1.8 Robustness Checks and Additional Tests

In this section I briefly discuss part of the preliminary tests needed regarding my baseline model specification and the narrative data.[34]

1.8.1 Linearity tests

To make sure that the smooth transition regime switching models are identified, I need to conduct a hypothesis testing of H_0: Linear model versus H_1: Logistic STVAR model. I conduct two type of linearity tests. First, we follow Terasvirta and Yang (2014) and use the LM-type test to compare the residual sum of squares of the linear model to the ones of a second- or third-order approximation os the STVAR specification. Then I use a standard likelihood ratio test. Both tests are in favor of the non-linear model.

To conduct the linearity test we approximate the logistic function by a 2nd or 3rd order Taylor expansion. The non-linear performs better compared to the linear model. The values for both the Akaike criterion and the Schwarz criterion are lower for the non-linear model, which indicate that it is the preferred model.

[34]Further details of the tests and results, as well as further robustness checks can be provided if requested.

	Linear Model	Non-Linear Model
AIC	4.15	4.06
BIC	4.61	4.58

Table 1.2: Linearity test.

1.8.2 Exogeneity of the narrative identified shocks

To investigate whether the identified adjustments are systematically uncorrelated with other developments affecting output, I use a simple test of exogeneity (Granger causality test). More precisely, I regress the narrative identified adjustments on the lag of output growth, and augment by including lagged values of the narrative measures. If the past variables are not able to predict a shift in the components of spending or taxes, then the shift is considered to be exogenous.

The results of the Granger causality tests that I run for each country and for each component show that, in most of the cases, the null hypothesis that the past variables predict the narrative measures is rejected. For Sweden and the Netherlands I am not able to reject the null hypothesis. Therefore I decide to drop these countries from our analysis.

1.8.3 Hypothesis Testing

Econometrically, one can examine whether the "when", the "how", or the "initial condition" matters more or less by testing different hypothesis.

Hypothesis Testing		
Cycle	$B_{1E} = B_{1R}$;	$B_{2E} = B_{2R}$
Composition	$B_{1E} = B_{2E}$;	$B_{1R} = B_{2R}$
Initial Condition	$B_0^E = B_1^E$;	$B_0^R = B_1^R$

Table 1.3: Different scenarios of hypothesis testing.

1.9 Concluding Remarks

The effect of fiscal austerity during economic downturns is the Gordian knot of policy discussions. In this paper I contribute to the empirical literature of fiscal policy in two ways. First, I study the relevance of non-linearities regarding the output effects of fiscal shocks. I propose a general encompassing model to study non-linearities. I focus on three types of non-linearities simultaneously, related to the "how" a fiscal adjustment is implemented, "when" and the initial condition of the economy. The simultaneous study of the initial condition, namely the debt ratio of the economy, with the other two non-linearities, captures the novelty of this paper. And, indeed, I find that it matters.

I examine the potential asymmetric response of fiscal consolidations by allowing for a non-linearity on the state of the economy, the composition of the fiscal adjustments and the government's budget fiscal position. I present an Interacted STVAR aiming to study these asymmetries. In general, policies implemented through expenditure-based adjustments seem to harm the economy less and work effectively. They are able to stabilize, and even reduce debt. The picture is different when I look into a composition of policies based on tax increases. The distortionary flavour that taxes potentially may have, generates an effect opposite from what the government of a country would desire. The effect of tax-based adjustments are, on average, the most recessionary. When debt is high, by increasing taxation, the fiscal authority fails to stabilize. However, when the authority decides to cut public expenditure during a good period, stabilization of debt is observed together with a negligible effect to the output growth. The heterogeneous response of the expenditure-based consolidations implemented during good periods when debt is high is an interesting policy implication that should be examined further. In addition, the evidence of the asymmetries between low and high ratios of debt should be evaluated to understand the channels of the transmission mechanism. For example, it could be important to control for a component of monetary policy, particularly when interest rates are close to the zero lower bound, and possibly study a related theoretical model.

Furthermore, I address some key problems in the econometrics of the existing literature. More precisely, I discuss the potential pitfalls of the use of the local projections method in the fiscal policy literature. I prove that the IRFs derived from the conventional approach are not the same as those derived from the local projections' approach. When I compare the IRFs derived from the two approaches, the two seem to differ and lead to completely different policy conclusions. Nevertheless, in my Monte Carlo experiments, my findings indicate that they are not statistically different.

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Appendix A: Debt

I will discuss econometrically why it is important to include debt. The reason is simple, omitting debt may deliver biased estimates. The aim is to estimate the effect of fiscal adjustments on the output growth. As I discussed in Section 3, the records of the fiscal adjustments are identified in a way that they are exogenous to the business cycle. However, they depend on one key motivation. The motivation is to decrease the government's deficit. Assume a simple model, with a focus just on output growth. Suppose that the true model is the following

$$\Delta y_t = \alpha + \beta \cdot Debt_{t-1} + \gamma \cdot e_t^{IMF} + \varepsilon_t.$$

I can reasonably assume that both $\beta < 0$ and $\gamma < 0$. The latter, can be seen also from Figure 12 for the linear case and from Figure 13 for the state-dependent case, where the effect of fiscal consolidations had a recessionary effect on output growth. At the same time, I have that

$$e_t^{IMF} = \kappa \cdot Debt_{t-1} + \upsilon_t,$$

where $\kappa > 0$, given the motivation of the fiscal adjustments. If I combine the two equations,

$$\Delta y_t = \alpha + (\frac{\beta}{\kappa} + \gamma) \cdot e_t^{IMF} + \nu_t$$

it is clear that if one considers just the fiscal adjustments , this would imply an overestimation of the effect $((\frac{\beta}{\kappa} + \gamma) < 0)$. Intuitively, in this case, one could also think that the stabilization feedback effect to the system, arising from debt, is missing.

Appendix B: Proofs of MA representation

Proof of Lemma 1. I proceed by induction.

Initial Step. $t = 0$. By (1.6), $y_0 = \alpha_0 y_{-1} + u_0 = u_0 + \alpha_0 y_{-1}$. At the same time, note that $\phi_{0,0} = \prod_{s=0+1}^{0} \alpha_s = 1$ and $\phi_{-1,0} = \prod_{s=-1+1}^{0} \alpha_s = \alpha_0$. I can conclude that

$$y_0 = \sum_{\tau=0}^{0} \phi_{\tau,0} u_\tau + \phi_{-1,0} y_{-1}.$$

Inductive Step. The statement is true for t. I next show it holds for $t+1$. By (1.6) and inductive hypothesis, it follows that

$$\begin{aligned}
y_{t+1} = \alpha_{t+1} y_t + u_{t+1} &= \alpha_{t+1} \left(\sum_{\tau=0}^{t} \left(\prod_{s=\tau+1}^{t} \alpha_s \right) u_\tau + \left(\prod_{s=-1+1}^{t} \alpha_s \right) y_{-1} \right) + u_{t+1} \\
&= \left(\sum_{\tau=0}^{t} \alpha_{t+1} \left(\prod_{s=\tau+1}^{t} \alpha_s \right) u_\tau + \alpha_{t+1} \left(\prod_{s=0}^{t} \alpha_s \right) y_{-1} \right) + u_{t+1}. \\
&= \sum_{\tau=0}^{t} \left(\prod_{s=\tau+1}^{t+1} \alpha_s \right) u_\tau + \left(\prod_{s=0}^{t+1} \alpha_s \right) y_{-1} + u_{t+1} \\
&= \sum_{\tau=0}^{t+1} \left(\prod_{s=\tau+1}^{t+1} \alpha_s \right) u_\tau + \left(\prod_{s=0}^{t+1} \alpha_s \right) y_{-1} \\
&= \sum_{\tau=0}^{t+1} \phi_{\tau,t+1} u_\tau + \phi_{-1,t+1} y_{-1}.
\end{aligned}$$

By induction, the statement follows. ■

Proof of Lemma 2. For each $t \in \mathbb{N}_0$ define

$$\tilde{u}_t = \beta_t e_t^{IMF} + u_t. \tag{1.8}$$

By (1.7), I have that

$$y_t = \alpha_t y_{t-1} + \tilde{u}_t \qquad \forall t \in \mathbb{N}_0.$$

By Lemma 1, I can write

$$y_t = \sum_{\tau=0}^{t} \phi_{\tau,t} \tilde{u}_\tau + \phi_{-1,t} y_{-1} \qquad \forall t \in \mathbb{N}_0 \tag{1.9}$$

where

$$\phi_{\tau,t} = \prod_{s=\tau+1}^{t} \alpha_s \qquad \forall \tau \in \{-1, 0, ..., t\}.$$

By plugging (1.8) in (1.9), I can conclude that for each $t \in \mathbb{N}_0$

$$\begin{aligned} y_t &= \sum_{\tau=0}^{t} \phi_{\tau,t} \left(\beta_\tau e_\tau + u_\tau\right) + \phi_{-1,t} y_{-1} \\ &= \sum_{\tau=0}^{t} \phi_{\tau,t} u_\tau + \sum_{\tau=0}^{t} \beta_\tau \phi_{\tau,t} e_\tau^{IMF} + \phi_{-1,t} y_{-1}, \end{aligned}$$

proving the statement.

Appendix: Tables and Figures

Horizon	Expansion	CI low Exp	CI up exp	Recession	CI low rec	CI up Rec
1	0.9800	0.5900	1.7900	0.1200	-0.3100	0.6500
2	-0.2300	-1.3600	0.8300	-0.5400	-2.2000	1.2400
3	-0.5200	-1.5900	0.3600	-0.7800	-1.8600	0.3500
4	-0.4300	-1.9700	1.0800	-0.6800	-1.3800	0.0100
5	-0.4900	-1.8700	0.9200	-0.7700	-1.5500	-0.1300

High Debt: The TB Cumulative Multiplier in recessions and expansions with the related upper or lower confidence band.

Horizon	Expansion	CI low Exp	CI up Exp	Recession	CI low Rec	CI up Rec
1	-0.3700	-0.6300	-0.1900	-0.3400	-0.4700	-0.2500
2	-0.2900	-0.5500	-0.0300	-0.2800	-0.4400	-0.1200
3	-0.2200	-0.4100	-0.0400	-0.2900	-0.4500	-0.1400
4	-0.2400	-0.4000	-0.0700	-0.3000	-0.4600	-0.1700
5	-0.2400	-0.3900	-0.0700	-0.3000	-0.4600	-0.1600

High Debt: The EB Cumulative Multiplier in recessions and expansions with the related upper or lower confidence band.

Horizon	Expansion	CI low Exp	CI up Exp	Recession	CI low Rec	CI up Rec
1	0.8831	0.5900	1.4000	0.1574	-0.0600	0.3800
2	0.5458	0.3600	0.8200	-0.0581	-0.3500	0.2000
3	0.5143	0.3100	0.7700	-0.2459	-0.6300	0.0700
4	0.5586	0.3500	0.8300	-0.4339	-1	-0.0600
5	0.6161	0.3900	0.9000	-0.6386	-1.4500	-0.1600

Low Debt: The TB Cumulative Multiplier in recessions and expansions with the related upper or lower confidence band.

Horizon	Expansion	CI low Exp	CI up Exp	Recession	CI low Rec	CI up Rec
1	-0.3619	-0.6200	-0.1700	-0.4527	-0.6300	-0.3300
2	-0.4415	-0.7500	-0.2200	-0.5062	-0.8100	-0.3100
3	-0.3912	-0.6500	-0.1800	-0.4348	-0.7400	-0.2300
4	-0.3598	-0.5900	-0.1700	-0.4206	-0.7100	-0.2500
5	-0.3466	-0.5600	-0.1700	-0.4132	-0.6600	-0.2700

Low Debt: The EB Cumulative Multiplier in recessions and expansions with the related upper or lower confidence band.

Variable	Coefficient (DeltaY)	Std. Error	T-statistic	Coefficient (DeltaT)	Std. Error	T-statistic	Coefficient (DeltaG)	Std. Error	T-statistic
(1-F)DeltaY	0.4167	0.0893	4.6645	0.0636	0.1313	0.4843	-0.1944	0.1846	-1.0531
(1-F)DeltaT	-0.2313	0.0802	-2.8854	-0.0417	0.1178	-0.3539	0.1177	0.1656	0.7106
(1-F)DeltaG	-0.2070	0.0610	-3.3965	0.0413	0.0896	0.4611	0.2633	0.1259	2.0909
(1-F)i	0.1325	0.0694	1.9099	0.1758	0.1020	1.7241	0.1991	0.1433	1.3890
(1-F)pi	-0.0017	0.0796	-0.0217	0.1477	0.1170	1.2623	-0.1581	0.1644	-0.9611
(1-F)Debt	-0.0083	0.0081	-1.0231	-0.0204	0.0119	-1.7193	-0.0578	0.0167	-3.4652
(1-F)eTB	-0.0129	0.0046	-2.8207	0.0231	0.0067	3.4466	-0.0190	0.0094	-2.0102
(1-F)eEB	0.0020	0.0035	0.5730	-1.1450e-04	0.0051	-0.0224	-0.0036	0.0072	-0.5057
(1-F)DeltaY	0.2041	0.1107	1.8435	0.4104	0.1628	2.5214	-0.3918	0.2287	-1.7129
(1-F)DeltaT	-0.1169	0.0750	-1.5593	-0.0149	0.1102	-0.1353	0.1605	0.1549	1.0362
(1-F)DeltaG	0.0991	0.0348	2.8495	-0.0526	0.0511	-1.0296	-0.3171	0.0718	-4.4155
(F)i	-0.0894	0.0671	-1.3332	-0.0674	0.0986	-0.6841	0.0749	0.1385	0.5405
(F)pi	-0.0202	0.0696	-0.2902	-0.0138	0.1023	-0.1350	0.0153	0.1437	0.1065
(F)Debt	0.0286	0.0078	3.6878	0.0143	0.0114	1.2589	-0.0606	0.0160	-3.7854
(F)eTB	-0.0061	0.0026	-2.3323	0.0086	0.0039	2.2436	0.0358	0.0054	6.6153
(F)eEB	-0.0083	0.0020	-4.1784	0.0049	0.0029	1.6636	-0.0096	0.0041	-2.3383

Estimation Results of the Fiscal STVAR with Debt (regressors of lag(1) - except from the identified shocks EB,TB).

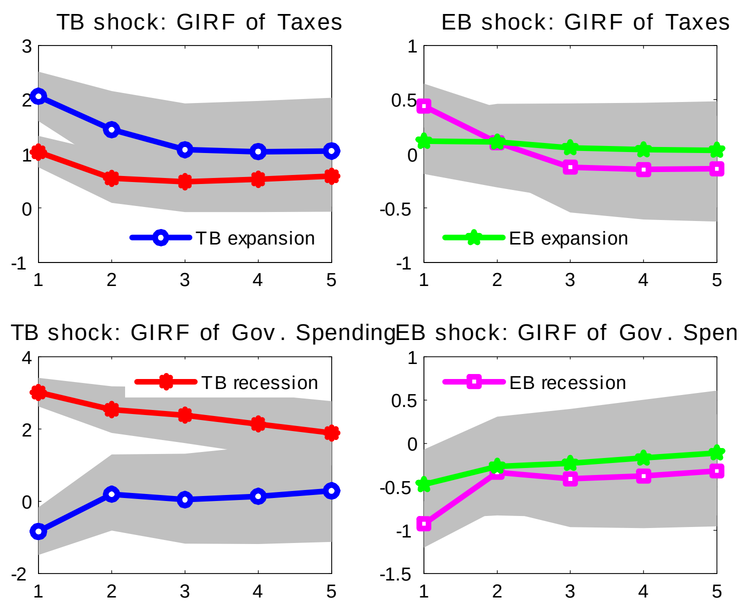

Figure 1.15: Cumulative GIRFs for the Fiscal STVAR with LOW Debt: The responses of taxes and government spending on a tax-based shock or an expenditute-based shock in recessions or expansions when the Debt ratio is low.

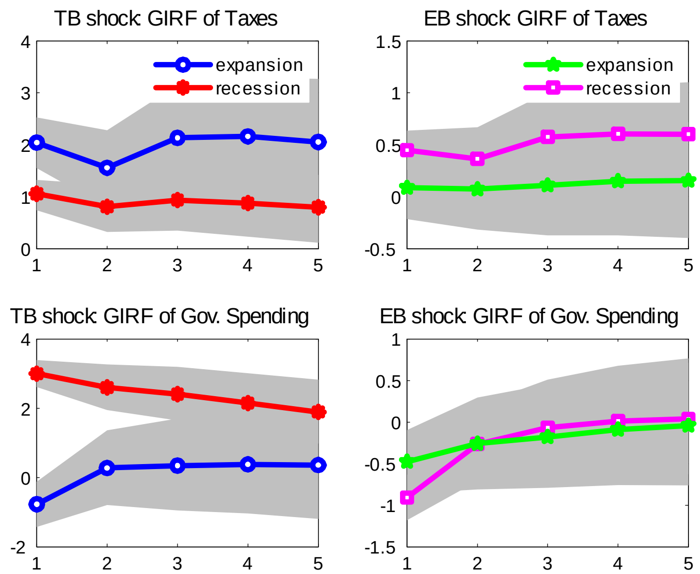

Figure 1.16: Cumulative GIRFs for the Fiscal STVAR with HIGH Debt: The responses of taxes and government spending on a tax-based shock or an expenditute-based shock in recessions or expansions when the Debt ratio is high.

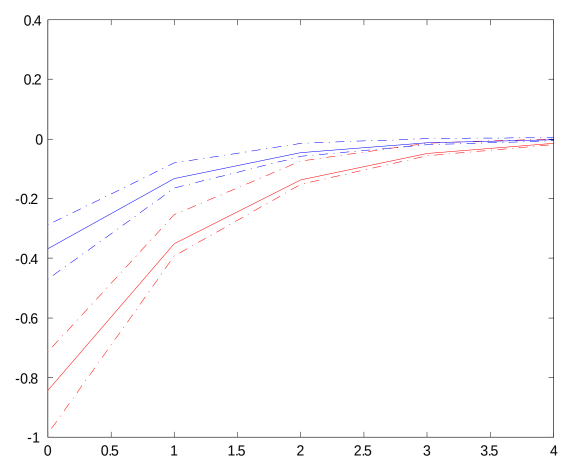

Figure 1.17: GIRF for the Linear 3-variate VAR: The output responce on an tax-based (red); expenditure-based (blue) fiscal adjustment

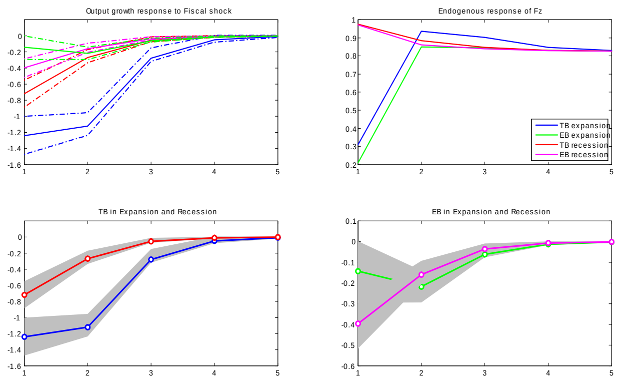

Figure 1.18: GIRF for the STVAR: EB and TB fiscal adjustments in Recessions and Expansions and the endogenous response of Fz

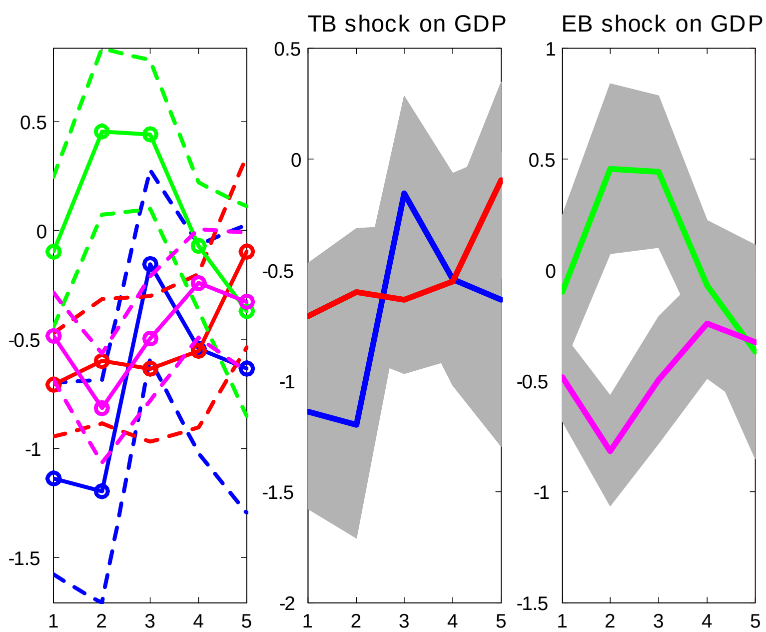

Figure 1.19: Data: IRFs derived with local projections.

Chapter 2

Fiscal Consolidation Plans: A Bayesian Approach

Abstract

We make use of a narrative panel dataset of 13 OECD countries that consists of anticipated and unanticipated changes of government spending and taxes. In the spirit of Bayesian hierarchical modeling, we use the narrative record of fiscal consolidation plans to examine the effects of multi-year fiscal changes (unanticipated and anticipated) on macroeconomic variables in each country. Existing studies typically pool country data due to the lack of observed fiscal episodes per country. We adopt a Bayesian approach to overcome this problem, which allows us to conduct a country-specific study. In addition, instead of evaluating the effects of a tax increase or government spending separately we take into account the correlation of the two.

For some countries the heterogeneous effects of the different components are evident. When we assume a non-informative prior, the lack of information in the data does not allow us to arrive to clear conclusions, which suggests that the prior belief dominates and influences the final results. For this reason we enhance our prior believes according to general country-specific features. Our results highlight that the transmission of fiscal policy highly depends on the economic environment.

2.1 Introduction

The recent financial crisis has renewed interest in the size of fiscal multipliers. Many macroeconomists are concerned with finding tools that will lead to economic stabilization, stimulation and growth. For instance, many countries are facing the challenge of decreasing their public debts. At the frontier of the academic and policy dispute stands the question of whether countries can succeed in reducing their deficits or their government debt without causing large output losses.

Empirically, the identification of the effects of fiscal consolidations is a crucial issue in this literature. A method that can isolate exogenous changes in government spending or taxation that are uncorrelated with contemporaneous economic shocks is required. Two main identification strategies have been proposed: The first is related to vector autoregression (VAR) identification schemes in which restrictions are imposed (e.g. coefficient restrictions à la Blanchard-Perotti (2002); sign restrictions à la Mountford and Uhlig (2009)). The second strategy is based on a method called the narrative approach (Romer and Romer 2010).The narrative approach identifies the historical accounts of variations in spending or taxation (and the information flow regarding these variations) which are assumed to be uncorrelated with contemporaneous economic shocks.

Econometricians usually base their information on the past and present values of the economic series in question. Therefore, they do not internalize the agents' future expectations. Agents, however, form expectations which take into account in their present values. This problem, called "nonfundamentalness", has been studied in the literature by Hansen and Sargent (1991) and Lippi and Reichlin (1993). But, despite its relevance, nonfundamentalness had not been taken widely into account in the macroeconomic literature until recently.

Nonfundamentalness relates to a phenomenon called "fiscal foresight". As discussed in recent studies (Leeper, Walker and Yang (2008), Mertens and Ravn (2010)), changes in tax and government spending policies are anticipated. Economic agents receive signals about future fiscal policy changes due to, for example, a government announcement. The agents, being rational, adjust their behavior according to these changes before the changes actually occur. In other words, agents anticipate and internalize forthcoming fiscal changes due to the lag between legislation and implementation. Due to the implementation lag, the shock does not affect fiscal variables immediately. However, if the innovation is known to the agent (one or more) lags before fruition, these variables lose informational content. This issue naturally complicates empirical analysis.

An alternative way of framing nonfundamentalness is in a context of omitted variables. More precisely, this problem originates from the disjointed information sets of the econometrician and the agents. The use of narrative measures allows the fundamental shocks to be retrieved, which is believed to be a solution to this informational insufficiency (Lippi and Reichlin (1994), Mertens and Ravn (2010)), consequently enlarging the econometrician's information space. This final idea reflects most of the solutions that have been proposed in the related empirical literature of fiscal shocks identification. For example, Ramey (2011) supplies information to the VAR (EVAR) by using ad hoc variables from the SPF (Survey of Professional Forecasters) to approximate the agents' expectations. Similarly, Leeper, Walker and Yang (2011) use the spread between municipal and treasury bonds as a measure of anticipation of future tax changes. Whether these variables are able to correctly capture the agents' expectations is a matter of assumptions.

The goal of this paper is to evaluate the effects of fiscal changes in macroeconomic variables in a sample of OECD countries. Similarly to the article of Alesina, Favero and Giavazzi (2013), we study a multi-year panel of 13 OECD countries. Instead of evaluating the effects of a tax increase or government spending cut separately, we study the different impacts of fiscal corrections (spending cuts or tax-based). These are classified as exogenous by taking into account the dynamics (unanticipated and anticipated announcements) and the heterogeneous nature of fiscal "plans" at the different country level. The timing convention of unanticipated and anticipated changes allows for a distinction between the date on which a government announces a fiscal policy change and the date on which this change becomes a law, i.e. the implementation lag. We build a dataset that consists of the multi-year structure of fiscal plans (i.e. unanticipated and anticipated shocks), rather than yearly shocks. In doing so, we add to the discussions of fiscal foresight and internalization of agents' expectations.

The aim of this paper is to incorporate the narratively identified components into a Bayesian hierarchical modeling approach. By using a hierarchical model and a Gibbs sampler, our main contribution is to exploit the informational content of the narrative measures for the identification of exogenous tax and government spending changes country-by-country. The sparse data that are usually retrieved from the narrative records lead to various estimation and identification problems. Instead of pooling all country data together, as is common in the literature, we exploit the attractive features of the Bayesian hierarchical modeling and the narrative approach to provide country-specific estimates that will be key for the derivation of the impulse response functions. By using an exchangeable prior in combination with the likelihood of the data of each country, we would like to quantify the heterogeneity present in the different fiscal policies of country. Such results are not attainable with the classical approach of pooled OLS.

Our findings indicate that for some countries the heterogeneous effects of the different components are evident. When we assume a non-informative prior, the lack of information in the data does not allow us to arrive to clear conclusions, which suggests that the prior belief dominates and influences the final results. For this reason we enhance our prior believes according to general country-specific features. Our preliminary results highlight that the transmission of fiscal policy highly depends on the economic environment.

The remainder of the paper is organized as follows. Section 2 motivates our research and provides a brief review of the related literature. Section 3 describes the new dataset. Section 4 discusses the model and the econometric methodology related to the use of the Gibbs sampler in the hierarchical model. In section 5, before moving to the presentation of our results, we illustrate some tests and diagnostics. Section 6 presents the country-specific prior assumptions.[1] The last section concludes.

2.2 Motivation

The cacophony of competing estimates of fiscal multipliers that arises in the continuous fiscal austerity debate is due to the fact that different models, relying on different assumptions and estimation methods, reasonably result in different predictions. Our goal is not to bring another source of noise into the picture. Rather, we

[1] This is work in progress.

attempt to build on the existing literature by combining existing conjectures. The following section presents the key studies from which we construct our analysis.

2.2.1 Related Literature

Mertens and Ravn (2013) examine the dynamic impact of federal tax policy reforms in the US. They study post-war tax changes that are identified by a Romer and Romer (2010) style narrative approach and they distinguish between two type of taxes instead of a single total tax. Taxes are decomposed into personal income and corporate income taxes, and they estimate the impact of unanticipated changes on average income taxes. A structural vector autoregressive model as in the Blanchard and Perotti (2002) approach is used. The authors, in contrast to Blanchard and Perotti (2002), do not calibrate the structural parameters but estimate them. In order to avoid imposing additional restrictions their method follows that of Romer and Romer (2010), exploiting the information of the narrative approach.[2] Narratively identified tax changes are used as proxies for structural tax shocks. A key assumption is that the narratively identified shock is not the true structural shock. Conversely, it is assumed that the narratively identified shock and the latent structural tax shock of interest are correlated and that the narratively identified shock is orthogonal to all

[2]Romer and Romer (2010) use economic reports of the President and other historical government documents to identify endogenous tax changes and exogenous ones. In brief, they first estimate the effects of tax shocks on output and then they re-estimate by adding control variables or splitting the sample.

other shocks. The two conditions of the proxies lead to the covariance restrictions of their procedure. While the proxies contain much information on latent tax shocks, they can also contain considerable measurement error since they derive from historical records. Given this fact, the authors introduce their method within a framework of a measurement error model.

Mertens and Ravn show that there are large and immediate output effects of both personal income and corporate income tax changes. Personal income tax cuts reduce tax revenues and increase debt, while corporate income tax cuts have little budgetary income effect. Moreover, the implications on macroeconomic variables are also different for the two type of taxes. A personal income tax cut leads to an increase in employment and hours worked per worker. On the contrary, the side of employment remains unchanged in the case of the corporate income tax cut. Consumption and investment both increase in response to a personal income tax cut. However, no change is observed for consumption (a sense of negative effect, barely significant) when corporate tax is decreased, while a positive effect is observed for investment.

Undoubtedly Mertens and Ravn use an identification scheme, correcting for measurement error problems, that highly contributes to the existing literature. However, the issue of the fiscal foresight is not taken into account, since they consider only unanticipated shifts.

On the other side, Ellahie and Ricco (2013) examine the heterogeneous effects of shocks of disaggregate components of government spending at federal, state and local level, on a variety of macroeconomic variables. They adopt a large information approach in a Bayesian VAR context (influenced by Giannone and Rechlin (2010)) as a method of identification of the government spending shocks. Their paper is close to Forni and Cambetti (2010) who investigate fiscal policy effects in a large factor model environment.

In this framework, agents base their decisions on all the information that is available. By using a large information approach with full Bayesian techniques, the authors are able to expand the econometrician's dataset. An expansion of the set of variables is associated with a dimensionality curse. The curse can be solved by using large Bayesian VARs.

What they find is that "information" is indeed important due to the forward looking behavior of the agents and that different components of government spending have heterogeneous effects which on aggregate may crowd out each other, showing a weak stimulative impact. They observe very strong responses of GDP to shocks in non-defense government investment. Consumption and investment react strongly to shocks in non-defense investment. Non-durable consumption and services respond strongly to state and local consumption. Real rates generally drop on impact and then recover.

Spending shocks are fundamental for large information BVARs. There is a large amount of heterogeneity across different shocks. Even though the authors take into account the different effects that arise by decomposing the government spending, they do not internalize the fact that these different components may be correlated. We will incorporate this point into this paper.

Alesina, Favero and Giavazzi (2013) investigate the effects of fiscal adjustments on economic output. By using the narrative approach identification technique, they contribute to this literature by taking into account fiscal plans, anticipated and unanticipated changes that occur in taxes and government spending.

Earlier studies presented results emphasizing that an increase on taxes is worse than a cut to government spending. However, as the authors point out, those studies were suffering from important identification problems. By using the panel dataset of Devries et al. (2011), Alesina et al. use the exogenous narratively identified shocks à la Romer and Romer (2010).[3] They impose cross-equation restrictions and allow for heterogeneity in fiscal correction reform. They use country fixed effects and allow for country-level heterogeneity of fiscal plans, since they observe heterogeneous correlation of anticipated and unanticipated changes of fiscal plans across countries.

A strength of the paper is the fact that they allow for a correlation between the unanticipated and anticipated shocks.

The importance of fiscal plans can be clearly seen in their results. Different responses of output on tax based versus expenditure based are observed. A drawback of this study arises from the fact that they base their identification in a pooled OLS estimation.

[3]Devries et al. (2011) examined accounts of official documents by analyzing the timing, size and main motivation of each fiscal action that was taken in each country under study.

Recently, hierarchical modeling has attracted more attention (e.g. Berger 1985; Gelman et al. 2004). Giannone, Lenza and Primiceri (2013), use an hierarchical modeling approach in the context of Bayesian VARs. By taking into account the uncertainty of the hyperparameters of the prior, they make an inference about the informativeness of different prior distributions in the context of Bayesian VARS (Del Negro and Shorfheide 2004; Giannone and Reichlin 2010). Their results show that such an estimation strategy provides very accurate out-of-sample predictions under the perspective of point and density forecasts, but also performs well in terms of the estimation of impulse response functions. We find this study highly influential, and we will try to incorporate this idea of the optimal choice of hyperparameters in our algorithm.[4]

A useful survey related to panel vector autoregressive models that discusses the use of the Bayesian random coefficient approach (related to the notion of the exchangeable prior) is the one of Canova and Ciccarelli (2013).

2.3 Data

This study relies on an extended dataset of Devries et al. (2011) of multi-year decomposed exogenous fiscal consolidations of 17 OECD countries (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the

[4]Work in progress...

Netherlands, Portugal, Spain, Sweden, United Kingdom, United States) for the period 1978 to 2009. Motivated by the literature of the narrative identification approach of Ramey and Shapiro (1998) and Romer and Romer (2010), we use this extended version of the narrative record of Devries et al. (2011) examined historical records available in official documents (Budget Reports, Budget Speeches, Central Banks Reports, Convergence and Stability Programs submitted by EU governments to European Commission, IMF Reports, OECD economic surveys) which allowed them to directly identify the size, timing and principal motivation behind any fiscal action taken by each government. The fiscal alterations are measured as a percentage of GDP. The focus is restricted to the identification of fiscal changes that are exogenous to the economic cycle, as well as changes that are motivated by the willingness to reduce government deficit. This implies that a fiscal consolidation with the goal of restraining domestic demand or any other countercyclical policy is not included in the dataset.We make use of the dataset created by Alesina et al. (2013), which included the multi-year style of fiscal consolidations.

2.4 Fiscal Plans

Most of the existing literature examines individual shifts in taxes or spending. However, in reality, it is rare for these different types of consolidations to be independent from one another. Studying the impact of fiscal adjustments in a multi-year framework is crucial. It allows us to understand the different effects across time of expenditure-based and tax-based policies. This distinction is important, since as Giavazzi and Pagano (1990), Alesina and Ardagna (2010, 2012), Alesina et al. (2013) have discussed, spending-based fiscal consolidations can be associated with mild and short-lived recessions rather than the prolonged, deep recessions that a tax-based consolidation would imply. In addition, the study of plans in a "dynamic" sense can reveal the nature of the policy shifts, anticipated versus unanticipated and transitory versus permanent. Usually unanticipated and anticipated shifts happen to be correlated, a stylized fact that we seek to take into account. Previous studies (Mertens and Ravn 2010) have, in contrast, evaluated the effects of unanticipated and anticipated changes by assuming the two are orthogonal. The differential persistence of fiscal policy changes is related to the different fiscal "styles" of stabilization. A shift is characterized as permanent when the unanticipated announcements of a plan are positively correlated with the anticipated changes of the following years. Alternatively, if a negative correlation is observed, then the shifts are "stop-and-go" (temporary). Moreover, a multi-year, multi-country panel of fiscal plans allows us to study the fiscal policy of various countries, which appears to have a heterogeneous profile of episodes. The above can be seen in Figure 1, where the narratively identified unanticipated and anticipated episodes for each country have been plotted.

By observing these plots, one can note the different fiscal style (in terms of the correlation of the unanticipated and anticipated changes, i.e. if a fiscal correction is

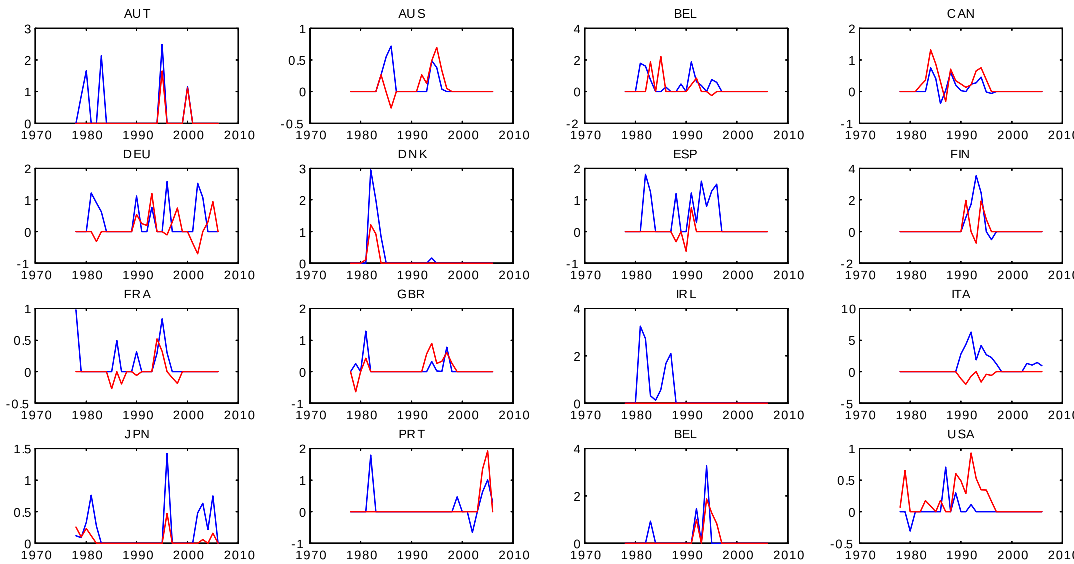

Figure 2.1: Unanticipated (blue) and Anticipated (red) Fiscal Adjustments

permanent or temporary), as well as the different number of episodes and sign and strength of correlation between anticipated and unanticipated changes.

2.4.1 Empirical Model

Fiscal Plans

Following Alesina et al. (2013), a fiscal plan can be seen as a multi-year process. This process is associated to a time of announcement which internalizes an immediate fiscal change at t (unanticipated) and a future change to be implemented at $t + j$ (anticipated), where j is the anticipation horizon. The unanticipated fiscal shocks at time t for a country i are defined as

$$e_{it}^u = \tau_{it}^u + g_{it}^u$$

where $\tau_{i,t}^u$ represents the unanticipated announcement of an increase in taxes at time t which is implemented the same year t, and analogously $g_{i,t}^u$ represents the "surprise" of a government expenditure reduction at time t (announced and implemented the same period). Similarly, the anticipated fiscal shocks are defined as

$$e_{it}^a = \tau_{it}^a + g_{it}^a$$

Let $\tau_{i,t,j}^a$ and $g_{i,t,j}^a$ denote the anticipated tax and government expenditure changes for country i respectively which are announced at year t with the implementation of the change being anticipated to happen in j years. For example, Alesina et al. (2013), due to evidence from the Devries et al. (2011) database, take $j = 3$ as the maximum anticipation horizon.

The observed anticipated shocks are defined as

$$\tau_{i,t,0}^a = \tau_{i,t-1,1}^a + \tau_{i,t-2,2}^a + \tau_{i,t-3,3}^a$$

$$g_{i,t,0}^a = g_{i,t-1,1}^a + g_{i,t-2,2}^a + g_{i,t-3,3}^a$$

$$e_{i,t,0}^a = \tau_{i,t,0}^a + g_{i,t,0}^a.$$

Fiscal consolidations are termed either "tax-based" (TB) or "expenditure-based" (EB). In general, a plan is TB (EB) if the sum of the unexpected plus the announced tax (expenditure) changes is greater than the sum of unexpected and expected expenditure (tax) changes.[5]

Model

We denote by Δy the outcome variable of interest, which is the GDP growth (annual growth rates). Following Alesina et al. (2013), we estimate a truncated moving average representation of the variable of interest. The interaction terms of the narrative measures, either unanticipated or anticipated (up to two years of anticipation), play the role of the shocks.

More precisely, the Truncated MA (2-years) takes the following form

$$\Delta y_{it} = a + B_{1i}\left(L\right)e^{u}_{i,t}TB_{it} + B_{2i}\left(L\right)e^{a}_{i,t,0}TB_{it} + \Gamma_{1i}\left(L\right)e^{u}_{i,t}EB_{it} + \Gamma_{2i}\left(L\right)e^{a}_{i,t,0}EB_{it} +$$
$$+\sum_{j=1}^{3}\delta_{ji}e^{a}_{i,t,j}TB_{it} + +\sum_{j=1}^{3}\zeta_{ji}e^{a}_{i,t,j}EB_{it} +$$
$$+\lambda_i + \chi_t + u_{it}$$

$$e^{a}_{i,t,t+1} = \phi_{1,i}e^{u}_{it} + \upsilon_{1,i,t}$$

[5]We run the competition between TB and EB plans.

$$e^a_{i,t,t+2} = \phi_{2,i} e^u_{it} + \upsilon_{2,i,t}$$

$$e^a_{i,t,t+3} = \phi_{3,i} e^u_{it} + \upsilon_{3,i,t} \tag{2.1}$$

where TB and EB are the dummies for the tax-based and expenditure-based plans respectively (a category of fiscal changes that have not been classified is considered as the base dummy). λ_i and χ_t are country and time fixed effects respectively. ϕ allows for country-level heterogeneity, $\upsilon_{jit} \sim N(0, \Sigma_\upsilon)$, $j = 1, 2, 3$, $i = 1, ..., N$, $t = 1, ..., T$.[6]

In the model we allow for two types of heterogeneity. On top of using country-specific coefficients, we account for between-country heterogeneity captured by the three additional regressions. These regressions reveal the style of plans in each country. The second type of heterogeneity refers to within-country heterogeneity. It arises from the diverse effects that the different types of TB or EB plans may produce in a country.

We use a truncated moving average representation because the length of the $B_i(L), \Gamma_i(L), ...$ polynomials are limited to 3 years. This does not change the results, since the omitted lags are orthogonal to the variables included.

To justify the above specification, it is important to provide some intuition. Changes in fiscal policy may affect the economy via three channels: The unanticipated shifts $e^u_{i,t}$, the implementation of adjustments that had been announced the

[6] $\# \; regr = 78$, $\# \; obs = 27$.

previous years $e^a_{i,t,0}$ and finally the anticipation of future changes $e^a_{i,t,j}$ that have been announced. These three channels will drive the forces depicted by the impulse response functions.

2.5 Bayesian Econometric Methodology

The Bayesian approach of hierarchical models builds on the early study of Gelfand et al. (1990).

The first part of (1) can be depicted in a general form as a simple linear regression

$$y_{it} = x'_{it}\beta_i + \varepsilon_{it}$$

$$\varepsilon_{it} \sim N(0, \sigma_i^2).$$

y_{it} corresponds to the outcome of interest, a $T \times 1$ vector for each country (i.e. $T \times N$), where $t = 1, ..., T$ is the number of years ($T = 27$) and $i = 1, ...N$ the number of countries (i.e. $N = 13$). Since each equation has the same regressors then $MLE = SUR = GLS = OLS$ equation by equation.

Dropping the subscripts, the linear regression model can be written as

$$Y = X\beta + \varepsilon$$

where, for each country, Y is a $T \times 1$ vector and X is a $T \times k$ matrix of regressors. This implies that the likelihood function is

$$p\left(Y|\beta, \sigma^2\right) = \left(\frac{1}{2\pi\sigma^2}\right)^{T/2} \exp\left\{-\frac{1}{2\sigma^2}\left(Y - X\beta\right)'\left(Y - XB\right)\right\}.$$

We assume a Normal-Inverse-Gamma (NIG) Prior. The prior of the vector of the country-specific coefficients conditional on the variance of the error of the model is

$$p\left(\beta_i|\sigma_i^2\right) \sim N(\bar{\beta}, \bar{V}\sigma_i^2).$$

$\bar{\beta}$ and $\bar{V}$ are treated as the hyperparameters of our model. In the beginning of our analysis, we set our prior to be centered around -1, i.e. we assume as a prior belief an homogeneous contractionary effect for the different components of fiscal consolidations. In this way, we will be able to test for the heterogeneity of the effects of the different categories of taxes and government spending. Then, in the second step of the Gibbs sampler algorithm, we will proceed with the optimal choice of the hyperparameters, as we will describe below. More precisely, we assume that the coefficients of the different countries originate from the same population. The prior for the variance of the error term is assumed to be distributed as an Inverse-Gamma (IG)

$$p\left(\sigma_i^2\right) \sim IG\left(a, b\right).$$

The prior density for σ^2, is given by

$$p\left(\sigma_i^2\right) = \frac{b^a}{\Gamma\left(a\right)}\left(\frac{1}{\sigma_i^2}\right)^{a+1} \exp\left(-\frac{b}{\sigma_i^2}\right)$$

where $\Gamma\left(\cdot\right)$ represents the Gamma function and $a, b > 0$. Given that the mode of an IG is $\frac{b}{a+1}$ and that the mean exists if $a > 1$, let us assume that we want the mode to be a small number, e.g. $\frac{b}{a+1} = \left(0.01\right)^2 \Leftrightarrow b = \left(0.01\right)^2\left(a+1\right)$. Let $\alpha = 2$, then

$b = 3\left(0.01\right)^2$. In the general form the joint conjugate prior of a country ι is

$$\begin{aligned} p\left(\beta,\sigma^2\right) &= p\left(\beta|\sigma^2\right)p\left(\sigma^2\right) = NIG\left(\bar{\beta},\sigma^2\bar{V},a,b\right) = \\ &= \frac{b^a}{\left(2\pi\right)^{k/2}|\bar{V}|^{1/2}\Gamma\left(a\right)}\left(\frac{1}{\sigma^2}\right)^{a+k/2+1}\exp\left[-\frac{1}{\sigma^2}\left\{b+\frac{1}{2}\left(\beta-\bar{\beta}\right)'|\bar{V}|^{-1}\left(\beta-\bar{\beta}\right)\right\}\right] \\ &\propto \left(\frac{1}{\sigma^2}\right)^{a+k/2+1}\exp\left[-\frac{1}{\sigma^2}\left\{b+\frac{1}{2}\left(\beta-\bar{\beta}\right)'|\bar{V}|^{-1}\left(\beta-\bar{\beta}\right)\right\}\right]. \end{aligned}$$

Since the prior of the parameters of interest belong to the conjugate prior family of NIG, then analytic form results for the posterior distribution can be derived.

$$p\left(\beta,\sigma_i^2|Y\right) \sim NIG\left(\hat{\beta},\hat{V},a^*,b^*\right)$$

More precisely, using the Bayes rule the posterior is

$$\begin{aligned} p\left(\beta,\sigma_i^2|Y\right) &= p\left(Y|\beta,\sigma^2\right)\times p\left(\beta,\sigma^2\right) \\ &\propto \left(\frac{1}{2\pi\sigma^2}\right)^{T/2}\exp\left\{-\frac{1}{2\sigma^2}\left(Y-X\beta\right)'\left(Y-XB\right)\right\}\times \\ &\quad \left(\frac{1}{\sigma^2}\right)^{a+k/2+1}\exp\left[-\frac{1}{\sigma^2}\left\{b+\frac{1}{2}\left(\beta-\bar{\beta}\right)'|\bar{V}|^{-1}\left(\beta-\bar{\beta}\right)\right\}\right] \\ &\propto \left(\frac{1}{\sigma^2}\right)^{a+(T+k)/2+1}\times \\ &\quad \exp\left[-\frac{1}{\sigma^2}\left\{b+\frac{1}{2}\left(\beta-\bar{\beta}\right)'|\bar{V}|^{-1}\left(\beta-\bar{\beta}\right)\right\}+\left(Y-X\beta\right)'\left(Y-XB\right)\right] \\ &= \left(\frac{1}{\sigma^2}\right)^{a^*+(T+k)/2+1}\times\exp\left[-\frac{1}{\sigma^2}\left\{b^*+\frac{1}{2}\left(\beta-\hat{\beta}\right)'|\hat{V}|^{-1}\left(\beta-\hat{\beta}\right)\right\}\right] \end{aligned}$$

where

$$\hat{\beta} = \left(X'X+\bar{V}^{-1}\right)^{-1}\left(X'Y+\bar{V}^{-1}\bar{\beta}\right),$$

$$\hat{V} = \left(X'X+\bar{V}^{-1}\right)^{-1},$$

$$a^* = \alpha + T/2,$$

$$b^* = b + \frac{1}{2}\left[\bar{\beta}'\bar{V}^{-1}\bar{\beta} + Y'Y - \hat{\beta}'\hat{V}^{-1}\hat{\beta}\right].$$

The Marginal Posterior Distribution of σ_i^2 follows an $IG\left(a^*, b^*\right)$, where

$$a^* = \alpha + T/2$$

while b^* can be rewritten as

$$\begin{aligned} b^* &= b + \frac{1}{2}\left[\bar{\beta}'\bar{V}^{-1}\bar{\beta} + Y'Y - \hat{\beta}'\hat{V}^{-1}\hat{\beta}\right] = \\ &= b + \frac{1}{2}\left(Y - X\bar{\beta}\right)'\left(I + X\bar{V}X'\right)^{-1}\left(Y - X\bar{\beta}\right) \end{aligned}$$

by applying the Sherman-Woodbury-Morrison identity.

The Conditional Posterior Distribution $p\left(\beta_i|\sigma_i^2, D\right) \sim N\left(\hat{\beta}_i, \hat{V}_i\right)$

$$\hat{\beta}_i = \left(X_i'X_i + \bar{V}^{-1}\right)^{-1}\left(X_i'Y_i + \bar{V}^{-1}\bar{\beta}\right) \tag{2.2}$$

$$\hat{V}_i = \sigma_i^2\left(X_i'X_i + \bar{V}^{-1}\right)^{-1}. \tag{2.3}$$

Analysis of the hyperparameters $\bar{\beta}, \bar{V}$ of the model:

Prior Distribution of the Hyperparameters:

$$\bar{\beta} \sim N\left(\eta, C\right),$$

$$\bar{V}^{-1} \sim W\left(\left(\rho R\right)^{-1}, \rho\right)$$

where we assume that the hyperparameters η, C are known. (**Note:** For the variance of the hyperparameter $\bar{V}$ we have to take into account that we want our posterior to be diagonal.)

Posterior Distribution of the Hyperparameters:

$$\bar{\beta}|\bar{V} \sim N\left(\hat{\eta}, D\right),$$

where $\hat{\eta} = D\left(N\bar{V}^{-1}\left(N\sum_{i=1}^{N}\beta_i\right) + C^{-1}\eta\right)$, $D = \left(N\bar{V}^{-1} + C^{-1}\right)^{-1}$

$$\bar{V}|\bar{\beta} \sim W\left(\left[\sum_i\left(\beta_i - \bar{\beta}\right)\left(\beta_i - \bar{\beta}\right)' + \rho R\right]^{-1}, N + \rho\right).$$

2.5.1 Gibbs Sampler

Step 1: $p\left(\beta_i, \sigma_i|\bar{\beta}, \bar{V}, data\right)$

1a. Draw $\left((\sigma_i^2)_{i=1}^{N}\right)^{(j)}$ from $p\left((\sigma_i^2)_{i=1}^{N}|\bar{\beta}, \bar{V}, data\right)$, where $i = 1, ..., N$ is the number of countries and $j = 1, ..., M$ (M : number of draws).

1b. Draw $\left((\beta_i)_{i=1}^{N}\right)^{(j)}$ from $p\left((\beta_i)_{i=1}^{N}|\left((\sigma_i^2)_{i=1}^{N}\right)^{(j)}, \bar{\beta}, \bar{V}, data\right)$.

Step 2: $p\left(\bar{\beta}, \bar{V}|\beta_i, \sigma_i, Y\right)$

2a. Draw $\left(\bar{\beta}\right)^{(j)}$ from $p\left(\bar{\beta}|\left(\beta_i\right)_{i=1}^{N}, (\sigma_i^2)_{i=1}^{N}, \bar{V}\right)$, where $i = 1, ..., N$ is the number of countries and $j = 1, ..., M$ (M : number of draws).

2b. Draw $\left(\bar{V}\right)^{(j)}$ from $p\left(diag(\bar{V})|\left(\beta_i\right)_{i=1}^{N}, (\sigma_i^2)_{i=1}^{N}, \bar{\beta}\right)$.

(where "$data$" corresponds to the available data Y, X).

2.6 Preliminaries

2.6.1 Exogeneity of The Narrative Variables

Before applying our methodology to data, it is crucial to first test for the exogeneity of the narrative variables. We want to investigate whether the identified adjustments are systematically uncorrelated with other developments affecting output. We use a simple test of exogeneity (Granger causality test). More precisely, we regress the narrative identified adjustments on the lag of output growth, and we augment by including lagged values of the narrative measures. If the past variables are not able to predict a shift in the components of spending or taxes, then we say that the shift is exogenous.

The results of the Granger causality tests that we run for each country and for each component show that, in most of the cases, the null hypothesis that the past variables predict the narrative measures is rejected. For Sweden and the Netherlands we were not able to reject the null hypothesis. Therefore we decide to drop these countries from our analysis.

2.6.2 Convergence Diagnostics

As it is common, we ignore some number of samples (500 draws out of 10000 initial draws) at the beginning (the so-called burn-in period). The reason is that the successive samples are not independent of each other but form a Markov chain with some amount of correlation. The stationary distribution of the Markov chain is the desired joint distribution over the variables, but it may take time for that stationarity to be reached. Therefore, convergence diagnostics are important to determine whether the sampler has reached its stationary distribution.

We present some convergence diagnostics for the first step of our algorithm. These tests confirm that the Gibbs sampler converges. More precisely, we first look at the time series trace (Figure 2), which shows the plot of the random variables that have been generated versus the number of iterations (burn-in draws are included). Figure 3 shows evidence of a stationary distribution.

The autocorrelation function (Figure 3) is very useful in accessing the MCMC sampler. We examine the serial autocorrelation as a function of the time lag. There is no autocorrelation. Note that, in general, a geometric decay is the picture that is desired.

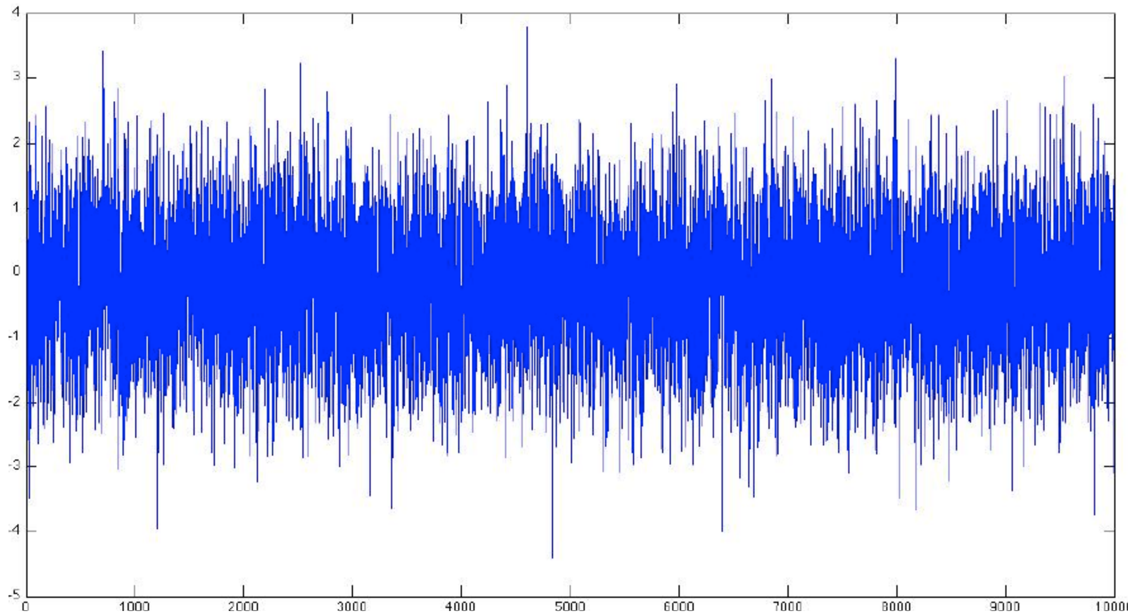

Figure 2.2: Trace of the Gibbs Sampler Draws

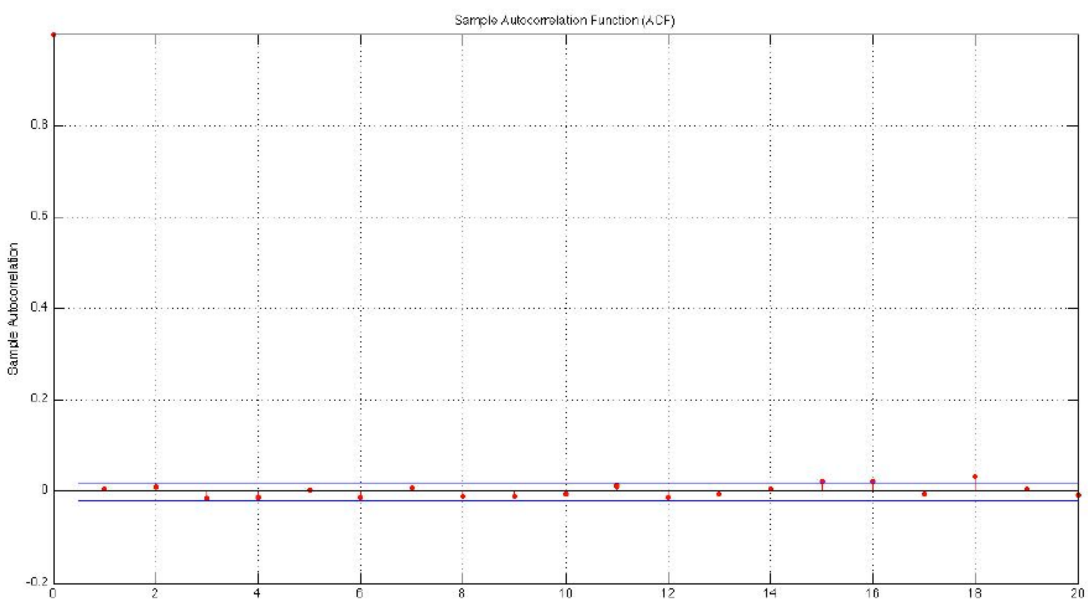

Figure 2.3: Autocorrelation Function of the Gibbs Sampler Draws

2.6.3 Code Check

In this subsection we run a simple check of the correctness of the algorithm To do so, we first replicate the initial aggregated data of Alesina et al. (2013) to arrive at the pooled OLS estimates. Then, we turn to the pooled data of all countries and impose in our algorithm a uniform prior by keeping the NIG prior, and simply using a prior distribution centered around a mean of zeros and a large variance. The results that we get are the same of Alesina et al. (2013) as desired, which is a positive signal that our algorithm is correct (Appendix - Figure 4).

2.7 Results

In this section we present some of the results. We study the potential for heterogeneous effects on output growth (future research will include results for other macroeconomic variables). The final period under study runs from the year 1981 to 2007[7]. First, we present the estimates of the ϕ of the associated equations in (1). As we observe in Table 1, there is evident heterogeneity on the design of the multi-year plans in different countries[8]. In the cases that there are too few observations available, we show a coefficient of zero. Except for Italy, in all the countries one-year anticipated announcements respond positively to unanticipated ones. However, for many countries the response is small and not statistically different from zero. Canada has a cumulative response higher than one. The results of Italy suggest a negative relation between the unanticipated and anticipated announcements, which implies that on average the Italian plans are "stop-and-go".

[7]The reason is that we lose observations by taking leads and lags of the variables in use.

[8]Note that we report the estimates for Finland and Sweden. As already mentioned, due to inspection of causality and lack of data, these countries are not included in our baseline study. Moreover, we do not include Germany, since for unified Germany, there is information on economic variables only after 1991.

Table 1: The Cross-country Heterogeneity in the Design of Multi-year Plan.

	AUS	AUT	BEL	CAN
$\phi_{1,i}$	0.31 (0.16)	0.35 (0.068)	0.22 (0.162)	1.4022 (0.17)
$\phi_{2,i}$	−0.24 (0.12)	0	0	0.65 (0.085)
$\phi_{3,i}$	−0.022 (0.011)	0	0	0.061 (0.045)
	DEU	DNK	ESP	FIN
$\phi_{1,i}$	0.002 (0.11)	0.41 (0.019)	0.036 (0.048)	0.021 (0.01)
$\phi_{2,i}$	0.024 (0.068)	0	0	0.019 (0.01)
$\phi_{3,i}$	0.024 (0.025)	0	0	0
	FRA	GBR	IRL	ITA
$\phi_{1,i}$	0.18 (0.08)	0.48 (0.16)	0.22 (0.162)	−0.24 (0.03)
$\phi_{2,i}$	−0.06 (0.035)	0.14 (0.05)	0	0
$\phi_{3,i}$	−0.027 (0.024)	0.007 (0.007)	0	0
	JPN	PRT	SWE	USA
$\phi_{1,i}$	0.26 (0.03)	0.52 (0.16)	0.55 (0.08)	0.41 (0.35)
$\phi_{2,i}$	0.011 (0.003)	0	0.33 (0.05)	0.32 (0.3)
$\phi_{3,i}$	0	0	0.22 (0.02)	0.199 (0.2)

Figures 5a and 5b (Appendix) depict the impulse response functions. In Figure 5a we present the median of the draws of the Gibbs sampler and in Figure 5b the impulse response functions with the associated confidence intervals. In these figures we can see the effects of the different types of adjustments on the output growth. Only for Austria, Ireland, Italy and Spain do the different plans appear to have diverse impacts on the output growth. In general, there is no obvious heterogeneity of the responses across countries. We discuss the results of the graphs below. First, we would like to highlight that we take our findings with caution. The reason for this is that the country-specific findings of the Gibbs-sampler are clearly affected by the prior distribution. More precisely, since there is a lack of information in the data, the posterior is centered around the prior. We tried different type of priors, non-informative with high variance and more informative.[9] Here, we present some results by using an informative prior that is centered around a contractionary scenario.[10] As discussed above, convergence is attained and the simulation converges in a distribution. The level of uncertainty is obviously affected by the variance that we impose in the prior. Moreover, for the countries which the ϕ coefficients are significant, the final results are highly driven by these correlations.

In Figure 5a, tax-based plans appear to be recessionary and long-lived for all countries. The picture is similar for the case of expenditure-based adjustments. For most of the countries, the recessionary impact is almost the same for the two components of fiscal changes. Tax-based components are more recessionary than expenditure based. The effect of transfer expenditure based is very small.

In Figure 5b we report the same impulse response functions as in Figure 5a, including the confidence intervals. The level of uncertainty is high, which changes completely the scaling of the graph. This is driven by the fact that for each country, the number of data points for each component is small.[11] The size of the variance of the prior also influences the uncertainty level. The uncertainty intervals almost the same for the different components due to both the lack of information and the same prior of variance.

In the POLS case (Alesina et al. (2013)), the IRFs for each country are almost the same (see Figure 6 - Appendix). The differences in the responses are driven from the different phis. In our case, we update our prior belief that the coefficients come from the same population and we let the specific dataset of each country to affect the IRF, by also taking into account the phi. However, since there is lack of information the final result is highly affected by the prior.

[9] We tried different prior scenarios, like expansionary, neutral and contractionary. For these scenarios we imposed priors with either heterogeneous prior effects for the different components or an homogenous prior belief. In addtion, we used different subgroups of countries, e.g. Euro currency countries and non-euro, or Mediterranean, central European, and Scandinavian. By having a less informative prior, the uncertainty is huge, and every time we rerun our algorithm the final results differ. On the other hand, a tighter prior clearly affects the result. The data do not provide much infomation.

[10] We assume that all the coefficients of the different components are exante the same, i.e. -0.5. In this way we would like to test if the data have sufficient information to update our prior and give us evidence of an heterogeneous effect of the different components.

[11] We can also notice the limited data points for different countries and components in Figure 2a,b. There are cases that there are no observations. Naturally, in this case the common homogenous prior guides the posterior.

2.8 Conclusion

Questions related to the effects of fiscal consolidations and fiscal austerity on output growth have generated an undoubtedly significant policy debate. The diverse answers provided are highly related to the model specification, identification assumptions and the data available. In this paper,we bring some of these reasonable pieces together and take into account the fiscal foresight phenomenon. The narrative approach provides us with directly identified shocks and shifts which are assumed to be "exogenous" and not a response of the state of output.

The paper uses a simple hierarchical modeling strategy driven from an exchangeable prior between countries. It proposes a Markov chain Monte Carlo algorithm which, in combination with the narrative identified shocks, allows us to conduct a country-by-country analysis. We study the heterogeneous effects of tax-based and government spending-based fiscal consolidations. By using the narrative method, it is assumed that the structural shocks are observed, and therefore the impulse response functions can be directly computed.

Our results overall indicate that we do not learn from the data and uncertainty persists. Starting from a prior belief of an homogenous contractionary effect of the different categories of taxes and government spending induces us to a contractionary posterior result. In all of the countries, the tax-based and the expenditure-based adjustments have a recessionary effect. For Austria, Ireland, Italy and Spain, these effects appear to be more heterogeneous.

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Appendix A: Data

- By "government", we mean the general government which represents both the State administration and local authorities. For the federal countries (Australia, Canada and United States) the data only refer to the central government (e.g. the Federal government of the US).
- As already discussed, in the dataset both unanticipated and anticipated changes are included. In the case that an announcement was made but not recorded in any historical source is assumed as it was not implemented and therefore is dropped.
- Interest on expenditure and revenue shocks with the primary objective of reducing the budget deficit, i.e he identified shocks do not have zero mean, only shocks which have a negative impact on the deficit are recorded (only tax increases and expenditure cuts).
- Data tax increases are measured by the expected revenue effect of each change in the tax code, as the percent of GDP.
- Spending cuts are changes in expenditure relative to the level that was expected absent the policy shift, way to capture the effect of new information (not relative to the previous year). Also measured as a percent of GDP.
- Data Sources: Output - Gross Domestic Product (OECD). OECD Economic Outlook database, the Action-based Dataset of Fiscal Consolidations of Devries et al. (2011), the IMF International Statistics (IFS), Country Budget Reports.
- Data Transformations: Real GDP growth: $dy_{it} = 100 \times \log\left(\frac{y_{it}}{y_{it-1}}\right)$.

Appendix B: Figures

	Beta_POLS (AGG)	Beta_Median (AGG)
e_u_TB	–0.90	–0.91
e_u_EB	–0.25	–0.25
e_a_TB	–0.90	–0.90
e_a_EB	–0.84	–0.84
e_u_TB(–1)	–1.05	–1.06
e_u_TB(–2)	–0.55	–0.56
e_u_EB(–1)	–0.20	–0.21
e_u_EB(–2)	0.30	0.30
e_a_TB(1)	0.29	0.32
e_a_TB(–2)	0.34	0.36
e_a_EB(–1)	–0.02	–0.04
e_a_EB(–2)	0.55	0.56
e_a1_TB	–0.31	–0.26
e_a1_EB	–0.16	–0.12

Figure 2.4: Code Check: Non-informative Prior

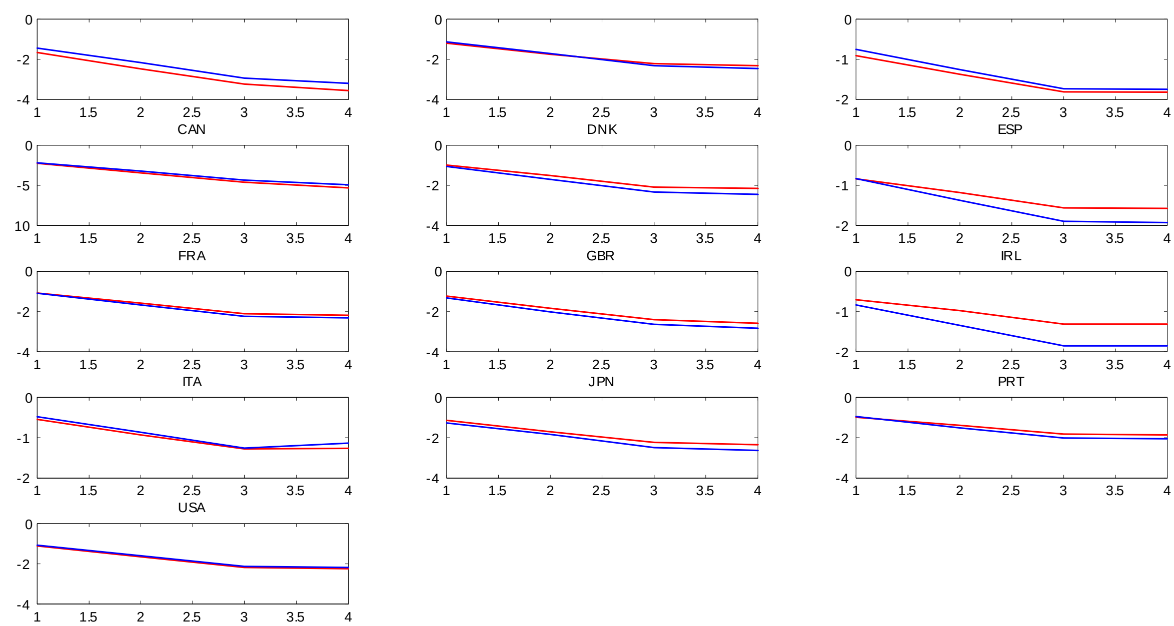


Figure 2.5: The Effect of EB and TB Fiscal Consolidations on Output Growth (Homogeneous Contractionary Prior)

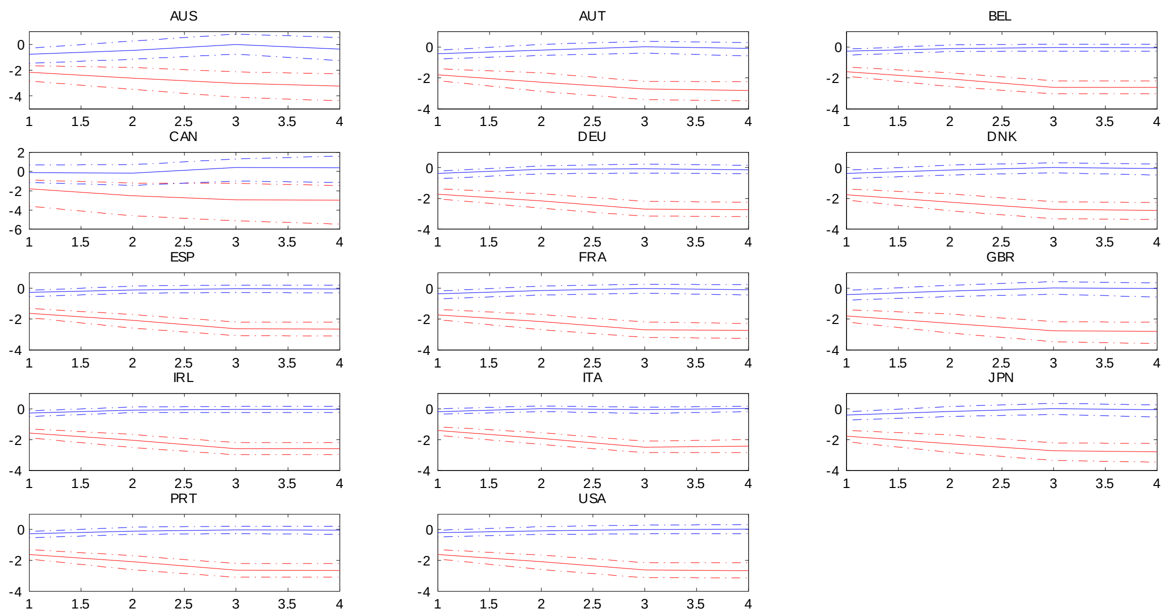


Figure 2.6: The effect of TB (red) and EB (blue) Adjustments on Output Growth

Chapter 3

Fiscal Consolidation Plans in Recessions and Expansions

Abstract

Fiscal austerity during economic downturns has undoubtedly generated a policy debate. In this paper we study the potential for heterogeneous effects of fiscal consolidations in recessions and expansions by taking into account the phenomenon of fiscal foresight. To do so we use a narrative panel dataset of 14 OECD countries that records unanticipated and anticipated fiscal changes announced by country governments. First, we consider a homogeneous multiplier. Then, we examine two types of asymmetries: an heterogeneous multiplier originating from the different categories of fiscal consolidations (expenditure-based versus tax-based), and an heterogeneous multiplier that takes into account the state of the economy. Our results suggest that there are heterogeneous implications along different stages of the business cycle. Forecast encompassing tests indicate that the two sources of asymmetry do not encompass one another. These tests support our evidence which shows that the effect of both tax-based and expenditure-based fiscal consolidations on the output growth during periods of slack is higher than that in periods of expansion, which is even more recessionary in the case of tax-based adjustments.

3.1 Introduction

The global financial crisis and the Great Recession have triggered questions about fiscal policy responses. Furthermore, due to rising government debt levels, many advanced economies have been engaging in fiscal consolidations. In this paper, we examine whether the effect of fiscal consolidations is different in periods of recessions and expansions.

The size of the fiscal multiplier has been broadly studied in the theoretical and empirical literature. Quantification is controversial. Answers vary and depend, to some extent, on the methodology, the nature of the shock, the identification scheme and the data. There are two main strands of identification in the empirical literature: the structural VAR approach (e.g. Blanchard and Perotti 2002) and the narrative approach (e.g. Romer and Romer 2010). An issue of the standard structural identification (SVAR) approach is the problem of non-fundamentalness in the estimation of fiscal shocks since this approach relies on current and past shocks. This problem is related to the fiscal foresight phenomenon. In this approach the information of news shocks and their future changes is not embedded. Therefore, the sets of information held by the econometrician and economic agents are not aligned. On the other hand, the narrative approach allows for the direct identification of exogenous shocks from past budget accounts, fiscal changes that were announced as a response to past economic conditions. For this reason it provides a way to take into account the information that influences the expectations of the economic agents.

Most of the fiscal policy literature had provided results on one aggregate multiplier without taking into account the state of the economy. The picture changed recently and there is a new strand of the literature (Auerbach and Gorodnichenko (2012) and Ramey and Zubairy (2014)) that considers that fiscal multipliers may differ depending on the business cycle phase. Accounting for heterogeneous effects is critical, since the size of the multiplier can be more relevant in circumstances of economic downturns than upturns. Theoretical studies, as Christiano et al. (2011) and Woodford (2010), also highlight the importance of the phase of the business cycle and study the multiplier effect when the economy is near the zero lower bound.

The main contribution of this paper is to study how state dependent multipliers may change if we consider the expectations of the economy. We seek to provide further evidence of the time-varying multiplier and to study the heterogeneous effects of fiscal consolidations in "bad" and "good" times in a model that accounts for unanticipated and anticipated announcements. Our starting point is the model of Alesina, Favero and Giavazzi (2014) (AFG, henceforth) which we extend to allow for the possibility of time-varying responses depending on whether the economy is in expansion or recession. The definition of the state of the economy is based on the recession dates of a translated OECD indicator. Our dataset includes information on fiscal consolidation changes, as a sum of tax cuts and government spending increases, for 14 OECD countries. As we have already highlighted the fiscal foresight phenomenon is a crucial component that leads to identification issues. When a government makes an announcement about a future fiscal change in order to decrease the government budget deficit, economic agents internalize this announcement into their decisions and actions. AFG build on this important point to examine a record of narratively identified exogenous shocks that are classified up to their timing convention (unanticipated and anticipated shocks). An unanticipated fiscal consolidation shock is a tax cut or government spending increase that was announced and implemented the same year, whereas an anticipated shock is a change that includes a lag (of 1, 2, 3 years) from the time of the announcement until the time of the implementation.

We use AFG's modeling approach as our baseline model. We first study a linear version of the truncated moving average (MA) model and estimate an homogeneous multiplier. Fiscal consolidations are a drag on the output growth in all countries. We proceed by adding two different sources of asymmetry, one at the time. First, we allow for an heterogeneous response of tax-based and expenditure-based plans, where we replicate the results of AFG and show that average tax-based fiscal plans are more recessionary than the average expenditure-based plans. Then, we extend the model and allow for the possibility of time-varying responses depending on whether the economy is in expansion or recession, which is the key novelty. Our results suggest that the effect of fiscal consolidations on output growth is more contractionary when the economy is operating with slack.

When we put the two sources of asymmetry together, we face a problem of over-parametrization. This relates to the so-called "curse of dimensionality". In order to save on the degrees of freedom, we incorporate a simple Bayesian approach into our estimation. The results indicate that tax-based consolidations implemented in periods of recessions are more contractionary than when they are implemented in periods of expansions. The same holds for the expenditure-based changes. Overall, the tax-based fiscal consolidations in crisis times are the most recessionary. Yet this result comes with a caveat: the confidence intervals of the impulse response functions are large. We therefore use this evidence to motivate a non-nested model comparison between the two models. This allows us to conduct out-of-sample predictions and compare them to the actual effects of new existing episodes for the years 2009-2013, which are perceived as years of crisis time.

The paper is structured as follows. In the next section of the paper we motivate our research and provide the literature review. Section 3 presents the definitions of the construction of the data. The different model specifications are presented in section 4 and the results in section 5. Section 6 shows the forecast encompassing tests. Section 7 concludes.

3.2 Related Literature

Fiscal consolidations are typically multi-year processes of policy actions that are announced by a government. It is reasonable to assume, as the literature does, that announcements made by a government consist of two parts: one part comes as a surprise to citizens about a correction that will be implemented immediately (the same year), while the second part is one that is announced to be implemented in the future. This relates to the so-called "implementation lag" and fiscal foresight. The problems that may arise due to the fiscal foresight phenomenon have been broadly studied in the literature (Leeper (2010), Lippi and Reichlin (1994)). A natural way to tackle this issue is by using the narrative identification approach. The paper by Romer and Romer (2010) on the US economy is the main reference paper for this approach in the fiscal policy literature. The narrative approach is based on the reading of official federal documents and budgetary reports. The authors investigate the aim, nature and timing of the fiscal changes that were announced in an economy through the years. Ramey (2011) highlights the importance of the timing information that is included in these announcements and presents measures (military spending news, survey of professional forecasters) to account for anticipations in government spending changes in the US. Mertens and Ravn (2011) followed and studied the different effects of expected and unexpected tax cuts in the US separately.

Devries et al. (2011) constructed an important dataset for 17 OECD countries for the period 1978-2009 of tax and spending changes, similar to the Romer and Romer (2010) approach. Their narrative record includes contemporaneous changes with the aim to reduce the budget deficit. These changes are considered exogenous because they are measures taken as a response to past economic conditions and not to prospective ones. Guajardo et al. (2014) study the effects of these unanticipated narratively identified shocks on macroeconomic variables. AFG extend the Devries et al. (2011) dataset and distinguish between expected and unexpected fiscal corrections. This allows them to study the impact of unanticipated and anticipated fiscal changes on the macroeconomy. One important aspect in contrast to Mertens and Ravn (2011) is that AFG assume that these two types of fiscal corrections are correlated. The degree of correlation varies between countries.

All of the above papers focus on the effect of a single multiplier, and do not distinguish between the phases of the business cycle. Recent studies have relaxed the assumption of a homogeneous multiplier across different states of the economy and seek to study non-linearities of the multiplier in different regimes. Different methods such as threshold VARs, Markov switching models, and smooth transitions VARs have been proposed in the literature to examine the effects in different regimes. Auerbach and Gorodnichenko (2010) employed a smooth transition model to study the size of the fiscal multiplier in recessions and expansions in an SVAR identification context for the US economy. Their model is based on a logistic distribution that controls for the transition from one regime to the other, with weights that are computed as a moving average of GDP growth. Auerbach and Gorodnichenko (2012) employ a similar methodology by using narrative data of OECD countries. They estimate their model with local projection methods à la Jorda (2005). In this method, local projections are computed for each horizon as a separate regression. This permits them to construct IRF and accommodate non-linearities without imposing dynamic restrictions as is the case in other regime switching models. The conclusion in both papers (Auerbach and Gorodnichenko 2010, 2012) is that the multipliers in different regimes differ. Ramey and Zubairy (2014) also adopt the local projections method in a state-dependent model to examine the possibility of a different response of government spending changes in periods of recessions compared to expansions. Ramey and Zubairys' results show that there is no evidence of heterogeneity.

This paper contributes to the empirical literature of the study of fiscal multipliers by examining the potential for heterogeneous effects of fiscal consolidation plans under the different state of the economy along the business cycle. We employ a different model environment and method of estimation compared to Auerbach and Gorodnichenko (2012) and Ramey and Zubairy (2014). Therefore a direct comparison is not obvious. In addition, while these authors focus on unanticipated fiscal changes, our research is on both unanticipated and anticipated changes, as well as the relation of the two, as in AFG. We employ a truncated MA representation (as Romer and Romer (2010)). The challenge of this type of data is the limited number of observations. This forces us to pool the country data together and therefore to estimate a quasi-panel. We allow for two types of heterogeneity: i) the heterogeneous styles of the fiscal consolidations (expenditure-based or tax-based) of each country, ii) the heterogeneous responses of plans in recessions and expansions.

3.3 Data

3.3.1 Fiscal Plans

Following the literature of the narrative identification approach (Ramey and Shapiro (1998) and Romer and Romer (2010)), Devries, Guajardo, Leigh and Pescatori (2011) identified fiscal adjustments by reading official historical sources of 17 OECD countries. These sources included documents as Budget Reports, Budget Speeches, Central Banks Reports, Convergence and Stability Programs submitted by EU governments to European Commission, IMF Reports, OECD economic surveys. In this way, they were able to directly identify the size, timing and principal motivation behind any fiscal action taken by each government. The focus is restricted to the identification of fiscal changes that are exogenous to the economic cycle, as well as changes that are motivated by the willingness to reduce the government deficit. This implies that a fiscal consolidation with the goal of restraining domestic demand or any other countercyclical policy is not included in the dataset. The final dataset consists of a time series of fiscal consolidations of 17 OECD countries. The countries included in the initial data are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, Portugal, Spain, Sweden, United Kingdom, United States, for the period 1978 to 2009. Alesina, Favero and Giavazzi (2014) extend this dataset. In contrast to the dataset of Devries et al. (2011), they divide the announcements into unanticipated and anticipated which allow them to

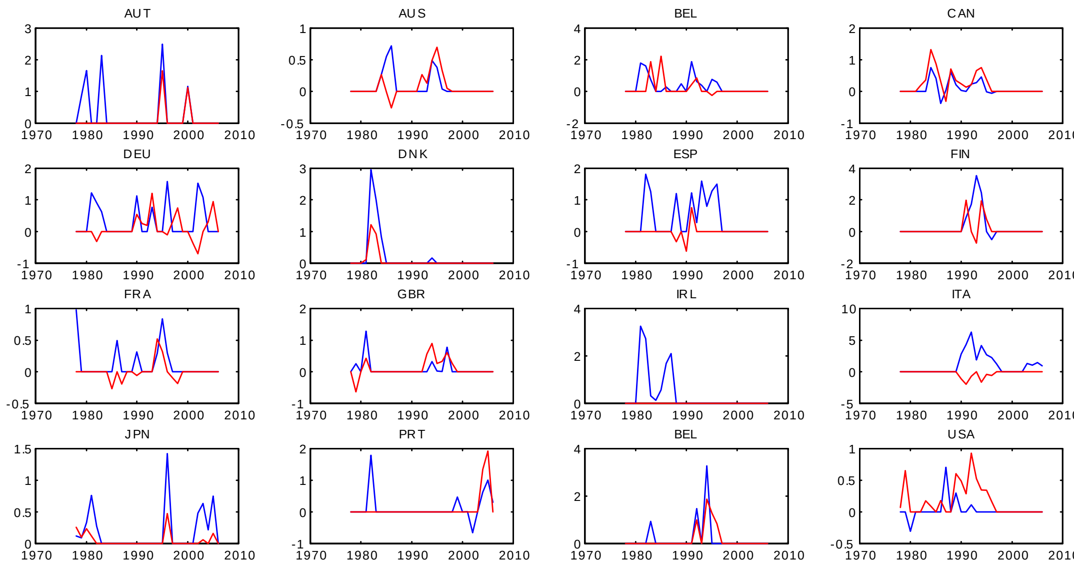


Figure 3.1: Unanticipated (blue) and Anticipated (red) Fiscal Adjustments

study the multi-year path of fiscal consolidations. The fiscal alterations are measured as a percentage of GDP.

The study of plans in a "dynamic" sense can reveal the nature of the policy shifts (anticipated versus unanticipated and transitory versus permanent). Usually unanticipated and anticipated shifts happen to be correlated, a stylized fact that we seek to take into account. Previous studies (Mertens and Ravn 2010) have, in contrast, evaluated the effects of unanticipated and anticipated changes by assuming that the two are orthogonal. The differential persistence of fiscal policy changes is related to the different fiscal "styles" of stabilization. A shift is characterized as permanent when the unanticipated announcements of a plan are positively correlated with the anticipated changes of the following years. Alternatively, if a negative correlation is observed, then the shifts are "stop-and-go" (temporary). Moreover, a multi-year, multi-country panel of fiscal plans allows us to study the fiscal policy of various countries, which appears to have a heterogeneous profile of episodes. The above can be seen in Figure 1, where the aggregate narratively identified unanticipated and anticipated episodes for each country have been plotted.

By observing these plots, one can notice the different fiscal styles, in terms of the correlation of the unanticipated and anticipated changes (i.e. if a fiscal correction is permanent or temporary), as well as the different number of episodes and sign and strength of correlation between anticipated and unanticipated changes.

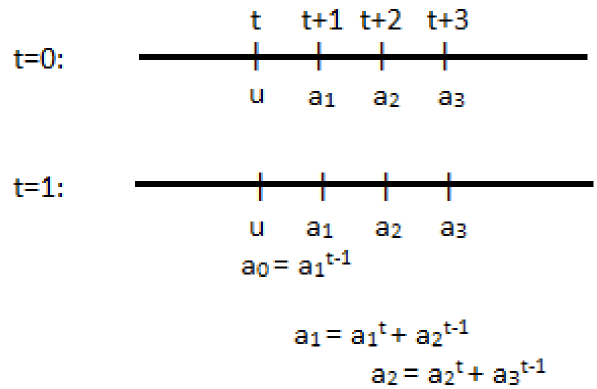


Figure 3.2: The timing assumption of a multi-year plan, which includes an unanticipated (u) announcement and an anticipated (a) announcement.

A fiscal plan can be seen as a multi-year process. This process is associated to a time of announcement which internalizes an immediate fiscal change at t (unanticipated) and a future change to be implemented at $t+j$ (anticipated), where j is the anticipation horizon. Following Alesina et al. (2014) and due to evidence from the Devries et al. (2011) database, we take $j=3$ as the maximum anticipation horizon. When the fiscal authority of a country makes an announcement of fiscal changes at time t (for example at time $t=0$, as we see in Figure 2) this announcement includes a component of adjustments that are going to be implemented immediately the year t, which are considered as a surprise for the citizens of the country, and a component of future adjustments, which will be anticipated by the citizens to be implemented in the future (at $t+1$, $t+2$, $t+3$). This implies that the next year (in Figure 2, $t+1$), the adjustments that are going to be implemented the same year include what it was announced in the past and a possible new "surprise" (and so on). The unanticipated fiscal shocks at time t for a country i are defined as

$$e_{it}^{u} = \tau_{it}^{u} + g_{it}^{u}$$

where $\tau_{i,t}^{u}$ represents the unanticipated announcement of an increase in taxes at time t which is implemented the same year t, and analogously $g_{i,t}^{u}$ represents the "surprise" of a government expenditure reduction at time t (announced and implemented the same period). Similarly, the anticipated fiscal shocks are defined as

$$e_{it}^{a} = \tau_{it}^{a} + g_{it}^{a}$$

Let $\tau_{i,t,j}^{a}$ and $g_{i,t,j}^{a}$ denote the anticipated tax and government expenditure changes for country i respectively which are announced at year t with the implementation of the change being anticipated to happen in j years.

The observed anticipated shocks are defined as

$$\tau^a_{i,t,0} = \tau^a_{i,t-1,1} + \tau^a_{i,t-2,2} + \tau^a_{i,t-3,3}$$

$$g^a_{i,t,0} = g^a_{i,t-1,1} + g^a_{i,t-2,2} + g^a_{i,t-3,3}$$

$$e^a_{i,t,0} = \tau^a_{i,t,0} + g^a_{i,t,0}.$$

Fiscal consolidations are termed either "tax-based" (TB) or "expenditure-based" (EB). In general, a plan is TB (EB) if the sum of the unexpected plus the announced tax (expenditure) changes is greater than the sum of unexpected and expected expenditure (tax) changes.[1]

Descriptive Statistics

3.3.2 Recession Series

We classify our economy as being in recession or expansion based on the recession dates that are available from the Federal Reserve Bank of Saint Louis. These dates are based on the OECD Composite Leading Indicator (CLI). The series of the CLI is based on the growth cycle approach, where business cycles and turning points are identified through a deviation from the trend method. The recession dates are available in quarterly data, are not seasonally adjusted and are recorded as a dummy variable (1: for recession, 0: for expansion). We have yearly data on the narratively identified shocks, therefore we translate the quarterly recession series of each country into a yearly recession series (Figure 3).

[1] We run the competition between TB and EB plans.

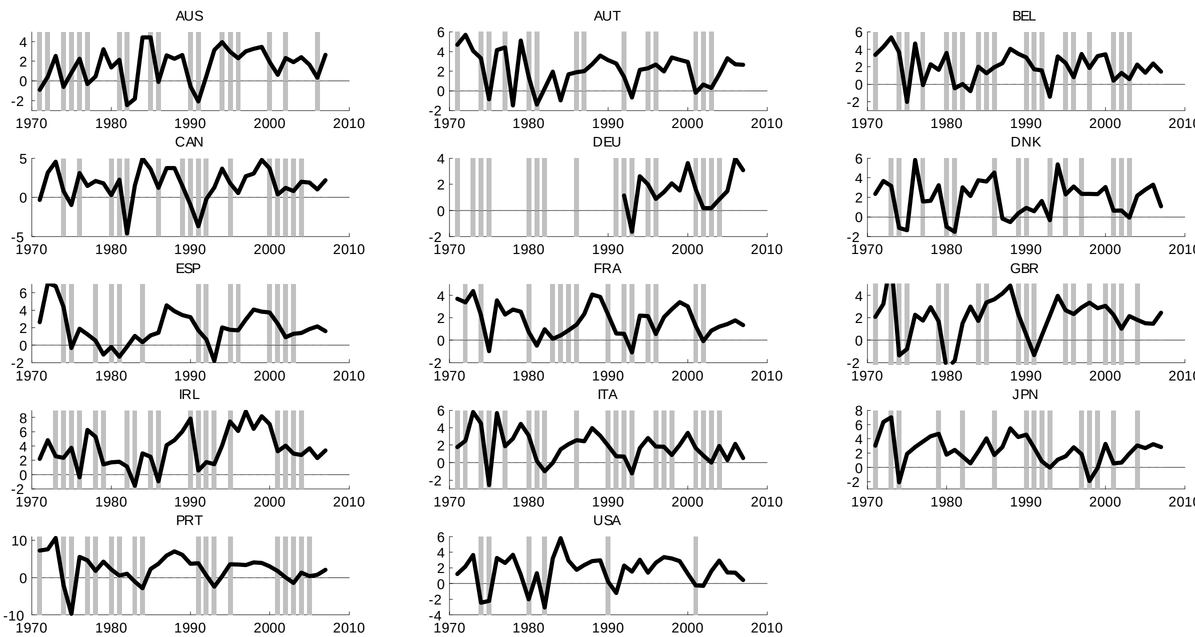


Figure 3.3: Recessions Dates (shaded grey area) versus per Capita GDP Growth (black line)

3.4 Model Specifications

We build on the model of AFG and we present the following specifications:

1. Homogeneous Case.
2. Heterogeneous Case: Tax-based and Expenditure-based Plans.
3. Heterogeneous Case: Recessions and Expansions.
4. Both sources of heterogeneity together: Expenditure-based versus Tax-based Fiscal Consolidations and the State of the Economy.

3.4.1 Homogeneous Case

We start with the simplest case, where there is no source of heterogeneity in the model. Our interest is to study the response of fiscal consolidation plans on output growth. We denote by Δy the outcome variable of interest, which is the GDP growth (annual growth rates). Our model specification takes the form a truncated moving average representation of the variable of interest. The interaction terms of the narrative measures, either unanticipated or anticipated (up to two years of anticipation), play the role of the shocks.

More precisely, the Truncated MA (2-years) is

$$
\begin{aligned}
\Delta y_{it} &= a + B_1(L)\, e^{u}_{i,t} + B_2(L)\, e^{a}_{i,t,0} + \\
&\quad + \sum_{j=1}^{3} \gamma_{i,j} e^{a}_{i,t,j} + \\
&\quad + \lambda_i + \chi_t + u_{it} \\
e^{a}_{i,t,t+1} &= \phi_{1,i} e^{u}_{it} + \upsilon_{1,i,t} \\
e^{a}_{i,t,t+2} &= \phi_{2,i} e^{u}_{it} + \upsilon_{2,i,t} \\
e^{a}_{i,t,t+3} &= \phi_{3,i} e^{u}_{it} + \upsilon_{3,i,t}
\end{aligned}
\tag{3.1}
$$

λ_i and χ_t are country and time fixed effects respectively. ϕ allows for country-level heterogeneity, $\upsilon_{jit} \sim N(0, \Sigma_\upsilon)$, $j = 1, 2, 3$, $i = 1, ..., N$ index countries and $t = 1, ..., T$ index time.

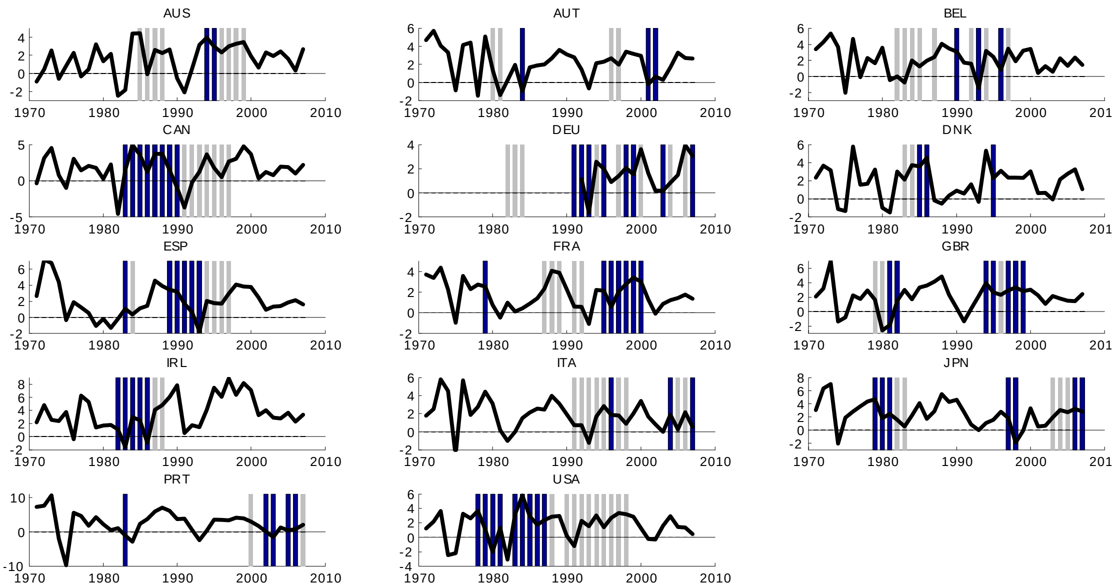


Figure 3.4: EB (blue) and TB (grey) Episodes versus per Capita GDP Growth (black line)

In this model specification we allow just for between-country heterogeneity captured by the three additional regressions. These regressions reveal the style of plans in each country.

We use a truncated moving average representation because the length of the $B_i(L)$ polynomials are limited to 3 years. This does not change the results, since the omitted lags are orthogonal to the variables included.

3.4.2 Heterogeneous Case: Tax-based and Expenditure-based Plans

In Figure 4 we observe the episodes of EB and TB plans that are recorded for each country. They are plotted versus the per capita output growth. The heterogeneity on the choice of the plans between the countries is evident. In addition, it is important to notice that the available episodes are not highly correlated with the business cycle.

We incorporate the above source of asymmetry related to the different type of plans in the following specification:

$$\begin{aligned}\Delta y_{it} &= a + B_1(L)\, e^u_{i,t} TB_{it} + B_2(L)\, e^u_{i,t} EB_{it} + \\ &+ \Gamma_1(L)\, e^a_{i,t,0} TB_{it} + \Gamma_2(L)\, e^a_{i,t,0} EB_{it} + \\ &+ \sum_{j=1}^{3} \gamma_{i,j} e^a_{i,t,j} TB_{it} + \sum_{j=1}^{3} \zeta_{i,j} e^a_{i,t,j} EB_{it} + \\ &+ \lambda_i + \chi_t + u_{it} \\ e^a_{i,t,t+1} &= \phi_{1,i} e^u_{it} + \upsilon_{1,i,t} \\ e^a_{i,t,t+2} &= \phi_{2,i} e^u_{it} + \upsilon_{2,i,t} \\ e^a_{i,t,t+3} &= \phi_{3,i} e^u_{it} + \upsilon_{3,i,t} \qquad (3.2)\end{aligned}$$

where Δy is as before the outcome variable, as λ_i are country fixed effects, χ_t are time fixed effects and $u_{it} \sim N(0, \Sigma)$, $i = 1, ..., N$, $t = 1, ..., T$. TB_{it} and EB_{it} are the dummies for .tax/ expenditure-based plans. Now in this model specification we allow for two types of heterogeneity. On top of the between-country heterogeneity captured by the three regressions related to the style of the plans of each country, we allow for a second type of heterogeneity. This refers to within-country heterogeneity and it arises from the diverse effects that the tax-based or the expenditure-based plans may produce.

3.4.3 Heterogeneous Case: Recessions and Expansions

In this specification we take into account the phase of the business cycle and we use the OECD indicator. The Truncated MA (2-years) takes the following form

$$\begin{aligned}\Delta y_{it} &= a + B_1(L)\, e^u_{i,t} R_{it} + B_2(L)\, e^u_{i,t} E_{it} + \\ &+ \Gamma_1(L)\, e^a_{i,t,0} R_{it} + \Gamma_2(L)\, e^a_{i,t,0} E_{it} + \\ &+ \sum_{j=1}^{3} \gamma_{i,j} e^a_{i,t,j} R_{it} + \sum_{j=1}^{3} \zeta_{i,j} e^a_{i,t,j} E_{it} + \\ &+ \lambda_i + \chi_t + u_{it} \\ e^a_{i,t,t+1} &= \phi_{1,i} e^u_{it} + \upsilon_{1,i,t} \\ e^a_{i,t,t+2} &= \phi_{2,i} e^u_{it} + \upsilon_{2,i,t} \\ e^a_{i,t,t+3} &= \phi_{3,i} e^u_{it} + \upsilon_{3,i,t} \qquad (3.3)\end{aligned}$$

where R_{it} and E_{it} are the dummies for the state of the economy (recession and expansion respectively). Δy, λ_i and χ_t are as earlier the outcome variable, the country and time fixed effects respectively. ϕ allows for country-level heterogeneity, $\upsilon_{jit} \sim N(0, \Sigma_\upsilon)$, $j = 1, 2, 3$, $i = 1, ..., N$ index countries and $t = 1, ..., T$ index time.

In this model we allow again for two types of heterogeneity. Compared to the previous specification the second type of heterogeneity originates from within-country heterogeneity related to the asymmetric effects that the state of the economy may produce.

3.4.4 Expenditure-based versus Tax-based Fiscal Consolidations and the State of the Economy

Our last specification includes all the different types of heterogeneities together.

$$\begin{gathered}
\Delta y_{it} = a + B_1(L) e^u_{i,t} TB_{it} + B_2(L) e^u_{i,t} EB_{it} + \\
+\Gamma_1(L) e^a_{i,t,0} TB_{it} + \Gamma_2(L) e^a_{i,t,0} EB_{it} + \\
+C_1(L) e^u_{i,t} R_{it} + C_2(L) e^u_{i,t} E_{it} + \\
+\Theta_1(L) e^a_{i,t,0} R_{it} + \Theta_2(L) e^a_{i,t,0} E_{it} + \\
+\sum_{j=1}^{3} \gamma_{i,j} e^a_{i,t,j} TB_{it} + \sum_{j=1}^{3} \zeta_{i,j} e^a_{i,t,j} EB_{it} + \\
+\sum_{j=1}^{3} \delta_{i,j} e^a_{i,t,j} R_{it} + \sum_{j=1}^{3} \psi_{i,j} e^a_{i,t,j} E_{it} + \\
+\lambda_i + \chi_t + u_{it} \\
e^a_{i,t,t+1} = \phi_{1,i} e^u_{it} + \upsilon_{1,i,t} \\
e^a_{i,t,t+2} = \phi_{2,i} e^u_{it} + \upsilon_{2,i,t} \\
e^a_{i,t,t+3} = \phi_{3,i} e^u_{it} + \upsilon_{3,i,t}
\end{gathered} \tag{3.4}$$

where TB_{it} and EB_{it} are the dummies for the tax-based and expenditure-based plans respectively (a category of fiscal changes that have not been classified is considered as the base dummy).and R_{it} and E_{it} are the dummies for the state of the economy (recession/ expansion). λ_i and χ_t are country and time fixed effects respectively. ϕ allows for country-level heterogeneity, $\upsilon_{jit} \sim N(0, \Sigma_\upsilon)$, $j = 1, 2, 3$, $i = 1, ..., N$ index countries and $t = 1, ..., T$ index time.

In this model we allow for 3 types of heterogeneity. Again we account for between-country heterogeneity from the additional regression that reveal the style of plans in each country. The second type of heterogeneity refers to within-country heterogeneity. It arises from the diverse effects that the different types of TB or EB plans may produce in a country. The third type is related to the country-heterogeneity of the state of the economy.

Like in the previous cases, we use a truncated moving average representation because the length of the $B_i(L), \Gamma_i(L), ...$ polynomials are limited to 3 years. This does not change the results, since the omitted lags are orthogonal to the variables included.

Bayesian Econometric Methodology

The Bayesian approach of hierarchical models builds on the early study of Gelfand et al. (1990).

The first part of (1) can be depicted in a general form as a simple linear regression

$$y_{it} = x'_{it}\beta_i + \varepsilon_{it}$$

$$\varepsilon_{it} \sim N(0, \sigma_i^2).$$

y_{it} corresponds to the outcome of interest, a $T \times 1$ vector for each country (i.e. $T \times N$), where $t = 1, ..., T$ is the number of years ($T = 27$) and $i = 1, ...N$ the number of countries (i.e. $N = 13$). Since each equation has the same regressors then $MLE = SUR = GLS = OLS$ equation by equation.

Dropping the subscripts, the linear regression model can be written as

$$Y = X\beta + \varepsilon$$

where, for each country, Y is a $T \times 1$ vector and X is a $T \times k$ matrix of regressors ($k =$?). This implies that the likelihood function is

$$p\left(Y|\beta, \sigma^2\right) = \left(\frac{1}{2\pi\sigma^2}\right)^{T/2} \exp\left\{-\frac{1}{2\sigma^2}\left(Y - X\beta\right)'\left(Y - XB\right)\right\}.$$

We assume a Normal-Inverse-Gamma (NIG) Prior. The prior of the vector of the country-specific coefficients conditional on the variance of the error of the model is

$$p\left(\beta_i|\sigma_i^2\right) \sim N(\bar{\beta}, \bar{V}\sigma_i^2).$$

$\bar{\beta}$ and $\bar{V}$ are treated as the hyperparameters of our model. In the beginning of our analysis, we set our prior to be centered around -1, i.e. we assume as a prior belief an homogeneous contractionary effect for the different components of fiscal consolidations. In this way, we will be able to test for the heterogeneity of the effects of the different categories of taxes and government spending. Then, in the second step of the Gibbs sampler algorithm, we will proceed with the optimal choice of the hyperparameters, as we will describe below. More precisely, we assume that the coefficients of the different countries originate from the same population. The prior for the variance of the error term is assumed to be distributed as an Inverse-Gamma (IG)

$$p\left(\sigma_i^2\right) \sim IG\left(a, b\right).$$

The prior density for σ^2, is given by

$$p\left(\sigma_i^2\right) = \frac{b^a}{\Gamma\left(a\right)}\left(\frac{1}{\sigma_i^2}\right)^{a+1}\exp\left(-\frac{b}{\sigma_i^2}\right)$$

where $\Gamma\left(\cdot\right)$ represents the Gamma function and $a, b > 0$. Given that the mode of an IG is $\frac{b}{a+1}$ and that the mean exists if $a > 1$, let us assume that we want the mode to be a small number, e.g. $\frac{b}{a+1} = \left(0.01\right)^2 \Leftrightarrow b = \left(0.01\right)^2\left(a+1\right)$. Let $\alpha = 2$, then $b = 3\left(0.01\right)^2$. In the general form the joint conjugate prior of a country ι is

$$\begin{aligned} p\left(\beta, \sigma^2\right) &= p\left(\beta|\sigma^2\right)p\left(\sigma^2\right) = NIG\left(\bar{\beta}, \sigma^2\bar{V}, a, b\right) = \\ &= \frac{b^a}{\left(2\pi\right)^{k/2}|\bar{V}|^{1/2}\Gamma\left(a\right)}\left(\frac{1}{\sigma^2}\right)^{a+k/2+1}\exp\left[-\frac{1}{\sigma^2}\left\{b+\frac{1}{2}\left(\beta-\bar{\beta}\right)'|\bar{V}|^{-1}\left(\beta-\bar{\beta}\right)\right\}\right] \\ &\propto \left(\frac{1}{\sigma^2}\right)^{a+k/2+1}\exp\left[-\frac{1}{\sigma^2}\left\{b+\frac{1}{2}\left(\beta-\bar{\beta}\right)'|\bar{V}|^{-1}\left(\beta-\bar{\beta}\right)\right\}\right]. \end{aligned}$$

Since the prior of the parameters of interest belong to the conjugate prior family of NIG, then analytic form results for the posterior distribution can be derived.

$$p\left(\beta, \sigma_i^2|Y\right) \sim NIG\left(\hat{\beta}, \hat{V}, a^*, b^*\right)$$

More precisely, using the Bayes rule the posterior is

$$\begin{aligned} p\left(\beta, \sigma_i^2|Y\right) &= p\left(Y|\beta, \sigma^2\right) \times p\left(\beta, \sigma^2\right) \\ &\propto \left(\frac{1}{2\pi\sigma^2}\right)^{T/2}\exp\left\{-\frac{1}{2\sigma^2}\left(Y-X\beta\right)'\left(Y-XB\right)\right\} \times \\ &\quad \left(\frac{1}{\sigma^2}\right)^{a+k/2+1}\exp\left[-\frac{1}{\sigma^2}\left\{b+\frac{1}{2}\left(\beta-\bar{\beta}\right)'|\bar{V}|^{-1}\left(\beta-\bar{\beta}\right)\right\}\right] \\ &\propto \left(\frac{1}{\sigma^2}\right)^{a+(T+k)/2+1} \times \\ &\quad \exp\left[-\frac{1}{\sigma^2}\left\{b+\frac{1}{2}\left(\beta-\bar{\beta}\right)'|\bar{V}|^{-1}\left(\beta-\bar{\beta}\right)\right\}+\left(Y-X\beta\right)'\left(Y-XB\right)\right] \\ &= \left(\frac{1}{\sigma^2}\right)^{a^*+(T+k)/2+1} \times \exp\left[-\frac{1}{\sigma^2}\left\{b^*+\frac{1}{2}\left(\beta-\hat{\beta}\right)'|\hat{V}|^{-1}\left(\beta-\hat{\beta}\right)\right\}\right] \end{aligned}$$

where

$$\hat{\beta} = \left(X'X + \bar{V}^{-1}\right)^{-1}\left(X'Y + \bar{V}^{-1}\bar{\beta}\right),$$
$$\hat{V} = \left(X'X + \bar{V}^{-1}\right)^{-1},$$
$$a^* = \alpha + T/2,$$
$$b^* = b + \frac{1}{2}\left[\bar{\beta}'\bar{V}^{-1}\bar{\beta} + Y'Y - \hat{\beta}'\hat{V}^{-1}\hat{\beta}\right].$$

The Marginal Posterior Distribution of σ_i^2 follows an $IG\left(a^*, b^*\right)$, where

$$a^* = \alpha + T/2$$

while b^* can be rewritten as

$$\begin{aligned} b^* &= b + \frac{1}{2}\left[\bar{\beta}'\bar{V}^{-1}\bar{\beta} + Y'Y - \hat{\beta}'\hat{V}^{-1}\hat{\beta}\right] = \\ &= b + \frac{1}{2}\left(Y - X\bar{\beta}\right)'\left(I + X\bar{V}X'\right)^{-1}\left(Y - X\bar{\beta}\right) \end{aligned}$$

by applying the Sherman-Woodbury-Morrison identity.

The Conditional Posterior Distribution $p\left(\beta_i|\sigma_i^2, D\right) \sim N\left(\hat{\beta}_i, \hat{V}_i\right)$

$$\hat{\beta}_i = \left(X_i'X_i + \bar{V}^{-1}\right)^{-1}\left(X_i'Y_i + \bar{V}^{-1}\bar{\beta}\right) \tag{3.5}$$

$$\hat{V}_i = \sigma_i^2\left(X_i'X_i + \bar{V}^{-1}\right)^{-1}. \tag{3.6}$$

3.5 Results

In this section we present our results. We examine the potential of heterogeneous effects of fiscal consolidations on output growth under the different specifications. The final period under study runs from the year 1981 to 2007[2]. First, we present the estimates of the ϕ of the associated equations in (1). As we observe in Table 2, there is evident heterogeneity on the design of the multi-year plans in different countries[3]. In the cases that there are too few observations available, we show a coefficient of zero. Except for Italy, in all the countries one-year anticipated announcements respond positively to unanticipated ones. However, for many countries the response is small and not statistically different from zero. Canada has a cumulative response higher

[2]The reason is that we lose observations by taking leads and lags of the variables in use.

[3]Note that we report the estimates for Finland and Sweden. As already mentioned, due to inspection of causality and lack of data, these countries are not included in our baseline study.

than one. The results of Italy suggest a negative relation between the unanticipated and anticipated announcements, which implies that on average the Italian plans are "stop-and-go".

Table 2: The Cross-country Heterogeneity in the Design of Multi-year Plan.

	AUS	AUT	BEL	CAN
$\phi_{1,i}$	0.31 (0.16)	0.35 (0.068)	0.22 (0.162)	1.4022 (0.17)
$\phi_{2,i}$	-0.24 (0.12)	0	0	0.65 (0.085)
$\phi_{3,i}$	-0.022 (0.011)	0	0	0.061 (0.045)
	DEU	DNK	ESP	FIN
$\phi_{1,i}$	0.002 (0.11)	0.41 (0.019)	0.036 (0.048)	0.021 (0.01)
$\phi_{2,i}$	0.024 (0.068)	0	0	0.019 (0.01)
$\phi_{3,i}$	0.024 (0.025)	0	0	0
	FRA	GBR	IRL	ITA
$\phi_{1,i}$	0.18 (0.08)	0.48 (0.16)	0.22 (0.162)	-0.24 (0.03)
$\phi_{2,i}$	-0.06 (0.035)	0.14 (0.05)	0	0
$\phi_{3,i}$	-0.027 (0.024)	0.007 (0.007)	0	0
	JPN	PRT	SWE	USA
$\phi_{1,i}$	0.26 (0.03)	0.52 (0.16)	0.55 (0.08)	0.41 (0.35)
$\phi_{2,i}$	0.011 (0.003)	0	0.33 (0.05)	0.32 (0.3)
$\phi_{3,i}$	0	0	0.22 (0.02)	0.199 (0.2)

3.5.1 Homogeneous Case

The impulse response functions (IRF) of the homogeneous case (Figure 5) indicate that on average fiscal consolidations have a contractionary effect on the economy. The

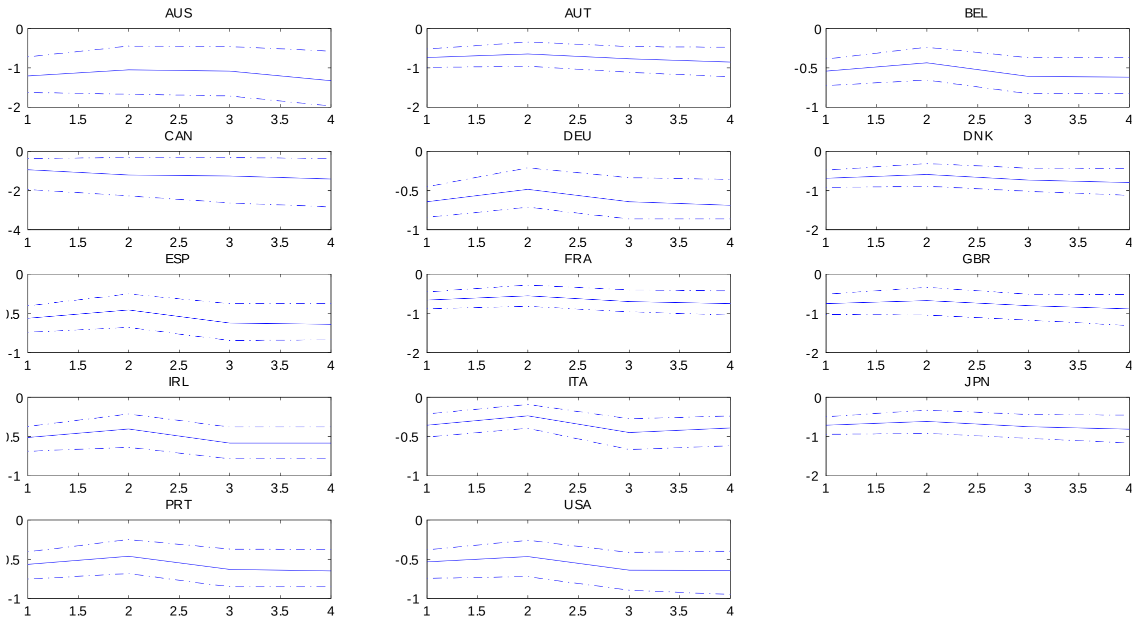


Figure 3.5: The Effect of Fiscal Consolidations on Output Growth

heterogeneity that we observe between the countries arises from the different styles of the plans (ϕ) of each country.

3.5.2 Heterogeneous Case: Expenditure-based and Tax-based Plans

In Figure 6 we observe the IRF of the effect of TB and EB fiscal consolidations on output growth. Here we replicate the results of AFG and we conclude that tax-based adjustments are more recessionary than expenditure-based adjustments.

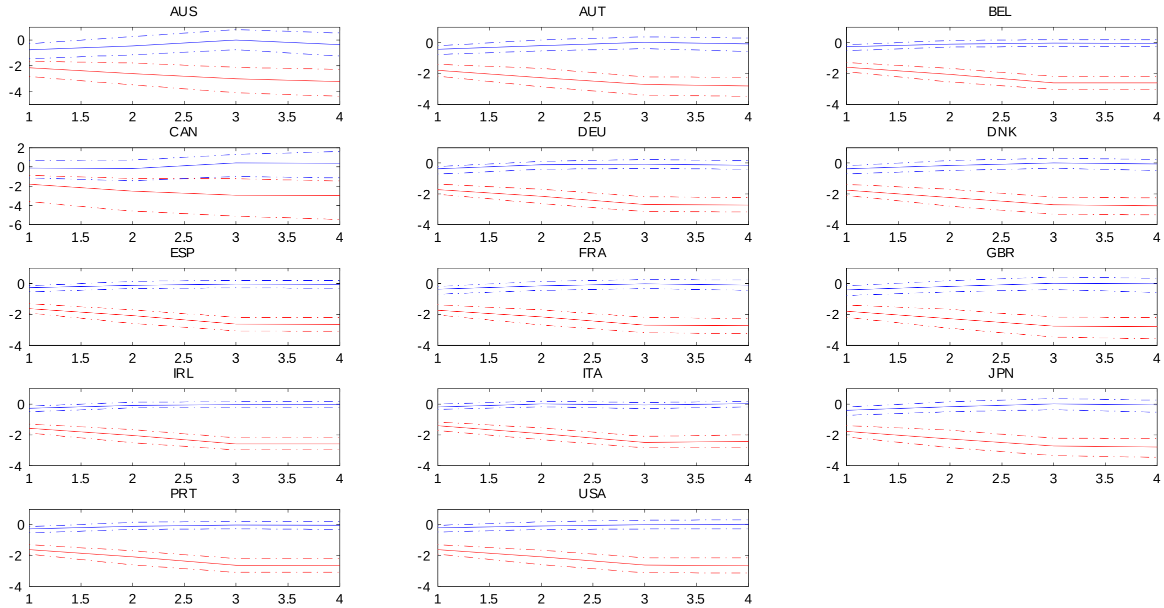


Figure 3.6: The effect of TB (red) and EB (blue) Adjustments on Output Growth

3.5.3 Heterogeneous Case: Recessions and Expansions

The effect of fiscal consolidation plans in recessions and in expansions on output growth for each country are presented via the impulse response functions of each country in Figure 7. The findings indicate that under recessions, fiscal consolidation plans appear to be recessionary and long-lived for all countries. When the economy is in expansion the effect of a fiscal consolidation is heterogeneous between countries. In most of the cases it is contractionary.

3.5.4 Expenditure-based versus Tax-based Fiscal Consolidations and the State of the Economy

In this case we are not able to proceed with the classical approach. The reason is that there are too many parameters and few observations. Therefore, we use a simple Bayesian approach (Gibbs sampling) as we discussed in the previous section.

In Figure 8 we see that the IRFs include big confidence intervals, for this reason we observe these results with caution. Evidence from Figure 8 (and Figure 9 -Appendix, where we zoom in just in one country, here Australia) shows that tax-based adjustments implemented during periods of recessions are more contractionary than the

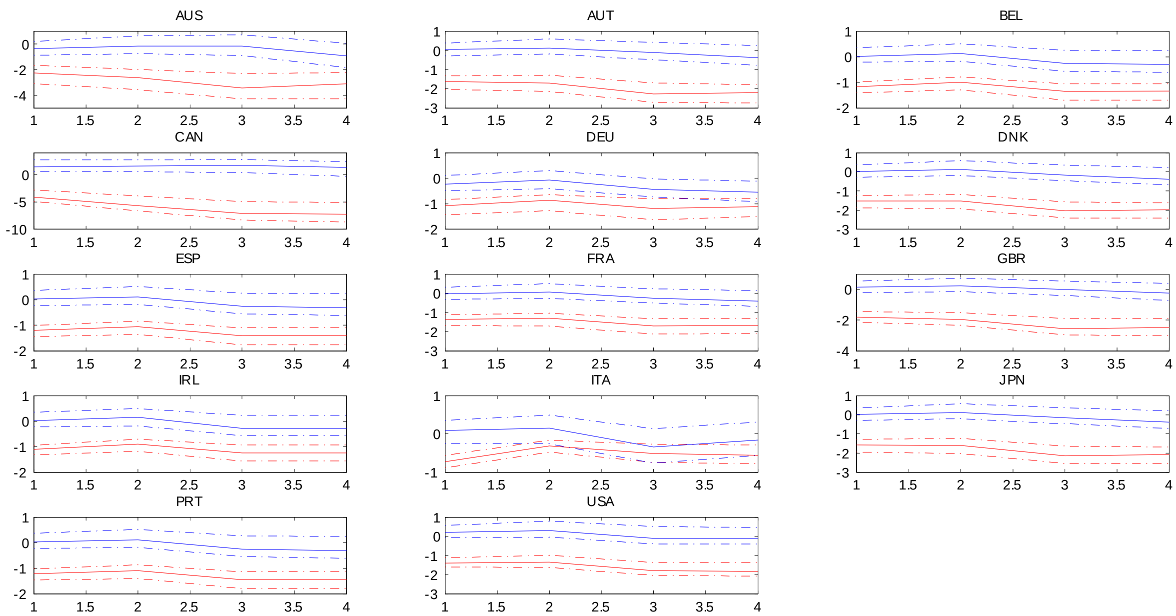
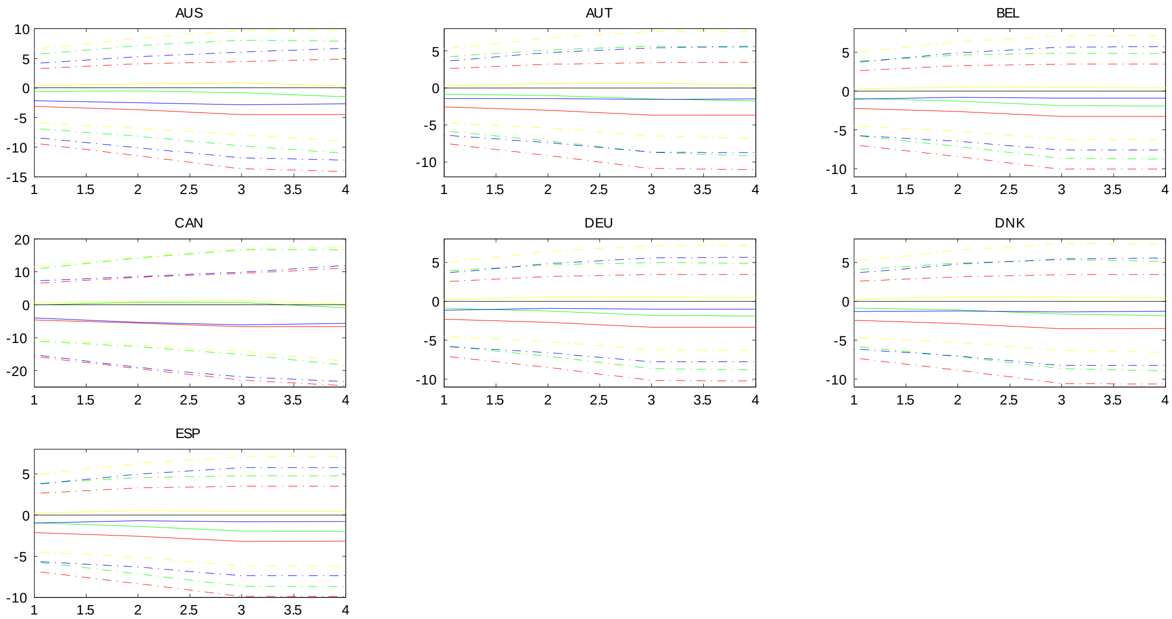


Figure 3.7: The Effect of Fiscal Consolidations in Recessions (red) and Expansions (red) on Output Growth



case of TB adjustments that are implemented in periods of expansions. The picture is similar for the expenditure-based changes. Overall, tax-based fiscal consolidations in crisis times are the most recessionary.

3.6 Forecast Performance

We use the above findings as evidence, but our aim is to examine if those findings indicate a correct direction. In the next section we proceed and evaluate the forecast performance of the two specifications (2&3) that include the two different types of asymmetry. We first examine whether the forecast of the one specification encompasses the other and the opposite.

3.6.1 Encompassing Tests - Non-Nested Model Comparison

Forecasting encompassing allows to directly analyze the two different sets of forecast arising from the specifications (2) and (3) and to examine whether the informational content of one is such that it dominates the other. If this is the case the dominant set of forecasts is said to forecast encompass the other.

Let the output growth be the variable of interest. Then consider the two sets of fitted values arising from the specification that accounts for EB and TB plans, and

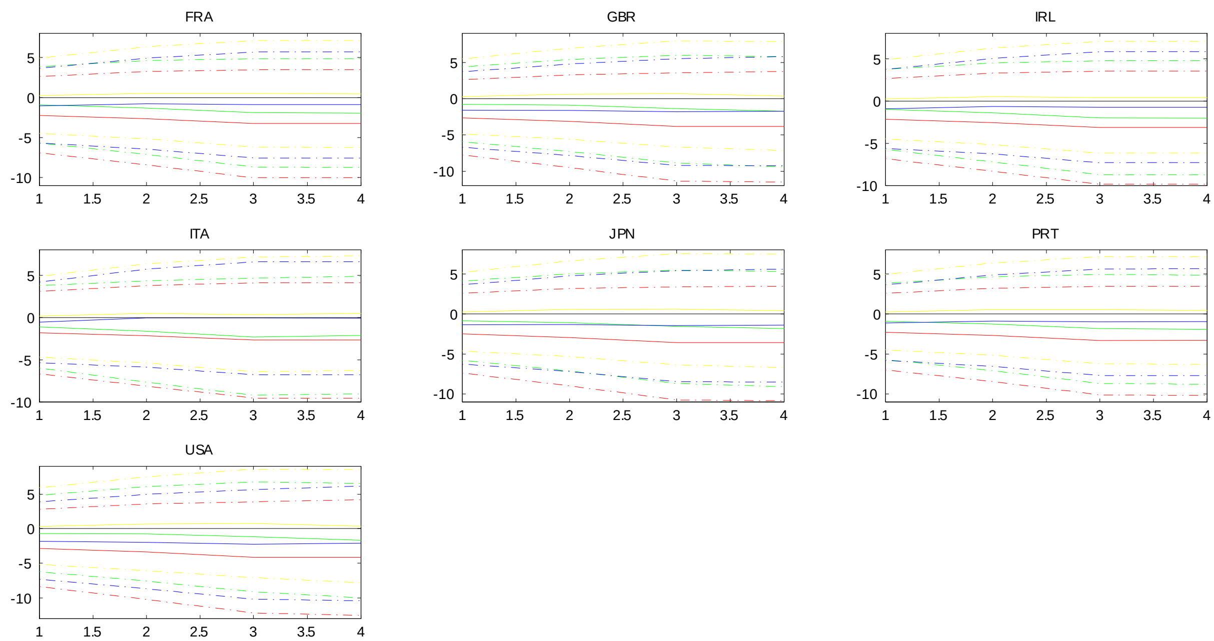


Figure 3.8: The Output Effect of TB under R (red), or E (green), of EB under R (blue), or E (yellow)

Variable	Coefficient	Std. Error	T-statistic
$\hat{\Delta y}_{it}^{EBTB}$	0.5286	0.1208	4.3751
$\hat{\Delta y}_{it}^{RE}$	0.4840	0.1210	4.0094

Table 3.1: Encompassing Test. Dependent Variable: Output Growth.

the fitted values of the specification that considers the state of the economy. The Fair and Shiller (1989) test employs the following testing equation:

$$\Delta y_{it} = \beta_1 \hat{\Delta y}_{it}^{EBTB} + \beta_2 \hat{\Delta y}_{it}^{RE}$$

where Δy_{it} is the output growth, $\hat{\Delta y}_{it}^{EBTB}$ are the fitted values of the specification that considers an heterogeneous response between EB and TB plans, whereas $\hat{\Delta y}_{it}^{RE}$ are the fitted values of the model that considers an heterogeneous response under the different state of the economy.

Forecast encompassing is examined via the significance of the β_i coefficients. Our findings (Table 2) show that both coefficients are statistically significant which indicates that none of the two models encompass one another.

An alternative way of forecast encompassing test (Chong-Hendry 1986) is based on the ability of one forecast to explain the error of the other. We denote the errors of a forecast as

$$e_{it}^{EBTB} = \Delta y_{it} - \hat{\Delta y}_{it}^{EBTB}$$

and

$$e_{it}^{RE} = \Delta y_{it} - \hat{\Delta y}_{it}^{RE}.$$

Then

$$e_{it}^{EBTB} = \lambda_2 \hat{\Delta y}_{it}^{RE} + \eta_{1t}$$

and

$$e_{it}^{RE} = \lambda_1 \hat{\Delta y}_{it}^{EBTB} + \eta_{2t}.$$

Insignificance of the λ_i coefficient determines whether forecast encompassing occurs. Our results show that both coefficients are insignificant ($\hat{\lambda}_2 = 0.0257$, std. error: 0.0284, t-statistic: 0.9061; $\hat{\lambda}_1 = 0.0280$, std. error: 0.0285, t-statistic: 0.9850), which indicates that none forecast encompasses the other.

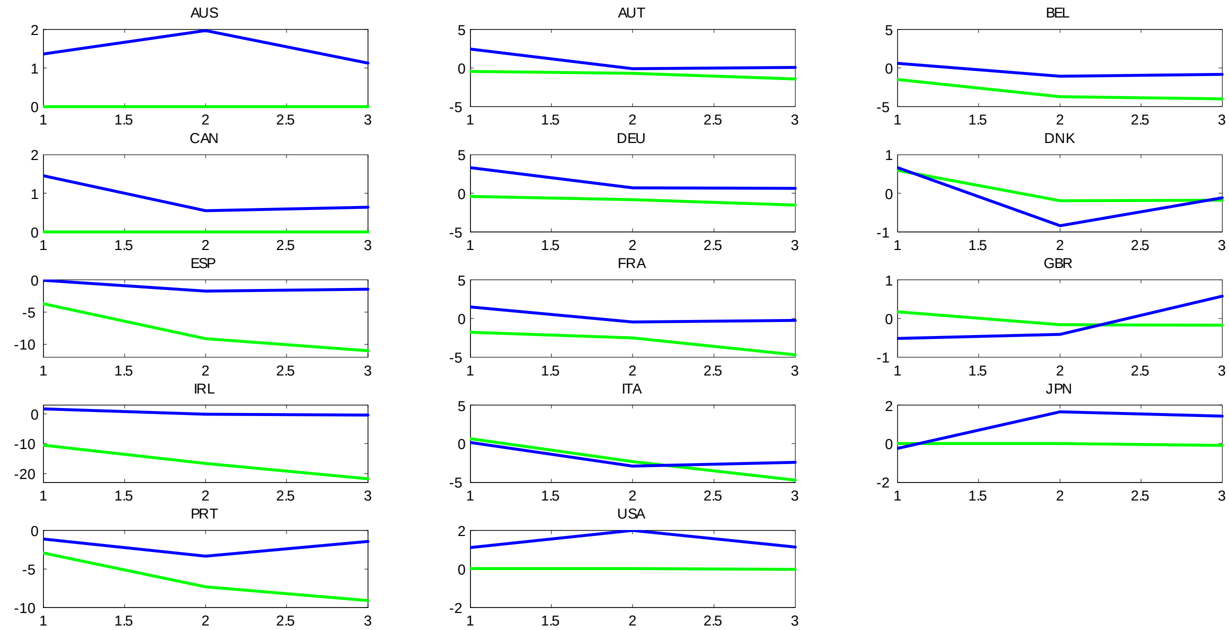


Figure 3.9: EBTB Projection (green) vs. Actual GDP Growth (blue)

3.6.2 Out-of-Sample Forecasts

To evaluate the forecasting performance of each of our specifications we feed our estimated model (years 1981 to 2007) with the actual plans implemented from 2009 to 2013 in each case. This means that we basically condition on the actual fiscal plans that each country adopted in each year. Then we compare these effects to the actual GDP growth realizations of the years 2010-2013.

We compare the effects of fiscal consolidation of the simulated path of output growth (green) for each specification to the actual GDP growth (blue).

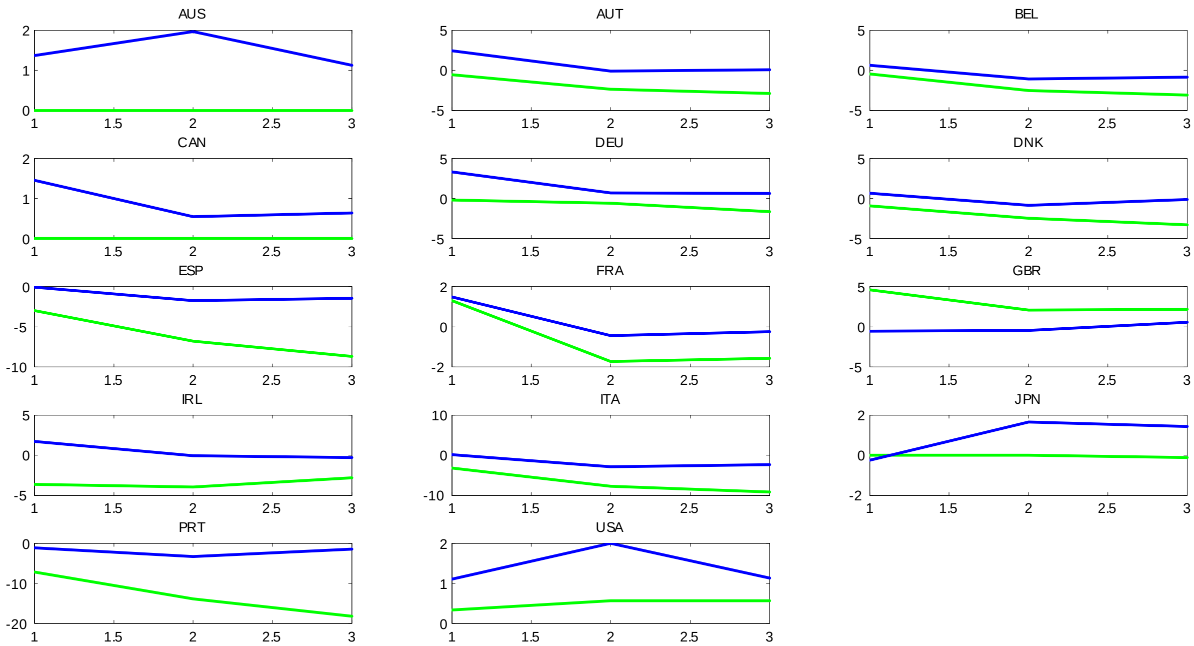


Figure 3.10: RecExp (green) vs. Actual GDP Growth (blue)

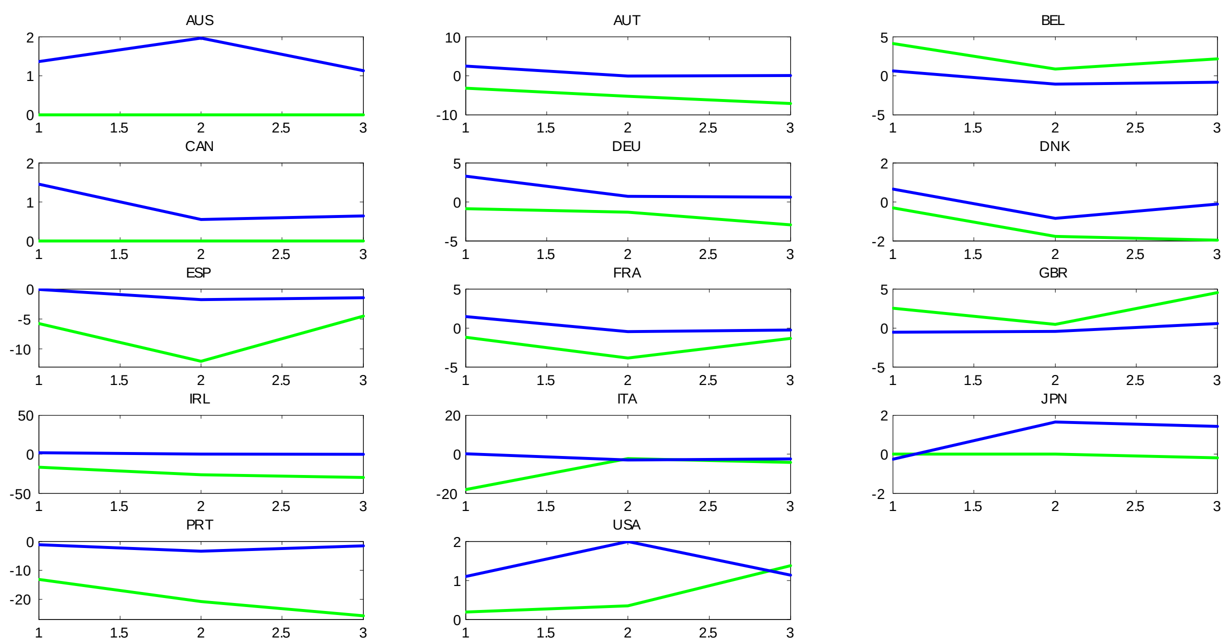


Figure 3.11: All (green) vs. Actual GDP Growth (blue)

3.7 Discussion

3.7.1 Endogenous State of the Economy

$$\begin{aligned}\Delta y_{it} = F\left(z_{it}\right) \times [A_1\left(L\right) e^u_{i,t} TB_{it} + A_2\left(L\right) e^u_{i,t} EB_{it} + \\ + \Gamma_1\left(L\right) e^a_{i,t,0} TB_{it} + \Gamma_2\left(L\right) e^a_{i,t,0} EB_{it} + \\ + \sum_{j=1}^{3} \gamma_{i,j} e^a_{i,t,j} TB_{it} + \sum_{j=1}^{3} \zeta_{i,j} e^a_{i,t,j} EB_{it}] + \\ + \left(1 - F\left(z_{it}\right)\right) \times [B_1\left(L\right) e^u_{i,t} TB_{it} + B_2\left(L\right) e^u_{i,t} EB_{it} + \\ + \Pi_1\left(L\right) e^a_{i,t,0} TB_{it} + \Pi_2\left(L\right) e^a_{i,t,0} EB_{it} + \\ + \sum_{j=1}^{3} \lambda_{i,j} e^a_{i,t,j} TB_{it} + \sum_{j=1}^{3} \xi_{i,j} e^a_{i,t,j} EB_{it}] + \\ + \lambda_i + \chi_t + u_{it}\end{aligned}$$

$$F\left(z_{it}\right) = \frac{\exp\left[-\gamma \frac{\Delta y_{it-1} + \Delta y_{it-2}}{2}\right]}{1 + \exp\left[-\gamma \frac{\Delta y_{it-1} + \Delta y_{it-2}}{2}\right]}, \quad \gamma > 0$$

$$e^a_{i,t,t+1} = \phi_{1,i} e^u_{it} + \upsilon_{1,i,t}$$

$$e^a_{i,t,t+2} = \phi_{2,i} e^u_{it} + \upsilon_{2,i,t}$$

$$e^a_{i,t,t+3} = \phi_{3,i} e^u_{it} + \upsilon_{3,i,t}$$

where TB_{it} and EB_{it} are the dummies for the tax-based and expenditure-based plans respectively (a category of fiscal changes that have not been classified is considered as the base dummy). λ_i and χ_t are country and time fixed effects respectively. ϕ allows for country-level heterogeneity, $\upsilon_{jit} \sim N\left(0, \Sigma_\upsilon\right)$, $j = 1, 2, 3$, $i = 1, ..., N$ index countries and $t = 1, ..., T$ index time.

In this model we allow for 3 types of heterogeneity. Again we account for between-country heterogeneity from the additional regression that reveal the style of plans in each country. The second type of heterogeneity refers to within-country heterogeneity. It arises from the diverse effects that the different types of TB or EB plans may produce in a country. The third type is related to the country-heterogeneity of the state of the economy.

We use a truncated moving average representation because the length of the $A_i(L)$, $B_i(L)$, $\Gamma_i(L)$,... polynomials are limited to 3 years. This does not change the results, since the omitted lags are orthogonal to the variables included.

Following Auerbach and Gorodnichenko, we denote by z the growth rate of output, as a moving average of two years. Finally we use as an index of the business cycle, a measure which is normalized to have unit variance so that γ is scale invariant,

$$Var\left(z_{it}\right)=1 \quad , \quad E\left(z_{it}\right)=0.$$

γ is calibrated in a way that the economy spends an $x\%$ of time in a recessionary regime - according to the OECD dates (i.e., $\Pr\left(\left(z_t\right)>0.8=0.2\right)$ where we define an economy to be in a recession if $F\left(z_t\right)>0.8$. The magnitude of γ is in line with estimates of logit regressions of the OECD dates on the measure of z.

3.7.2 Alternative State Indicators

3.8 Concluding Remarks

The effect of fiscal austerity during economic downturns stands at the frontier of policy discussions. In this paper we examine the potential asymmetric response of fiscal consolidation plans under different states of the economy. We study a narrative record of fiscal consolidations of 14 OECD countries. Instead of individual shocks, we simulate plans of expected and unexpected policy actions, in order to overcome the problem of fiscal foresight. Our interest lies in an heterogeneous multiplier. An heterogeneity that originates from both the nature of the adjustments (Tax-based or Expenditure-based) and the diverse economic conditions that exist in an economy under different phases of the business cycle. For each country we follow the recession dates indicated by the OECD and the Federal Reserve of Saint Louis.

Our results support the initial assumption of a nonlinear effect on output under both sources of asymmetry. The IRFs indicate that the effect of fiscal consolidations, if made during a period of recession, is larger than during an expansion. The picture is similar when we study the heterogeneous response of expenditure-based versus tax-based adjustments. When we account for both types of asymmetries, our findings indicate that tax-based consolidations implemented in periods of recessions are more contractionary than when they are implemented in periods of expansions. The same holds for expenditure-based changes. Overall, tax-based fiscal consolidations in crisis times are the most recessionary. Our forecast encompassing tests support these findings, which we highlighted that we take them with caution. Yet the forecasting performance of each of the model specifications do not encompass each other.

The evidence of this asymmetry should be evaluated further, in order to understand the channels of the transmission mechanism. For example, it could be important to control for a component of the monetary policy, particularly when the interest rates are close to the zero lower bound. In addition, it would be important to study a related theoretical model.

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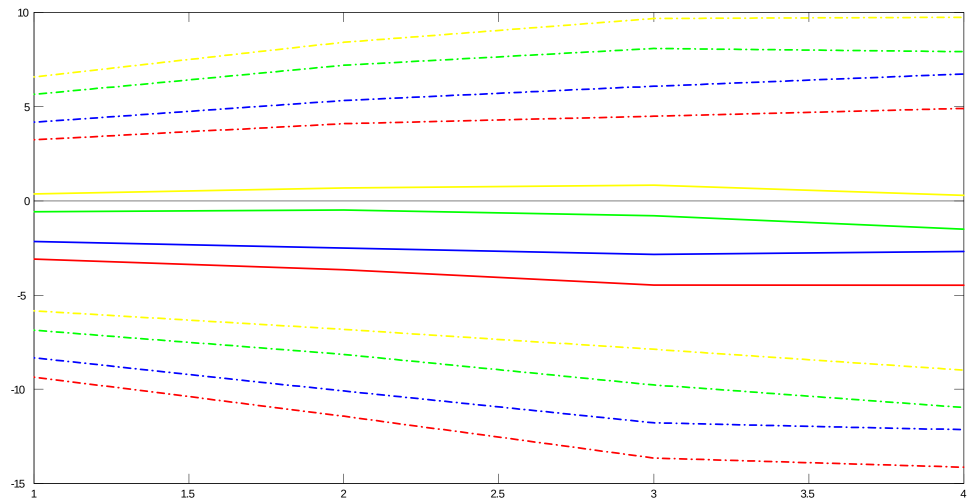

Figure 3.12: Australia. The Output Effect of TB under R (red), or E (green), of EB under R (blue), or E (yellow)

Appendix: