TOHOKU UNIVERSITY

DOCTORAL THESIS

The Macroeconomic Effects of Fiscal Policy

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Declaration of Authorship

I, Lamia BAZZAOUI, declare that this thesis titled, “The Macroeconomic Effects of Fiscal Policy” and the work presented in it are my own. I confirm that:

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- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
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Abstract

Graduate School of Economics and Management

Doctor of Philosophy in Economics

The Macroeconomic Effects of Fiscal Policy

by Lamia BAZZAOUI

In this thesis, I attempt to study the effects of fiscal policy on inflation, the current account balance and private consumption. The first chapter focuses on the relationship between fiscal policy and inflation. The study is conducted using a panel VAR approach based on data for 44 countries over the period 1960-2018, while accounting for the difference in monetary policy frameworks and the levels of fiscal space. Results suggest that fiscal deficits are less likely to cause inflation when monetary policy is based on targets. In addition, budget deficits are inflationary in the group of countries without a solid national monetary policy framework (such as dollarized Latin American economies). Finally, the fiscal space level is not useful in explaining the relationship between fiscal policy and inflation. In the second chapter, I try to verify whether cyclicality can shed some light on the relationship between government spending and the current account balance. This study is conducted based on quarterly panel data for 51 countries, from 2002Q1 to 2018Q4, using a heterogeneous structural panel vector autoregression (VAR) methodology. Findings confirm the importance of cyclicality in understanding the dynamics between aggregate variables. On the other hand, the relationship between the current account and disaggregate fiscal variables is characterized by substantial heterogeneity. Therefore, the panel study is supplemented with a time series approach to uncover the main public spending components that affect the current account by country. Two components are found to be connected to the current account in some cases: subsidies and property income. Finally, in the third chapter, I use a New-Keynesian model with non-Ricardian households to analyze the impact of different fiscal policy measures on private consumption. A Markov-switching approach is applied to solve and estimate the model outside and at the Zero Lower Bound (ZLB). Estimation is based on Japanese data over the period 1980Q1-2020Q3. I also analyze the changes in the model's behavior following two different fiscal rule specifications. Results show that consumption does not respond positively to fiscal stimulus measures, even after inclusion of rule-of-thumb consumers. This results from the prevalence of Ricardian behavior in the model, in addition to the decline in real wages that follows most measures. Inclusion of distortionary taxation alters the variables' responses through the impact of tax rate movements. Conversely, the presence of the ZLB is not found to affect the model substantially, except after a consumption or a wage income tax cut. Although both measures are generally detrimental to the economy, they have the potential to yield better results over the long-run when the ZLB is binding. A capital income tax cut is found the be the optimal fiscal stimulus measure. Its impact mainly results from the increase in investment which shifts the economy's productive capacity upward, thereby boosting consumption and real wages. Finally, a variance decomposition analysis shows that consumption is mainly driven by labor supply and technology shocks.

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List of Abbreviations

CA	**C**urrent **A**ccount
CAB	**C**urrent **A**ccount **B**alance
DSGE	**D**ynamic **S**tochastic **G**eneral **E**quilibrium
ESA	**E**uropean **S**ystem of **A**ccounts
IFS	**I**nternational **F**inancial **S**tatistics
IRF	**I**mpulse **R**esponse **F**unctions
IT	**I**nflation **T**argeting
GFS	**G**overnment **F**inance **S**tatistics
GIRF	**G**eneralized **I**mpulse **R**esponse **F**unctions
GMM	**G**eneralized **M**ethod of **M**oments
HP	**H**odrick **P**rescott
MPF	**M**onetary **P**olicy **F**ramework
MS	**M**arkov-**S**witching
OBC	**O**ccasionnally **B**inding **C**onstraint
PS	**P**rimary **S**urplus
PVAR	**P**anel **V**ector **A**uto **R**egression
PVM	**P**resent **V**alue **M**odel
RS	**R**egime-**S**witching
VAR	**V**ector **A**uto **R**egression
ZLB	**Z**ero **L**ower **B**ound

Introduction

The recent growing interest in fiscal policy marks an important shift in macroeconomic thought. So far, the common belief in macroeconomics has been that monetary policy (and especially the use of interest rates to control inflation) is the primary tool to conduct stabilization. But the difficulties that have arisen in the recent years (a lackluster growth, higher welfare expenditures, uncertainty about the efficacy of unconventional monetary policy, etc) proved challenging for the traditional macroeconomic policy approaches.

At the same time, the renewed attention towards fiscal policy revealed that many steps still need to be done before it can be used efficiently. First, a better understanding of the way government expenditures, taxation and debt interact with the aggregate economy is of immense importance. The present thesis attempts to partially address this issue by studying the effects of fiscal policy on inflation, the current account and private consumption.

The first chapter focuses on the question of whether large, sustained government deficits cause higher inflation. The choice of this topic as a subject of investigation is motivated by the concerns raised by excessive budget deficits in the past years. The present situation is unprecedented not only because the size of these deficits reached a level that hasn't been seen since the end of World War II but also because they have been accompanied by a persistently low inflation. Therefore, it is important to build a better insight into the conditions that can make budget deficits inflationary in order to understand why inflation has stayed at a low level despite a growing public debt in the recent period. Such an understanding would also be useful to know whether an inflation uproar is to be expected in the forthcoming years. To study this topic, I adopt a panel VAR approach based on data for 44 countries over the period 1960-2017. The use of a panel approach to deal with this issue is not very common in the literature but is justified by the many advantages it offers over a pure time series or cross-sectional analysis. The most significant benefit is the fact that it provides a broader view on the subject since panel data contain more information and variability than individual country data. I additionally control for two elements that I consider as important in explaining differences among countries: the monetary policy framework and the level of fiscal space.

Conclusions from this chapter suggest that a fiscal determinacy of the price level is less likely to occur when monetary policy is based on targets. In addition, budget deficits are inflationary in the group of countries without a solid national monetary policy framework (such as dollarized Latin American economies). Finally, the fiscal space level is not useful in explaining the relationship between fiscal deficits and inflation.

In the second chapter, I attempt to understand how fiscal policy is related to countries' external balances. The high fiscal deficits of the recent years justify the need for this inquiry. In addition, although the concurrence of large fiscal and current account deficits in the early 1980s gave rise to the label of 'twin deficits', empirical evidence suggests that both deficits do not always move in the same direction. My main contribution is to incorporate cyclicality as a fundamental element that explains the diverging empirical evidence on the topic. I also use both aggregate and disaggregate fiscal variables. This study is conducted based on quarterly panel data for 51 countries, from 2002Q1 to 2018Q4, using an approach that relies mainly on the heterogeneous structural panel vector autoregression (VAR) methodology of Pedroni (2013). The core advantage of this methodology lies in the fact that it offers the possibility of decomposing impulse responses into common and idiosyncratic components, while considering the underlying sample heterogeneity. I conclude from this study that cyclicality matters when modeling the relationship between the current account and fiscal policy at the aggregate level. More specifically, a negative relationship between government spending and the current account is found to hold only for countries with a countercyclical fiscal policy and a procyclical current account. This result is mainly explained by a negative response to property income (mostly interest payments) in this group (and also to social benefits in some countries). In general, results at the disaggregate level reveal a substantial heterogeneity across countries. Therefore, the panel approach is supplemented with a country by country investigation using Bayesian VAR methods. Findings from this part show that subsidies and property income are the government spending components that are most likely connected to the current account. In the particular case of property income, a relationship with the current account is especially noted for countries where sovereign credit risk is perceived as relatively high by international markets.

In the last chapter, I turn to the issue of macroeconomic stabilization using fiscal stimulus measures. In the recent crisis, with monetary policy facing the liquidity trap and the financial sector in an unstable state, governments resorted to fiscal policy to sustain demand

and avert an aggravation of macroeconomic conditions. Still, the use of fiscal measures to smooth business cycle fluctuations does not have unanimous support, especially that its effects are the matter of sizable controversy in economic discussions. In this study, I attempt to analyze the effects of a government spending increase and different tax cuts on private consumption, using Japanese data. Reasons for the focus on consumption are twofold. First, there is a considerable disagreement in the literature about how it reacts to fiscal stimulus. Second, I consider that it can be a key lever in the success of fiscal measures since it often represents the largest component of output. I use a standard New-Keynesian model (based on Smets and Wouters (2003)) and incorporate different elements in the analysis to verify if they can improve consumption's response to fiscal policy: non-Ricardian consumers, two different assumptions on the fiscal rule (lump-sum taxes and distortionary taxation) and the Zero Lower Bound on interest rates. Estimation of the model is based on a Markov-switching regimes approach applied to Japanese data over the period 1980Q1-2020Q3. The main findings are as follows. First, although the inclusion of rule-of-thumb consumers generates a greater dependence of consumption on income, it is not sufficient to generate a crowding-in effect of consumption after fiscal stimulus measures. This results from the fact that Ricardian behavior remains prevalent in the model but also from the decline in real wages that can be observed after most measures. Second, including distortionary taxation alters the model's behavior through the adjustments of the different tax rates (that follow a hump-shaped pattern). Nonetheless, consumption remains closely linked to lump-sum taxes' response even after inclusion of the other taxes. Third, no difference can be observed in the model's response after a government spending increase and a capital income tax cut between the regime at the ZLB and the regime outside it. But a difference between both regimes can be seen after a consumption or a wage income tax cut. These two measures are generally both detrimental to the economy, but they have the potential to yield better results over the long-run at the ZLB. Fourth, by comparing the different fiscal stimulus measures, a capital income tax cut appears to be the most beneficial policy, although it has the disadvantage of increasing public debt more significantly. Finally, a variance decomposition analysis shows that consumption is mainly driven by labor supply and technology shocks.

Chapter 1

Effects of fiscal policy on inflation: a panel VAR approach

1.1 Introduction

In recent decades, many countries attempted to bolster weak economic growth using fiscal policy. The resulting increase in public debt, macroeconomic imbalances, and more particularly, effects on the price level, are now a source of public concern. Nonetheless, the fears of an inflation outburst resulting from high indebtedness can only be justified if a verifiable relationship between inflation and fiscal policy exists.

The literature usually links inflation to monetary policy factors. For example, the monetarist view suggests that inflation is the result of too much money chasing too few goods and often considers the demand for money, interest rates, and exchange rates. In general, the conduct of monetary policy is considered as a major determinant of inflation dynamics and the primary explanation for the recent low levels of inflation.

Fiscal determinacy of the price level, on the other hand, is based on the idea that governments running persistent deficits will eventually have to finance those deficits through money creation (seigniorage), thus producing higher inflation, especially when GDP growth rates are lower than interest rates (Sargent and Wallace (1981)). Most popular works in this respect are those on the fiscal theory of the price level (FTPL). Nevertheless, prior empirical studies find little success in uncovering strong evidence for its validity or in deriving consistent results across advanced and developing economies.

I believe that the absence of conclusive empirical evidence in this area of research can be partially justified by the fact that effects of monetary policy are not usually controlled for. The main hypothesis in this chapter is that inflation is more likely to respond to fiscal policy measures when monetary policy is based on some particular approaches (typically coinciding with regimes of passive monetary policy/active fiscal policy). It is therefore important to account for the difference in monetary policy frameworks across periods and countries. In addition, I assume that the fact that it is more common to find a closer relationship between inflation and fiscal deficits in developing rather than advanced economies can be explained by a difference in the debt repayment capacity. I therefore also control for this factor by including a measure of fiscal space in the analysis.

Based on a linearized equation derived from a government's intertemporal budget constraint, the present study employs a panel vector auto-regression (VAR) model for a sample of 44 countries over the period 1960–2017. The panel approach presents several advantages over the more traditional country by country analysis. First, it provides estimates that reflect the common behavior of the sample while controlling for individual heterogeneity. Therefore, it offers a more general conclusion on the topic than would be possible from a time-series approach. Second, the additional cross-sectional dimension allows for a gain in degrees of freedom (compared to time-series). Finally, the greater variability that characterizes panel data improves the efficiency of econometric estimates.

The underlying theoretical model used in this study links the inflation rate to both fiscal and monetary policy variables, in addition to economic growth rates. Both a restricted and an unrestricted panel VAR approaches are adopted in the estimation. Changes of inflation's response to fiscal variables are analyzed based on the categories of monetary policy frameworks. The main findings indicate that fiscal variables are less likely to affect inflation when monetary policy is based on targets. In particular, inflation is less responsive to fiscal shocks in inflation targeting regimes (and also to interest rates shocks). On the other hand, the category that encompasses countries without a national monetary policy framework (such as partially dollarized Latin American countries) is the one in which budgets deficits are inflationary. In a subsequent step, the fiscal space variable is included into the model but is not found to be useful in explaining the relationship between the primary balance and inflation.

1.2 Literature review

There are three broad approaches to link fiscal policy with inflation. The traditional approach is based on the government budget constraint. It has been first used by Sargent and Wallace (1981) to establish a link between fiscal policy and the price level. They derived the fiscal determinacy of prices from the government's intertemporal budget constraint, expressed as

$$G_t + i_{t-1}B_{t-1} = T_t + (B_t - B_{t-1}) + (H_t - H_{t-1}) \tag{1.1}$$

where G_t is government expenditures on goods, services, and transfers at time t and T_t is the tax revenue. i_{t-1} is the interest rate, B_t is interest-bearing debt, and H_t is the stock of base or high-powered money. Thus, $i_{t-1}B_{t-1}$ represents interest payments on total outstanding debt and $B_t - B_{t-1}$ denotes new issues of interest-bearing debt. Equation (1.1) shows that the government can fund its expenditures either through taxes, newly issued debt, or printing new currency ($H_t - H_{t-1}$).[1] Their model predicts that if interest rates on bonds are higher than the economy's growth rate, then the real stock of bonds will grow faster than the economy. However, since the demand for bonds places an upper limit on the stock of bonds, the government will finance both the principal and the interest eventually through seigniorage. In other words, the fiscal authority's decisions can induce the printing of more money, and therefore inflation.

Most of the existing empirical studies on the fiscal determinacy of the price level use the government's intertemporal budget constraint as the starting point to determine both the analytical approach and the explanatory variables. Some of these studies (Table 1.1) focus on the link between fiscal deficits and inflation, while others examine the relationship between fiscal surpluses and public debt or use a different approach. However, most studies do not provide conclusive evidence for the existence of the fiscal determinacy of prices. For example, Catao and Terrones (2005) and Fischer, Sahay, and Végh (2002) conclude that fiscal deficits are the main drivers of high inflation only for high-inflation developing countries. Bohn (1998) and Bajo-Rubio, Díaz-Roldán, and Esteve (2009) follow a different approach using the primary surplus and the debt-to-GDP ratio.[2] They conclude that the fiscal authority acts in a Ricardian fashion,[3] as do Canzoneri, Cumby, and Diba (2001) and Creel and Le Bihan (2006). Conversely, Favero and Monacelli (2005) show the presence of alternating Ricardian and non-Ricardian regimes.

Another theory that advocates the fiscal determinancy of prices is the Fiscal Theory of the Price Level (FTPL). It is based on the assumption of a dominant fiscal policy. The central equation of the FTPL is the government debt valuation equation, which sets the real value of

[1] Based on equation (1.1), Sargent and Wallace (1981) provide an expression for the inflation rate depending on the stock of interest-bearing government debt per capita, assuming that fiscal policy dominates monetary policy. That is, the fiscal authority independently sets its budget, announcing current and future deficits and surpluses. The amount of revenue to be raised is then determined based on these decisions. The monetary authority then finances the discrepancy between the revenue demanded by the fiscal authority and the number of bonds that can be sold to the public with seigniorage. Leeper (1991) defines this as an "active" fiscal policy and "passive" monetary policy scenario, where the fiscal authority's actions constrain monetary policy, which simply reacts to government debt shocks.

[2] Bajo-Rubio, Díaz-Roldán, and Esteve (2009) focus on a sample of 11 EU countries, while Bohn (1998) studies only the US.

[3] According to Sargent (1982) (pp. 6–7), in a Ricardian regime, the issuing of additional Interest-bearing government securities is always accompanied by a planned increase in future explicit tax collections which is sufficient to repay the debt. In the second polar regime (non-Ricardian), additional interest-bearing government securities signify the government's promise to eventually monetize the interest-bearing debt.

government debt equal to the expected present value of future fiscal surpluses.

$$\frac{B_{t-1}}{p_t} = \sum_{j=0}^{\infty} E_t \left(m_{t,t+j} s_{t+j} \right) \tag{1.2}$$

where B_{t-1} is the one-period nominal debt issued at $t-1$ due at t, p_t is the price level, s_t is the real primary government surplus including seigniorage, and $m_{t,t+j}$ is the discount factor. Several studies provide the derivation of this equation, such as those by Sims (1994) and Woodford (1994) and Woodford (1995). The valuation equation is usually obatined from the intertemporal government budget constraint, with the government debt (B_{t-1} in the LHS) expressed in nominal terms and the present value of primary surpluses (RHS) in real terms.[4]

A direct way to verify the FTPL is through an estimation of equation (1.2). However, this approach poses many challenges. First, the variable representing the present value of future primary surpluses would be hard to measure and analyze.[5] Second, the choice of the discount rate would have a significant impact on the results. A change in inflation could reflect a change in the discount rate rather than a movement in fiscal variables (Cochrane (2019b)). Furthermore, inferring concrete policy implications from this formal expression is not straightforward. Using a similar expression with alternative empirical approaches, some studies were however able to confirm the validity of the FTPL, for instance, Loyo (1999) and Tanner and Ramos (2003) for Brazil or Fan, Minford, and Ou (2013) for the UK.[6]

Another limit of the government's valuation equation is the fact that it omits many important economic variables that play a key role in inflation dynamics. One example is the economic growth rate. As pointed out by Sargent and Wallace (1981), the fiscal determinacy of prices occurs when economic growth rates are below interest rates. Such a condition cannot be verified through the valuation equation. Therefore, a more comprehensive theoretical framework is needed, one with assumptions that are closer to the actual economic dynamics.

Sims (2011) suggests such a framework. It is a New-Keynesian style model with long-term debt and sticky prices.[7] One important implication of this framework is that, even

[4]Cochrane (2005) presents this relation as an asset pricing model based on a different logic. The underlying idea is that nominal debt, including the monetary base, is a claim on the government's future primary surpluses (in the same way a stock is a claim on future earnings). As argued by the author, the market determines bond prices depending on bond yields and future streams of expected primary surpluses (also see Cochrane (2019a)).

[5]In addition, the judgment could be biased by business cycle fluctuations, as primary surpluses are likely to fall during recessions and increase thereafter.

[6]Fan, Minford, and Ou (2013) find that the 1970s inflation outburst resulted from an increased level of expenditure unmatched in the previous decades.

[7]Cochrane (2018) provides the derivation and solution of this model.

in an active fiscal/passive monetary policy equilibrium, the monetary variables still have a powerful effect on both output and inflation. In this model, contractionary monetary policies first lead to a drop in inflation, then produce exactly the opposite effect with a time lag. Fiscal variables can be considered a part of this dynamic in the sense that interest rate changes affect the market value of bond prices. More precisely, when interest rates are high, the real value of government debt appears to be greater than its real market value for investors. Consequently, the demand for government debt increases at the expense of the demand for goods and services, which leads to lower aggregate demand, and therefore, lower prices. On the other hand, the model also shows that an expansionary fiscal shock creates a boom in consumption and an upward unanticipated spurt in the inflation rate. In this case, inflation is fiscally determined through the output transmission channel.[8]

More recently, Cochrane (2019a) studied the fiscal roots of inflation based on the following log linearized identity.

$$v_t + r^n_{t+1} - \pi_{t+1} - g_{t+1} = s_{t+1} + v_{t+1} \tag{1.3}$$

where v_t represents the market value of debt; r^n_t, the nominal returns on the government debt portfolio with a maturity length of n; π_t, the inflation rate; g_t, the GDP growth; s_t, the real primary surplus; and $r^n_t - \pi_t - g_t$, the discount rate for the RHS terms. More details on this model are provided in Appendix A. An expression derived from this identity (see Appendix) shows that unexpected inflation less the unexpected nominal return on government bonds must equal the innovation in the present value of future surpluses to GDP. Therefore, it links the unexpected inflation rate to both the monetary and fiscal variables, in addition to GDP growth (included in the discount rate of the present value). Using US data on government bonds from the database of Hall, Payne, and Sargent (2018), Cochrane reports that a positive monetary policy shock (defined as a shock to interest rates not accompanied by a movement in future primary surpluses) is super-Fisherian and raises inflation immediately. A negative fiscal shock (defined as a shock to future primary surpluses not accompanied by a movement in interest rates) induces a protracted inflation. The disinflation resulting from a recessionary shock corresponds entirely to a decline in discount rates, leading to higher debt. In the present paper, I apply a similar approach based on different assumptions using

[8] This mechanism is described with more details in Cochrane (2018).

panel data for 44 countries (over the period 1960-2017). I also attempt to compare the findings across subsamples constructed based on monetary policy frameworks and on the level of fiscal space.

1.3 Theoretical model

I follow Cochrane (2019a) in deriving a model for inflation that accounts for the effect of fiscal policy, in addition to two important determinants of inflation in theory: monetary policy (through the interest rate) and aggregate demand (through GDP growth). Nonetheless, the model I use is based on the intertemporal government budget constraint and not on an asset pricing approach. In addition, I consider the stock of government debt instead of the market value of bonds.[9] Finally, money is not included in the variable of government debt as this may generate a bias when studying the relationship between debt and inflation.

Considering the following government intertemporal budget constraint:

$$B_t - B_{t-1} - R_t B_{t-1} = G_t - T_t \tag{1.4}$$

where B_t denotes the stock of government debt in nominal terms at time t; R_t, the nominal interest rate on government bonds; G_t, nominal government spending and T_t, taxes. This relation states that government spending and interest payments are financed through taxes or new issuance of debt.

The percent change in the value of the government bond portfolio can be expressed by h, such that: $B_t = (1+h)\ B_{t-1}$. Then, equation (1.4) becomes:

$$B_{t-1}\,(h - R_t) = G_t - T_t = -PS_t \tag{1.5}$$

where PS_t is the primary surplus at time t.

Since the change in public debt also depends on government bond yields, I assume that it can be expressed as a linear function of this variable such that $h = kR_t$ for a given coefficient

[9] It is more challenging to empirically verify a model that includes bond prices for different maturities in a panel study due to the lack of data.

k $(0 < k < 1)$. Then, equation (1.5) can be expressed as

$$B_{t-1} = \frac{PS_t}{R_t\,(1-k)} \tag{1.6}$$

With θ_t being GDP growth, rescaling by real GDP (y_t) leads to

$$\frac{B_{t-1}}{y_{t-1}\theta_t} = \frac{PS_t}{y_t R_t\,(1-k)} \tag{1.7}$$

For B_{yt-1} representing the term B_{t-1} rescaled by GDP and PS_{yt} representing the term (PS_t) rescaled by GDP, this relation is equivalent to

$$B_{yt-1} = \frac{\theta_t PS_{yt}}{R_t\,(1-k)} \tag{1.8}$$

Dividing this equation by p_t yields

$$\frac{B_{yt-1}}{p_t} = \frac{\theta_t}{R_t\,(1-k)}\frac{PS_{yt}}{p_t}. \tag{1.9}$$

With inflation corresponding to $\pi_t = \frac{p_t}{p_{t-1}}$ and the output-adjusted real primary surplus being $ps_{yt} = \frac{PS_{yt}}{p_t}$, we get

$$\frac{B_{yt-1}}{\pi_t p_{t-1}} = \frac{\theta_t ps_{yt}}{R_t\,(1-k)} \tag{1.10}$$

Considering real debt over GDP at time $t-1$ as b_{yt-1}= $\frac{B_{yt-1}}{p_{t-1}}$, then:

$$\frac{b_{yt-1}}{\pi_t} = \frac{\theta_t ps_{yt}}{R_t\,(1-k)} \tag{1.11}$$

Taking logs and bringing real debt over GDP to the RHS, the following equation is obtained:

$$\log\left(\pi_t\right) = \log\left(b_{yt-1}\right) - \log(\theta_t) - \log\left(ps_{yt}\right) + \log\left(R_t\right) + log\,(1-k) \tag{1.12}$$

In this equation, it appears that both fiscal and monetary policy, in addition to growth, affect the inflation level. Based on this model, I expect a positive relationship between inflation and public debt and a negative relationship between inflation and the primary balance.

Moreover, the response of inflation to interest rates is assumed to be positive.[10] These expectations are consistent with the neo-Fisherian view and the conclusions in Sims (2011) and Cochrane (2018).

Finally, a negative relationship between inflation and the GDP growth rate is expected. This result contradicts the conventional Keynesian and neo-Keynesian frameworks, according to which this relation should be positive (the AD-AS model, Phillips Curve). Nonetheless, this assumption is consistent with the findings of several empirical studies and theoretical models.[11]

1.4 Data and approach

Unlike previous studies that focus on a single country, I study the inflation-fiscal variables relationship using a panel VAR (PVAR) model over a long time-span to draw more general conclusions on the issue. Equation (1.12) contains the key variables required for the analysis. I examine their relationship using a sample of 44 countries listed in Appendix B from 1960 to 2017. Data and sources are defined in Appendix C. I further use the monetary policy classification compiled by Cobham (2018) and data related to government revenues to determine the fiscal space level for the sample countries, as explained in this section.

The importance of accounting for monetary policy frameworks is justified by the common belief that the 1990s shift in monetary policy thinking by setting up rules or targets (money, credit, exchange rates, interest rates, and inflation) has played a major role in controlling the inflation rate and addressing the dynamic inconsistency issue.[12] A consensus among this

[10]The term representing bond yields (R_t) can be proxied by short term interest rates. In reality, it varies depending on debt maturity, but if we assume only one category of bonds with maturity (n), the term structure equation implies $R_t^n = i_t i_{t+1} i_{t+2} \dots i_{t+n-1}$, where (i_t) is the annualized short-term interest rate. And the relation (1.12) becomes:

$$\log(\pi_t) = \log(b_{yt-1}) - \log(\theta_t) - \log(ps_{yt}) + \frac{1}{n}\log\left(\prod_{j=t}^{n} i_j\right) + log(1-k)$$

[11]For example, Stockman (1981) establishes that an increase in the inflation rate results in a lower steady-state output level by reducing the purchasing power of money balances, and thus the demand for goods and capital (this model assumes that part of the investment projects is financed through cash). Similarly, most money and endogenous growth models conclude that the inflation rate reduces both the return on capital and the growth rate in the long-run (Arawatari, Hori, and Mino (2018), Vaona (2012)). Empirically, several studies reveal an overall negative effect of inflation on growth and detect the presence of non-linearity in this relationship (e.g., Kormendi and Meguire (1985), Fischer (1993), Gomme (1993), De Gregorio (1992), Andres and Hernando (1997)).

[12]Dynamic inconsistency refers to changes in the decisions of monetary authorities and the absence of commitment to a single optimal policy. Especially when output is below the optimal level, monetary authorities have the incentive to move away from an announced target to generate “surprise” inflation, and thereby create a short-term

literature is that commitment is a better policy because it generates lower average inflation in the long run (Barro and Gordon (1983), Rogoff (1985)). The gains from commitment are the direct consequence of the role of expectations in shaping economic conditions. More specifically, inflation targeting regimes are thought to contribute to lower inflation levels and higher monetary policy credibility.

I verify this assumption by applying Cobham (2018)'s MPFs classification to the sample.[13] This author distinguishes between different frameworks based on whether the monetary authorities publish targets for some objectives and whether such targets exist for monetary aggregates, exchange rates, inflation, and other variables. Based on this definition and some additional criteria, Cobham identifies 32 categories (Appendix D). Data are available only for the period between 1980 and 2016. I therefore reduce the sample to this duration when including the MPF classification. By introducing this classification, I conjecture that a scarcity of fiscal dominance episodes would be reflected in the results through a difference in outcomes across frameworks, as monetary policy would be considered as the main driver of inflation in that case. More particularly, a weaker reaction of inflation to fiscal policy is expected in MPFs that correspond to an active monetary policy regime.

In addition to MPFs, sample countries are also classified depending on their fiscal space level[14] in a subsequent step. The reason why fiscal space is considered to be an important factor is that higher deficits are more likely to cause macroeconomic imbalances and disturbances in the price level when countries have a limited capacity to repay their debt and ensure sovereign solvency.

The literature on fiscal space introduces many different measures. One frequently used approach is the "fiscal gap" approach, which is based on the difference between a given level of public debt or fiscal balance and a benchmark level considered as the sustainable level (Ostry et al. (2010), Ghosh et al. (2013)).[15] Other studies (e.g., Buiter (1985), Buiter, Corsetti, and Roubini (1993), Auerbach and Gale (2011) derive an index of fiscal sustainability based

increase in growth. Hence, it is usually based on the idea that the relationship between inflation and GDP growth is positive.

[13]Cobham (2018) defines a MPF as a combination of objectives, constraints, and conventions for monetary authorities. Constraints and conventions include "rules or disciplines to which authorities are subject (voluntarily or involuntarily), the nature of the financial and monetary markets and institutions, the understanding of key macroeconomic relationships, and the political environment" (Cobham (2018), p. 6). More details by country can also be found in the following link `http://monetaryframeworks.org/countries`.

[14]See definition in Heller (2005).

[15]This benchmark level can be estimated in various ways, such as the signal approach by Kaminsky, Lizondo, and Reinhart (1998) or the present value of future primary balances (Bohn (1998) and Bohn (2008), Ostry et al. (2010), Ghosh et al. (2013).

on the projections of future balances depending on the macroeconomic outlook and forecasts of the discount rate. Aizenman and Jinjarak (2010) suggest an alternative fiscal space measure called the "de facto fiscal space," defined as the inverse of the number of tax-years needed to repay the debt. This ratio requires an estimation of the de facto tax base corresponding to the realized tax collection averaged across multiple years to smooth for business cycle fluctuations. I use a similar definition in this study. First, the ratio of public debt divided by total government revenues is calculated. This ratio reflects the number of years of revenue needed to repay the outstanding public debt on a given date. Then, fiscal space is defined as the inverse of that ratio. In Appendix E, I summarize the most recent available value (2016), some descriptive statistics of the calculated measure, and the correlation coefficients with the primary balance for all sample countries.

1.5 Econometric methodology

After a correlation analysis (see following section), I proceed with the estimation of a panel VAR model using the variables of equation (1.12). The panel VAR model is as follows.

$$z_t = c + \varnothing z_{t-1} + w_t \tag{1.13}$$

where

$$z_t = \begin{pmatrix} ps_{yt} \\ b_{yt} \\ \theta_t \\ i_t \\ \pi_t \end{pmatrix} \varnothing = \begin{pmatrix} \varnothing_{11} & \varnothing_{12} & \varnothing_{13} & \varnothing_{14} & \varnothing_{15} \\ \varnothing_{21} & \varnothing_{22} & \varnothing_{23} & \varnothing_{24} & \varnothing_{25} \\ \varnothing_{31} & \varnothing_{32} & \varnothing_{33} & \varnothing_{34} & \varnothing_{35} \\ \varnothing_{41} & \varnothing_{42} & \varnothing_{43} & \varnothing_{44} & \varnothing_{45} \\ \varnothing_{51} & \varnothing_{52} & \varnothing_{53} & \varnothing_{54} & \varnothing_{55} \end{pmatrix} \text{and } w_t = \begin{pmatrix} v_{1t} \\ v_{2t} \\ v_{3t} \\ v_{4t} \\ v_{5t} \end{pmatrix}$$

Where ps_y denotes the primary surplus over GDP, b_y the log of public debt over GDP, θ the GDP growth rate, i the short-term interest rate and π the inflation rate. Since the model is estimated based on panel data, the vectors z_t, c and w_t can be interpreted as the stacked version of vectors z_{it}, c_i and w_{it}, respectively, where the index i indicates the different cross-sections (sample countries).

Panel VAR models are built on the same logic as standard time-series VARs and can be estimated using similar methods. However, they offer some key advantages over a time-series approach. First, panel VARs rely on the assumption that the cross-sectional units share the same underlying data generating process with common parameters across units.[16] As a result, the obtained estimates reflect the common behavior of the group while controlling for individual heterogeneity. Second, the additional cross-sectional dimension is beneficial because it provides a gain in degrees of freedom. In addition, panel data are characterized by a greater variability than time-series. And because of this variability, the prospects for obtaining accurate estimates are improved and the model is more likely to efficiently capture the relationship between macroeconomic variables.

The estimation of standard VAR models in their reduced-form can be straightforwardly performed through OLS. However, the interpretation of the estimation results would be biased if the different variables are correlated with each other (as is typically the case in macroeconomic models). Such correlation creates a dependence between the different error terms across equations. To overcome this identification problem, many techniques have been developed. One of them is the recursive VAR approach which rests on the inclusion of some contemporaneous values as regressors. In that case, estimation by OLS produces residuals that are uncorrelated across equations.

I apply this approach in a first step using a Cholesky decomposition of the covariance matrix, which yields a unique lower triangular matrix. The Cholesky decomposition is based on an active fiscal policy/passive monetary policy setting, with the following ordering of the variables: the primary balance over GDP (most exogenous), public debt over GDP, GDP growth rate, short-term interest rates, and inflation (same as in (1.13)). I adopt this ordering because if fiscal policy is active, then the fiscal variables would be the most exogenous, and the short term interest rate would, on the contrary, be more endogenous. In this setting, I expect that inflation fluctuations would result from dynamics affecting both the fiscal and monetary variables. Analysis of this recursive VAR model is made based on variance decompositions.

Despite the advantages of the recursive approach, it is subject to the so-called ordering problem. The chosen ordering determines which variables are contemporaneously unaffected by which other variables and it may not always be accurate. Therefore, I use other methods that address the endogeneity issue without relying on the recursive VAR restrictions. I

[16] Cross-sectional heterogeneity can be modeled as panel-specific fixed effects.

first re-estimate the panel VAR model based on the generalized method of moments (GMM) methodology suggested by Sigmund and Ferstl (2017). This approach is particularly useful to eliminate the Nickell bias (Nickell (1981)) that arises when the demeaning process, which subtracts the individual's mean values from the respective variables, induces a correlation between error terms and regressors, thereby leading to inconsistent ordinary least squares (OLS) estimates. Sigmund and Ferstl (2017) provide an extension to Anderson and Hsiao (1982) for the first difference GMM estimator using lags of the endogenous variables as instruments (Holtz-Eakin, Newey, and Rosen (1988) and Arellano and Bond (1991)) and to the more complex system GMM estimator (Blundell and Bond (1998)). Details on the estimation are provided in Appendix F.

Analysis of this unrestricted VAR model is based on generalized impulse response functions as suggested by Pesaran and Shin (1998). The main advantage of this approach is that response functions are not sensitive to the ordering of variables in the VAR model (as opposed to orthogonalized impulse response functions (OIRF)). Therefore, as opposed to OIRF that can yield different results depending on the estimation assumptions, the generalized impulse responses are unique and fully take account of the historical patterns of correlations observed amongst the different shocks. More details on GIRF estimation compared to OIRF are provided in Appendix G.[17] The choice of relying on both a restricted and an unrestricted VAR approach in the analysis is motivated by robustness concerns.

1.6 Correlation analysis

Table 1.2 exhibits correlation coefficients between the main variables of the model for the whole sample. The highest correlation coefficient is the one between interest rates and inflation, with a positive sign (66%). The inflation rate's correlation with fiscal variables is very weak. Finally, GDP growth is negatively correlated with public debt and positively with the primary balance.

As shown on Table 1.3, these correlation coefficients differ significantly across monetary policy frameworks. The highest correlation coefficient between inflation and the primary balance is 23% in the case of discretionary regimes. The correlation coefficient between

[17] GIRF also have some shortcomings. Some authors (e.g.Kim (2013)) posit that GIRF are based on restrictions that are more extreme than OIRF since they imply that each variable is ordered first and therefore rest on assumptions that contradict each other.

inflation and interest rates is also the strongest for this same category (88%). In both cases, the relationship is positive. A negative relationship between the primary balance and inflation is only noted in three cases: absence of a national framework (excluding EU countries),[18] mixed targets, and monetary targets. As opposed to other categories, regimes of mixed targets and monetary targets contain only a few observations (the mixed targets category applies to a few years in the 1980s for three countries (France, Germany and Italy) while monetary targets apply to 7 countries during the 1980s and the beginning of the 1990s). Finally, in the case of EU countries (mostly Euro zone countries), the correlation between inflation and interest rates is very high and positive, while the correlation between inflation and the primary balance is very low.

I then split the sample into two fiscal space categories based on the middle quantile. S1 is the subsample of higher fiscal space countries that require few years of revenue to repay their debt and S2 is the subsample of economies with lower fiscal space, which require many years of revenue to repay their debt. Correlation coefficients for these two categories are shown on Table 1.4. The correlation between inflation and the primary balance appears as positive and higher for economies with the lowest levels of fiscal space. Correlation between inflation and public debt is negative for the S1 subsample, implying that higher debt for countries with enough revenues is accompanied by lower inflation. Conversely, this coefficient is positive but very small for the S2 subsample. Finally, correlation coefficients between inflation and short-term interest rates are positive and high in both groups of countries.

1.7 Empirical results

In this section, I estimate and analyze the dynamics within the panel VAR model based on two approaches. In the first approach, the Cholesky decomposition is used to impose a recursive structure on the model. Then, estimation is made based on the OLS methodology and forecast error variance decompositions are derived. In the second approach, I relax the restrictions on the VAR model and re-estimate it using a GMM methodology. Then, generalized impulse response functions are calculated for different shocks and inflation's response for the whole sample is examined. At this stage, I also compare the results across different monetary policy frameworks and different levels of the fiscal space.

[18] This category contains mostly countries in which there is a significant use of a foreign currency with limited monetary policy operations for a large part of the sample period.

1.7.1 Estimation of a recursive Panel VAR model

1.7.1.1 Model OLS estimates

Table 1.5 shows the reduced-form VAR estimates in addition to the contemporaneous coefficients of the structural model based on the recursive Cholesky orthogonalization. The relationship between fiscal variables appears to be weak in both the reduced-form model and the contemporaneous coefficients matrix. In contrast, the relationship between inflation and the short-term interest rate is highly statistically significant. Finally, it can also be noted that the sign of the contemporaneous coefficient of the interest rate in the inflation equation is negative.[19]

1.7.1.2 Forecast error variance decomposition

The contribution of each variable to the overall variation in inflation is estimated using the model described previously and the recursive restrictions. Results of the forecast error variance decomposition of inflation (see Figure 1.1) clearly indicate that exogenous shocks to the interest rates or past inflation explain a significant share of the inflation's variation (between 10% at the beginning and 21% at the end of the observation period for the interest rate and 88% in period 1 for past inflation). The impact of public debt on inflation is almost absent (around 0.6%). The share of shocks to the primary balance, although not zero, is also very small (from 1.4% to 2.7%). Therefore, fiscal policy affects inflation but not to the same extent as monetary policy.

Using the same model to generate the forecast error variance decomposition of public debt (Figure 1.2), I find no evidence of a contribution of inflation to public debt (limited to 0.5%). Public debt is significantly affected by past debt (around 70%) and a growing contribution of the primary balance (as expected) (progressively reaching 28.8%); however, the other variables are insignificant.

1.7.2 Estimation of an unrestricted Panel VAR model

1.7.2.1 GMM estimates

I derive the first difference GMM estimator as described in Appendix F, after applying forward orthogonal transformation to the data (see Appendix H). The estimation results (Table

[19] Consistent with the theoretical assumptions of Cochrane (2018) and Sims (2011).

1.6) indicate that public debt, economic growth, interest rates, and inflation all have a significant autoregressive coefficient. Conversely, in the inflation equation, the only significant variable is the interest rate, with a high positive coefficient. The fiscal variables' coefficients are negative but not statistically significant.

1.7.2.2 Generalized impulse response functions after fiscal, monetary and recessionary shocks in the whole sample

I then examine the impact of shocks to different variables on inflation using the generalized impulse response functions. I first examine the effects of a fiscal policy shock, monetary policy shock, and recessionary shock on all variables. In a subsequent step, I incorporate two additional elements that represent idiosyncratic characteristics: the monetary policy frameworks and the fiscal space level.

Fiscal policy shocks

A positive one SD innovation in the primary balance (Figure 1.3) generates a positive but small movement in growth and interest rates (less than 0.02 units). Public debt reacts negatively and significantly (a response that reaches -0.07 after 6 periods as the effect of fiscal surpluses cumulates). Conversely, inflation's response is poorly statistically significant. A positive shock to public debt (Figure 1.4) leads to lower primary balances, an increase in interest rates, higher inflation and lower growth.

Monetary policy shocks

A positive one SD innovation in short-term interest rates (Figure 1.5) causes a positive and notable response in the inflation rate (almost one to one response). Movements in other variables are relatively smaller in magnitude. The reaction of primary balances and public debt is positive in the short-run. But the response of public debt eventually gets negative indicating the efficacy of the contractionary policy in reducing debt. Finally, as expected, GDP growth responds negatively and significantly.

Recessionary shocks

In the final step, I apply a negative shock to growth to determine the impact of a recessionary episode (Figure 1.6). Inflation's response is negative, although not very significant. It quickly returns to its initial level (this is consistent with a Phillips curve as the growth level also adjusts). Impacts on the primary balance and the interest rate are very small in magnitude with large confidence bands. Finally, public debt also responds positively and significantly (which is consistent with expectations).

1.7.2.3 Inflation's response by Monetary Policy Framework (GIRF)

I split the data using the MPF classification by Cobham (2018) (for the period 1980–2016). Findings indicate that the relationship between inflation and the primary balance is not uniform across monetary policy regimes (Figure 1.7). A significant and negative response in inflation can only be seen in cases of absence of a national framework (and after the second quarter).[20] Response of inflation in discretionary regimes is of a high magnitude but poorly statistically significant. Response of EU countries is relatively significant but very small and positive (suggesting that higher deficits are accompanied by a low inflation). Finally, response of inflation in other frameworks is extremely small in magnitude and not significant.

On the other hand, I find a very strong and positive response of inflation to interest rate shocks in discretionary regimes. Inflation also responds positively and significantly to interest rates in exchange rate targets frameworks (although with a smaller magnitude). Reaction to interest rates in the absence of a national monetary policy framework is also positive and relatively high. Finally, inflation responds poorly to interest rates in inflation targeting regimes and in EU countries.

The response of inflation to primary balance shocks in countries with no solid national monetary policy framework suggests that a policy that increases taxation or reduces government expenditure in this group would eventually lower inflation. This finding does however not necessarily imply inflationary budget deficits as fiscal policy might have asymmetrical effects. I therefore apply a negative shock to the primary balance to verify inflation's response after a shock of opposite sign. Results (reported on Figure 1.8) confirm that inflation after a negative fiscal shock only occurs in the group with no national MPF.

1.7.2.4 Inflation's response by level of the fiscal space (GIRF)

Impulse response functions by fiscal space level after a positive shock to primary balances are reported on Figure 1.9. The relationship between primary balances and inflation appears to be positive and significant in the short-run for high fiscal space countries. On the other

[20] This subsample includes the following countries: Panama, Paraguay, Uruguay, Costa Rica, Dominican Republic, Honduras, Haiti and Colombia. It also includes Ghana.

hand, response of inflation in low fiscal space countries is poorly significant. After applying a negative shock to the primary balance, response is not significant in both cases (Figure 1.10). Conversely, the relationship between inflation and the short-term interest rate is strong and positive in both groups as shown on Figure 1.11. These first results imply that the fiscal space level is not useful in explaining the relationship between the primary balance and inflation. This is unsurprising as the low fiscal space group contains countries with very different characteristics (See Appendix E). But even if countries of the low fiscal space group are separated based on their income level, no homogeneous response is found. However, when the distinction is made based on monetary policy frameworks, a negative and significant relationship between the primary balance and inflation is once again found in the group of countries with no national MPF (Figure 1.12)

1.8 Discussion and concluding remarks

Previous empirical studies, notably those by Bohn (1998), Bajo-Rubio, Díaz-Roldán, and Esteve (2009) and Canzoneri, Cumby, and Diba (2001), reject the fiscal determinacy of the price level and conclude that governments act in a Ricardian fashion. This claim is justified by the presence of an adjustment of primary surpluses to changes in public debt. In the present paper, I reach a similar conclusion for the following reasons. First, the forecast error variance decomposition shows almost no relation between public debt and inflation (Figures 1.1 and 1.2). The primary balances' contribution to inflation variations is also relatively weak. Second, inflation's response to movements in primary balances for the whole sample is not statistically significant. And after controlling for monetary policy frameworks, a significant response only occurs in cases where there is no national monetary policy framework. Contrariwise, inflation is not sensitive to fiscal policy when monetary policy is based on targets. I especially note that inflation is less sensitive to both shocks to the primary balance and those to interest rates in inflation targeting regimes.

This outcome is not surprising; it is consistent with conclusions from previous discussions on monetary policy (Kydland and Prescott (1977), Barro and Gordon (1983)), according to which, inflation's sensitivity to shocks decreases when central banks operate under commitment. The main justification for this is that such regimes require independent monetary authorities. Therefore, in these cases, governments are less likely to pressure central banks to finance their deficits by generating excess liquidity or to keep interest rates low in order to minimize the borrowing costs. In the language of Leeper (1991), fiscal policy is "passive" and monetary policy is "active," such that there is no fiscal dominance. Consequently, I conclude that a fiscal determinacy of the price level typically occurs in passive monetary policy regimes. In the sample, the "no national framework" category (which includes many partially dollarized Latin American economies) provides one example of such regimes. The main implication of this finding is that running persistent deficits will not lead to unexpected higher inflation unless monetary policy is not active. Finally, the analysis based on fiscal space levels shows that the fiscal space is not useful in explaining the relationship between primary balances and inflation. It is only possible to find a significant relationship within fiscal groups after isolating the group of countries with no national MPF, which further corroborates the study's main conclusion on the importance of monetary policy.

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Tables

TABLE 1.1: Some empirical studies on the fiscal determinacy of the price level

Paper	Sample	Methodology	Conclusion
Catao and Terrones (2005)	107 countries over 1960–2001	ARDL model	Inflation and fiscal deficits are only correlated in the case of high-inflation, developing economies
Bohn (1998)	US data 1916-1995	OLS regressions by periods+ a non linear model for PB (based on debt)	The fiscal authority acts in a ricardian fashion (Primary Balance adjusts)
Bajo-Rubio, Díaz-Roldán, and Esteve (2009)	11 EU countries 1970-2005	Cointegration analysis and Granger causality tests	No evidence of FTPL (PB adjust to debt)
Canzoneri, Cumby, and Diba (2001)	postwar U.S. data 1951-1995	VAR, IRF	Evidence of a ricardian regime
Favero and Monacelli (2005)	US 1960–2002	Markov-switching regression methods	Alternated ricardian and non-ricardian regime
Tanner and Ramos (2003)	Brazil 1991-2000	VAR, IRF and Granger causality tests	fiscal dominance for the case of Brazil for some important periods
Creel and Le Bihan (2006)	France, Germany, Italy, the UK and the US data 1963-2001	VAR, IRF (same approach as Canzoneri) + separation between structural/cyclical PB	FTPL non valid
Fan, Minford, and Ou (2013)	The U.K. in the 1970s	ARIMA model for inflation, ADF and cointegration tests	Behaviour of inflation can be explained by the FTPL (gov. expenditures)

TABLE 1.2: Correlation coefficients between the model's main variables

	ps_y	b_y	π	i	θ
ps_y	100%				
b_y	**-13%**	100%			
π	**2%**	0%	100%		
i	5%	-1%	**66%**	100%	
θ	15%	**-19%**	3%	0%	100%

Notes: ps_y: primary surplus over GDP, b_y: log of public debt over GDP, π: inflation rate, i: short-term interest rate, θ: growth rate of GDP per capita

TABLE 1.3: Correlation coefficients of inflation with interest rates and the primary balance by monetary policy framework

Correlation	**Inflation and Interest rates**	**Inflation and primary balance**
Discretionary regimes	88%	23%
Inflation targeting (IT)	40%	8%
Exchange rate targets (ERTs)	51%	15%
EU countries	87%	1%
No national framework (exclud. EU)	28%	-15%
Mixed targets	85%	-30%
Monetary targets (MTs)	75%	-16%

Notes: Classification of the sample by monetary policy framework is based on the database of Cobham (2018). The categories of "Mixed targets" and "Monetary targets" contain a small number of observations over the sample period

TABLE 1.4: Correlation coefficients of inflation with the fiscal variables and interest rates by fiscal space categories

Correlation	**S1**	**S2**	**Global**
Inflation/ primary balance	7%	33%	32%
Inflation/ public debt	-13%	3%	-3%
Inflation/short-term interest rate	90%	82%	86%

Notes: S1: High fiscal space (50th upper percentile); S2: low fiscal space (50th lower percentile)

TABLE 1.5: Panel VAR OLS Estimation

	Reduced-form VAR				
	ps_y	b_y	θ	i	π
Lag 1 ps_y	**0.830***	**-0.667***	**0.252***	-0.130	-0.986
	(0.0116)	*(0.1012)*	*(0.0663)*	*(0.0887)*	*(0.9052)*
Lag 1 b_y	0.001	**0.947***	**-0.009***	-0.006	-0.020
	(0.0006)	*(0.0054)*	*(0.0035)*	*(0.0047)*	*(0.0483)*
Lag 1 θ	-0.007	**-0.116***	**0.233***	-0.027	0.274
	(0.0036)	*(0.0309)*	*(0.0203)*	*(0.0271)*	*(0.2765)*
Lag 1 i	0.001	**-0.035***	**0.032***	**0.879***	**1.924***
	(0.0020)	*(0.0171)*	*(0.0112)*	*(0.0150)*	*(0.1525)*
Lag 1 π	0.000	0.003	0.001	**-0.010***	**0.312***
	(0.0003)	*(0.0025)*	*(0.0017)*	*(0.0022)*	*(0.0228)*
Constant	-0.003	**0.219***	**0.081***	**0.041***	-0.057
	(0.0023)	*(0.0205)*	*(0.0013)*	*(0.0018)*	*(0.1835)*
	Contemporaneous coefficients				
	ps_y	b_y	θ	i	π
ps_y	1	**1.172***	**-0.291***	**-0.538***	1.656
		(0.1757)	*(0.1094)*	*(0.1553)*	*(1.3234)*
b_y	0	1	**0.228***	**-0.0445***	-0.148
			(0.0126)	*(0.0190)*	*(0.1618)*
θ	0	0	1	**0.156***	**-0.836***
				(0.0289)	*(0.2471)*
i	0	0	0	1	**-5.828***
					(0.1734)
π	0	0	0	0	1

Notes: *** p<0.001, **p<0.01, *p<0.05. Standard errors in brackets ps_y: primary surplus over GDP, b_y: log public debt/GDP, θ: growth rate, i: interest rate, π: inflation rate. Contemporaneous coefficients obtained through Cholesky orthogonalization using the ordering of the variables that is displayed on the table

TABLE 1.6: Panel VAR GMM Estimation

	ps_y	b_y	θ	i	π
Lag 1 ps_y	8.1820	-1.0367	0.2123	-2.2192	-11.4538
	(10.7477)	*(0.6839)*	*(0.4580)*	*(3.4129)*	*(8.5006)*
Lag 1 b_y	-0.3483	**0.9448***	0.0004	0.1029	-0.1038
	(0.4910)	*(0.0284)*	*(0.0248)*	*(0.1571)*	*(0.1534)*
Lag 1 θ	-3.3278	-0.0786	**0.4696***	0.9481	0.9424
	(4.7177)	*(0.2211)*	*(0.2077)*	*(1.4744)*	*(0.6138)*
Lag 1 i	-0.3201	0.0947	-0.0026	**0.8783***	**3.8592***
	(1.8159)	*(0.2080)*	*(0.1238)*	*(0.2925)*	*(1.2843)*
Lag 1 π	0.033	-0.0176	0.0027	-0.0005	**0.1168***
	(0.2301)	*(0.0277)*	*(0.0152)*	*(0.0319)*	*(0.0501)*

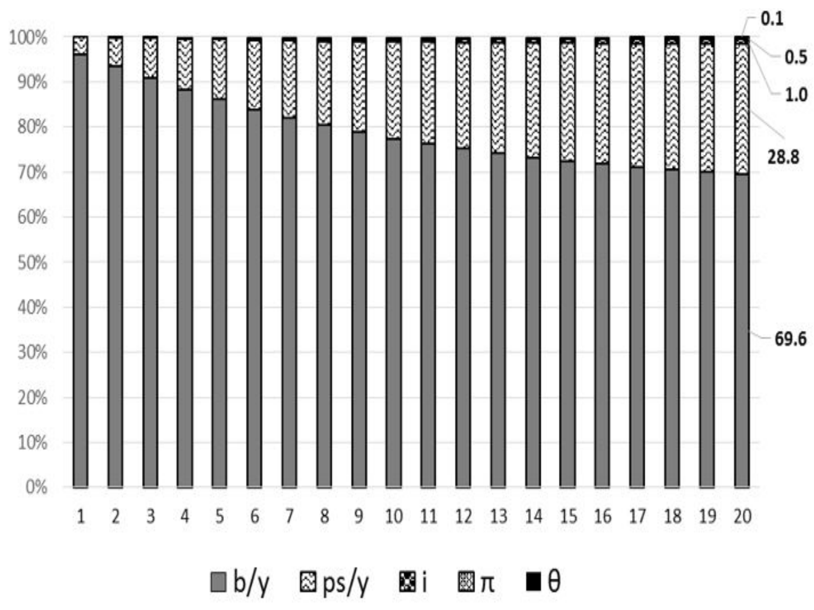
Notes: *** p<0.001, **p<0.01, *p<0.05. Standard errors in brackets ps_y: primary surplus over GDP, b_y: log public debt/GDP, θ: growth rate, i: interest rate, π: inflation rate. Forward orthogonal transformation is applied to the variables. Hansen test of overidentified restrictions: chi2(1375)=35.2, proba >chi2=1

Figures

FIGURE 1.1: Variance decomposition of inflation using Cholesky (d.f. adjusted) factors

ps/y: primary surplus over GDP, b/y: log of public debt over GDP, π: inflation rate, i: short-term interest rate, θ: growth rate of GDP per capita

FIGURE 1.2: Variance decomposition of public debt using Cholesky (d.f adjusted) factors



ps/y: primary surplus over GDP, b/y: log of public debt over GDP, π: inflation rate, i: short-term interest rate, θ: growth rate of GDP per capita

FIGURE 1.3: Response to a positive shock to the primary balance (with 95% confidence intervals)

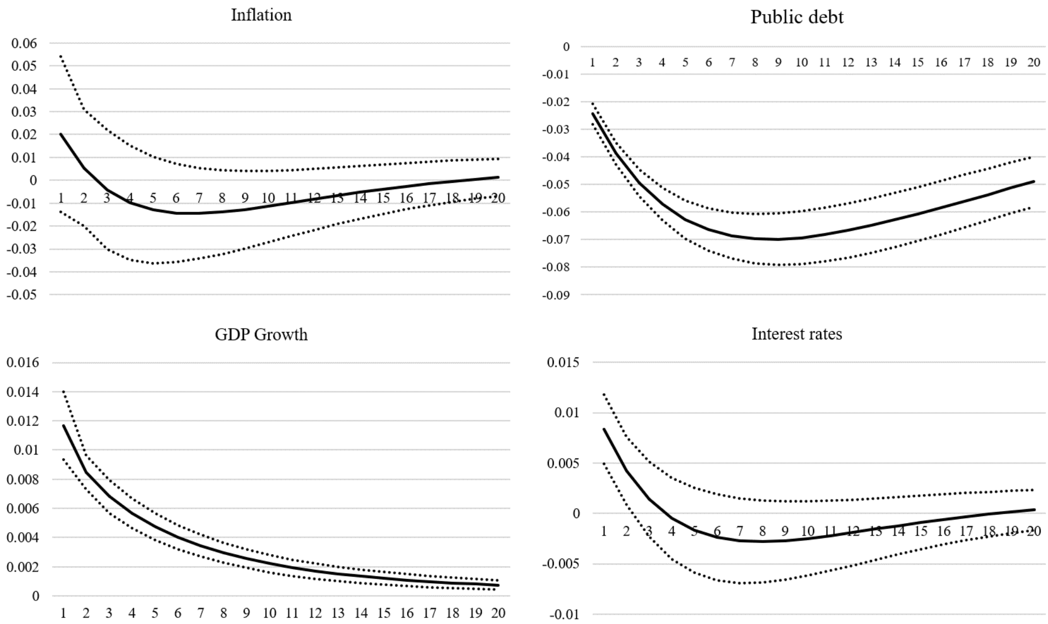


FIGURE 1.4: Response to a positive shock to public debt (with 95% confidence intervals)

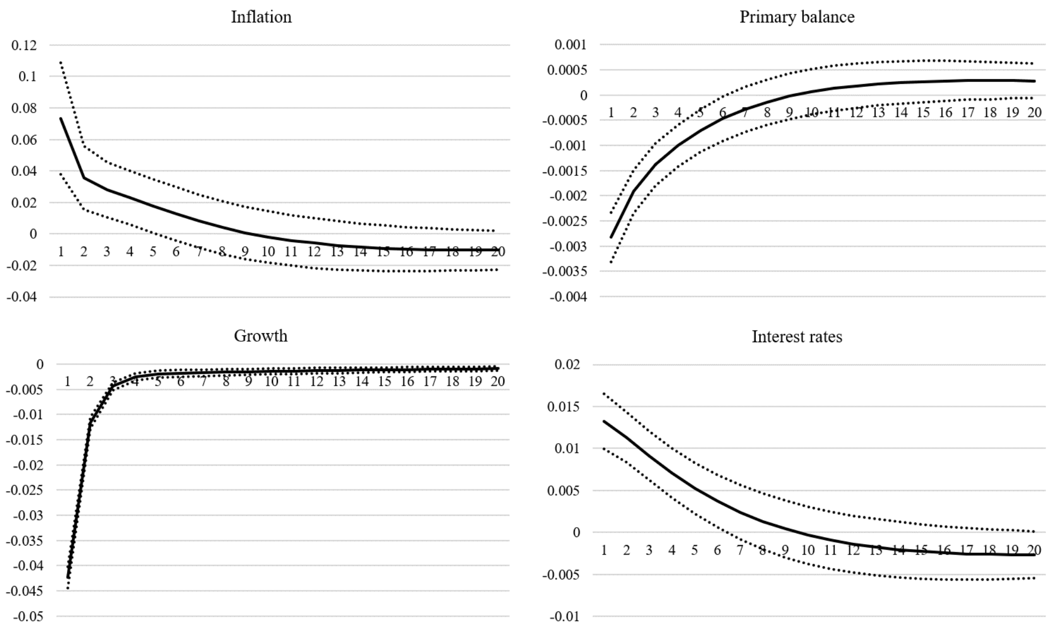


FIGURE 1.5: Response to a positive shock to interest rates (with 95% confidence intervals)

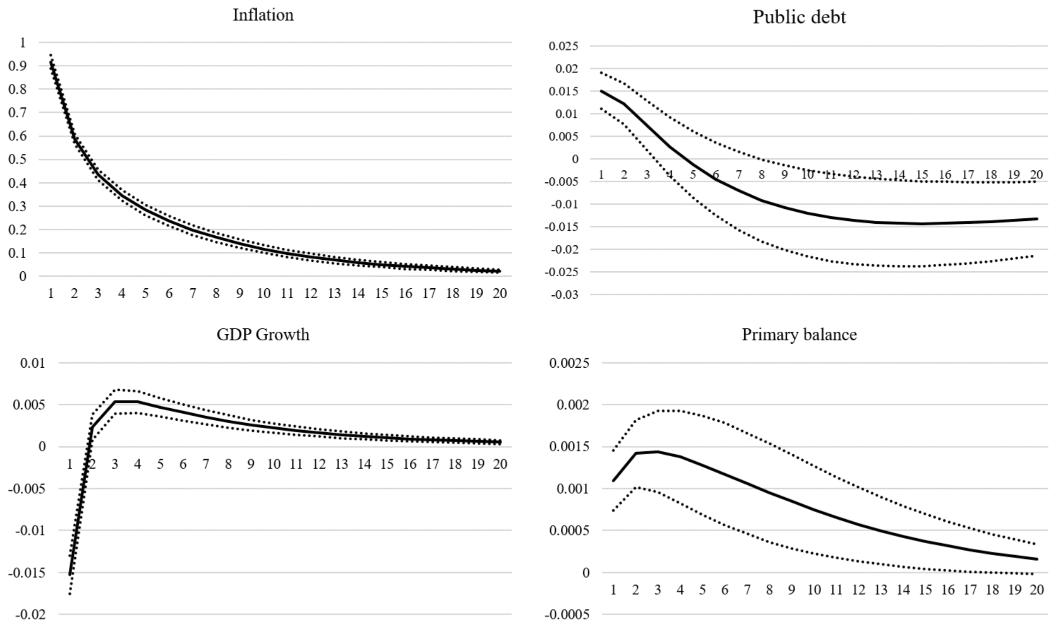


FIGURE 1.6: Response to a negative shock to growth (with 95% confidence intervals)

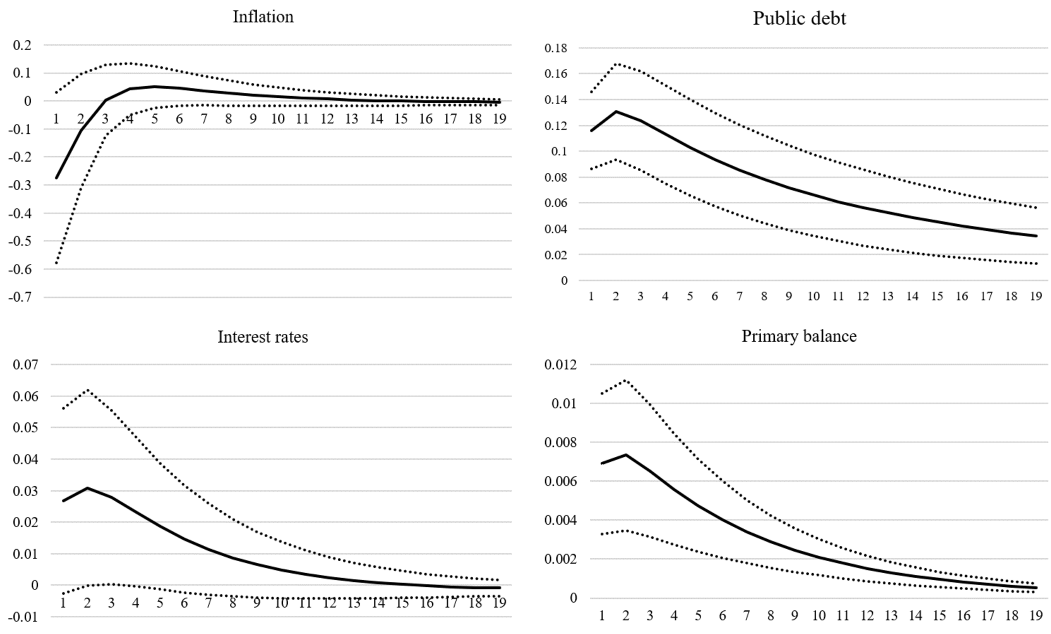
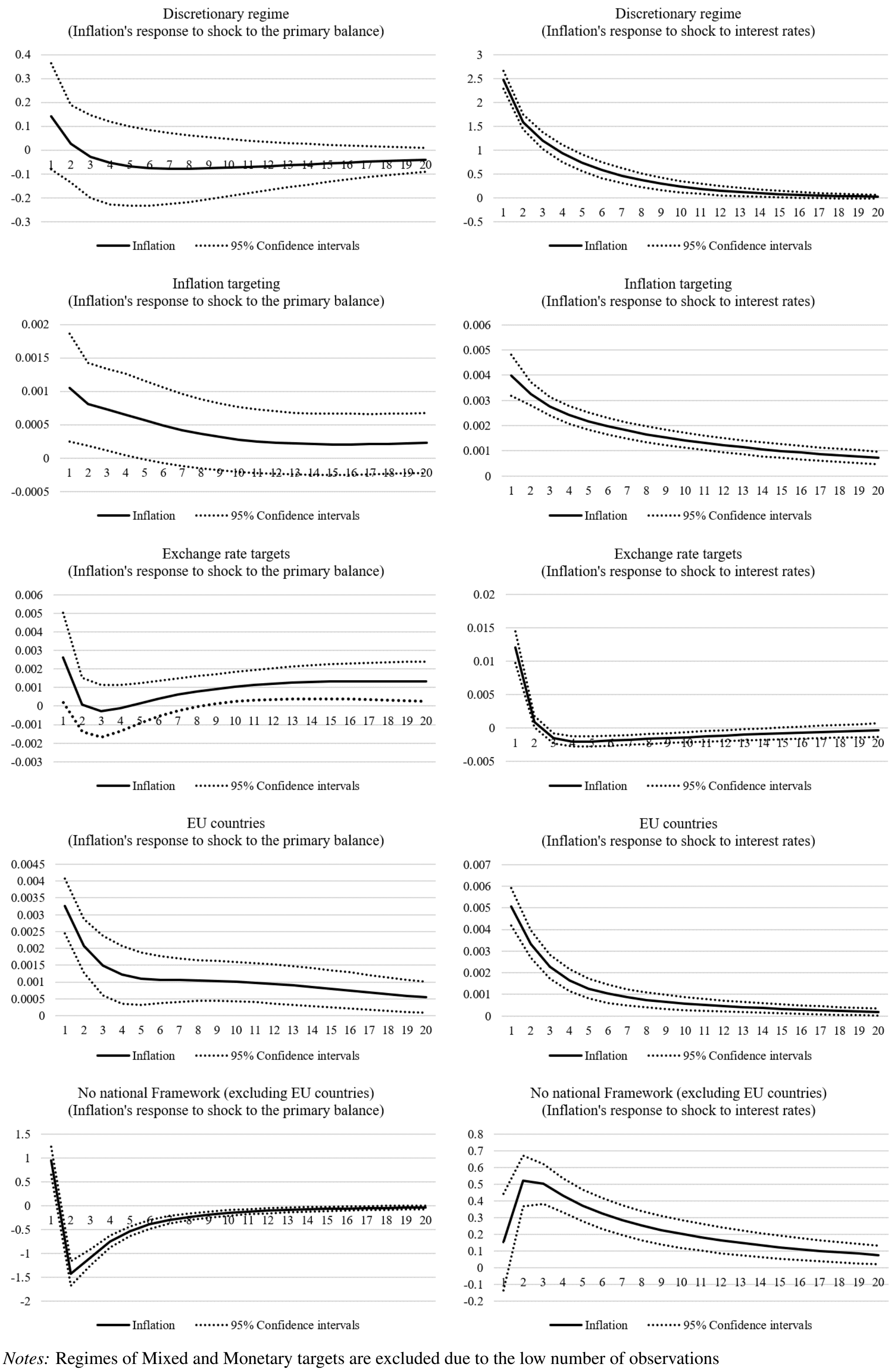
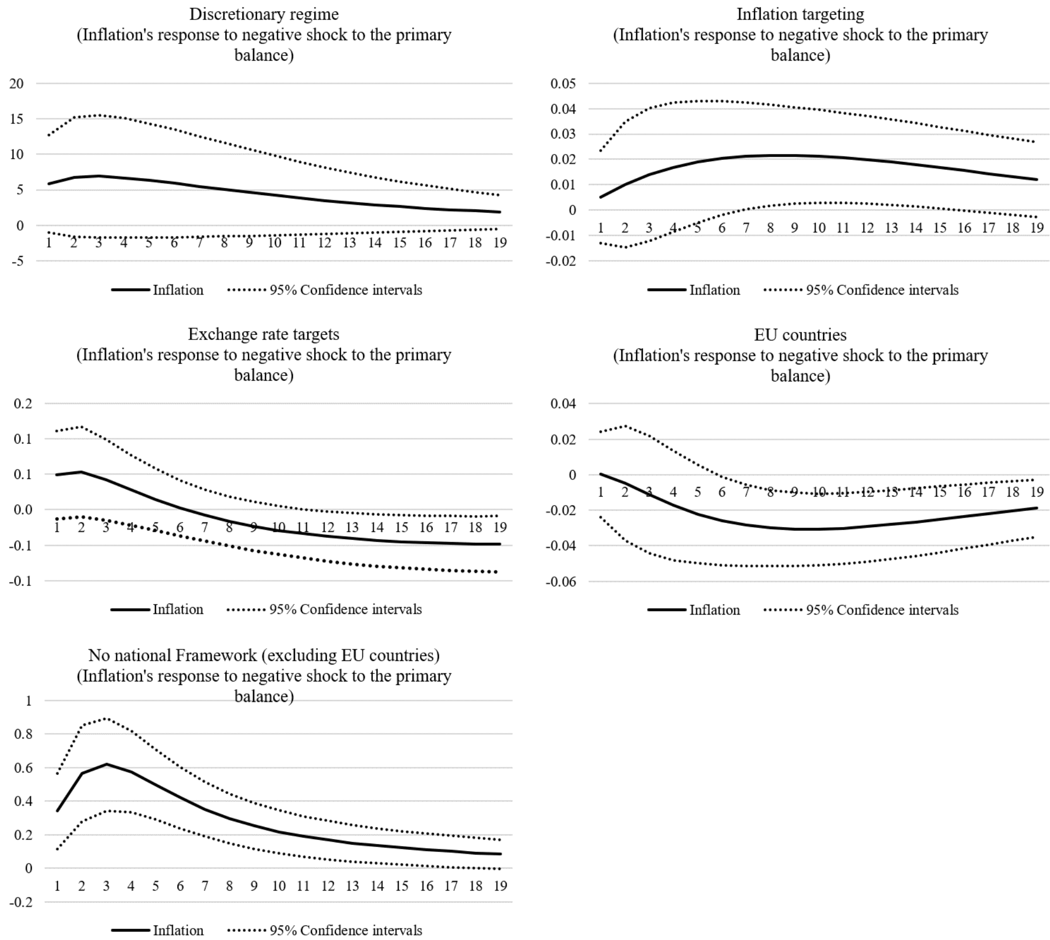


FIGURE 1.7: Response of Inflation to a positive shock to the primary balance and interest rates by Monetary Policy Framework



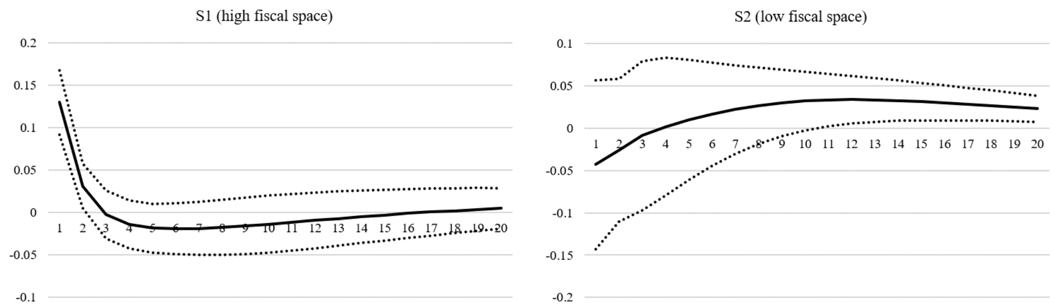
Notes: Regimes of Mixed and Monetary targets are excluded due to the low number of observations

FIGURE 1.8: Response of Inflation to a negative shock to the primary balance by Monetary Policy Framework (with 95% confidence intervals)



Notes: Regimes of Mixed and Monetary targets are excluded due to the low number of observations

FIGURE 1.9: Response of Inflation to a one SD positive shock to the primary balance by Fiscal space group (with 95% confidence intervals)



Notes: The value of the shock corresponding to a one standard deviation of the primary balance is 0.02 in S1 and 0.026 in S2

FIGURE 1.10: Response of Inflation to a negative shock to the primary balance by Fiscal space group (with 95% confidence intervals)

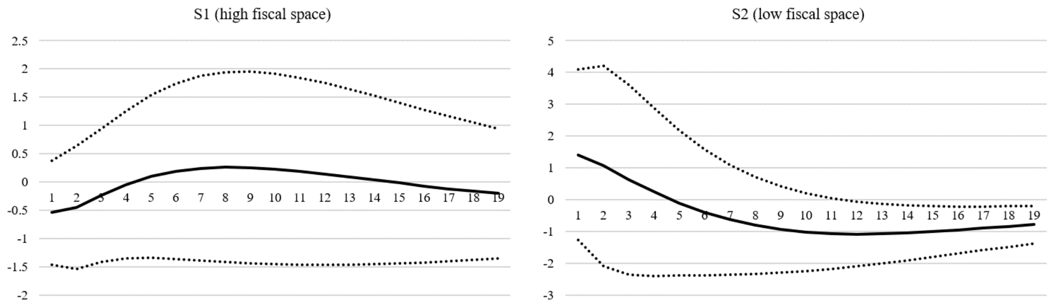
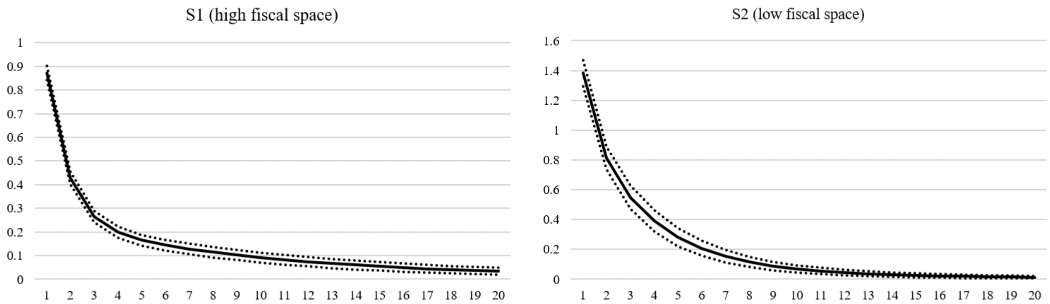
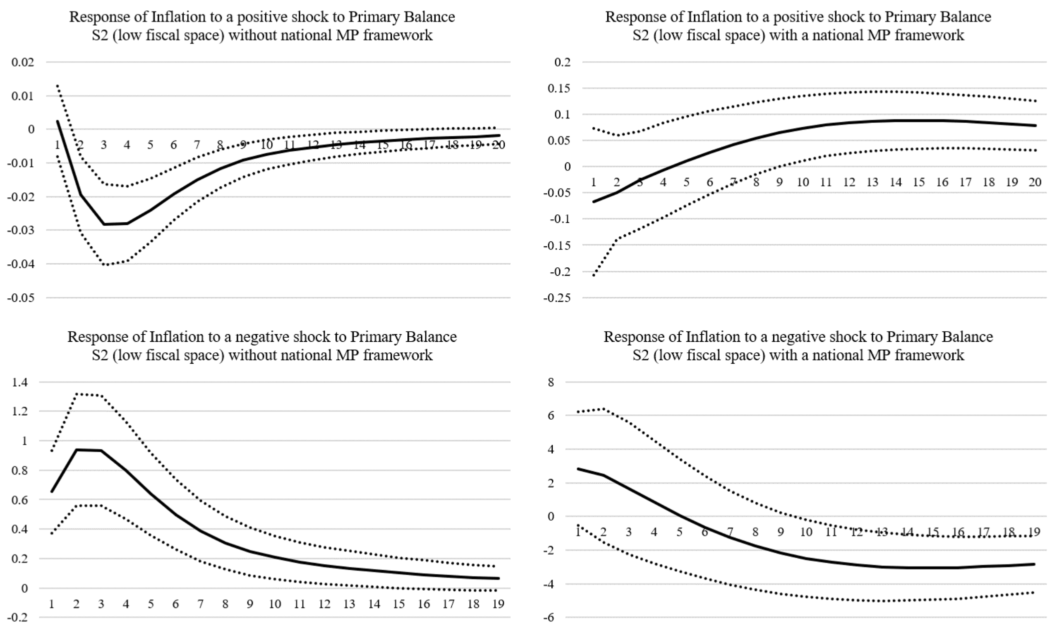


FIGURE 1.11: Response of Inflation to a one SD positive shock to interest rates by Fiscal space group (with 95% confidence intervals)



Notes: The value of the shock corresponding to a one standard deviation in interest rates is 0.15 in S1 and 0.21 in S2

FIGURE 1.12: Response of Inflation to a shock to primary balances in low fiscal space countries (with 95% confidence intervals)



Appendix A: A short summary of the model of Cochrane (2019a)

The starting point of Cochrane's model is the following expression:

$$\sum_{j=0}^{\infty} Q_t^{(t+j)} B_{t-1}^{(t+j)} + M_{t-1} = P_t sp_t + \sum_{j=0}^{\infty} Q_t^{(t+1+j)} B_t^{(t+1+j)} + M_t \tag{1.14}$$

Where $Q_t^{(t+j)}$ denotes the time t price for bonds with maturity $t+j$, $B_{t-1}^{(t+j)}$ the number of these bonds at time t-1 and M_{t-1} non-interest-bearing money at time $t-1$. The variable sp_t is the real primary surplus or deficit (excluding interest payments). This expression therefore indicates that money at the end of period t corresponds to money available from the previous period, plus the effects of bonds sales or purchases, less money soaked up by primary surpluses. Setting the nominal end-of-period market value of debt as follows

$$V_t = \sum_{j=0}^{\infty} Q_t^{(t+1+j)} B_t^{(t+1+j)} + M_t$$

And the nominal return on the portfolio of government debt as

$$R_{t+1}^n \equiv \frac{M_t + \sum_{j=0}^{\infty} Q_{t+1}^{(t+1+j)} B_t^{(t+1+j)}}{M_t + \sum_{j=0}^{\infty} Q_t^{(t+1+j)} B_t^{(t+1+j)}}$$

Shifting the time index forward in the above expression (1.14) to $t+1$, using the definition of the nominal return of the bonds portfolio and dividing by $P_{t+1}Y_{t+1}$, the following expression is obtained

$$\frac{V_t}{P_t Y_t} R_{t+1}^n \frac{P_t}{P_{t+1}} \frac{Y_t}{Y_{t+1}} = \frac{sp_{t+1}}{Y_{t+1}} + \frac{V_{t+1}}{P_{t+1} Y_{t+1}}$$

Taking logs

$$v_t + r_{t+1}^n - \pi_{t+1} - g_{t+1} = log\left(\frac{sp_{t+1}}{Y_{t+1}} + \frac{V_{t+1}}{P_{t+1} Y_{t+1}}\right)$$

Setting $sy_{t+1} = \frac{sp_{t+1}}{Y_{t+1}}$ and linearizing in terms of sy_{t+1} leads to the expression

$$v_t + r_{t+1}^n - \pi_{t+1} - g_{t+1} = s_{t+1} + \rho v_{t+1} \tag{1.15}$$

Where $s_{t+1} = \rho \frac{sy_{t+1}}{e^v}$ and $\rho \equiv e^{-(r^n - \pi - g)}$[21]
Cochrane uses this identity to infer the value of s_{t+1} from US bonds data. The analysis is on the other hand based on the following expressions derived from this same identity. First, a present value identity obtained by iterating forward

$$v_t = \sum_{j=1}^{\infty} \rho^{j-1} s_{t+j} + \sum_{j=1}^{\infty} \rho^{j-1} g_{t+j} - \sum_{j=1}^{\infty} \rho^{j-1} \left(r_{t+j}^n - \pi_{t+j}\right) \tag{1.16}$$

[21] For $r^n - \pi = g$, the expression becomes $v_t + r_{t+1}^n - \pi_{t+1} - g_{t+1} = s_{t+1} + v_{t+1}$.

Second, an unexpected inflation identity obtained from time $t+1$ innovations defined as $\Delta E_{t+1} = E_{t+1} - E_t$

$$\Delta E_{t+1}\pi_{t+1} - \Delta E_{t+1}r^n_{t+1} = -\sum_{j=0}^{\infty}\rho^j \Delta E_{t+1}s_{t+1+j} - \sum_{j=0}^{\infty}\rho^j \Delta E_{t+1}g_{t+1+j} + \sum_{j=0}^{\infty}\rho^j \Delta E_{t+1}\left(r^n_{t+1+j} - \pi_{t+1+j}\right) \tag{1.17}$$

Third, an expression that excludes the return on bonds from the LHS as follows

$$\sum_{j=0}^{\infty}\omega^j \Delta E_{t+1}\pi_{t+1+j} = -\sum_{j=0}^{\infty}\rho^j \Delta E_{t+1}s_{t+1+j} - \sum_{j=0}^{\infty}\rho^j \Delta E_{t+1}g_{t+1+j} + \sum_{j=1}^{\infty}\left(\rho^j - \omega^j\right)\Delta E_{t+1}\left(r^n_{t+1+j} - \pi_{t+1+j}\right) \tag{1.18}$$

Where ω^j is the rate of decline of the face value of debt with maturity j
All of these expressions imply the existence of a relationship between inflation, fiscal variables, GDP growth and returns on bond portfolios. In particular, equation (1.16) indicates that a decline in the present value of surpluses (resulting from lower surpluses, lower GDP growth or higher discount rates) corresponds to lower real market value of debt over GDP. At the same time, equation (1.17) implies that a reduction of the present value of future surpluses may be caused by unexpected inflation or negative returns on bonds. These negative returns can be explained by a decline in nominal long-term bond prices. Similarly, these two expressions can also be used to explain the mechanism by which changes in public debt or expected future surpluses can affect unexpected inflation.

Equation (1.18) implies that a shock to the present value of future surpluses can lead to a drawn-out period of inflation that slowly devalues the outstanding of long-term bonds.[22] It also implies that a government that funds itself with near-perpetuites (case of $\omega = \rho$) can pay off its current debt while completely ignoring real interest rate variation. Finally, it shows that a rise in expected future inflation not accompanied by a change in the present value of surpluses results in a decline in current inflation.[23]

[22] On the condition that $\omega > 0$.

[23] We can note the parallel with the "stepping on a rake" mechanism described in Cochrane (2018) and Sims (2011) by which an increase in interest rates by the monetary authority leads to a temporary decline in inflation, followed by higher future inflation.

Appendix B: Sample countries

Group	Countries		
ADVANCED	Australia	Austria	Belgium
	Canada	Denmark	Finland
	France	Germany	Greece
	Iceland	Ireland	Italy
	Japan	Netherlands	New Zealand
	Norway	Portugal	South Korea
	Spain	Sweden	Switzerland
	United Kingdom	United States	
EMERGING AND MIDDLE-INCOME	Argentina	Brazil	Chile
	Colombia	Costa Rica	Dominican Republic
	India	Mexico	Morocco
	Pakistan	Panama	Paraguay
	Peru	Philippines	South Africa
	Thailand	Turkey	Uruguay
LOW-INCOME AND DEVELOPING	Ghana	Haiti	
	Honduras		

Appendix C: A general overview of data

Based on the theoretical model, I use the following variables in the empirical study.

- Level of Primary Balance/GDP (%): data for primary balances are retrieved from the dataset of Mauro et al. (2013). Missing data are completed from various databases such as the OECD, the World Bank and the website http://moxlad-staging.herokuapp.com/home/es for Latin American economies.

- Log of public debt to GDP: I use the underlying dataset of the paper Mauro et al. (2013). Missing data are then completed from various sources such as the website "tradingeconomics.com" and the database of Reinhart and Rogoff (2009).

- GDP growth (%): data of GDP per capita are extracted from the World Bank database.

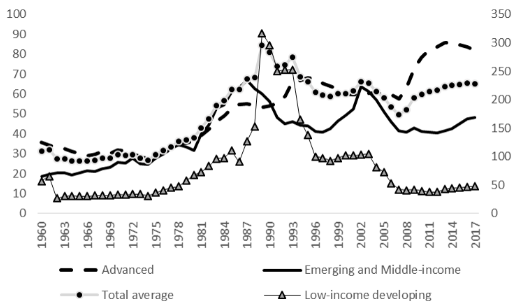
- Short term interest rates: data are collected from several sources, more specifically from the IFS, Eurostat, the OECD database and in some cases from central banks' websites.

- Inflation rate: data are calculated from the Consumer Price Index (with 2010 as the base year), taken from the World Bank database. Missing data are completed based on Reinhart and Rogoff (2009).

Yearly evolution of data shows that the level of indebtedness has overall been increasing over the recent years. By revenue groups (using the IMF classification), economies affected the most by this increase are advanced economies (see figure below); whereas developing and emerging economies have been deleveraging in the recent decade. In the particular case of low-income developing economies, the most extreme levels of debt have been observed in the 1980s (scaled on the right axis on the figure below).

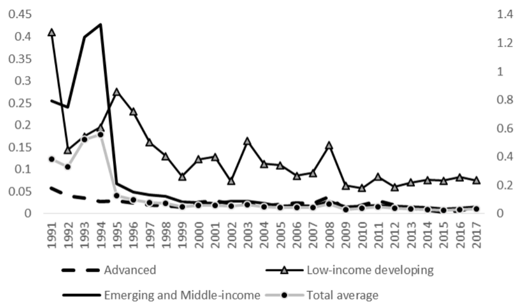
Inflation levels became very low for all countries after 1995 (see figure below, emerging economies and total average are modeled on right axis). The most extreme levels have been observed in the 1970s hyperinflation episode (not included in the figure), especially for advanced economies. In emerging economies, the maximum level of inflation is observed in 1990 (because of a very high inflation level in Argentina, Brazil and Peru).

Average Public debt to GDP evolution



(Low-income developing series plotted on the right axis)

Average Inflation



(Emerging middle-income and total average series plotted on the right axis)

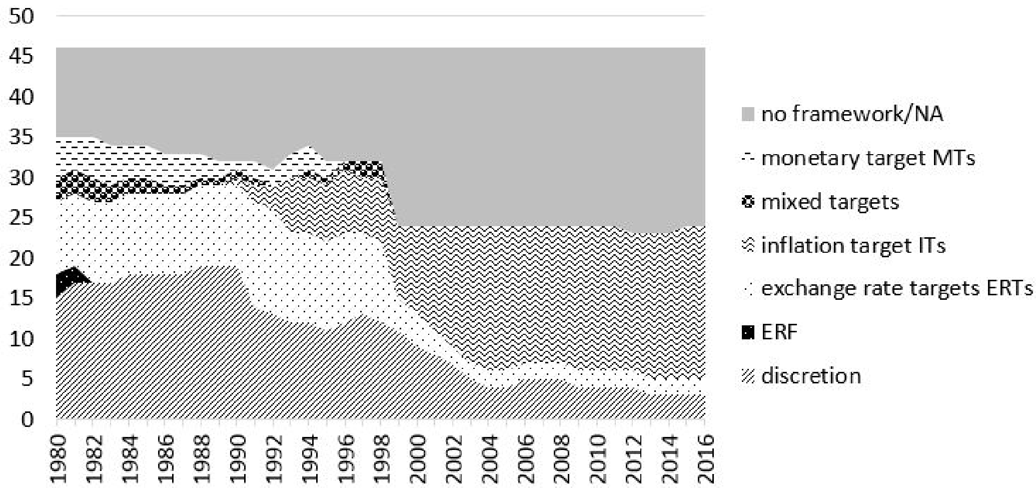
Appendix D: Classification of monetary policy frameworks

Cobham (2018) identified 32 different monetary policy frameworks, aggregated into the following 9 broad categories (based on target variables). Some of these categories are not represented by any country from the sample.

- Direct controls: multiple exchange rates and/or controls on direct lending, interest rates, etc
- Fixed exchange rates: exchange rate fixed by intervention, some or no monetary instruments in use or pure currency board (domestic currency 100% backed by foreign currency, no monetary instruments in use)
- Exchange rate targets (ERT)
- Monetary targets (MT)
- Inflation targeting (IT)
- Mixed targets: monetary targets and exchange rate fixes or targets, monetary dominant or use of three full targets (or fixes) (money, ER and IT), whichever dominant
- Unstructured, loosely structured discretion: ineffective set of instruments and incoherent mix of objectives
- Well structured discretion
- No national framework: this category encompasses cases where a different sovereign currency is used (such as dollarization) in addition to membership in a currency union (euro) (I distinguish between both cases during the analysis)

Using this classification for the sample (see following figure), it can be noted that the IT regime has spread significantly after the 1990s, while the framework of "Monetary targets" disappeared and "Exchange rate targets" and discretionary regimes[24] became less frequent.

Number of countries by monetary policy framework (sample countries)

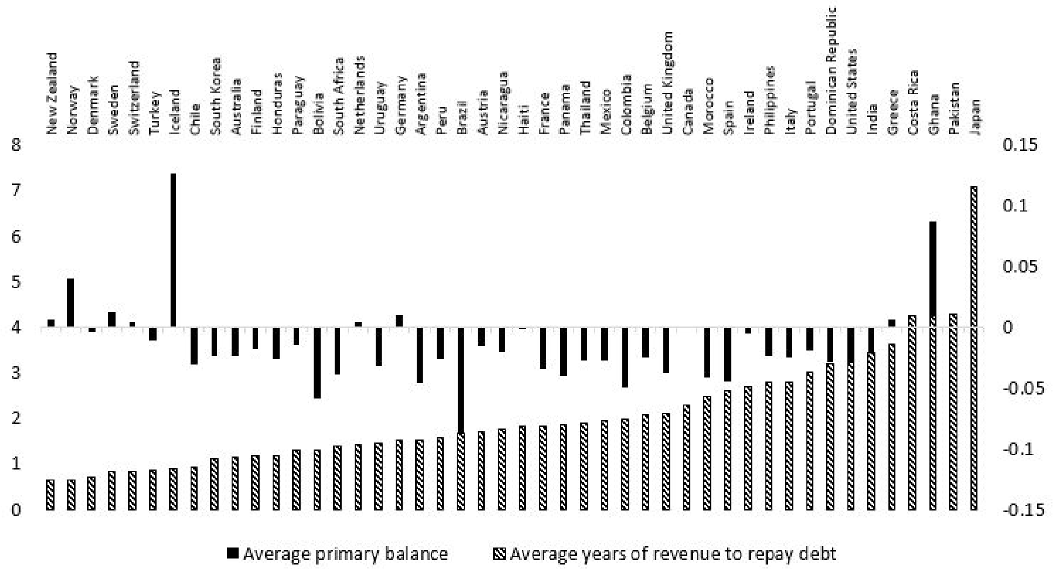


[24] Corresponding to the category "Unstructured or loosely structured discretion".

Appendix E: Estimated fiscal space

Table(a) provides the most recent available value (2016), the average and some descriptive statistics of the calculated fiscal space measure. From a simple observation of data, the link between the fiscal balance and fiscal space does not seem obvious, since both groups of countries running substantial budget deficits and those with high surpluses can have either low or high fiscal space.

Primary balance and fiscal space by country 2016



(Average primary balance plotted on the right axis)

However, correlation coefficients between fiscal space and the primary balance appear to be significant in many countries (see table (b)), even though the correlation sign varies (it is negative in cases like Japan, Australia, Brazil and the USA, and positive in some other cases, such as Belgium, Mexico and Pakistan, etc). It can also be noted that, after the 2007 crisis, the fiscal space measure has worsened for advanced economies in particular (for example Japan, from 3.4 to 6.9 or the USA, from 1.8 to 2.9), reflecting the use of fiscal stimulus after the recession. In contrast, emerging and developing economies, which suffered from a deteriorating fiscal stance during the 1980s debt crisis, have had a better fiscal space indicator over the last decade.

Table (a): Inverse of fiscal space ratio (in years): descriptive statistics by country

	2016 Value	Average	Min	Max	Stand. Deviation	Number of observations
Advanced economies	**2.00**	**1.55**	**0.25**	**7.38**	**1.01**	**851**
Australia	1.13	0.64	0.26	1.13	0.22	37
Austria	1.69	1.31	0.81	1.70	0.21	37
Belgium	2.08	2.23	1.58	2.80	0.35	37
Canada	2.28	1.90	1.18	2.36	0.31	37
Denmark	0.71	0.97	0.50	1.45	0.25	37
Finland	1.16	0.71	0.25	1.16	0.30	37
France	1.82	1.11	0.45	1.82	0.42	37
Germany	1.52	1.29	0.74	1.93	0.32	37
Greece	3.64	2.67	1.04	3.82	0.73	37
Iceland	0.90	1.20	0.55	2.47	0.52	37
Ireland	2.70	2.05	0.67	3.52	0.81	37
Italy	2.80	2.42	1.74	2.84	0.27	37
Japan	7.09	4.33	1.75	7.38	2.02	37
Netherlands	1.41	1.38	0.91	1.68	0.20	37
New Zealand	0.65	0.97	0.40	1.71	0.35	37
Norway	0.65	0.71	0.52	1.04	0.16	37
Portugal	3.01	1.64	0.70	3.01	0.61	37
South Korea	1.11	0.74	0.31	1.13	0.26	37
Spain	2.62	1.35	0.35	2.62	0.60	37
Sweden	0.83	0.92	0.63	1.29	0.18	37
Switzerland	0.84	1.53	0.84	2.18	0.37	37
United Kingdom	2.12	1.44	1.02	2.23	0.37	37
United States	3.22	2.14	1.29	3.30	0.57	37
Emerging and Middle -income	**2.16**	**3.16**	**0.16**	**236.11**	**11.32**	**666**
Argentina	1.53	2.33	0.50	8.06	1.46	37
Brazil	1.66	1.49	0.85	2.23	0.36	37
Chile	0.93	1.21	0.16	4.00	1.05	37
Colombia	1.99	12.27	0.61	236.11	46.64	37
Costa Rica	4.25	4.63	1.60	8.88	2.36	37
Dominican Republic	3.18	3.32	1.19	10.20	2.28	37
India	3.45	2.67	1.36	3.78	0.92	37
Mexico	1.96	2.28	1.50	3.73	0.59	37
Morocco	2.49	3.41	1.45	6.27	1.30	37
Pakistan	4.29	4.97	3.64	6.85	0.77	37
Panama	1.86	2.84	1.57	5.14	0.87	37
Paraguay	1.28	2.38	0.67	5.58	1.47	37
Peru	1.59	2.69	1.04	5.50	1.18	37
Philippines	2.78	3.78	2.23	6.62	0.93	37
South Africa	1.39	1.20	0.78	1.68	0.22	37
Thailand	1.88	1.75	0.21	3.39	0.78	37
Turkey	0.86	1.27	0.72	2.46	0.41	37
Uruguay	1.45	2.31	0.79	5.39	1.15	37
Low-income developing	**2.07**	**6.51**	**0.77**	**53.23**	**8.44**	**185**
Bolivia	1.31	5.05	0.83	45.89	7.85	37
Ghana	4.25	3.99	1.45	10.12	2.03	37
Haiti	1.81	7.78	0.81	35.02	7.79	37
Honduras	1.18	3.19	0.77	6.76	1.57	37
Nicaragua	1.77	12.56	1.77	53.23	13.02	37
TOTAL	**2.07**	**2.72**	**0.16**	**236.11**	**7.79**	**1702**

Notes: Fiscal space is defined as the sum of total government revenues divided by public debt. The inverse of this measure reflects the number of years of revenue needed to repay the outstanding of public debt at a given date

Table (b): Correlation coefficients between the primary balance and the inverse of the fiscal space ratio (The number of years of revenue needed to repay the debt)

	Inverse of fiscal space ratio (years)			**Correlation coefficient**		
	1980-2016	**1980-2006**	**2007-2016**	**1980-2016**	**1980-2006**	**2007-2016**
Argentina	2.3	2.6	1.6	31%	18%	67%
Australia	0.6	0.6	**0.7**	-47%	-41%	-41%
Austria	1.3	1.2	**1.5**	-47%	-51%	16%
Belgium	2.2	2.3	2.0	63%	61%	-57%
Bolivia	5.1	6.5	1.0	-71%	-73%	-8%
Brazil	1.5	1.4	**1.7**	-65%	-64%	-10%
Canada	1.9	1.8	**2.1**	-3%	40%	-84%
Chile	1.2	1.5	0.5	15%	8%	-71%
Colombia	12.3	16.3	1.4	-1%	-3%	-87%
Costa Rica	4.6	5.4	2.5	57%	47%	-6%
Denmark	1.0	1.1	0.7	29%	10%	-90%
Dominican Rep.	3.3	3.7	2.3	26%	25%	-48%
Finland	0.7	0.6	**0.9**	-62%	-45%	-86%
France	1.1	0.9	**1.6**	-49%	-27%	-18%
Germany	1.3	1.2	**1.7**	-3%	-6%	-77%
Ghana	4.0	4.5	2.7	10%	-6%	28%
Greece	2.7	2.4	**3.4**	-21%	10%	19%
Haiti	7.8	9.9	2.0	-2%	10%	18%
Honduras	3.2	3.9	1.3	45%	41%	-82%
Iceland	1.2	1.0	**1.8**	-60%	-42%	-87%
India	2.7	2.4	**3.3**	35%	56%	-56%
Ireland	2.0	1.9	**2.6**	-37%	-12%	-24%
Italy	2.4	2.4	**2.6**	9%	17%	-14%
Japan	4.3	3.4	**6.9**	-84%	-75%	-92%
Mexico	2.3	2.5	1.8	66%	54%	-35%
Morocco	3.4	3.9	2.0	-29%	-33%	-58%
Netherlands	1.4	1.4	1.4	-11%	19%	-79%
New Zealand	1.0	1.1	0.7	-29%	-72%	-94%
Nicaragua	12.6	16.2	2.8	-1%	19%	74%
Norway	0.7	0.7	**0.8**	52%	43%	60%
Pakistan	5.0	5.2	4.4	55%	63%	-52%
Panama	2.8	3.3	1.7	12%	-11%	-21%
Paraguay	2.4	2.9	1.0	19%	19%	23%
Peru	2.7	3.2	1.3	-43%	-50%	-24%
Philippines	3.8	3.9	3.4	22%	13%	-58%
Portugal	1.6	1.3	**2.5**	-42%	3%	9%
South Africa	1.2	1.2	1.1	-10%	4%	-88%
South Korea	0.7	0.6	**1.0**	-63%	-49%	-73%
Spain	1.4	1.1	**2.0**	-34%	58%	-52%
Sweden	0.9	1.0	0.8	7%	9%	-37%
Switzerland	1.5	1.6	1.2	-1%	-33%	88%
Thailand	1.7	1.7	**2.0**	-44%	-42%	-34%
Turkey	1.3	1.3	1.1	46%	49%	-26%
United Kingdom	1.4	1.3	**1.9**	-69%	-15%	-64%
United States	2.1	1.8	**2.9**	-66%	-6%	-49%
Uruguay	2.3	2.5	1.8	8%	1%	89%

Appendix F: GMM methodology for estimating panel VAR models

The baseline PVAR model extends the model by Holtz-Eakin, Newey, and Rosen (1988) to allow for p lags of m endogenous variables, k predetermined variables, and n strictly exogenous variables, such that:

$$y_{i,t} = (I_m - \sum_{l=1}^{p} A_l)\mu_i + \sum_{l=1}^{p} A_l y_{i,t-l} + Bx_{i,t} + Cs_{i,t} + \varepsilon_{i,t} \tag{1.19}$$

with I_m being an $m \times m$ identity matrix, $y_{i,t}$ representing an $m \times 1$ vector of endogenous variables, $y_{i,t-l}$ representing an $m \times 1$ vector of lagged endogenous variables, $x_{i,t}$ being a $k \times 1$ vector of predetermined variables, $s_{i,t}$ being an $n \times 1$ vector of strictly exogenous variables, and $\varepsilon_{i,t}$ being the idiosyncratic error vector. A_l $(m \times m)$, B $(m \times k)$, and C $(m \times n)$ being the parameter matrices. μ_i is an individual error component representing the fixed effects.

First, fixed effects are removed. This can be done by transforming this relation into its first difference or by applying the forward orthogonal transformation (suggested by Arellano and Bover (1995) to minimize data losses resulting from data gaps (Appendix H)). Based on the first difference representation, the derived first difference GMM moment conditions are

$$\text{E}(\Delta\varepsilon_{i,t} y_{i,j}^T)\text{=0 j} \in \{1,\dots, \text{T-2}\}$$

$$\text{E}(\Delta\varepsilon_{i,t} x_{i,j}^T)\text{=0 j} \in \{1,\dots, \text{T-1}\}$$

$$\text{E}(\Delta\varepsilon_{i,t} \Delta s_{i,t}^T)\text{=0}$$

Considering that

$$q_{i,t}^T := (y_{i,t-p-1}^T, \dots, y_{i,1}^T, x_{i,t-1}^T, \dots, x_{i,1}^T, \Delta s_{i,t}^T)$$

After stacking the model over time, the moment conditions for each i are

$$\text{E}[Q_i^T(\Delta E_i)] = 0$$

Considered as equivalent to the sample average $g(\Phi) = \frac{1}{N}\sum_{i=1}^{N} g_i(\Phi)$ where:

$$g_i(\Phi) = (Q_i \otimes I_{m\times m})(vec(\Delta E_i))$$

The number of moment conditions depends on the values of $p, m, k,$ and n. There are two solutions to reduce this number, namely to fix a maximal lag length after which no further instruments are used, or to start with a different minimal lag. This idea can be applied to the lagged endogenous variables and predetermined variables. The other is collapsing the instruments such that the first difference GMM moment conditions become

$$\text{E}[\textstyle\sum_{j=1}^{T-2} (\Delta\varepsilon_{i,t} y_{i,j}^T)] = 0$$

$$\text{E}[\textstyle\sum_{j=1}^{T-1} (\Delta\varepsilon_{i,t} x_{i,j}^T)] = 0$$

$$\text{E}(\Delta\varepsilon_{i,t} \Delta s_{i,t}^T)\text{=0}$$

In addition, Q_i reduces to a $(T-2) \times (T-2)$ matrix. The GMM estimator is derived by minimizing the function

$$\Pi(\Phi) = (\textstyle\sum_{i=1}^{N} Z_i^T vec(\Delta Y_i - [\Delta Y_{i,-1} \Delta X_i \Delta S_i]\Phi))^T \Lambda_Z^{-1}$$
$$(\textstyle\sum_{i=1}^{N} Z_i^T vec(\Delta Y_i - [\Delta Y_{i,-1} \Delta X_i \Delta S_i]\Phi)),$$

where Φ is an $m \times (m \times p + k + n)$ matrix of parameters, defined as $[\text{A B C}]$, where the parameter matrices A, B, and C have the same dimensions as in equation (1.19); Z_i is equal to $Q_i \otimes I_{m\times m}$; and $\Lambda_Z$is the GMM weighting matrix. This matrix is defined in line with the relevant literature through a one- or two-step estimation procedure. In the one-step estimation procedure, it is defined following Binder, Hsiao, and Pesaran (2005)

$$\Lambda_Z = [\sum_{i=1}^{N} Q_i^T D D^T Q_i] \otimes I_{m\times m},$$

where D serves as a $(T-1)\times T$ linear transformation matrix such that for any matrix V_i, $DV_i=\Delta V_i$ The two-step estimation uses the residuals of the one-step estimation as ΔE_i. In addition, Sigmund and Ferstl (2017) address the case of a system GMM estimator, which performs better than the first difference GMM estimator. The additional moment conditions in this case are

$$E[\varepsilon_{i,t} + (I - \sum_{j=1}^{p} A_j)\mu_i(y_{i,t-1} - y_{i,t-2})^T] = 0\,, \qquad t \in \ 3,4,\ldots T$$

$$E[\varepsilon_{i,t} + (I - \sum_{j=1}^{p} A_j)\mu_i(x_{i,t} - x_{i,t-1})^T] = 0\,, \qquad t \in \ 2,3,\ldots T$$

$$E[\varepsilon_{i,t} + (I - \sum_{j=1}^{p} A_j)\mu_i s_{i,t}^T] = 0\,, \qquad t \in \ 2,3,\ldots T$$

Appendix G: Orthogonalized and Generalized impulse response functions

Suppose we have the following standard VAR(1) model

$$Z_t = \theta_0 + \theta Z_{t-1} + \varepsilon_t \tag{1.20}$$

With $Z_t = \begin{bmatrix} b_t \\ p_t \end{bmatrix}$, $\theta_0 = \begin{bmatrix} \theta_{b0} \\ \theta_{p0} \end{bmatrix}$, $\theta = \begin{bmatrix} \theta_{11} & \theta_{12} \\ \theta_{21} & \theta_{22} \end{bmatrix}$ and $\varepsilon_t = \begin{bmatrix} \varepsilon_{bt} \\ \varepsilon_{pt} \end{bmatrix}$

Backward iteration yields the following expression

$$Z_t = \theta_0 + \theta(\theta_0 + \theta Z_{t-2} + \varepsilon_{t-1}) + \varepsilon_t$$
$$Z_t = \theta_0 + \theta \times \theta_0 + \theta^2 Z_{t-2} + \theta \times \varepsilon_{t-1} + \varepsilon_t$$

Similarly

$$Z_t = \theta_0 + \theta \times \theta_0 + \theta^2(\theta_0 + \theta Z_{t-3} + \varepsilon_{t-2}) + \theta \times \varepsilon_{t-1} + \varepsilon_t$$
$$Z_t = \theta_0 + \theta \times \theta_0 + \theta^2 \times \theta_0 + \theta^3 Z_{t-3} + \theta^2 \varepsilon_{t-2} + \theta \times \varepsilon_{t-1} + \varepsilon_t$$
$$Z_t = \theta_0(1 + \theta + \theta^2) + \theta^3 Z_{t-3} + (\theta^2 \varepsilon_{t-2} + \theta \times \varepsilon_{t-1} + \varepsilon_t)$$

More generally

$$Z_t = \theta_0(1 + \ldots + \theta^n) + \theta^{n+1} Z_{t-(n+1)} + \sum_{i=0}^{n} \theta^i \varepsilon_{t-i}$$

If the stability condition holds, then θ^{n+1} would tend towards 0 as n approaches infinity. This leads to the MA representation of the VAR model

$$Z_t = \mu + \sum_{i=0}^{n} \theta^i \varepsilon_{t-i}$$

Impulse response functions express the response of one endogenous variable to an impulse in another endogenous variable. Based on the MA representation of the VAR model, IRF can be stated as follows

$$\boldsymbol{IRF(k,r) = \frac{\partial Z_{t+k}}{\partial(\varepsilon_t)_r} = \theta^k e_r} \tag{1.21}$$

where k is the number of periods after the shock to the r^{th} component of and e_r is a 2×1 vector with 1 in the rth column and 0 otherwise.

In the traditional impulse response functions, the disturbances terms are correlated since they incorporate the contemporaneous effects of all the endogenous variables. To use the structural form of the VAR model, the VAR system can be written as follows

$$\begin{bmatrix} 1 & A_{12} \\ A_{21} & 1 \end{bmatrix} \begin{bmatrix} b_t \\ p_t \end{bmatrix} = \begin{bmatrix} \phi_{b0} \\ \phi_{p0} \end{bmatrix} + \begin{bmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{bmatrix} \begin{bmatrix} b_{t-1} \\ p_{t-1} \end{bmatrix} + \begin{bmatrix} w_{bt} \\ w_{pt} \end{bmatrix} \tag{1.22}$$

Considering that A=$\begin{bmatrix} 1 & A_{12} \\ A_{21} & 1 \end{bmatrix}$, $\phi_0 = \begin{bmatrix} \phi_{b0} \\ \phi_{p0} \end{bmatrix}$, $\phi = \begin{bmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{bmatrix}$ and $W_t = \begin{bmatrix} w_{bt} \\ w_{pt} \end{bmatrix}$

Then

$$AZ_t = \phi_0 + \phi Z_{t-1} + W_t \tag{1.23}$$

In this case, W_t is a vector of uncorrelated white-noise disturbances.

Also

$$Z_t = A^{-1}\phi_0 + A^{-1}\phi Z_{t-1} + A^{-1}W_t \tag{1.24}$$

With: $\theta_0 = A^{-1}\phi_0$, $\theta = A^{-1}\phi$ and $\varepsilon_t = A^{-1}W_t$

Also

$$\varepsilon_t = A^{-1}W_t = \begin{bmatrix} 1 & A_{12} \\ A_{21} & 1 \end{bmatrix}^{-1} \begin{bmatrix} w_{bt} \\ w_{pt} \end{bmatrix} = \begin{bmatrix} \frac{1}{1-A_{12}A_{21}} & \frac{-A_{12}}{1-A_{12}A_{21}} \\ \frac{-A_{21}}{1-A_{12}A_{21}} & \frac{1}{1-A_{12}A_{21}} \end{bmatrix} \begin{bmatrix} w_{bt} \\ w_{pt} \end{bmatrix}$$

Thus

$$\varepsilon_{bt} = \frac{w_{bt} - A_{12}w_{pt}}{1-A_{12}A_{21}}$$
$$\varepsilon_{pt} = \frac{-A_{21}w_{bt} + w_{pt}}{1-A_{12}A_{21}}$$

It is clear that the error terms of ε_t are composites of the two shocks from the two variables of the model. Because of this feedback effect, it is difficult to estimate the structural model. But after estimating the reduced-form VAR model, it is possible to decompose ε_t by finding a matrix A such that $\varepsilon_t = A^{-1}W_t$

Since the objective is to isolate a disturbances vector that would have a diagonal variance covariance matrix, one way is using the Cholesky decomposition on the variance covariance matrix of ε_t to find a lower triangular matrix A^{-1}, such that $A^{-1}A'^{-1} = E(\epsilon\epsilon')$. Simultaneously, the variance covariance matrix of W_t will be diagonal since $E(ww') = AE(\epsilon\epsilon')A' = AA^{-1}A'^{-1}A' = I$

Using the structural model, the orthogonal impulse response function are obtained

$$\boldsymbol{OIRF\,(k,r) = \frac{\partial Z_{t+k}}{\partial (W_t)_r} = B_k e_r} \tag{1.25}$$

such that $B_k = \theta^k A^{-1}$

The main limit of using the Cholesky-decomposition is its dependence on the ordering of the variables. To remedy this issue, Pesaran and Shin (1998) suggested an alternative approach which is the Generalized Impulse Response Functions (GIRF). They described GIRF as the outcome of a conceptual experiment in which the effect over time of a hypothetical vector of shocks δ hitting the economy at time t is compared with a base-line profile at time $t+k$ given the economy's history. Therefore the disturbances vector comprises both the shocks expected to hit the economy before t and the vector δ. Formally:

$$GIRF(k, \delta, \Omega_{t-1}) = E[Z_{i,t+k} | \varepsilon_{i,t} = \delta_r, \Omega_{t-1}] - E[Z_{i,t+k} | \Omega_{t-1}] \tag{1.26}$$

With Ω_{t-1} being the set of available information about economic history at time $t-1$. The idea of Pesaran and Shin (1998) approach is choosing to shock only one element (the rth element) and integrate the effects of other shocks using the historically observed distribution of the errors. The Σ_ε being the variance covariance matrix of ε_t, GIRF are thus expressed as

$$GIRF(k,r,\Sigma_\varepsilon) = E[Z_{i,t+k}|\varepsilon_{i,t,r} = \delta_r, \Sigma_\varepsilon] - E[Z_{i,t+k}|\Sigma_\varepsilon] \tag{1.27}$$

As pointed out by Koop, Pesaran, and Potter (1996), if the vector of random shocks is considered as jointly normally distributed, then the conditional expectation of the shocks is a linear function of δ

$$E(\varepsilon_t \varepsilon_{t,r} = \delta_r) = (\sigma_{1r}, \sigma_{2r}, \ldots, \sigma_{mr})' \sigma_{rr}^{-1} \delta_r = \Sigma_\varepsilon \sigma_{rr}^{-1} \delta_r \tag{1.28}$$

The generalized impulse response of the effect of a shock to the rth equation at time t on Z_{t+k} is given by

$$\theta^k E(\varepsilon_t \varepsilon_{t,r} = \delta_r) = (\tfrac{\theta^k \Sigma_\varepsilon}{\sqrt{\sigma_{rr}}})(\tfrac{\delta_r}{\sqrt{\sigma_{rr}}})$$

By setting $\delta_r = \sqrt{\sigma_{rr}}$, and considering that $\sigma_{r,r}$ is the r-th diagonal element of Σ_ε, the following expression is obtained

$$\boldsymbol{GIRF(k,r,\Sigma_\varepsilon) = \theta^k \Sigma_\varepsilon (\sigma_{r,r})^{-1/2}} \tag{1.29}$$

Appendix H: Forward orthogonal transformation

The forward orthogonal transformation was suggested by Arellano and Bover (1995) to minimize data losses due to data gaps. Based on the following panel VAR model that includes fixed effects

$$y_{i,t} = \mu_{i,t} + \sum_{l=1}^{p} A_l y_{i,t-l} + B x_{i,t} + C s_{i,t} + \epsilon_{i,t} \tag{1.30}$$

where $(y_{i,t})$ is a vector of endogenous variables for the (i_{th}) cross-section at time (t), $(y_{i,t-1})$ a vector of lagged endogenous variables, $(x_{i,t})$ a vector of predetermined variables potentially correlated with past error terms, $(s_{i,t})$ a vector of strictly exogenous variables independent from error terms and $(\epsilon_{i,t})$ a vector of i.i.d. disturbance terms. When the first difference transformation is used, the expression becomes

$$\Delta y_{i,t} = \sum_{l=1}^{p} A_l \Delta y_{i,t-l} + B \Delta x_{i,t} + C \Delta s_{i,t} + \Delta \epsilon_{i,t} \tag{1.31}$$

On the other hand, if forward orthogonal transformation is applied, variables are replaced by the following expression

$$y_{i,t+1}^{L} = c_{i,t} \left(y_{i,t} - {}^{1}\!/_{T_{i,t}} \sum_{s>t} y_{i,s} \right) \tag{1.32}$$

Where $c_{i,t} = \sqrt{{}^{T_{i,t}}\!/(T_{i,t}+1)}$

Chapter 2

Cyclicality, Fiscal Policy and the Current Account Balance

2.1 Introduction

Among macroeconomic issues raised by recent years' expansionary fiscal policies, the expected response of the current account (CA) balance is one of the most ambiguous and difficult to understand and predict. On the one hand, some theoretical models suggest that fiscal deficits are accompanied by CA deficits if the relationship between private savings and investment is constant. On the other hand, large budget deficits increase interest rates and reduce the ability to borrow in international markets and, thereby, affect investments negatively and domestic savings positively, leading to CA surpluses. Understanding the relationship between fiscal policy and the CA is important especially that many countries have simultaneously suffered from fiscal and CA deficits in the recent years, and have highly prioritized improving these deficits by formulating appropriate economic policies.

So far, the existing empirical research on the topic produced mixed results across regions and countries. The main focus of the present paper is to understand whether fiscal cyclicality explains some of this heterogeneity based on data for 51 countries, from 2002Q1 to 2018Q4. Using the intertemporal model of the CA as a theoretical basis, the empirical investigation includes correlation coefficients, a panel VAR and a times series VAR analyses. The main novelty of the approach I use lies in the following features: (1) the adoption of a fully structural panel VAR that decomposes impulse responses into common and idiosyncratic components, while considering the underlying sample heterogeneity (based on Pedroni (2013)), (2) the use of quarterly disaggregate fiscal data in addition to aggregate fiscal variables, and (3) the use of fiscal cyclicality to explain the relationship between the main variables. More particularly, the decomposition of impulse responses between common and idiosyncratic components provides the advantage of accounting for cross-sectional dependence since responses of shocks that are common across members of the panel can be isolated. In addition, this approach is useful in assessing the homogeneity within groups of countries by comparing between idiosyncratic and common responses to shocks of the same nature, in terms of sign and magnitude.

In the panel VAR study, the obtained results indicate that the ability of fiscal policy to affect the CA varies based on the interaction of both variables with the business cycle. Indeed, the expected negative impact of aggregate government spending only appears clearly in countercyclical economies, with a procyclical CA. This is mainly exlained by a negative response of the CA to property income (and also to social benefits in some countries), in this group. Nevertheless, accounting for cyclicality is not sufficient to explain the dynamics between disaggregate fiscal data and the CA in all country groups. This results from a substantial heterogeneity within each group, reflected in both quartile impulse responses and the decomposition into idiosyncratic and common shocks.

In a subsequent step, I derive the main determinants of the CA by country from the present value model using a time-series Bayesian VAR approach. Results show that the largest components of public spending (compensation of employees, intermediate consumption, and social benefits) do not strongly contribute to the CA variation. This finding implies that aggregate demand (specifically the change in imports of goods and services resulting from changes in government consumption and wages) is not the main channel through which fiscal policy affects the current account. In contrast, property income is found to be a significant CA determinant in countries where sovereign credit risk is perceived as relatively high by the market over the sample period (such as Italy, Spain and Portugal). Additionally, subsidies play a significant role in the CA variation of some countries (e.g. Croatia, Austria, Spain and Bolivia).

The remainder of the chapter is organized as follows: In the next section, a literature review on the relationship between the CA and fiscal policy is provided. Section 3 discusses the theoretical background. Section 4 shortly reviews some contributions of the literature on fiscal cyclicality. In Section 5, the dataset and methodology are decribed. The main stylized facts from a preliminary correlation analysis are provided in Section 6. Sections 7 and 8 present the main findings of the empirical study based on the Structural-panel and time-series VAR analyses. Finally, the last section offers some concluding remarks.

2.2 Literature review

There are numerous literatures and theories on the link between the CA and fiscal policy. Traditionally, it has been assumed that the CA moves in the same direction as the fiscal balance (as in the twin deficits hypothesis[1] or the Mundell-Fleming framework[2]). In contrast, some other theories suggest that fiscal deficits might actually improve the CA. One example is the two-country real business cycle model of Baxter (1995) that shows that a transitory reduction in distortionary tax rates on labor income, financed by future lump-sum taxes, may improve the CA but worsen the government budget. Another example is the model of Obstfeld and Rogoff (1995a) which states that a government spending increase tends to lead to an improvement of the CA as consumers smooth consumption (following the movement in output caused by the increase). In addition, this model also implies that fiscal expansions may depreciate the nominal and real exchange rate as a result of higher interest rates.

Similarly, opposing views can be found in the literature on the relationship between the CA and components of the budget balance. For instance, the Ricardian Equivalence Hypothesis (Barro (1974)) implies that there is no relationship between a CA deficit and taxes because tax changes have no impact on private consumption. Conversely, the intertemporal model of the CA implies a straightforward and negative relationship between the CA and government expenditures (see following section).

In the empirical literature, the link between fiscal policy and the CA is analyzed through different approaches. One approach is based on the "twin deficits" theoretical literature and consists in directly examining the relationship between fiscal and CA balances (see examples in Appendix A). Another approach aims at uncovering the main determinants of the CA using broader models that also include fiscal variables (e.g. Chinn and Prasad (2003)). Finally, another category of research attempts to empirically verify the implications of the intertemporal model for the CA (discussed in the following section). Overall, the empirical literature is also characterized by a lack of consensus. Litsios and Pilbeam (2017) explain this disaccord by the different methodologies used and the underlying structural forces in the sample countries that may lead to different correlations.

[1] Formally, the relationship between the CA and the fiscal balance is clear based on the identity $S^p - I + FB = CA$, derived from national income identities, where S^p represents private savings, I national investment, and FB is the fiscal balance, with $FB = T - G = S^g$ (which is government savings). G is government expenditures on goods and services and T is tax revenues.

[2] This model shows that a budget deficit leads to a CA deficit through an increase in interest rates, in addition to other transmission channels that depend on the exchange rate regime and the nature of capital mobility.

2.3 Theoretical background

The main theoretical background for the present study is the intertemporal model of the current account as discussed by Obstfeld and Rogoff (1995b). It is based on an expression for the current account that can be derived from two elements. The first element is the national income identity and is used to get the following expression of the CA

$$CA_t = r_t A_t + Y_t - C_t - G_t - I_t \tag{2.1}$$

where A_t is the economy's stock of net foreign claims at the end of period $(t-1)$, r_t is the net interest rate paid on these assets, Y_t is the net domestic product, G_t is government consumption, and I_t is net investment. The second element is the permanent income hypothesis that implies the existence of a relationship between consumption and the present value of the income path (equivalent to the present value of the constant income). Based on this idea, the permanent level of consumption can be expressed in terms of the permanent levels of the net domestic product, investment, and government expenditures.

These two elements yield the following expression that constitutes the prevalent theoretical framework for studying the dynamics of the CA (details on the derivation of the model are provided in Appendix B).

$$\begin{aligned} CA_t &= (r_t - \tilde{r}_t)A_t + (Y_t - \tilde{Y}_t) - (G_t - \tilde{G}_t) - (I_t - \tilde{I}_t) \\ &+ \left[1 - \frac{1}{(\widetilde{\beta/R})^{\sigma}}\right](\tilde{r}_t A_t + \tilde{Y}_t - \tilde{G}_t - \tilde{I}_t) \end{aligned} \tag{2.2}$$

The letters with a tilde represent the permanent level of the variables and $(\widetilde{\beta/R})^{\sigma}$ is the weighted average ratio of the $(s-t)$ period's subjective and market discount factors

$$(\widetilde{\beta/R})^{\sigma} \equiv \frac{\sum_{s=t}^{\infty} R_{t,s}\left(\beta^{s-t}/R_{t,s}\right)^{\sigma}}{\sum_{s=t}^{\infty} R_{t,s}} \tag{2.3}$$

where the market discount rate for consumption at time s is

$$R_{t,s} = \frac{1}{\prod_{v=t+1}^{s}(1+r_v)} \tag{2.4}$$

It can be clearly seen from this approach that the intertemporal model rests on the fundamental idea that the CA movements can be explained by permanent income fluctuations. In other words, the model implies that the CA can be perceived as a consumption smoothing tool by domestic residents (through foreign borrowing and lending). This idea is reflected in Equation (2.2) where the CA appears to depend on the short-run components of output, government spending, investment, in addition to net foreign claims multiplied by the short-run component of interest rates and a final term that represents consumption tilting due to differences between world interest rates and the domestic rate of time preference.[3] This last term implies that if the domestic rate of time preference is lower than future world interest rates,[4] there will be a secular tendency toward CA deficits, higher external debt and declining consumption (because in that case $\widetilde{(\beta\backslash R)}^{\sigma} < 1$).

Still, empirically, short-run dynamics are not often accounted for in studies of the intertemporal model of the CA. Instead, the most common approach is based on the following present value model (PVM)

$$CA_t = -\sum_{i=1}^{\infty} \left(\frac{1}{1+r}\right)^i E_t \Delta NO_{t+i} \tag{2.5}$$

where the net output NO_t is given by $NO_t = Y_t - I_t - G_t$ and $\Delta NO_{t+i} = NO_{t+i} - NO_{t+i-1}$, with Y_t, I_t, G_t representing output, investment and government spending, respectively. The non-stochastic world real interest rate r is assumed to be positive. This model can be obtained from the total income identity with the use of an expression for the permanent level of consumption (see more details in Appendix C). The commonly used approach to verify the present value model (PVM) of the CA is the methodology of Campbell (1987) and Campbell and Shiller (1987) (see Appendix C).

Some authors succeeded in verifying the PVM through empirical data (Campa and Gavilan (2011); Hoffmann (2013)). However, more frequently, the PVM is rejected in the empirical literature (Ghosh and Ostry (1995); Milbourne and Otto (1992); Otto (1992); Sheffrin and Woo (1990)). Usually, the modeled CA exhibits less volatility than the actual data.

Many studies attempted to uncover the reasons behind the empirical failure of the PVM.

[3]It can be noted that consumption for a consumer that does not tolerate intertemporal substitution ($\sigma = 0$) is always set at the permanent level of $\tilde{r}_t A_t + \tilde{Y}_t - \tilde{G}_t - \tilde{I}_t$. Therefore, consumption tilting from the permanent value mainly depends on the term defined in (2.3)

[4]Implying the home country is more impatient than the rest of the world and therefore the present value of future income is perceived as lower than in the rest of the world

In some of them, inclusion of shocks to interest rates has been reported to improve the fit of the PVM (Bergin and Sheffrin (2000)). Some other reasons have been discussed by Nason and Rogers (2006).[5] Most of these discussed factors were found to matter in some way but not sufficiently to replicate the PVM predictions. For instance, the attention paid to transitory fiscal shocks was found to be justified but lacking some other important factors. In particular, the internalized risk premium[6] and exogenous world real interest rate shocks were identified as some of the important factors that had to be included.

In the present research, I focus on the impact of changes in government spending on the CA. Fiscal shocks have been found to significantly explain some of CA variability in many studies. Abbas et al. (2011) identified three major channels of transmission of these shocks to the CA (changes in aggregate demand and in the real exchange rate caused by government's consumption or investment, and interest rates). On the other hand, Ahmed (1986) and Ahmed and Rogers (1995) explained the importance of fiscal shocks by the fact that they affect external borrowing decisions. External borrowing is also closely related to the spread between domestic and world interest rates (as discussed in Nason and Rogers (2006)). This spread determines the costs of using the CA to smooth consumption for a given open economy (through foreign assets). Therefore, shocks that affect these costs (e.g. shocks to a country's risk premium) and those that affect fiscal variables in general (e.g. by increasing debt), are important in explaining the CA's response to fiscal policy.

One example of such shocks are those to the business cycle. Formally, it can be seen from the expression (2.2) that there is an interaction between the CA and cyclical components of the permanent income variables. Among those components are short-run fluctuations in government spending. For this reason, I consider that the nature of the response of fiscal variables to business cycle fluctuations is a determining factor in the interaction between the CA and government spending. More concretely, there are more chances of observing a reaction of the CA to fiscal shocks in a context where fiscal policy strongly adjusts to the business cycle than in a context where fiscal policy is acyclical (because of the size of the cyclical component). This intuition is present in the intertemporal model of the CA. In addition, as both expressions (2.2) and (2.1) imply a "ceteris paribus" negative relationship

[5] The 'usual suspects' for the PVM rejection by the data have been identified by Nason and Rogers (2006) as the non-separable preferences, fiscal policy, real interest rate shocks, external imperfect international capital mobility, and internalized risk premium.

[6] This factor alters the labor market response to permanent income shocks.

between government spending and the CA, it is natural that this relationship would be altered if the model's variables are endogenous (in particular if the cyclical components of output and those of government spending are correlated). Therefore, I consider that fiscal cyclicality can provide an explanation to the discrepancy in the literature that has been discussed in the previous section. This assumption is all the more justified by the fact that fiscal cyclicality has been reported to vary across countries (see following section).

2.4 Literature on cyclicality

Expectations regarding fiscal cyclicality in the literature vary based on the theoretical framework. The traditional Keynesian view is based on the idea that public expenditures should move in a countercyclical fashion and act as a catalyst for aggregate demand in times of recession. In contrast, the neoclassical framework precludes any countercyclical role for fiscal policy and often considers that government expenditures follow an exogenously given process (see Lucas Jr and Stokey (1983)).[7]

Empirical studies on fiscal cyclicality have also led to mixed results. The most common findings indicate that policy tends to be less countercyclical than what the Keynesian theory suggests. More specifically, several empirical studies have found that fiscal policy in developing countries is procyclical (Gavin and Perotti (1997); Talvi and Végh (2005); Braun (2001); Lane (2003); Thornton (2008)). Conversely, research on OECD economies usually reports an acyclical or slightly countercyclical fiscal policy (Lane (2003); Wyplosz (2002)).

On the other hand, according to Kaminsky, Reinhart, and Vegh (2004), the CA would be procyclical in the standard model, since borrowing from abroad should be countercyclical to ensure consumption-smoothing.[8] They provided the following explanations to a countercyclical CA: a procyclical investment that dominates the savings effect, distortions in consumption induced by temporary policies leading to countercyclical savings (since consumption increases in prosperous times), and residents' dissaving as capital inflows increase in prosperous times.

[7] Lane (2003) noted that, in the neoclassical framework, government consumption would be expected to be countercyclical if public and private consumption were substitutes in utility, and procyclical if they were complements.

[8] Changes in the CA can be explained by the capital account if the impact of international reserves is ignored.

2.5 Data and Approach

This study is conducted in three steps. In the first step, I calculate cyclicality measures and perform a correlation analysis. Second, I estimate a panel VAR model based on the heterogeneous structural approach of Pedroni (2013). In a final step, I use a time series VAR model to proceed with a country by country analysis.

2.5.1 Correlation analysis and cyclicality measures

For the first step, quarterly data for a sample of 57 high- and middle-income countries for the period 1995Q1–2019Q2 are used (Data description is provided in Appendix D). Data are extracted in real terms or deflated through a GDP deflator, and are on a per capita basis. Fiscal cyclicality is measured in line with the recommendations of Kaminsky, Reinhart, and Vegh (2004). They argued that the concept of fiscal policy cyclicality should be defined based on policy instruments, that is, government consumption and tax rates, as opposed to endogenously determined outcomes (the fiscal balance or tax revenues).[9] Further, they demonstrated how the use of any variable expressed as a percentage of gross domestic product (GDP) could be misleading in analyzing cyclical dynamics. Therefore, I choose to rely on data in domestic currencies instead of ratios over GDP. The cyclical components are extracted through the Hodrick-Prescott (HP) filter as it is a frequently used approach in the literature on fiscal cyclicality.[10]

After a general examination of the HP-de-trended data, from which I draw some stylized facts, I introduce disaggregate fiscal data into the analysis. This additional step is justified by the need to explain the mechanism through which fiscal spending can affect the CA with more clarity. The use of disaggregate spending data has been done in many previous studies on various topics (e.g. Lane (2003), Hercowitz and Strawczynski (2004), Castles and Dowrick (1990), Marattin and Salotti (2011)) but can be more rarely found in the literature related to the relationship between the CA and fiscal variables.

Disaggregate data of government expenditures are obtained from the Government Finance Statistics (GFS) databases of Eurostat and the IMF. The Eurostat database is based on the ESA 2010 accounting standards. Government expenditures are defined as the sum of

[9] Tax rates are not used in the present study because data are more difficult to obtain.
[10] Talvi and Végh (2005), Kaminsky, Reinhart, and Vegh (2004), Calderon et al. (2017).

12 ESA categories[11] (see the definitions provided in Appendix E), which I reduce to the 6 major components that are used in the IMF GFS database, in order to combine data from the two sources. Due to data availability, the sample is reduced to 51 countries for the period 2002Q1–2018Q4 when disaggregate data are included. Using disaggregate data, I also proceed with cyclical components extraction and correlation coefficients analysis.

2.5.2 Panel VAR approach

In the second step, I estimate a linear VAR model for the Current Account using variables from the intertemporal model of equation (2.2). At this stage, data are converted from domestic currency to percentage of GDP to be able to conduct panel analysis. I also proceed with a demeaning of the data. The employed estimation method is the heterogeneous structural VAR approach of Pedroni (2013). Its unique feature is the fact that it accounts for the presence of heterogeneity within the panel. The heterogeneity that is accounted for goes beyond the simple fixed effects and extends to all of the dynamics of the model. And it can be concretely observed through the decomposition of the different impulse responses into responses to idiosyncratic and common shocks. The estimated VAR model for a country i is expressed as follows

$$Z_{it} = AZ_{i,t-1} + \epsilon_{it} \tag{2.6}$$

With the vector Z_{it} defined as

$$Z_{it} = [G_{it}\ r_{it}\ NFA_{it}\ I_{it}\ CA_{it}]'$$

where G_{it} is total government expenditures of country i and is replaced by disaggregate government spending variables in a subsequent step, r_{it} is the short-term interest rate, NFA_{it} represents the net foreign assets, I_{it} is net investment, and CA_{it} the Current Account Balance. As opposed to the PVM of equation (2.5), two additional variables are included: Net foreign assets as they have often been found to affect CA volatility (e.g., Das (2016),Chinn and Prasad (2003)) and short-term interest rates since they improve the fit of the present value model when included (Bergin and Sheffrin (2000)).

[11] ESA 2010 Manual, p. 274.

I use the model to study the impact of changes in government spending on the CA for groups based on fiscal cyclicality measures (terciles). The econometric approach[12] can be summarized as follows (see more details in Appendix F):

1. Estimating the reduced-form VAR model (2.6) country by country
2. Calculating the time effects across the sample (or group of countries) $\bar{Z}_t = N_t^{-1} \sum_{i=1}^{N_t} Z_{it}$ and using them to estimate a VAR model for the sample (or group)
3. Using the identifying restrictions to obtain the structural composite and common shocks estimates from the estimations in steps 1 and 2, respectively
4. For each country, running a regression between its composite shocks and the common shocks to obtain the idiosyncratic shocks (corresponding to the residuals)
5. Computing the composite, common and member-specific impulse response functions
6. Using the distribution of the estimated responses to describe properties of the sample (median, first and third quartiles)

The decomposition of the different responses between those to idiosyncratic and those to common shocks provides many advantages. The first advantage is the control for cross-sectional dependence, since responses of shocks that are common across members of the panel can be isolated. The second advantage is the ability to assess the homogeneity within groups of countries by comparing between idiosyncratic and common responses to shocks of the same nature, both in terms of sign and magnitude. More precisely, it is expected that most of the responses would be to common shocks for a group that is highly homogeneous. On the other hand, if the relationship between variables is the same across countries but shocks are mostly idiosyncratic (low dependence within the group), then the share of the idiosyncratic response from the total response would be higher but the sign of this response would be the same as the common response.

The identification strategy is based on a scenario of an exogenous fiscal policy and an endogenous CA balance. Thereby government expenditures are placed first and the CA last in the Cholesky ordering (same ordering as in equation (2.6)). Also, as a robustness check, different orderings are tried for the model's variables in the first estimation of the model with

[12] Implemented using an algorithm by Góes (2016) based on Pedroni (2013).

aggregate data. Finally, in the model with disaggregate data, Granger causality tests are used as a reference to order disaggregate fiscal variables.

2.5.3 Country by country analysis

In a subsequent step, the study is supplemented with a time-series analysis of CA fiscal determinants using a Bayesian VAR approach based on an independent normal-Wishart prior and Gibbs sampling with 10000 iterations and 200 burn-in draws for distribution properties of unconditional posteriors. I also compare results from this estimation with those based on a Litterman-Minnesota prior (more details are provided in Appendix G).

2.6 Stylized facts

This section presents an overview of the main stylized facts uncovered through a general examination of the collected data. Different sample splits are applied, comparing OECD with non-OECD countries, as well as different regional and income groups.

Stylized fact 1: Generally, fiscal policy tends to be countercyclical or acyclical in the OECD group and procyclical in non-OECD economies

In line with results of previous empirical studies, I find that the fiscal policy in OECD countries is, in most cases, either acyclical or countercyclical whereas in developing economies, and particularly Latin American countries, it is procyclical (Table 2.1).

Stylized fact 2: The CA tends to behave acyclically or countercyclically

As opposed to expectations, the CA does not appear to be procyclical during the studied period (Table 2.1). The correlation coefficient between cyclical components of the CA and GDP is negative in 33 countries and positive in 18.[13] This result could be due to dynamics of the exchange rate (a positive reaction to output) or as previously stated in section 2, to countercylical savings, high capital inflows in expansions or procyclical investments that overpower the savings effects. It could also be explained by a positive correlation between output and expectations of future income, leading to a positive response of private consumption and thereby a negative impact on the CA (based on the Permanent Income Hypothesis).

[13] Countries with the most procyclical CA include Croatia (0.77) and Canada (0.56).

Stylized fact 3: The correlation between the CA and government consumption expenditure differs across countries leading to poor average coefficients by groups

The average correlation coefficients between cyclical components of the CA and general government consumption expenditures by income groups and by regions are weak (Table 2.1). Nonetheless, coefficients by country are not small, they just differ substantially within each group. This result is not surprising given the fact that countries are characterized by different cyclicality of both fiscal policy and the current account.

After inclusion of disaggregate data, I then examine the share of each category of public spending in total expenditures and estimate the correlation with GDP and the CA.

Stylized fact 4: The most significant components of government spending are "Compensation of employees',' "Social benefits" and "Intermediate consumption of goods and services"

The most significant components appear to be "Compensation of employees," "Social benefits," and "Intermediate consumption of goods and services," with a total share of 75% in all expenditures (Table 2.2). It can also be noted that the shares for "Compensation for employees" and, especially, "Intermediate consumption of goods and services" are relatively larger for non-OECD/ middle-income economies compared to OECD/high-income economies. The opposite is true for social benefits.

Stylized fact 5: Procyclicality of middle-income economies appears more notably in "Compensation of employees" and "Intermediate consumption"

Fiscal cyclicality measures for disaggregate spending data (Table 2.3) indicate that the procyclicality of non-OECD/middle-income is more notable in "Compensation of employees" and "Intermediate consumption of goods and services."

Stylized fact 6: Average correlation by groups between disaggregate government expenditures and the CA is small due to differences across countries

Average correlation coefficients (Tables 2.3 and 2.4) reveal an overall weak relationship between cyclical components of disaggregate expenditures and the CA, by groups of countries. As in stylized fact 3, these small figures result from significant discrepancies between countries of each group and not from a weak interrelation between fiscal variables and the CA.

2.7 The CA and Aggregate Government Spending

In the following sections, I use the structural panel VAR approach of Pedroni (2013) to analyze the relationship between government spending and the CA by groups of countries. This approach controls for country fixed effects and allows for full heterogeneity of dynamics across countries. Its main advantage compared to standard panel VAR methods is the decomposition of individual shocks into idiosyncratic and common components. The identification strategy is based on a scenario of an exogenous fiscal policy and an endogenous CA. Thereby, in the ordering of the variables, government expenditures are placed first and the CA last (alternative orderings are tried in Appendix H).

2.7.1 General estimation of the CA model for the whole sample

In a first step, I proceed with a general estimation of median composite impulse responses of the CA to a one-unit shock in the other variables of the model (Equation (2.6)). The result is shown on Figure 2.1 with confidence intervals based on 100 bootstrap repetitions. From previous theoretical discussions and empirical studies, it would be expected that total government spending would have a negative impact on the CA balance. Results show a negative median response. However, the wideness of confidence bands suggests that the relationship is not statistically strong.

To verify the robustness of this finding, I use the distribution of all individual responses to plot the median, average, and the 1st and 3rd quartiles of responses. Since this representation shows the response of most of the sample, it is more informative than the median with bootstrap confidence intervals or the traditional averaging methods used for panels. The resulting figure (Figure 2.2) shows that the response of the CA to total government expenditures and to interest rate shocks is disparate across sample countries.[14] Conversely, the CA responds positively and significantly to a change in net foreign assets and negatively to a change in gross fixed capital formation in both Figures 2.1 and 2.2. It is also important to note that the magnitude of the response to government spending and interest rate shocks is smaller than the magnitude of the response to net foreign assets.[15] Finally, to verify the validity of the identification strategy, the model is re-estimated using different orderings of

[14] More precisely, 22 out of the 51 countries show an immediate positive response

[15] Responses of the CA to net foreign assets, gross fixed capital formation and the interest rate are not discussed in the remainder of the paper as they do not differ, in subsequent estimations, from those in Figures 2.1 and 2.2.

the variables. Results (reported on Appendix H) show no significant difference between the alternative specifications.

2.7.2 The impact of cyclicality on the relationship between the CA and total government spending

In this section, I examine whether fiscal cyclicality explains the discrepancy across countries in the relationship between the two key variables. To do so, I first divide the sample into terciles based on fiscal cyclicality (i.e. the correlation between cyclical components of GDP and total government expenditures, as in Table 2.1). The aim is to separate the sample into countercyclical, acyclical, and procyclical countries. The following groups are obtained:

- Group 1: countercyclical countries, corresponding to the 1st tercile group in terms of measures of fiscal cyclicality (correlation with GDP $<$ -0.09)
- Group 2: countries in the 2nd tercile group, with a fiscal cyclicality measure between -0.09 and 0.05
- Group 3: group of procyclical countries (3rd tercile group) with a fiscal cyclicality measure $>$ 0.05

I also distinguish, within each group, between countries in which the CA is positively correlated with GDP and those with a negative correlation. The model is then re-estimated for each of these groups. If the ability of fiscal policy to affect the CA depends on its interaction with the business cycle, then the response of the CA to fiscal shocks would be homogeneous within groups of similar cyclicality. For example, if the CA is procyclical, then a negative relationship between government spending and the CA would be clearly visible in countercyclical economies. On the other hand, the relationship would be less predictable if fiscal policy or the current account are acyclical.

This assumption is confirmed through an estimation of average correlation coefficients by cyclicality group (Table 2.5). First, I remark that the correlation between the CA and government spending is higher in countercyclical economies. Second, I note that this correlation is only negative in countercyclical economies with a procyclical CA (10 out of 51 countries) or -with a smaller coefficient- in procyclical economies with a countercyclical CA (also 10 out of 51 countries). The relationship between the two variables is on the other hand positive for countercylical economies with a countercyclical CA.

Using the structural panel VAR model, quartile composite impulse responses are estimated for the cyclical groups of Table 2.5. The outcome, on Figure 2.3, confirms the findings from the correlation analysis for countercyclical economies. Response in the case of procyclical economies is statistically less significant as the median lies close to zero. I conclude from this section that, as opposed to predictions from the theory, a positive shock to aggregate government spending does not necessarily induce a negative response from the current account. Cyclicality of both fiscal policy and the CA affect the relationship between the two variables. Finally, response of the CA to public spending shocks is more uniform and significant in countercyclical economies.

2.8 The CA and Disaggregate Government Spending

I then replace total government expenditures in the model by disaggregate fiscal data.[16] A first analysis is made on the countercyclical group, where a significant response was noted in the previous section (more details on this group are provided in Appendix I).

2.8.1 Response of the CA to disaggregate fiscal spending variables in countercyclical economies

After separating the group of countercyclical economies based on CA cyclicality, the following conclusions are drawn.

In the countercylical group with a countercyclical CA

As reported in the previous section, the CA responds positively to a positive government spending shock in the group of countercyclical economies with a countercyclical CA. Detailed responses by country show that all 7 countries of the group respond positively to the shock, except for Switzerland. By spending component, the average response of the CA is positive after a shock to all variables, except subsidies. Nonetheless, the highest responses on impact are those to social benefits and compensation of employees. At the second quarter, the responses to intermediate consumption and subsidies get significantly higher (and also compensation of employees to a lesser extent), whereas the responses to property income[17]

[16]As it is difficult to order disaggregate expenditures based on economic logic, Granger causality tests are used as a reference. The following ordering of the variables is obtained: property income, subsidies, compensation of employees, intermediate consumption, social benefits, other expenditures, interest rate, net foreign assets, gross fixed capital formation, and the CA.

[17]Property income comprises payable income such as interests, dividends and rents on natural resources. The share of interest payments is however the most significant one (particularly interests on debt securities).

and social benefits drop.

This implies that the immediate response of the CA to social benefits and compensation of employees is the main driver behind the positive response to total government spending on impact, while responses to intermediate consumption and subsidies also explain the positive response in the second quarter. Details by country indicate that the response to social benefits is positive on impact in all countries, except France. On the other hand, the group's average response to compensation of employees, intermediate consumption and subsidies is mainly driven by responses of two countries: Latvia and Slovakia. Therefore, I conclude that the positive response in this group is essentially explained by the positive response of the CA to social benefits, which also represent the largest and most countercyclical component of total government spending, on average (see Appendix I).

In the countercylical group with a procyclical CA

In this group of 10 countries, the CA responds negatively to a positive government spending shock. The average response of the CA to this shock is negative in all countries, except Denmark. By component, the average response of the CA is negative on impact only after a shock to property income (and to a lesser extent "other expenses"). The highest positive responses are the ones to intermediate consumption and to subsidies. These responses get negative in the third quarter.

Details by country indicate that, on impact, the response of the CA to property income shocks is negative in all countries, except Austria and Belgium. In the following quarters, the response of Japan and Croatia gets notably positive. The negative weight of the response to property income in total government spending is mitigated by the positive response to intermediate consumption and subsidies, that can be observed in most countries. Finally, the response to social benefits is negative in most countries but appears positive on average, primarily because of a positive and high response in Luxembourg and Belgium. To sum up, in this group, there is a negative response in total spending because of a negative response to property income and (although less homogeneous) a negative response to social benefits. This can be seen on Figure 2.4.

2.8.2 Decomposition between common and idiosyncratic shocks in the model with disaggregate fiscal variables

It has been seen from the previous section that there are differences across countries in terms of the response of the CA to the different spending components. These differences are even more marked in the groups of acyclical and procyclical economies. Although different other groupings of countries are tried (such as regions and income), it is difficult to detect obvious patterns for each component. The heterogeneity that characterizes the relationship between the CA and spending components is confirmed by the decomposition of composite shocks into idiosyncratic and common shocks.

Figure 2.5 (based on fiscal cyclicality groups) reveals that most composite responses are characterized as responses to idiosyncratic rather than to common shocks.[18] Further, responses to common shocks are opposite in direction to responses to idiosyncratic shocks in some cases. That is because countries within each panel do not respond in a similar way to global shocks.[19] For instance, the 2007 financial crisis led to a deterioration of the fundamentals of some countries (a negative shock, especially in 2008Q4), but countries that have been able to weather the crisis or those that were affected after a delay, do not exhibit a significant change in the variables at the same period (the changes in the residuals are small). Consequently, in the latter group, common shocks and composite shocks are negatively related.

Figure 2.6 provides an example based on the decomposition of the median composite response to property income in the fiscal cyclicality group 1.[20] In this case, the reason common and composite shocks are negatively correlated is that the average property income for the countries in the group received a negative shock in 2008Q4, but at the individual level, many countries were either less affected or received this fiscal shock on a different date in 2008 or 2009.[21]

[18] The corresponding quartile impulse response functions (based on fiscal cyclicality groups) are reported in Appendix J

[19] While decomposing individual composite shocks, the term of the loading matrix corresponding to common shocks is negative, implying a negative correlation between individual and common shocks.

[20] In Figure 2.6, I separate group 1 into two subgroups: subgroup (a), with countries for which responses to common shocks and those to composite shocks have opposite signs; and subgroup (b), in which both responses have the same direction. I find that, at the time of the crisis, the interest rate is the main driving factor behind property income shocks in almost all countries. In most countries in the group, this variable was negatively affected in 2018Q4, as a result of governments' intervention at the time. However, while in countries of subgroup (a) the resulting structural shock to property income is positive due to a negative effect from interest rates, in subgroup (b), the resulting structural shock is negative.

[21] Expressing the structural shock to the variable s at time t as $\epsilon_{st} = {\beta_s}^{-1}\mu_t$, where μ_t is a vector of reduced-form shocks at t and β_s a vector of contemporaneous effects on s from the Cholesky factor. The main element in μ_t in the example is the interest rate (in 2018Q4) with a significant negative shock. However, in subgroup (a), the

2.8.3 A time-series analysis of the CA model with disaggregate data

The heterogeneity of responses to disaggregate government spending shocks suggests the absence of a strong and robust relationship between a particular spending category and the CA, for a given group of countries. Therefore, I run a time-series analysis to uncover the strongest contributors to CA determination by country. Bayesian VAR estimation is used based on an independent normal-Wishart prior with Gibbs sampling (see Appendix G) to derive the variance decomposition of the CA by country (Table 2.6). The choice of this method is justified by the need to account for the uncertainties related to the determination of parameter values. As a robustness check, the same model is re-estimated with a different prior specification based on the Litterman-Minnesota approach (Table 2.7). In a few countries (e.g., Hong Kong and Singapore), the two approaches yield substantially different outcomes but for most of the sample, the results are consistent.

The variance decomposition (values after 8 quarters) clearly indicates the absence of common patterns within groups of similar fiscal cyclicality. It can also be noted that the relationship between the CA and the variables of property income and social benefits in countercyclical economies is not particularly strong (despite findings of section 2.8.1). The main explanation is the fact that CA's response to shocks to these two variables is lower in magnitude when compared to other variables of the model (e.g. NFAs) for each country. This is confirmed by plotting responses of the CA by country after a shock to all variables on the same chart.[22] Therefore, results of section 2.8.1 imply that there is a relatively homogeneous relationship (in terms of sign) between the CA and the variables of property income and social benefits in countercyclical economies. They do not imply that these variables are the most important determinant of CA variations.

In general, the variance decomposition shows that the three largest components of government expenditures (compensation of employees, intermediate consumption, and social benefits) play a minor role in CA determination. That is an interesting finding since many authors believe that the main channel through which fiscal policy influences the CA is aggregate demand as changes in government consumption and wages affect imports of goods and

corresponding factor in $\beta_s{}^{-1}$is also negative, leading to an overall positive structural shock, while in subgroup (b), this term is positive

[22]Unreported here due to space limits.

services. But the weak contribution of compensation of employees and intermediate consumption is an indication that this is not the case. Exceptionally, the share of government compensation of employees in the cases of Estonia and Slovenia is higher than that of all other variables.[23]

A high share of subsidies in the CA variance decomposition could be an indication that subsidized industries strongly rely on imports or exports, but further investigation is necessary to confirm it. In countercyclical economies, this category plays a significant role in Croatia and to a lesser extent Austria and Germany.[24] In acyclical economies, and under both specifications, the highest contribution of subsidies can be seen in Spain. In procyclical economies, there is a relatively marked contribution of subsidies in Bolivia. In the particular Bolivian case, the government sector is strongly intertwined with the external sector, and particularly the hydrocarbons sector (natural gas), which accounts for approximately half of the total exports, and is managed by SOEs.[25] The importance of SOEs is also a notable feature of the Croatian economy.[26]

Property income[27] appears to be a significant contributor to CA variation in some high-income countries such as Italy, Spain, Portugal and Greece. Among middle-income economies, there is a marked contribution of property income to the CA variation in Armenia, Indonesia and Kazakhstan. As many of these countries are characterized by high net borrowing from abroad over the recent years, external indebtedness could be a viable explanation to this finding. To verify this assumption, the obtained results for property income's contribution (from table 2.6) are plotted along with values of average net external debt to GDP over the last decade for the sample.[28] The scatter plot (Figure 2.7) shows a positive correlation between the two. Further, I examine several fiscal space indicators for these countries (over the period

[23]The overall value of compensation of employees in the Estonian CA balance has also significantly increased after 2004. In fact, after joining the EU, the rapid expansion of the Estonian economy and growth of employment coupled with the negative population growth contributed to the need of foreign skilled labour thereby increasing the share of non-resident employment.

[24]Under the Independent Normal Wishart prior specification (Table 2.6), this is also the case in Japan and the United States but this result is not robust under the alternative prior specification and also does not appear if impulse reponse functions are calculated.

[25]After its privatization in the 1990s, this sector was renationalized in 2006.

[26]SOEs are present in various industries among which the energy sector (making up a large share of imports and exports) where they generate 70% of total revenues (see Tabak and Zildzovic (2018)). In addition, the level of subsidies is considered to be relatively high in Croatia with a value of almost 2.5% of GDP (when the average for the EU is 1%).

[27]Mainly interest payments.

[28]Depending on data availability, used sources are the WDI and Eurostat's "Balance of Payment and other external statistics" databases.

of study and in 2019) and compare them with a benchmark of other countries where property income was found to contribute poorly to the CA.[29] Results are shown on Table 2.8.

Although these countries have a lower fiscal space on average compared to the benchmark (higher debt and deficits over tax revenues), their level of external debt is not superior to the one in the benchmark. On the contrary, it appears that many countries with excessively high external debt ratios have an almost null contribution of property income to CA variation (e.g. Belgium, Ireland, Switzerland and United Kingdom). Conversely, the main difference with the benchmark group is in the market perception. Countries with a high contribution of property income appear to be characterized by high CDS spreads and relatively lower ratings of foreign currency long-term sovereign debt. This lower perception by the market may explain a higher volatility of interest payments on external public debt. It can also be noted that the share of short-term central government debt in this group is on average higher. Thereby, I conclude that property income contributes more significantly to CA variation in countries where sovereign credit risk is perceived as high by the market. This finding corroborates conclusions from Nason and Rogers (2006) on the important role played by interest rates and in particular countries' risk premium to explain CA volatility.

Unsurprisingly, net foreign assets strongly affect the CA of Luxembourg, Belgium, and the United Kingdom. This component exhibits, on average, less weight in middle-income economies, except in Turkey, which has emerged as a significant capital investor abroad in recent decades. Gross fixed capital formation generally plays a small role in CA determination, with the exception of Ireland, the Netherlands, and, to a much lesser extent, Lithuania, Belarus and Croatia. Finally, in both estimated models, the highest level of CA persistence is noted in the cases of France and Colombia.

[29] Data are taken from the database of Kose et al. (2017). I focus on seven indicators: the level of government debt and the fiscal balance over tax revenues, the share of government debt held by non-residents, the level of central government debt maturing in less than 12 months over GDP, the level of external debt over GDP. Two indicators reflecting market perception are also included: the 5-year sovereign CDS spreads (in basis points) and the foreign currency long-term sovereign debt ratings (based on an index from 1-21, where 1 is the worst rating and 21 the best rating)

2.9 Concluding remarks

Using various statistical methods, I investigated the relationship between the CA and government expenditure. The main findings confirm previously reported difficulties in obtaining strong empirical evidence in favor of the PVM for a panel of advanced and developing countries. But they also provide some explanations as to why the existing literature is characterized by many discrepancies.

The main conclusions are as follows. First, as opposed to predictions from several previous studies and theories, a positive shock to aggregate government spending does not always induce a negative response in the current account. Cyclicality of both fiscal policy and the CA affect this response. More particularly, this response is negative and significant only in the case of countercylical economies with a procyclical current account. In this particular group, the CA responds negatively to shocks to property income and (in some countries) social benefits. CA's response is also significant but positive in countercyclical economies with a countercyclical CA, which is mainly explained by a positive response to social benefits. One reason for the significance of the relationship with social benefits is the fact that it is the only spending component that is always countercyclical, in countercyclical economies.

Second, the relationship between disaggregate government spending categories and the CA is characterized by a strong heterogeneity, that shows in the decomposition of shocks between common and idiosyncratic components. The main results from a time series approach imply that changes in wages and government consumption of goods and services are not the main channels through which fiscal policy affects the current account. In contrast, subsidies are found to play an important role in the CA variation of some countries such as Croatia, Austria, Spain and Bolivia. In addition, property income expenditures affect the CA more markedly in economies where sovereign credit risk is perceived as relatively high by the market.

Finally, interactions between the CA and disaggregate public spending are too complex to be uncovered through a panel approach. Not only do they vary from one country to the other but also within the same country, between periods, depending on government orientations and policies, in addition to structural and conjunctural factors. Further scrutiny within the conditions and channels through which each spending component affects the CA falls beyond the scope of this study but could be an interesting avenue for future research.

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Tables

TABLE 2.1: Correlation coefficient between detrended current account and fiscal variables and cyclicality of the current account and government expenditures by group of countries

	Correlation of the Current Account with		**Cyclicality Measures**	
	Government Expenditures	Fiscal Balance	Current Account	Government Expenditures
All	**-0.07**	**0.00**	**-0.13**	**0.08**
OECD	-0.04	-0.03	-0.09	0.04
non-OECD	-0.11	0.04	-0.18	0.14
Income groups				
High Income	-0.06	-0.01	-0.12	0.07
Middle-Income	-0.10	0.02	-0.14	0.12
Regions				
East Asia	0.00	-0.05	-0.13	0.01
Eastern Europe	-0.16	0.09	-0.22	0.09
Latin America	-0.01	-0.02	-0.18	0.20
North America	0.24	0.01	-0.05	-0.27
Pacific	-0.02	-0.09	-0.23	0.19
South-East Asia	-0.18	0.05	-0.13	0.14
Southern Africa	-0.16	-0.10	-0.19	0.28
West and Central Asia	-0.01	0.08	-0.08	0.08
Western Europe	-0.06	-0.06	-0.04	0.05

Notes: All variables are in real terms per capita, detrended using the Hodrick Prescott filter. The values in the table represent average correlation coefficients over groups (calculated on a country by country basis). Cyclicality measures correspond to the correlation coefficients with GDP.

TABLE 2.2: Breakdown of government expenses by category

Government Expenses categories	**All subsample**	**Income group**		**OECD group**	
		High Income	**Middle income**	**non-OECD**	**OECD**
Compensation of employees	**27%**	**27%**	**29%**	**30%**	**26%**
Intermediate consumption	**19%**	**17%**	**23%**	**24%**	**15%**
Property income	6%	5%	8%	6%	7%
Subsidies	4%	4%	5%	5%	4%
Social benefits	**34%**	**38%**	**25%**	**27%**	**40%**
Other expenses	10%	9%	10%	10%	9%

Notes: The share of each component is calculated based on the average values per country (based on variables in real terms per capita). The obtained shares per country are then averaged over groups of countries. For EU countries, data for government expenses are extracted from the Government Finance Statistics database of Eurostat (based on ESA 2010 standards). For non EU countries, data are extracted from the Government Finance Statistics database of International Financial Statistics (IMF). Values in bold correspond to shares above 10%.

TABLE 2.3: Cyclicality measures, correlation of government expenses categories with the current account

Government expenses	**All**	**Income group**		**OECD group**	
		High Income	**Middle income**	**non-OECD**	**OECD**
		Correlation with GDP			
Compensation of employees	*0.17*	*0.02*	*0.51*	*0.38*	*0.03*
Intermediate consumption	*0.15*	*0.03*	*0.41*	*0.34*	*0.02*
Property Income	0.12	0.05	0.27	0.15	0.09
Subsidies	0.02	-0.08	0.27	0.19	-0.09
Social Benefits	*0.00*	*-0.16*	*0.34*	*0.18*	*-0.13*
Other expenses	-0.01	-0.07	0.12	0.03	-0.04
		Correlation with the Current Account			
Compensation of employees	*0.04*	*0.05*	*0.02*	*0.04*	*0.05*
Intermediate consumption	*-0.03*	*-0.01*	*-0.09*	*-0.06*	*-0.01*
Property Income	0.03	0.03	0.04	0.02	0.03
Subsidies	0.00	0.02	-0.05	-0.10	0.07
Social Benefits	*0.07*	*0.08*	*0.05*	*0.07*	*0.06*
Other expenses	-0.05	-0.02	-0.10	-0.08	-0.02

Notes: The values in the table represent average correlation coefficients (calculated on a country by country basis). The underlying data correspond to cyclical components of the variables.

TABLE 2.4: Correlation of disaggregate government expenditures with the current account (by region)

	Compensation of employees	**Intermediate consumption**	**Property Income**	**Subsidies**	**Social Benefits**	**Other expenses**
East Asia	0.04	0.11	-0.03	0.07	0.003	-0.12
Eastern Europe	0.08	-0.18	0.15	-0.05	0.21	-0.12
Latin America	0.04	0.10	0.03	-0.01	0.07	-0.04
North America	0.06	0.09	0.15	-0.04	-0.01	0.24
Pacific	-0.02	-0.13	-0.28	0.07	-0.09	-0.04
South-East Asia	0.07	0.06	-0.17	-0.26	-0.02	-0.03
Southern Africa	0.24	-0.09	-0.12	-0.17	-0.17	-0.35
West and Central Asia	0.02	-0.02	0.00	0.04	0.11	0.08
Western Europe	0.03	0.01	0.01	0.08	0.02	-0.01
Total	**0.05**	**-0.03**	**0.03**	**0.00**	**0.07**	**-0.05**

Notes: The values in the table represent average correlation coefficients (calculated on a country by country basis). The underlying data correspond to cyclical components of the variables.

TABLE 2.5: Correlation between the Current Account and Total government expenditures by cyclicality groups

Fiscal cylicality group	Correlation of the CA with GDP: Negative	Correlation of the CA with GDP: Positive	Total Average
Countercyclical (group 1)	0.26	-0.14	0.02
Acyclical (group 2)	0.02	0.04	0.02
Procyclical (group 3)	-0.09	0.09	-0.03
Total Average	**0.04**	**-0.05**	**0.01**

Notes: The table values correspond to correlation coefficients between the current account and total government expenditures for each group. Fiscal cyclicality groups (rows) are each subdivided in two groups based on the correlation sign between the CA and GDP (columns). The fiscal cyclicality group 1 includes countries of the 1st tercile in terms of measures of fiscal cyclicality defined as the correlation between cyclical components of GDP and government expenditures (corresponding to a fiscal cyclicality $<$ -0.09). Group 2 is the group of countries of the 2nd tercile in terms of measures of fiscal cyclicality (fiscal cyclicality measure between -0.09 and 0.05). Group 3 is the group of countries of the 3rd tercile in terms of measures of fiscal cyclicality (fiscal cyclicality measure above 0.05).

TABLE 2.6: Variance decomposition of the CA by country after 8 quarters (Independent Normal-Wishart prior)

a. Group 1 (countercyclical)

Countries	pi	sub	comp	ic	sb	oth	rate	nfa	gfcf	ca
High-Income										
Austria	0.03	0.33	0.14	0.09	0.02	0.04	0.03	0.15	0.06	0.11
Belgium	0.04	0.06	0.07	0.04	0.05	0.06	0.05	0.45	0.03	0.15
Canada	0.08	0.16	0.12	0.08	0.09	0.08	0.05	0.06	0.03	0.26
Chile	0.07	0.05	0.06	0.10	0.05	0.03	0.23	0.09	0.03	0.30
Croatia	0.05	0.52	0.06	0.02	0.03	0.03	0.02	0.04	0.13	0.10
Denmark	0.07	0.08	0.07	0.10	0.08	0.03	0.10	0.24	0.08	0.15
Finland	0.14	0.07	0.07	0.10	0.03	0.09	0.05	0.17	0.02	0.26
France	0.04	0.06	0.11	0.08	0.05	0.03	0.03	0.04	0.05	0.51
Germany	0.09	0.14	0.08	0.11	0.06	0.02	0.03	0.17	0.03	0.26
Japan	0.15	0.39	0.06	0.07	0.02	0.03	0.02	0.01	0.03	0.23
Latvia	0.05	0.15	0.05	0.08	0.04	0.04	0.14	0.10	0.04	0.29
Luxembourg	0.07	0.07	0.05	0.06	0.03	0.03	0.04	0.39	0.03	0.22
Slovakia	0.08	0.07	0.08	0.16	0.05	0.04	0.02	0.05	0.03	0.43
South Korea	0.15	0.09	0.05	0.06	0.08	0.05	0.16	0.09	0.02	0.26
Sweden	0.05	0.05	0.06	0.07	0.02	0.04	0.10	0.36	0.02	0.22
Switzerland	0.06	0.10	0.07	0.08	0.06	0.04	0.07	0.23	0.03	0.26
United States	0.08	0.51	0.02	0.04	0.05	0.13	0.03	0.04	0.02	0.08
Average	**0.08**	**0.17**	**0.07**	**0.08**	**0.05**	**0.05**	**0.07**	**0.16**	**0.04**	**0.24**
Standard Deviation	**0.04**	**0.16**	**0.03**	**0.03**	**0.02**	**0.03**	**0.06**	**0.13**	**0.03**	**0.11**

b. Group 2 (acyclical)

Countries	pi	sub	comp	ic	sb	oth	rate	nfa	gfcf	ca
High-Income										
Czech Republic	0.07	0.13	0.14	0.12	0.03	0.06	0.04	0.29	0.02	0.11
Estonia	0.08	0.14	0.26	0.05	0.03	0.08	0.01	0.07	0.08	0.19
Greece	0.17	0.10	0.07	0.03	0.08	0.04	0.04	0.03	0.06	0.37
Hong Kong	0.33	0.14	0.02	0.03	0.03	0.05	0.05	0.04	0.02	0.30
Italy	0.36	0.04	0.11	0.06	0.04	0.07	0.04	0.07	0.03	0.18
Lithuania	0.11	0.10	0.05	0.07	0.05	0.03	0.02	0.11	0.20	0.25
Netherlands	0.06	0.06	0.05	0.04	0.05	0.06	0.05	0.22	0.31	0.11
New Zealand	0.09	0.10	0.06	0.05	0.03	0.05	0.20	0.24	0.04	0.16
Portugal	0.25	0.10	0.05	0.05	0.09	0.05	0.10	0.07	0.05	0.20
Singapore	0.45		0.06	0.05	0.03	0.03	0.05	0.09	0.02	0.23
Slovenia	0.11	0.04	0.21	0.04	0.03	0.02	0.04	0.16	0.07	0.27
Spain	0.16	0.26	0.11	0.03	0.04	0.04	0.11	0.04	0.14	0.08
United Kingdom	0.06	0.05	0.03	0.04	0.17	0.08	0.04	0.30	0.02	0.20
Average	**0.18**	**0.10**	**0.09**	**0.05**	**0.05**	**0.05**	**0.06**	**0.13**	**0.08**	**0.20**
Standard Deviation	**0.13**	**0.06**	**0.07**	**0.02**	**0.04**	**0.02**	**0.05**	**0.09**	**0.08**	**0.08**
Middle-Income										
Bulgaria	0.13	0.19	0.11	0.13	0.11	0.03	0.10	0.04	0.01	0.15
Colombia	0.11	0.08	0.04	0.04	0.03	0.03	0.04	0.07	0.06	0.49
Indonesia	0.19	0.04	0.07	0.06	0.04	0.06	0.05	0.16	0.05	0.29
Romania	0.09	0.14	0.09	0.07	0.17	0.03	0.01	0.02	0.10	0.28
Thailand	0.17	0.06	0.06	0.02	0.09	0.02	0.03	0.12	0.06	0.36
Average	**0.14**	**0.10**	**0.07**	**0.06**	**0.09**	**0.03**	**0.05**	**0.08**	**0.06**	**0.31**
Standard Deviation	**0.04**	**0.06**	**0.02**	**0.04**	**0.05**	**0.01**	**0.03**	**0.05**	**0.03**	**0.11**

c. Group 3 (procyclical)

Countries	pi	sub	comp	ic	sb	oth	rate	nfa	gfcf	ca
High-Income										
Australia	0.03	0.12	0.08	0.05	0.19	0.03	0.14	0.07	0.02	0.28
Hungary	0.05	0.04	0.04	0.04	0.03	0.03	0.02	0.03	0.03	0.69
Iceland	0.10	0.20	0.04	0.07	0.05	0.10	0.07	0.18	0.12	0.08
Ireland	0.04	0.04	0.03	0.04	0.04	0.03	0.04	0.03	0.65	0.06
Norway	0.10	0.06	0.07	0.08	0.03	0.04	0.05	0.16	0.05	0.38
Average	**0.06**	**0.09**	**0.05**	**0.05**	**0.07**	**0.04**	**0.06**	**0.09**	**0.18**	**0.30**
Standard Deviation	**0.03**	**0.06**	**0.02**	**0.01**	**0.06**	**0.03**	**0.04**	**0.06**	**0.24**	**0.23**
Middle-Income										
Armenia	0.22	0.07	0.07	0.07	0.03	0.03	0.06	0.19	0.10	0.17
Belarus	0.03	0.05	0.09	0.04	0.10	0.08	0.04	0.13	0.24	0.19
Bolivia	0.05	0.14	0.06	0.03	0.04	0.04	0.04	0.04	0.07	0.49
Brazil	0.14	0.06	0.05	0.04	0.04	0.05	0.20	0.09	0.17	0.15
Georgia	0.19	0.04	0.06	0.09	0.04	0.03	0.17	0.03	0.05	0.31
Kazakhstan	0.13	0.10	0.05	0.04	0.07	0.04	0.13	0.04	0.02	0.38
Mexico	0.09	0.09	0.05	0.08	0.04	0.05	0.06	0.25	0.02	0.27
Moldova	0.10	0.06	0.19	0.03	0.03	0.04	0.05	0.17	0.02	0.32
Peru	0.05		0.04	0.11	0.05	0.05	0.06	0.10	0.16	0.38
South Africa	0.06	0.05	0.04	0.13	0.08	0.09	0.04	0.10	0.06	0.35
Turkey	0.10	0.05	0.06	0.09	0.06	0.09	0.05	0.15	0.11	0.23
Average	**0.10**	**0.07**	**0.07**	**0.07**	**0.05**	**0.05**	**0.08**	**0.12**	**0.09**	**0.30**
Standard Deviation	**0.06**	**0.03**	**0.04**	**0.03**	**0.02**	**0.02**	**0.06**	**0.07**	**0.07**	**0.10**

Notes: ca= current account balance, pi= property income , sub= subsidies, comp= compensation of employees, ic= intermediate consumption, sb= social benefits, oth= other expenditures, rate= interest rate, nfa= net foreign assets, gfcf= gross fixed capital formation. Data in domestic currency divided by GDP. Group 1 includes countries of the 1st tercile in terms of measures of fiscal cyclicality defined as the correlation between cyclical components of GDP and government expenditures (corresponding to a fiscal cyclicality < -0.09). Group 2 is the group of countries of the 2nd tercile in terms of measures of fiscal cyclicality (fiscal cyclicality measure between -0.09 and 0.05). Group 3 is the group of countries of the 3rd tercile in terms of measures of fiscal cyclicality (fiscal cyclicality measure above 0.05). Values above 0.2 are highlighted. Cholesky ordering: pi, sub, comp, ic, sb, oth, rate, nfa, gfcf, ca

TABLE 2.7: Variance decomposition of the CA by country after 8 quarters (Litterman-Minnesota prior)

a. Group 1 (countercyclical)

Countries	pi	sub	comp	ic	sb	oth	rate	nfa	gfcf	ca
High-Income										
Austria	0.01	0.18	0.12	0.02	0.04	0.05	0.00	0.19	0.16	0.23
Belgium	0.02	0.04	0.03	0.03	0.03	0.04	0.03	0.44	0.03	0.32
Canada	0.08	0.02	0.02	0.01	0.02	0.00	0.03	0.02	0.00	0.78
Chile	0.02	0.01	0.05	0.02	0.06	0.00	0.06	0.02	0.06	0.69
Croatia	0.02	0.23	0.12	0.04	0.01	0.04	0.02	0.02	0.17	0.33
Denmark	0.05	0.09	0.06	0.03	0.07	0.03	0.03	0.23	0.08	0.33
Finland	0.05	0.07	0.03	0.02	0.01	0.04	0.00	0.20	0.01	0.58
France	0.00	0.01	0.01	0.04	0.00	0.00	0.00	0.02	0.01	0.90
Germany	0.04	0.10	0.05	0.08	0.03	0.00	0.01	0.07	0.02	0.61
Japan	0.03	0.06	0.02	0.01	0.06	0.03	0.00	0.01	0.04	0.74
Latvia	0.00	0.08	0.07	0.01	0.01	0.02	0.13	0.18	0.02	0.49
Luxembourg	0.05	0.02	0.01	0.01	0.02	0.01	0.01	0.49	0.03	0.36
Slovakia	0.03	0.01	0.09	0.11	0.05	0.01	0.00	0.07	0.01	0.61
South Korea	0.03	0.05	0.03	0.01	0.01	0.01	0.07	0.08	0.03	0.70
Sweden	0.01	0.01	0.02	0.08	0.00	0.03	0.01	0.28	0.01	0.56
Switzerland	0.01	0.04	0.02	0.01	0.01	0.00	0.00	0.25	0.01	0.65
United States	0.01	0.02	0.00	0.01	0.10	0.18	0.05	0.09	0.11	0.43
Average	**0.03**	**0.06**	**0.04**	**0.03**	**0.03**	**0.03**	**0.03**	**0.16**	**0.05**	**0.55**
Standard Deviation	**0.02**	**0.06**	**0.04**	**0.03**	**0.03**	**0.04**	**0.03**	**0.14**	**0.05**	**0.18**

b. Group 2 (acyclical)

Countries	pi	sub	comp	ic	sb	oth	rate	nfa	gfcf	ca
High-Income										
Czech Republic	0.08	0.08	0.11	0.06	0.01	0.02	0.00	0.32	0.03	0.29
Estonia	0.00	0.09	0.16	0.01	0.07	0.04	0.01	0.13	0.01	0.47
Greece	0.07	0.05	0.14	0.01	0.00	0.00	0.01	0.00	0.02	0.69
Hong Kong	0.00	0.00	0.02	0.00	0.00	0.02	0.02	0.02	0.01	0.90
Italy	0.27	0.02	0.07	0.02	0.08	0.02	0.02	0.10	0.01	0.39
Lithuania	0.04	0.05	0.02	0.05	0.01	0.00	0.02	0.09	0.18	0.54
Netherlands	0.02	0.05	0.03	0.01	0.03	0.02	0.02	0.20	0.35	0.28
New Zealand	0.10	0.02	0.01	0.03	0.00	0.03	0.08	0.29	0.08	0.35
Portugal	0.09	0.05	0.12	0.01	0.14	0.02	0.02	0.04	0.12	0.38
Singapore	0.01	0.00	0.01	0.02	0.00	0.00	0.01	0.09	0.04	0.81
Slovenia	0.02	0.01	0.22	0.04	0.02	0.00	0.00	0.18	0.02	0.49
Spain	0.24	0.15	0.12	0.02	0.06	0.00	0.06	0.00	0.08	0.26
United Kingdom	0.00	0.00	0.04	0.02	0.05	0.01	0.02	0.34	0.00	0.51
Average	**0.07**	**0.04**	**0.08**	**0.02**	**0.04**	**0.01**	**0.02**	**0.14**	**0.07**	**0.49**
Standard Deviation	**0.09**	**0.04**	**0.06**	**0.02**	**0.04**	**0.01**	**0.02**	**0.11**	**0.09**	**0.20**
Middle-Income										
Bulgaria	0.09	0.12	0.04	0.10	0.11	0.01	0.01	0.01	0.01	0.48
Colombia	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.05	0.03	0.87
Indonesia	0.15	0.02	0.05	0.00	0.01	0.01	0.04	0.05	0.00	0.66
Romania	0.02	0.04	0.07	0.05	0.05	0.01	0.00	0.06	0.05	0.66
Thailand	0.04	0.04	0.00	0.00	0.04	0.00	0.00	0.14	0.05	0.68
Average	**0.06**	**0.05**	**0.03**	**0.03**	**0.04**	**0.01**	**0.01**	**0.06**	**0.03**	**0.67**
Standard Deviation	**0.05**	**0.04**	**0.03**	**0.04**	**0.04**	**0.00**	**0.02**	**0.04**	**0.02**	**0.12**

c. Group 3 (procyclical)

Countries	pi	sub	comp	ic	sb	oth	rate	nfa	gfcf	ca
High-Income										
Australia	0.00	0.02	0.07	0.01	0.13	0.04	0.04	0.05	0.00	0.64
Hungary	0.15	0.00	0.08	0.04	0.01	0.02	0.00	0.02	0.06	0.61
Iceland	0.13	0.05	0.01	0.08	0.04	0.11	0.07	0.15	0.10	0.27
Ireland	0.01	0.00	0.01	0.01	0.02	0.00	0.00	0.02	0.72	0.20
Norway	0.05	0.01	0.03	0.01	0.00	0.04	0.01	0.25	0.01	0.59
Average	**0.07**	**0.02**	**0.04**	**0.03**	**0.04**	**0.04**	**0.02**	**0.10**	**0.18**	**0.46**
Standard Deviation	**0.06**	**0.02**	**0.03**	**0.03**	**0.05**	**0.04**	**0.02**	**0.09**	**0.27**	**0.19**
Middle-Income										
Armenia	0.19	0.02	0.04	0.00	0.01	0.00	0.04	0.09	0.27	0.33
Belarus	0.00	0.07	0.05	0.00	0.03	0.01	0.00	0.16	0.18	0.49
Bolivia	0.03	0.13	0.09	0.00	0.02	0.00	0.00	0.00	0.00	0.73
Brazil	0.07	0.01	0.00	0.01	0.02	0.04	0.09	0.13	0.10	0.52
Georgia	0.03	0.01	0.02	0.08	0.01	0.00	0.11	0.02	0.01	0.71
Kazakhstan	0.08	0.05	0.01	0.01	0.01	0.01	0.07	0.00	0.00	0.76
Mexico	0.01	0.03	0.02	0.01	0.00	0.01	0.01	0.15	0.04	0.74
Moldova	0.06	0.02	0.13	0.01	0.01	0.00	0.01	0.05	0.02	0.69
Peru	0.04	0.00	0.03	0.01	0.01	0.02	0.01	0.09	0.10	0.70
South Africa	0.00	0.00	0.01	0.01	0.02	0.03	0.03	0.04	0.01	0.82
Turkey	0.07	0.03	0.01	0.08	0.02	0.04	0.08	0.23	0.14	0.31
Average	**0.05**	**0.03**	**0.04**	**0.02**	**0.01**	**0.02**	**0.04**	**0.09**	**0.08**	**0.62**
Standard Deviation	**0.05**	**0.04**	**0.04**	**0.03**	**0.01**	**0.01**	**0.04**	**0.07**	**0.08**	**0.17**

Notes: ca= current account balance, pi= property income , sub= subsidies, comp= compensation of employees, ic= intermediate consumption, sb= social benefits, oth= other expenditures, rate= interest rate, nfa= net foreign assets, gfcf= gross fixed capital formation. Data in domestic currency divided by GDP. Group 1 is the sample's 1st tercile in terms of measures of fiscal cyclicality ($<$ -0.09). Group 2 is the 2nd tercile (between -0.09 and 0.05). Group 3 is the 3rd tercile (above 0.05). Values greater than 0.2 are highlighted. Cholesky ordering: pi, sub, comp, ic, sb, oth, rate, nfa, gfcf, ca

TABLE 2.8: Fiscal space indicators of countries with the highest/lowest contribution of property income to the CA variation

Average measures over the period 2002-2019

	Debt/Tax rev	FB/Tax rev	Debt N res%	St debt	Ext debt	CDS spreads	Ext debt rating
Countries with highest contribution of property income to the CA (Tables 2.6 and 2.7)							
Armenia	227.0	-20.9	NA	2.2	68.4	NA	9.1
Greece	682.4	-27.0	78.4	14.3	191.6	3361.3	10.5
Indonesia	285.2	-12.9	56.7	2.2	36.2	236.2	10.1
Italy	430.8	-11.8	34.5	20.0	112.3	129.7	15.9
Kazakhstan	73.8	7.3	NA	6.8	82.9	195.4	12.5
Portugal	446.7	-22.2	57.0	12.8	205.0	194.9	14.8
Spain	343.2	-20.9	40.4	15.7	150.4	110.0	17.4
Average	**355.6**	**-15.5**	**53.4**	**10.6**	**121.0**	**704.6**	**12.9**
Countries with lowest contribution of property income to the CA (Table 2.6)							
Australia	94.6	-7.3	41.1	2.4	95.2	28.3	20.8
Austria	272.5	-9.0	68.6	7.2	177.2	41.6	20.7
Belarus	163.9	-18.3	NA	NA	45.5	NA	6.7
Belgium	342.6	-8.6	53.0	12.4	253.3	50.4	19.2
France	314.8	-15.8	52.0	12.9	185.7	40.6	20.2
Ireland	258.7	-18.3	55.2	3.6	768.4	148.5	17.7
Average	**241.2**	**-12.9**	**54.0**	**7.7**	**254.2**	**61.9**	**17.5**
Countries with lowest contribution of property income to the CA (Table 2.7)							
Estonia	37.4	0.4	NA	0.2	91.3	146.1	16.7
Latvia	148.5	-9.2	58.5	3.2	127.0	223.1	14.1
South Africa	166.2	-13.3	29.1	7.2	34.0	172.2	12.9
Sweden	104.8	0.2	23.1	5.1	169.5	20.9	20.9
Switzerland	226.7	0.6	9.0	2.4	240.2	42.2	21.0
United Kingdom	259.5	-19.3	27.5	7.4	313.9	41.9	20.4
Average	**157.2**	**-6.8**	**29.5**	**4.3**	**162.7**	**107.7**	**17.7**

Measures for 2019

	Debt/Tax rev	FB/Tax rev	Debt N res%	St debt	Ext debt	CDS spreads	Ext debt rating
Countries with highest contribution of property income to the CA (Tables 2.6 and 2.7)							
Armenia	311.2	-6.1	NA	5.4	86.9	NA	8.2
Greece	840.3	2.8	88.8	9.9	245.4	261.7	8.3
Indonesia	259.2	-18.9	58.2	2.5	35.9	91.1	12.9
Italy	475.0	-5.5	31.9	18.6	124.8	139.2	12.7
Kazakhstan	103.3	-3.0	NA	5.7	86.0	129.4	12.3
Portugal	517.4	0.4	49.3	9.5	192.2	40.5	12.6
Spain	453.1	-13.6	46.0	12.6	170.2	49.5	14.8
Average	**422.8**	**-6.3**	**54.8**	**9.2**	**134.5**	**118.6**	**11.7**
Countries with lowest contribution of property income to the CA (Table 2.6)							
Australia	168.3	-13.6	39.5	2.8	110.6	17.7	21.0
Austria	255.1	2.4	60.0	6.9	154.2	4.2	20.0
Belarus	189.7	3.6	NA	NA	63.2	NA	6.7
Belgium	332.9	-6.6	55.7	9.8	243.5	6.2	18.3
France	368.4	-11.3	48.8	11.3	230.7	NA	19.0
Ireland	233.9	2.1	58.8	6.0	715.9	31.3	16.7
Average	**258.0**	**-3.9**	**52.6**	**7.4**	**253.0**	**14.9**	**16.9**
Countries with lowest contribution of property income to the CA (Table 2.7)							
Estonia	40.3	0.2	NA	0.4	74.1	NA	17.7
Latvia	182.1	-1.9	67.8	4.5	117.7	NA	15.3
South Africa	242.8	-20.6	38.0	9.5	53.4	181.9	11.0
Sweden	88.1	1.3	14.2	4.3	170.0	3.6	21.0
Switzerland	199.2	7.0	7.2	1.6	271.1	NA	21.0
United Kingdom	327.3	-8.9	37.4	9.4	312.0	10.9	19.0
Average	**180.0**	**-3.8**	**32.9**	**4.9**	**166.4**	**65.5**	**17.5**

Notes: Debt/Tax rev: General government gross debt in % of average tax revenues, FB/Tax rev: Fiscal balance in % of average tax revenues, Debt Nres%: General government debt held by nonresidents in % of total, St debt: Central government debt maturing in 12 months or less in % of GDP, Ext debt: Total external debt stocks in % of GDP, CDS spreads: 5-year sovereign CDS spreads (basis points), Ext debt rating: Foreign currency long-term sovereign debt ratings (index from 1-21, with 21 the best rating). Data source: Kose et al. (2017)

Figures

FIGURE 2.1: Median response of the current account to one unit composite shocks for the whole sample with bootstrap confidence intervals based on 100 repetitions

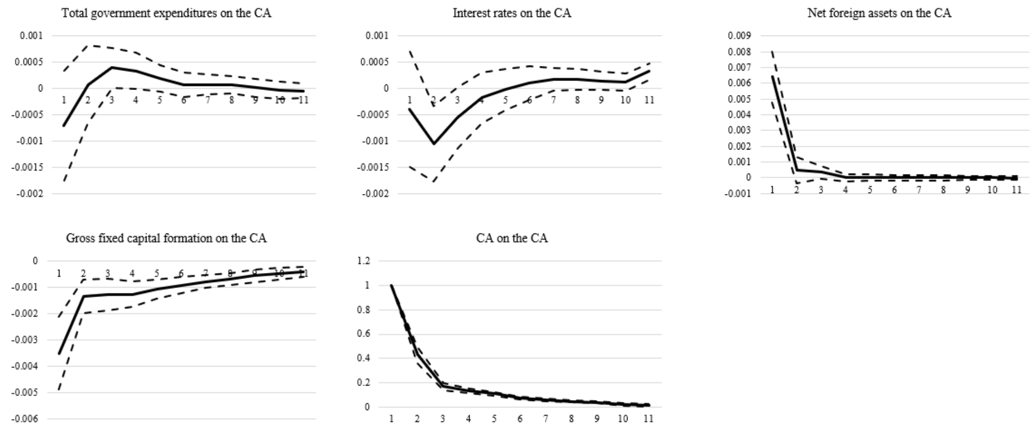


FIGURE 2.2: Quartile composite impulse responses of the CA to one unit shocks to the model variables for the whole sample

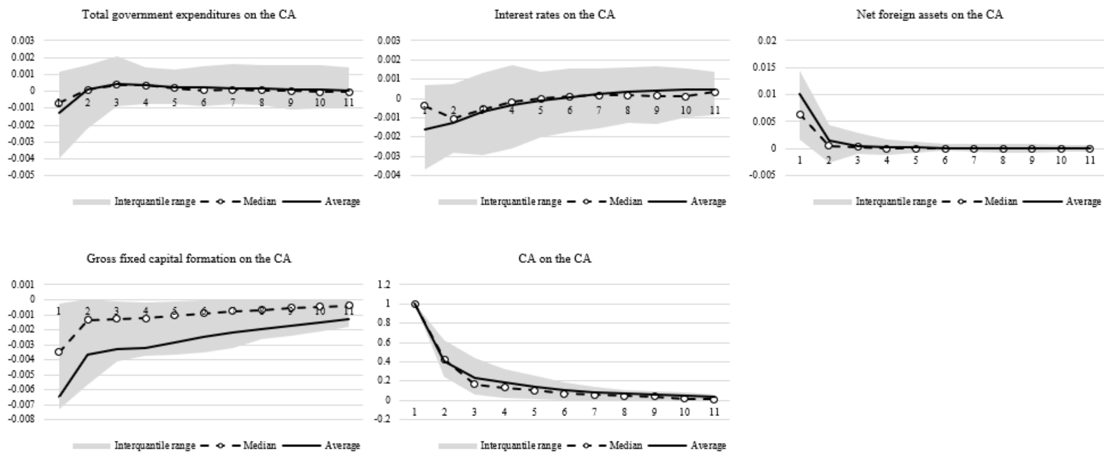
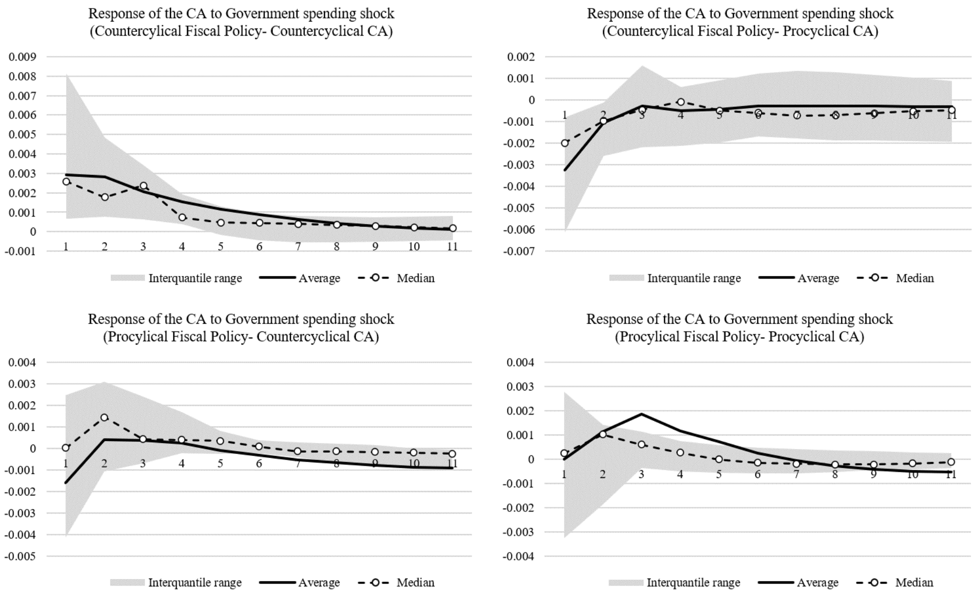


FIGURE 2.3: Quartile composite impulse responses of the CA to a one unit shock to total government expenditures by groups of fiscal and CA cyclicality



Notes: The correlation between cyclical components of GDP and total government spending is used as a measure for fiscal cyclicality. Countries are said to be countercyclical if they belong to the first tercile (correlation < -0.09) and procyclical if they belong to the third tercile (correlation above 0.05). To reproduce the same groups as Table 5, the CA is considered as countercylical if the correlation between its cyclical component and that of GDP is negative and procyclical otherwise.

FIGURE 2.4: Quartile composite impulse responses of the CA to a one unit shock to social benefits and property income in countercyclical economies

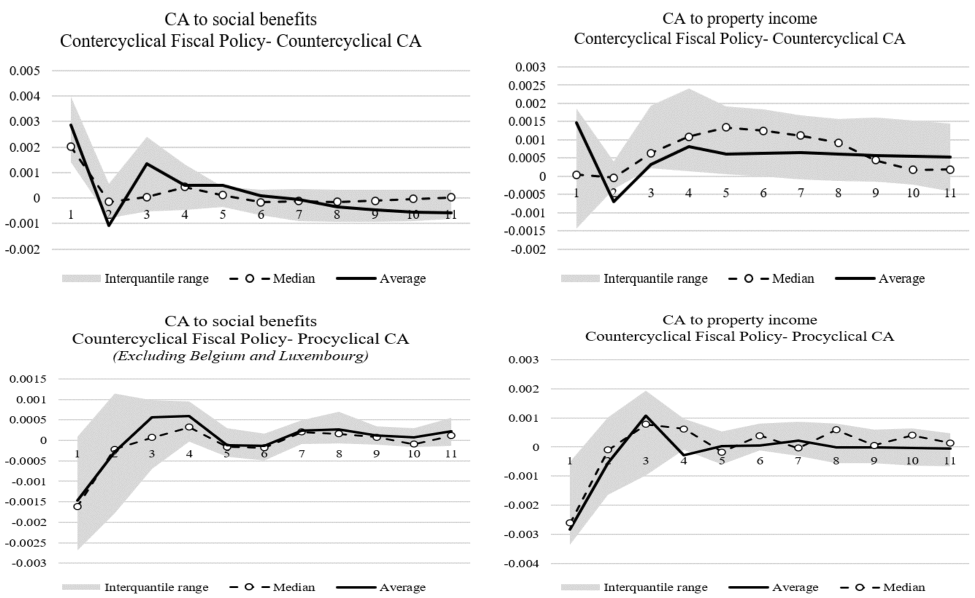
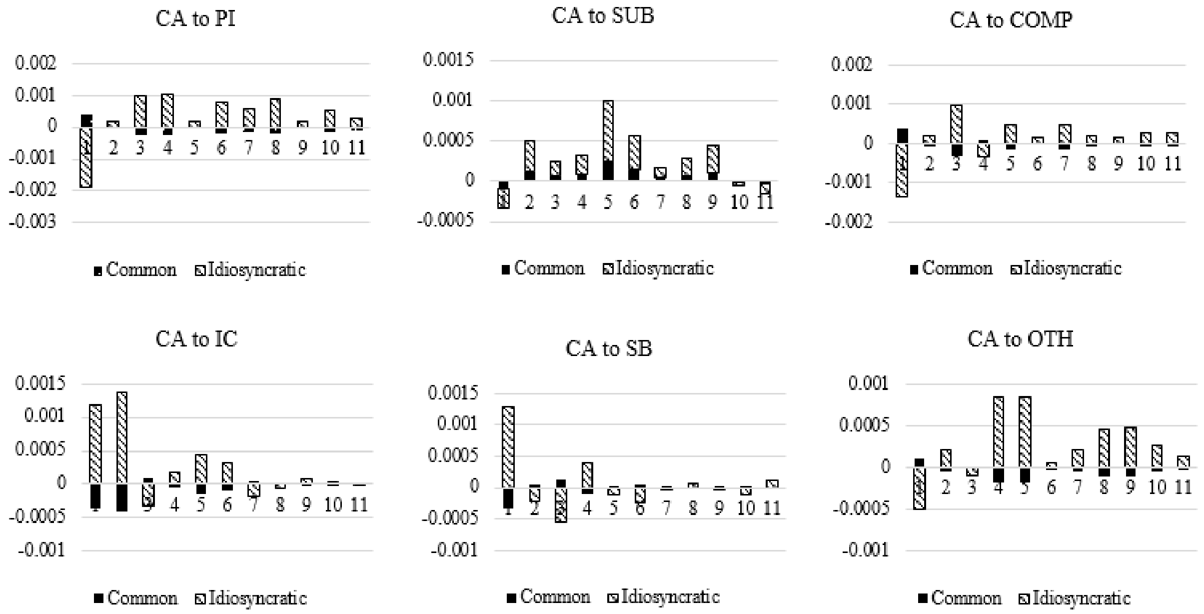
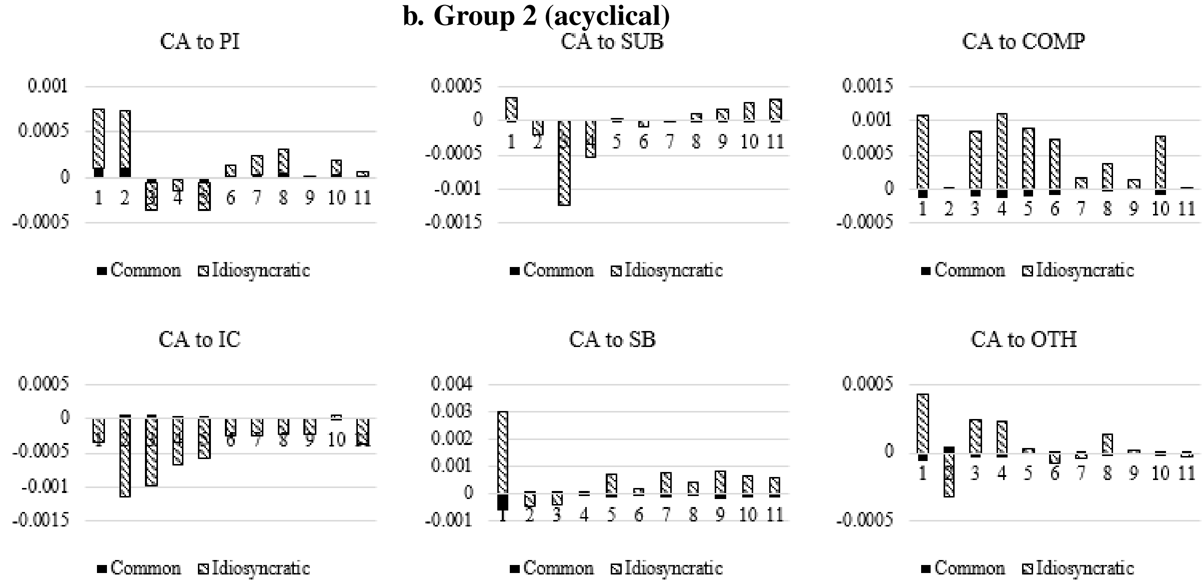


FIGURE 2.5: Decomposition of the median composite response of the current account to a one-unit composite shock to disaggregate government expenditures between common and idiosyncratic responses (by fiscal cyclicality group)

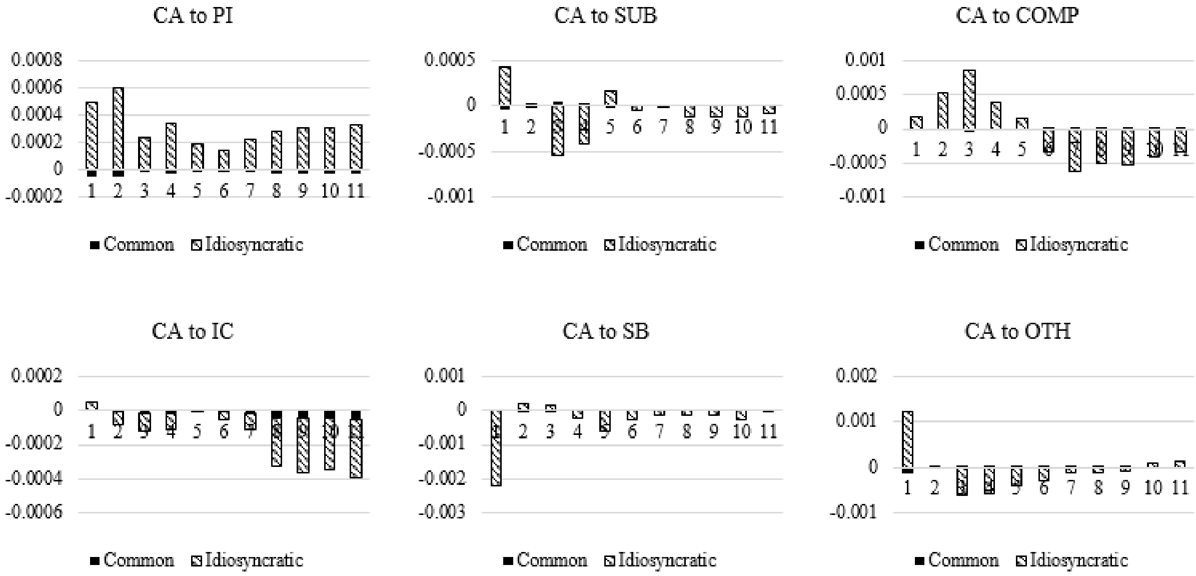
a. Group 1 (countercyclical)



b. Group 2 (acyclical)

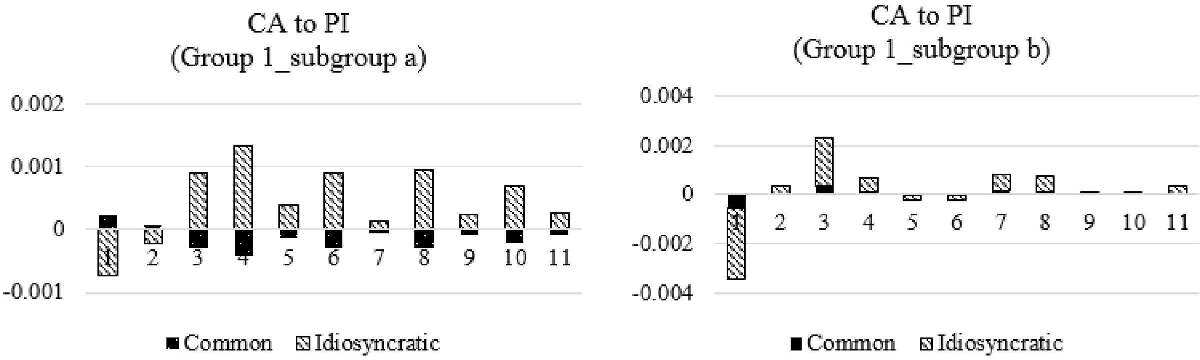


c. Group 3 (procyclical)



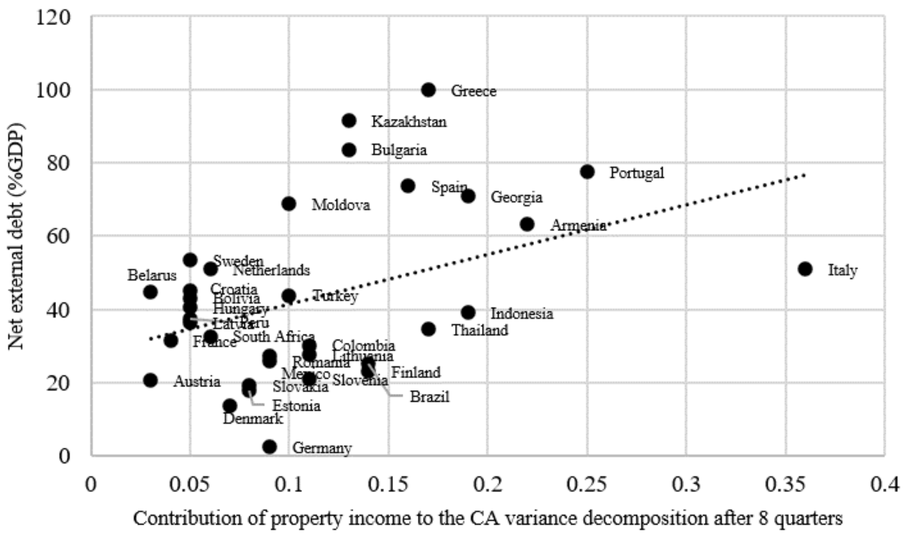
Notes: CA= current account balance, PI= property income, SUB= subsidies, COMP= Compensation of employees, IC= intermediate consumption, SB= social benefits, OTH= Other expenditures. Data in domestic currency divided by GDP. Group 1 is the group of countries of the 1st tercile in terms of measures of fiscal cyclicality defined as the correlation between cyclical components of GDP and government expenditures (< -0.09). Group 2 is the group of countries of the 2nd tercile (between -0.09 and 0.05). Group 3 is the the 3rd tercile (fiscal cyclicality measure above 0.05).

FIGURE 2.6: Decomposition of the median composite response of the current account to a one unit composite shock to property income expenditures between common and idiosyncratic responses (by subgroups of group 1)



Notes: CA= ratio of current account balance/GDP, PI= property income/GDP. Group 1 contains countries of the 1st tercile in terms of fiscal cyclicality (value < -0.09). Subgroup (b) includes the countries of Croatia, Denmark, Finland, Luxembourg and Switzerland and subgroup (a) the remaining 11 countercyclical economies

FIGURE 2.7: Scatter plot of property income contribution to the CA variation based on results of the variance decomposition in Table 6, by level of average net external debt to GDP



Notes: Data for the X axis are from results on Table 2.6. Data of Net External Debt to GDP correspond to the average of net external debt over the last 10 years, available for 34 out of the 51 sample countries and calculated from the databases of the WDI and Eurostat's "Balance of Payments and other external statistics".

Appendix A: Empirical literature on the twin deficits hypothesis

Previous empirical studies on the twin deficits hypothesis (part 1)

Study	Countries	Period	Methodology	Conclusion
Abell (1990)	USA	1979-1985 (monthly)	VAR (multivariate extension), Granger causality tests, impulse response functions	Twin deficits are connected through the transmission mechanisms of interest rates and exchange rates
Alkswani (2000)	Saudi Arabia	1970-1999	Cointegration analysis, error correction models, granger causality tests	CAB causes FB
Altintas and Taban (2011)	Turkey	1974-2010	ARDL, cointegration analysis, Granger causality	Twin deficits co-moving together in the long-run
Anoruo and Ramchander (1998)	5 southeast-Asian developing economies	1960-1993 (unbalanced)	VAR model, causality tests	CAB causes FB, bi-directional causality for Malaysia
Bernheim (1988)	USA, Canada, Japan, Mexico, UK, Germany	1960-1984	OLS	1$ increase in fiscal deficit leads 0.30$ decline in CA surplus
Campa and Gavilan (2011)	10 euro area countries	1977Q1-2005Q4 (unbalanced)	Estimation based on an intertemporal model for the CA, VAR, Granger causality tests, volatility, decomposition, tests for structural breaks	Model accepted for 6 countries + Derivation of expectations of future income and relative prices underlying the CAB
Chihi and Normandin (2013)	24 developing countries	1960-2005 (unbalanced)	VAR models, covariance analysis	Positive co-movement between the external and budget deficits
Chinn and Prasad (2003)	18 industrialized + 71 developing economies	1971-1995	Cross-section and panel regression techniques	CAB positively correlated with FB and initial shocks of net foreign assets
Darrat (1988)	USA	Quarterly data from 1960 to 1984	Granger multivariate causality tests + Akaike error criterion	Bi-directional causality
Enders and Lee (1990)	USA	Quarterly data from 1947Q3 to 1987Q1	VAR	Temporary increase in budget deficit worsens CA deficit
Engel and Wang (2011)	25 OECD countries	1973Q1 to 2006Q3	Volatility, correlation analysis, simulations based on a RBC two-sector model including durables and nondurables	Volatility of imports and exports 3x higher than GDP, imports and exports are pro-cyclical, and positively correlated with each other, net exports are counter-cyclical
Ghosh and Ostry (1995)	5 industrialized + 45 developing countries	quarterly unbalanced data from 1960 to 1991	VAR (consumption-smoothing approach)	Hypothesis of full consumption smoothing accepted for 2/3 of developing economies
Glick and Rogoff (1995)	G7 countries	1961-1990	Regression analysis using different models for investment and the current account and global/ country-specific productivity shocks	Positive response of investment to shocks, negative response of the CAB only in country-specific shocks
Hoffmann (2013)	China	1982-2007	VAR GMM , structural shocks, and FEVD, based on an estimated present-value model with non-tradable goods	Model explains more than 70% of the CA variation, importance of the consumption titling and smoothing adjustment channel based on prices expectations, factors related to China's domestic financial development are key in understanding global imbalances
Holmes (2011)	US	1960Q1-2008Q4	Markov-switching regimes regression analysis	Long-run positive relationship between FB and CAB
Hutchison and Pigott (1984)	USA	1973-1983	Heuristic, nontechnical analysis based on a theoretical framework linking FB to CAB	Causality from FB to CAB through exchange rates (affected by interest rates)

Previous empirical studies on the twin deficits hypothesis (part 2)

Study	Countries	Period	Methodology	Conclusion
Kearney and Monadjemi (1990)	8 countries	Quarterly data from 1972Q1–1987Q4	VAR	Validation of the twin deficits hypothesis, bi-directional causality
Kumhof and Laxton (2013)			Simulation of an increase in fiscal deficits in a derived open economy business cycle model with finite-horizon households	Higher fiscal deficits lead to a short-run and long-run deterioration of the current account balance. Permanently higher fiscal deficits increase interest rates.
Lane (2003)	22 OECD countries	1960–1998	OLS+Weighted LS	Countries with volatile output and dispersed political power are the most likely to run pro-cyclical fiscal policies
Leachman and Francis (2002)	USA	Quarterly data 1974 Q1-1992 Q2	Co-integration and multicointegration	Causality from FB to CAB, no co-integration
Litsios and Pilbeam (2017)	Greece, Portugal, Spain	1980Q2- 2015 Q2	ARDL bounds cointegration test	CAB contains unit root after joining Euro zone + presence of statistical association between FB and CAB
Miller and Russek (1989)	USA	Quarterly, 1946Q1-1987Q3	Deterministic + stochastic techniques for separating the secular components from the cyclical components of the twin deficits, + cointegration analysis	Absence of co-integration, short-run causality from budget deficit to trade deficit
Normandin (1999)	USA, Canada	Quarterly data 1950 Q1-1992 Q3	VAR, causality tests, GMM estimations,unit root tests, cointegration tests	Twin deficits hypothesis confirmed + taking into account the stochastic properties of the budget deficit is crucial.
Otto (1992)	USA + Canada	Quarterly data, USA 1950Q1 to 1988Q4 and Canada 1950Ql to 1987Q4.	VAR estimation based on a life-cycle model	Rejection of the consumption-smoothing hypothesis
Ratha (2012)	India	1998-2009 (quarterly and monthly)	A bounds- testing approach to cointegration and error-correction modelling	Twin deficit hypothesis in the short-run, REH in the long-run
Saeed and Khan (2012)	Pakistan	1972 to 2008	Cointegration analysis, Granger causality	the twin deficit hypothesis is accepted by rejecting REH, CAB granger causes FB
Trachanas and Katrakilidis (2013)	Portugal, Ireland, Italy, Greece, Spain	1971-2009	Linear and asymmetric cointegration tests, allowing for structural breaks	No linear cointegration, existence of asymmetric long-run effects from FB to CAB
Tufail et al. (2014)	Pakistan	1972 to 2011	Cointegration analysis, VECM and causality tests	Bi-directional causality between FB and CAB, long-run effect of FB on CAB
Vamvoukas (1999)	Greece	1948-1993 (annual data)	Cointegration analysis, error correction models, Granger causality tests	Causality from FB to CAB in short and long-run
Winner (1993)	Australia	1948-1989	OLS regression	Rejection of the twin deficits hypothesis, REH holds for the Australian case
Zamanzadeh and Mehrara (2011)	Iran	1959-2007	Cointegration analysis, Vector error correction model (VECM)	Twin deficits hypothesis accepted, REH rejected
Zietz and Pemberton (1990)	USA	Quarterly data, 1972-1987	2SLS for a structural simultaneous equation framework including three different transmission channels	Budget deficit does not explain the 1980s CA deficit. Transmission channels from FB to CAB are more likely to be revenues and consumption than interest and exchange rates

Appendix B: The Intertemporal model of the Current Account

The intertemporal model of the current account is based on an expression for the current account that can be derived from two elements. The first element is the national income identity $Y_t = I_t + G_t + NX_t + C_t$ where the net exports NX_t are the difference between the CA and income from net foreign assets $NX_t = CA_t - r_t A_t$. This identity leads to the following relation of the CA

$$CA_t = r_t A_t + Y_t - C_t - G_t - I_t \tag{2.7}$$

where A_t is the economy's stock of net foreign claims at the end of period $(t-1)$, r_t is the net interest rate paid on these assets, Y_t is the net domestic product, G_t is government consumption, and I_t is net investment.

By definition, it is also established that $CA_t = A_{t+1} - A_t$. Forward iteration of this expression using (2.7) and the transversality condition on external debt lead to

$$\sum_{s=t}^{\infty} R_{t,s} C_s = (1 + r_t) A_t + \sum_{s=t}^{\infty} R_{t,s} (Y_s - G_s - I_s) \tag{2.8}$$

where $R_{t,s}$ is defined as $R_{t,s} = \frac{1}{\prod_{v=t+1}^{s}(1+r_v)}$ with $R_{t,t} = 1$

The second element is the permanent income hypothesis which implies that the permanent level of consumption is determined by the permanent levels of the net domestic product, investment, and government expenditures. This relationship can be inferred from the optimality condition $u'(C_t) = \beta (1 + r_{t+1}) u'(C_{t+1})$, based on the assumption of intertemporal separability of consumer's utility. For $\sigma > 0$ representing the elasticity of intertemporal substitution and $u(C) = \frac{C^{1-1/\sigma} - 1}{1 - 1/\sigma}$, this condition implies that $C_{t+1} = \beta^{\sigma}(1 + r_{t+1})^{\sigma} C_t$ where $\beta \in (0, 1)$. Using this expression in (2.8) leads to (2.9).

$$C_t = \frac{(1 + r_t) A_t + \sum\limits_{s=t}^{\infty} R_{t,s} (Y_s - G_s - I_s)}{\sum_{s=t}^{\infty} R_{t,s} \left(\beta^{s-t} / R_{t,s}\right)^{\sigma}} \tag{2.9}$$

Then defining the permanent level of a given variable X as $\tilde{X}_t = \frac{\sum_{s=t}^{\infty} R_{t,s} X_s}{\sum_{s=t}^{\infty} R_{t,s}}$, and using the fact that $\frac{1+r_t}{\sum_{s=t}^{\infty} R_{t,s}} = \tilde{r}_t$ since $\sum_{s=t+1}^{\infty} R_{t,s} r_s = 1$, the following expression for the CA is obtained

$$\begin{aligned} CA_t &= (r_t - \tilde{r}_t)A_t + (Y_t - \tilde{Y}_t) - (G_t - \tilde{G}_t) - (I_t - \tilde{I}_t) \\ &+ \left[1 - \frac{1}{(\widetilde{\beta/R})^{\sigma}}\right] (\tilde{r}_t A_t + \tilde{Y}_t - \tilde{G}_t - \tilde{I}_t) \end{aligned} \tag{2.10}$$

Where the letters with a tilde represent the permanent level of the variables and $(\widetilde{\beta/R})^{\sigma}$ is the weighted average ratio of the $(s-t)$ period's subjective and market discount factors

$$(\widetilde{\beta/R})^{\sigma} \equiv \frac{\sum_{s=t}^{\infty} R_{t,s} \left(\beta^{s-t}/R_{t,s}\right)^{\sigma}}{\sum_{s=t}^{\infty} R_{t,s}} \tag{2.11}$$

Appendix C: The Present Value Model of the Current Account

The present value model of the CA is as follows

$$CA_t = -\sum_{i=1}^{\infty} \left(\frac{1}{1+r}\right)^i E_t \Delta NO_{t+i} \tag{2.12}$$

where the net output NO_t is given by $NO_t = Y_t - I_t - G_t$ and $\Delta NO_{t+i} = NO_{t+i} - NO_{t+i-1}$, with Y_t, I_t, G_t representing output, investment and government spending, respectively. This model can be derived from the total income identity, expressed as

$$Y_t = I_t + G_t + NX_t + rA_t + r(1+r)^{-1} \sum_{i=0}^{\infty} (1+r)^{-i} E_t \{Y_{t+i} - I_{t+i} - G_{t+i}\} \tag{2.13}$$

where the net exports NX_t are the difference between the CA and income from net foreign assets $NX_t = CA_t - rA_t$ and consumption has been replaced by the following equation[30]

$$\tilde{C}_t = rA_t + r(1+r)^{-1} \sum_{i=0}^{\infty} (1+r)^{-i} E_t \{Y_{t+i} - I_{t+i} - G_{t+i}\}$$

An expression for the CA can be inferred from (2.13)

$$CA_t = NO_t - r(1+r)^{-1} \sum_{i=0}^{\infty} \left(\frac{1}{1+r}\right)^i E_t NO_{t+i}$$

[30] See Nason and Rogers (2006).

Finally, using the fact that $r(1+r)^{-1}\left(\frac{1}{1+r}\right)^{i} NO_{t+i} = \frac{NO_{t+i}(1+r) - NO_{t+i}}{(1+r)^{i+1}} = \frac{NO_{t+i}}{(1+r)^{i}} - \frac{NO_{t+i}}{(1+r)^{i+1}}$, equation (2.12) is obtained.

To empirically verify this model, the approach of Campbell and Shiller (1987) and Campbell (1987) is usually applied. It consists in estimating the following VAR model and then testing some restrictions

$$Z_t = AZ_{t-1} + \mu_t \tag{2.14}$$

Where $Z_t = [\Delta NO_t, CA_t]'$, A is the compaion matrix and μ_t a vector of mean zero and homoscedastic errors. The forecast of Z_{t+i} for any period i can therefore be expressed as

$$E_t Z_{t+i} = A^i Z_t \tag{2.15}$$

This can be generalized to VAR models of p higher orders where Z_t would be a $2p$ dimensional vector such that $Z_t = [\Delta NO_t, \ldots, \Delta NO_{t-p+1}, CA_t, \ldots, CA_{t-p+1}]'$. The restrictions on the VAR model can be obtained by noting that the expression (2.12) can be rewritten as

$$g' Z_t = -\sum_{i=1}^{\infty} \left(\frac{1}{1+r}\right)^{i} h' A^i Z_t \tag{2.16}$$

Where g' and h' are row vectors with $2p$ elements, all of which are zero except for the $p+1^{st}$ element of g' and the first element of h' which are unity. This last expression implies that

$$g' = -h' A \left[I - \frac{A}{(1+r)}\right]^{-1} \frac{1}{(1+r)} \tag{2.17}$$

A first test of the present value model consists in regressing $CA_{f,t}$ (estimated through the VAR system) on the vector Z_t and verifying the $p+1^{st}$ coefficient or in performing a χ^2 test for the values of g'. Another test consists in verifying the implied restrictions on the individual coefficients of the loading matrix A and which can be obtained by multiplying in (2.17) by $\left[I - \frac{A}{(1+r)}\right]$

$$g' \left[I - \frac{A}{(1+r)}\right] = -h' A \frac{1}{(1+r)} \tag{2.18}$$

As shown in Campbell (1987), if it is assumed that the matrix A corresponds to

$$A = \begin{bmatrix} a_1 & \ldots\ldots & a_p & b_1 & \ldots\ldots\ldots & b_p \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ c_1 & \ldots\ldots & c_p & d_1 & \ldots\ldots & d_p \\ . & . & . & . & . & . \\ . & . & . & . & . & . \end{bmatrix}$$

Then the condition (2.18) is equivalent to the following restrictions on individual coefficients $a_1 = c_1, \ldots, a_p = c_p$, $d_1 - b_1 = (1 + r)$, $b_2 = d_2, \ldots, b_p = d_p$. To test those restrictions, it is possible to subtract the ΔNO_t equation in the VAR model from the CA_t equation to get

$$CA_t - \Delta NO_t = (c_1 - a_1)\, \Delta NO_{t-1} + \ldots + \left(c_p - a_p\right) \Delta NO_{t-p} + (d_1 - b_1)\, CA_{t-1} \\ + (d_2 - b_2)\, CA_{t-2} + \ldots + \left(d_p - b_p\right) CA_{t-p} + u_{2t} - u_{1t}$$

In that case, it is possible to use a single-equation regression to verify that

$$CA_t - \Delta NO_t - (1 + r)\, CA_{t-1} = u_{2t} - u_{1t}$$

Meaning that the left hand side (usually expressed with a script notation as $\mathcal{CA}_t$) cannot be predicted with lagged ΔNO_t and CA_t. This can be checked using a Wald test. Several extensions have been provided to the basic PVM. For example, İşcan (2002) included the categories of durable and non-traded goods in the model. Bergin and Sheffrin (2000) also included the distinction between traded and non-traded goods and added the variables of interest rate and exchange rate.

Appendix D: Data description

Data have been extracted from the following sources, in millions of domestic currency, used in real terms and divided by the population (population data from the IFS)

Variable	Data source	Adjustment
Gross Domestic Product	Data in real terms from the IMF's International Financial Statistics (IFS) database	Gaps completed using nominal series and GDP deflator calculated from annual series, or using growth rate of annual real series (in absence of nominal quarterly data)
Net Foreign Assets	IMF- Balance of Payments and International Investment Position database	
Current account balance	Data in nominal terms from Datastream (DS mnemonic = "country code" & CURBALA)	Deflated using calculated GDP deflator. For data only available in US dollars, data for other variables converted to US dollars based on PPP (from the World Bank database)
General government consumption expenditure	Data in real terms from Datastream (DS mnemonic: "country code" & XGCSA.D, if absent data without seasonal adjustment taken instead, DS mnemonic: "country code" & XGCSA.C)	
Gross fixed capital formation	Data in current prices from Datastream ("country code" & GFCF.C), or from the IFS	Converted to real terms using a deflator calculated based on annual nominal and real series from IFS
Private consumption	Data in current prices from Datastream ("country code" & CNPER.D), or from the IFS	
Short-term interest rates	Short-term interest rates from IFS (IMF)	Gaps completed based on Short-term interest rates from Datastream (OECD: "country code" & OCFISTR, Oxford economics: "country code" & XRCB..R) or the Policy rate (Datastream: "country code" & PRATE.) or the Money Market rates (IFS)

Variable	Data source	Adjustment
Fiscal balance	Data in current prices from Datastream ("country code" & GOVBALA) or from the IFS	Deflated using calculated GDP deflator
Disaggregate fiscal data (European Union)	Government Finance Statistics (Eurostat) http://ec.europa.eu/eurostat/data /database (access from website: General and regional statistics >>Economy and Finance >>Government Statistics)	Deflator calculated from real Government consumption expenditures series and nominal series extracted from IFS (when unavailable, calculation is made from annual data)
Disaggregate fiscal data (non-EU countries)	Government Finance Statistics (IMF), "Expense" dataset http://data.imf.org/?sk= 3C005430-5FDC-4A07-9474-64D64F1FB3DC	Deflator calculated from real Government consumption expenditures series and nominal series extracted from IFS, averaged yearly (when unavailable, calculation is made from annual data)

Additional adjustments

The initial dataset comprises 57 countries with data from 1995Q1 to 2019Q2. For reasons of data availability, 6 non-EU countries are excluded from the sample when disaggregate data are added to the analysis. Eurostat disaggregate fiscal data are available for the 28 European Union (EU) countries, starting from 2002. The values match those of the Government Finance Statistics of the IMF (except that the latter excludes the categories of tax expenses and transfers). For non-EU countries, data are extracted from the IMF Government Finance Statistics database. This subsample consists of 23 non-EU countries. Disaggregate fiscal data are deflated using a price deflator calculated from nominal and real government consumption expenditures. The series are then divided by the population size. For fiscal data of countries that were available on an annual basis, temporal disaggregation is performed through JDemetra+ software[31](provided by Eurostat). The quarterly values are estimated using quarterly GDP as the higher frequency indicator series, based on the Chow-Lin method (Chow and Lin (1971)) that assumes the quarterly residuals follow an autoregressive process of order 1 (AR1). After those adjustments, the resulting dataset is a balanced panel of 51 countries over the period 2002Q1-2018Q4.

[31] http://ec.europa.eu/eurostat/cros/content/download_en (replacing old Ecotrim)

Appendix E: Description of government expenses categories

Government expenditure comprises the following ESA categories. These definitions have been taken from the ESA 2010 manual (Chapters 3 and 4).

- **P2 Intermediate consumption**: intermediate consumption consists of goods and services consumed as inputs by a process of production, excluding fixed assets whose consumption is recorded as consumption of fixed capital. The goods and services are either transformed or used up by the production process.
- **P5 Gross capital formation**: includes in addition to gross fixed capital formation, changes in inventories and acquisitions less disposals of valuables.
- **D1 Compensation of employees**: defined as the total remuneration, in cash or in kind, payable by an employer to an employee in return for work done by the latter during an accounting period. It includes wages and salaries in addition to social contributions such as pensions.
- **D29 Other taxes on production, payable**: consist of all taxes that enterprises incur as a result of engaging in production, independent of the quantity or value of the goods and services produced or sold.
- **D3 Subsidies, payable**: current unrequited payments which general government or the institutions of the European Union make to resident producers.
- **D4 Property income, payable**: property income (D.4) accrues when the owners of financial assets and natural resources put them at the disposal of other institutional units. The income payable for the use of financial assets is called investment income (e.g., interests and dividends), while that payable for the use of a natural resource is called rent. Property income is the sum of investment income and rent.
- **D5 Current taxes on incomes, wealth, etc.**: "current taxes on income, wealth, etc." (D.5) cover all compulsory, unrequited payments, in cash or in kind, levied periodically by general government and by the rest of the world on the income and wealth of institutional units, and some periodic taxes which are assessed neither on that income nor that wealth.
- **Social benefits**: social benefits include the following:
  - D62 Social benefits other than social transfers in kind, made up of:
    - Social security benefits in cash: social security benefits in cash are social insurance benefits payable in cash to households by social security funds. Reimbursements are excluded and treated as social transfers in kind (D.632).

    * Other social insurance benefits: other social insurance benefits correspond to benefits payable by employers in the context of other employment related social insurance schemes. Other employment-related social insurance benefits are social benefits (in cash or in kind) payable by social insurance schemes other than social security to contributors to the schemes, their dependents or their survivors.
    * Social assistance benefits in cash: social assistance benefits in cash are current transfers payable to households by government units or NPISHs to meet the same needs as social insurance benefits but which are not made under a social insurance scheme requiring participation usually by means of social contributions.
  - **D632 Social transfers in kind- purchased market production**: individual goods and services in the form of reimbursements by social security funds of approved expenditures made by households on specific goods and services; or provided directly to the beneficiaries by market producers from which general government purchases the corresponding goods and services.

- **D7 Other current transfers**: include net non-life insurance premiums, non-life insurance claims, Current transfers within general government, Current international cooperation, miscellaneous current transfers and VAT- and GNI-based EU own resources.

- **D8 Adjustment for the change in pension entitlements**: the adjustment for the change in pension entitlements (D.8) represents the adjustment needed to make appear in the savings of households the change in the pension entitlements on which households have a definite claim. The pension entitlement change comes from contributions and benefits recorded in the secondary distribution of income account.

- **D9 Capital transfers, payable**: capital transfers require the acquisition or disposal of an asset, or assets, by at least one of the parties to the transaction. Whether made in cash or in kind, they result in a commensurate change in the financial, or non-financial, assets shown in the balance sheets of one or both parties to the transaction.

- **NP Acquisitions less disposals of non-produced assets**: non-produced assets consist of assets that have not been produced within the production boundary, and that may be used in the production of goods and services. This includes acquisitions of natural resources, contracts/leases/licenses, goodwill and marketing assets.

Appendix F: Methodology for conducting heterogeneous structural panel VAR analysis

I briefly describe Pedroni (2013) approach in the following. Consider a panel composed of $i = 1, \ldots, N$ individual members, each of which consists of an $M \times 1$ vector of observed endogenous variables y_{it}. The data are assumed to be observed over T time periods $(t = 1, ..., T)$ for each member and used after de-meaning, where the $M \times 1$ vector of de-meaned data is $z_{it} = y_{it} - \bar{y}_i$. Structural composite white noise shocks ϵ_{it} may be cross-sectionally dependent as expressed by the relation $\epsilon_{it} = \Lambda_i \bar{\epsilon}_t + \tilde{\epsilon}_{it}$, where $\bar{\epsilon}_t$ and $\tilde{\epsilon}_{it}$ represent common white noise shocks shared by all members and member-specific idiosyncratic white noise shocks, respectively, and Λ_i is an $M \times M$ diagonal matrix with the loading coefficients. The two types of shocks are assumed to be orthogonal to each other. The moving average representation of the model is as follows: $R_i (L) z_{it} = \mu_{it}$, where $R_i (L) = I - \sum_{j=1}^{P_i} R_{ij} L^j$, with P_i the lag truncation value, which can differ from one cross section to the other. The associated structural form model is $z_{it} = A_i (L) \epsilon_{it}$ or $B_i (L) z_{it} = \epsilon_{it}$, where $B_i (L) = A_i (L)^{-1}$. Short-run restrictions can be imposed on the $B_i (0)$ matrix. In the special case of recursive restrictions (used in the present study), this is equivalent to the Cholesky orthogonalization. The identification strategy is based on a scenario of an exogenous fiscal policy and an endogenous CA balance. Thereby, government expenditures are placed first and the CA last in the Cholesky ordering.

The first step of the methodology is to estimate the reduced-form VAR through ordinary least squares (OLS) . Initially, the model is estimated separately for each cross section. Then, to capture the common dynamics, the $M \times 1$ vector of common time effects $\bar{z}_t = N_t^{-1} \sum_{i=1}^{N_t} z_{it}$ is calculated and the corresponding reduced-form VAR model $\bar{R} (L) \bar{z}_t = \bar{\mu}_t$ is estimated. Then, the appropriate identifying restrictions are used to obtain the structural shock estimates $\epsilon_{it} = B_i (L) R_i (L)^{-1} \mu_{it}$ and $\bar{\epsilon}_t = \bar{B} (L) \bar{R} (L)^{-1} \bar{\mu}_t$. Moreover, to obtain the elements of the loadings matrix Λ_i, $N \times M$ OLS regressions of ϵ_{it} on $\bar{\epsilon}_t$ are run, based on the relation $\epsilon_{it} = \Lambda_i \bar{\epsilon}_t + \tilde{\epsilon}_{it}$. At this stage, I report the median impulse responses for the subsamples along with bootstrap confidence intervals from 100 repetitions.

In the final step, the quartile impulse responses are estimated with the decomposition of responses between those to common and those to idiosyncratic shocks. The composite impulse response functions calculated from the individual structural VAR estimation can be decomposed into common and idiosyncratic shocks as follows: First, a re-scaling of the responses to idiosyncratic shocks is required, based on the following argument: The variances for the structural shocks can be expressed as $E \left[\epsilon_{it} \epsilon_{it}' \right] = E \left[(\Lambda_i \bar{\epsilon}_t + \tilde{\epsilon}_{it}) (\Lambda_i \bar{\epsilon}_t + \tilde{\epsilon}_{it})' \right] = \Omega_{i,\epsilon} = \Lambda_i \Omega_{i,\bar{\epsilon}} \Lambda_i' + \Omega_{i,\tilde{\epsilon}}$. Setting $\Omega_{i,\bar{\epsilon}} = \Omega_{i,\epsilon} = I$, implies $\Omega_{i,\tilde{\epsilon}} = I - \Lambda_i \Lambda_i{}'$. This means that responses to common shocks for unity-sized shocks would correspond to responses to idiosyncratic shocks for shocks of size $1 - \Lambda(m, m)^2$, where $m = 1, ..., M$ (since Λ_i is diagonal). To perform the re-scaling, the expression for composite structural shocks can be rewritten as $\epsilon_{it} = \Lambda_i \bar{\epsilon}_t + \left(I - \Lambda_i \Lambda_i'\right)^{1/2} \tilde{\epsilon}_{it}^*$. Finally, this re-scaled form can be used to decompose the impulse responses such that $A_i(L)\,\epsilon_{it} = A_i(L)\left(\Lambda_i \bar{\epsilon}_t + \left(I - \Lambda_i \Lambda_i'\right)^{\frac{1}{2}} \tilde{\epsilon}_{it}^*\right)$, leading to the decomposition (for a one unit shock) $A_i(L) = \bar{A}_i(L) + \tilde{A}_i(L)$ where $\bar{A}_i(L) = A_i(L)\,\Lambda_i$ and $\tilde{A}_i(L) = A_i(L)\left(I - \Lambda_i \Lambda_i'\right)^{\frac{1}{2}} = A_i(L) - \bar{A}_i(L)$. The sample distribution of estimated responses can be used to describe the properties of the sample (with the median, and the 1st and 3rd quartiles used as confidence intervals) or to create fitted values for member-specific impulse responses.

Appendix G: Methodology for estimating individual Bayesian VAR models by country

The time-series Bayesian VAR approach used on the paper is based on independent normal-Wishart priors with Gibbs sampling, from which the variance decomposition is derived. The independent normal-Wishart priors set for β and Σ (respectively the vector of parameters and the residual variance-covariance matrix) are

$$\beta \sim N(\beta_0, V_0)$$

$$\Sigma \sim \mathrm{IW}(S_0, \alpha_0)$$

β_0 is a vector of nearly all zeros except the diagonal elements corresponding to coefficients of a variable's first own lag (hyper-parameter μ_1) that can be set to a different value, usually 1 for a random walk or less for a AR(1) process. In the present case, the prior means are set to zero. For V_0, the following hyperparameters are used $\lambda_1 = 0.1$, $\lambda_2 = 0.5$, $\lambda_3 = 1$ and $\lambda_4 = 100$, common in the literature. The residual standard deviations of the variables are calculated based on an unrestricted least square estimate. Conditional posterior distributions for the dataset y are

$$(\beta | y, \Sigma) \sim \mathrm{N}(\bar{\beta}, \bar{V})$$

$$(\Sigma | y, \beta) \sim \mathrm{IW}(\bar{S}, \bar{\alpha})$$

where

$$\bar{V} = \left({V_0}^{-1} + \left(\hat{\Sigma}^{-1} \otimes (X'X)^{-1}\right)\right)^{-1}$$

$$\bar{\beta} = \bar{V}\left({V_0}^{-1}\beta_0 + \left(\hat{\Sigma}^{-1} \otimes X'\right) y\right)$$

$$\bar{S} = S_0 + E'E$$

$$\bar{\alpha} = \alpha_0 + T$$

where $S_0^{-1} = \lambda_1 I$, ${V_0}^{-1} = \lambda_2 I$, and $\alpha_0 = \lambda_3$. With the residual matrix $E = Y - XB$ for $\beta = vec(B)$, $y = vec(Y)$ and X the regressors matrix. The scale matrix $\bar{S}$ and the degrees of freedom $\bar{\alpha}$ are calculated based on prior error variance of endogenous variables S_0[32] and prior degrees of freedom of the error-term α_0. The prior degrees of freedom to are set to be equal to 10 (number of endogenous variables). Based on an initial estimate of Σ, a Gibb's sampler is used to obtain properties of the

[32] Following Karlsson (2012), S_0 can be set to be the diagonal variance covariance matrix obtained from individual AR regressions.

unconditional posteriors with 10000 iterations and 200 burn-in draws. As a robustness check, I also estimate the same model using the Litterman-Minnesota prior based on hyper-parameters $\lambda_1 = 0.1$, $\lambda_2 = 0.99$, $\lambda_3 = 1$ and determination of the residual variance-covariance matrix from univariate autoregressive estimates.

Appendix H: Estimation of the CA model with Aggregate Government Spending based on different Cholesky orderings

To verify the validity of the identification strategy, different other orderings of the variables in the VAR model are tried. In a first step, the following alternatives are used and compared with the baseline ordering (all with exogenous spending and endogenous CA):

- **Baseline** government expenditures, the short-term interest rate, net foreign assets, net investment, and the Current Account Balance.
- **Alternative 1** government expenditures, the short-term interest rate, net investment, net foreign assets, and the Current Account Balance.
- **Alternative 2** government expenditures, net foreign assets, the short-term interest rate, net investment, and the Current Account Balance.
- **Alternative 3** government expenditures, net foreign assets, net investment, the short-term interest rate, and the Current Account Balance.
- **Alternative 4** government expenditures, net investment, the short-term interest rate, net foreign assets, and the Current Account Balance.
- **Alternative 5** government expenditures, net investment, net foreign assets, the short-term interest rate, and the Current Account Balance.

Estimation results are identical across these alternative specifications. An example of impulse response functions of the CA to a shock to government spending is shown in Figure (a).

In a second step, government spending is placed at different other positions. At this stage, the response of the CA remains similar in shape but the number of countries with a positive response slighlty decreases (lower upper quartile) as government spending gets closer to the fourth position (see Figure (b)).[33] Finally, Figure (c) shows some responses if the CA is placed at different positions in the Cholesky ordering. It can be noted that if the CA is placed before government spending, then the response is much less significant (interquartile range between -0.6 and 0.4). On the other hand, placing the CA before or after the interest rate does not change much. To conclude, it appears

[33] If government spending is placed last and the CA fourth, the response resembles the one in Figure (c) (CA placed before government spending).

that different orderings do not significantly affect the CA's response to government spending shocks, unless the CA is placed before government spending. But even in that case, the main conclusion from the first estimation of the model does not change.

Figure (a)

Response of the CA to a positive government spending shock for 5 alternative orderings

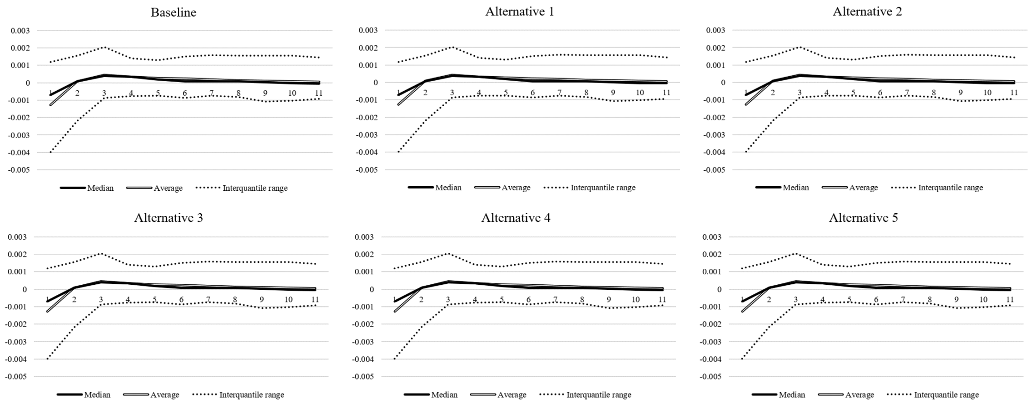


Figure (b)

Response of the CA to a positive government spending shock with different orderings of government spending

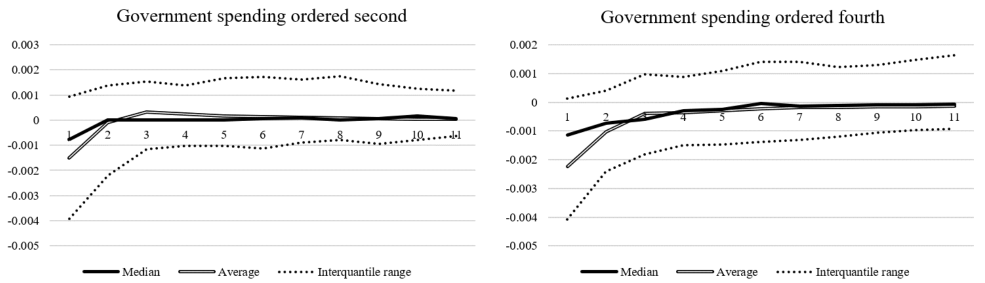
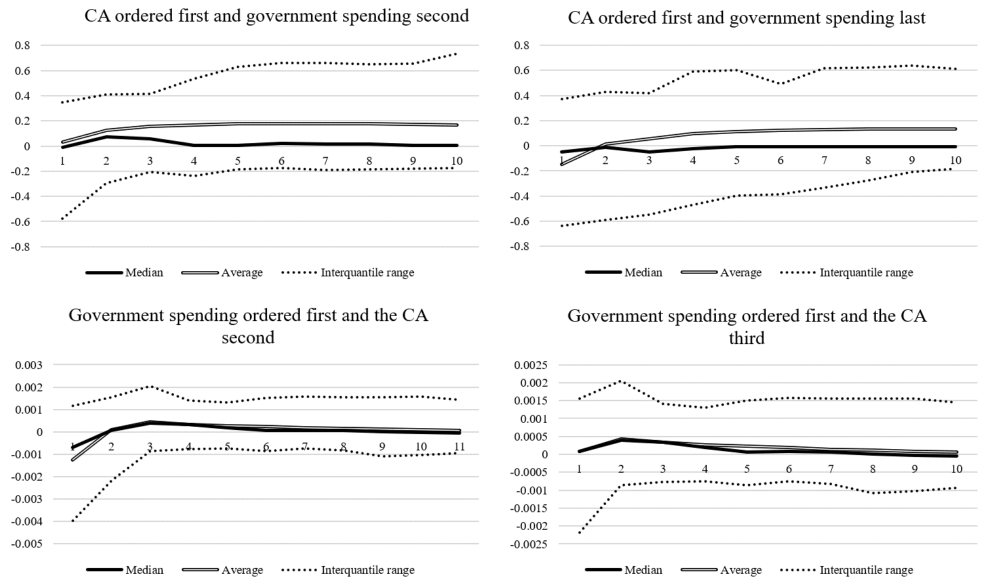


Figure (c)

Response of the CA to a positive government spending shock with different orderings of the CA



Appendix I: The CA and disaggregate government spending in countercyclical economies

First, some descriptive figures on the group of countercyclical economies are extracted (displayed on the following tables).

Table (a): Average values of the CA, total Government spending and shares of spending components from total spending

Countries	CA/ GDP	Gov. Spend./ GDP	Share from total spending COMP	IC	PI	SUB	SB	OTH
Countercyclical economies with countercyclical CA								
Chile	-0.003	0.22	0.28	0.13	0.03	0.18	0.23	0.15
France	-0.004	0.52	0.25	0.10	0.05	0.04	0.48	0.09
Latvia	-0.054	0.29	0.30	0.19	0.03	0.03	0.33	0.10
Slovakia	-0.044	0.37	0.22	0.15	0.05	0.03	0.48	0.07
South Korea	0.023	0.19	0.23	0.18	0.05	0.10	0.26	0.18
Switzerland	0.102	0.30	0.24	0.15	0.03	0.10	0.37	0.11
United States	-0.035	0.33	0.28	0.17	0.12	0.01	0.40	0.02
Average	**-0.002**	**0.32**	**0.26**	**0.15**	**0.05**	**0.07**	**0.36**	**0.10**
Countercyclical economies with procyclical CA								
Austria	0.024	0.49	0.22	0.13	0.06	0.03	0.46	0.10
Belgium	0.017	0.53	0.24	0.08	0.08	0.06	0.47	0.07
Canada	-0.013	0.35	0.32	0.23	0.11	0.03	0.25	0.06
Croatia	-0.006	0.44	0.27	0.18	0.06	0.05	0.37	0.08
Denmark	0.053	0.51	0.32	0.17	0.04	0.04	0.36	0.07
Finland	0.014	0.50	0.28	0.20	0.03	0.03	0.40	0.06
Germany	0.060	0.44	0.18	0.11	0.05	0.02	0.56	0.08
Japan	0.030	0.35	0.17	0.09	0.07	0.02	0.58	0.07
Luxembourg	0.072	0.33	0.23	0.09	0.01	0.03	0.53	0.11
Sweden	0.054	0.51	0.27	0.18	0.03	0.03	0.37	0.12
Average	**0.03**	**0.44**	**0.25**	**0.14**	**0.05**	**0.04**	**0.43**	**0.08**

Table (b): Cyclicality measures by variable

Countries	CA	Gov. Spend.	COMP	IC	PI	SUB	SB	OTH
Countercyclical economies with countercyclical CA								
Chile	-0.34	-0.42	-0.13	0.14	0.13	0.10	-0.04	-0.45
France	-0.14	-0.13	-0.14	0.05	0.31	-0.43	-0.16	-0.06
Latvia	-0.77	-0.18	0.35	0.05	-0.60	0.08	-0.50	0.02
Slovakia	-0.28	-0.20	-0.04	0.02	-0.07	0.07	-0.17	-0.17
South Korea	-0.47	-0.23	-0.19	-0.35	0.37	-0.23	0.20	0.00
Switzerland	-0.16	-0.15	-0.58	-0.38	0.50	-0.48	-0.57	0.38
United States	-0.68	-0.67	-0.55	-0.42	-0.02	-0.22	-0.63	-0.68
Average	**-0.41**	**-0.28**	**-0.18**	**-0.13**	**0.09**	**-0.16**	**-0.27**	**-0.14**
Countercyclical economies with procyclical CA								
Austria	0.09	-0.12	-0.09	0.04	0.12	0.00	-0.07	-0.08
Belgium	0.06	-0.13	0.11	-0.16	0.20	0.37	-0.15	-0.13
Canada	0.65	-0.36	-0.44	-0.07	0.53	-0.09	-0.72	-0.13
Croatia	0.81	-0.25	0.37	0.56	-0.39	-0.56	-0.12	-0.21
Denmark	0.01	-0.22	-0.26	-0.08	-0.35	-0.26	-0.17	0.00
Finland	0.11	-0.29	-0.04	0.06	0.32	0.10	-0.33	-0.13
Germany	0.30	-0.23	-0.11	0.05	0.32	-0.42	-0.19	-0.07
Japan	0.25	-0.73	0.01	-0.14	0.18	-0.69	-0.38	-0.64
Luxembourg	0.11	-0.22	0.08	0.06	0.01	-0.03	-0.19	-0.04
Sweden	0.36	-0.14	0.02	-0.02	0.19	0.00	-0.26	-0.08
Average	**0.28**	**-0.27**	**-0.03**	**0.03**	**0.11**	**-0.16**	**-0.26**	**-0.15**

Notes: CA= current account balance, Gov. Spend.= Total Government spending, COMP= Compensation of employees, IC= intermediate consumption, PI= property income, SUB= subsidies, SB= social benefits, OTH= Other expenditures. Cyclicality measures correspond to the correlation coefficients between cyclical components of the variables and those of GDP.

From Table (a), it appears that countries with a procyclical CA tend to have a positive CA balance. The ratio of total government spending over GDP is on average between 0.30 and 0.55 for all countercyclical economies. Also, the major contributors to total government spending in the group appear to be social benefits and compensation of employees. In Table (b), the most countercyclical spending components are highlighted for each country. The categories of spending with the highest negative correlation values differ country by country. Nevertheless, it can be seen that social benefits is the only category of spending that is always countercyclical.[34] Compensation of employees is on the other hand more often countercyclical in the group with a countercyclical CA than in the one with a procyclical CA.

Then, to explain the significant responses of the CA to aggregate government spending in the countercyclical group (see section 2.7.2), quartile impulse responses are estimated at the aggregate level, by government spending component and by country (unreported here due to space constraints). The main conclusions from this analysis are reported in the following.

Countercylical economies with a countercyclical CA

In this subgroup, the response of the CA is positive after a government spending shock. By country, the CA in all countries responds positively to positive government spending shocks, except for Switzerland (where the response only gets positive from the second quarter). By component, the average response of the CA is positive on impact after a shock to all variables except subsidies. The highest responses on impact are those to social benefits, compensation of employees. At the second quarter, the responses to intermediate consumption and subsidies get significantly higher (and also compensation of employees to a lesser extent), whereas the responses to property income and social benefits drop. By country and spending component, the main conclusions are as follows:

- The CA responds positively to social benefits on impact in all countries, except France. The highest immediate response is noted in Switzerland and Chile. This response gets negative in the second quarter for Slovakia (then positive for the rest of the period).
- The immediate response of the CA to compensation of employees' shocks is positive in only three countries: Slovakia, Latvia and (with a lower magnitude) Chile.
- The response to intermediate consumption shocks is also positive on impact in all countries, except Switzerland. The highest response is noted in Slovakia and Latvia. The response of Slovakia gets very high at the second quarter.
- Finally, the average response of the CA to subsidies shocks is driven mainly by the response of Latvia (only positive response). At the second quarter, the response of Slovakia also becomes positive and high.

[34]There is only one exception which is South Korea.

Countercylical economies with a procyclical CA

In this subgroup, the response of the CA is negative after a government spending shock. By country, the CA responds negatively to positive government spending shocks in all countries, except for Denmark. By spending component, the average response of the CA on impact is negative only after a shock to property income and to a lesser extent other expenses. The highest positive responses are the ones to intermediate consumption and to subsidies. These responses get negative in the third quarter. Finally, by country and spending component, the following can be noted:

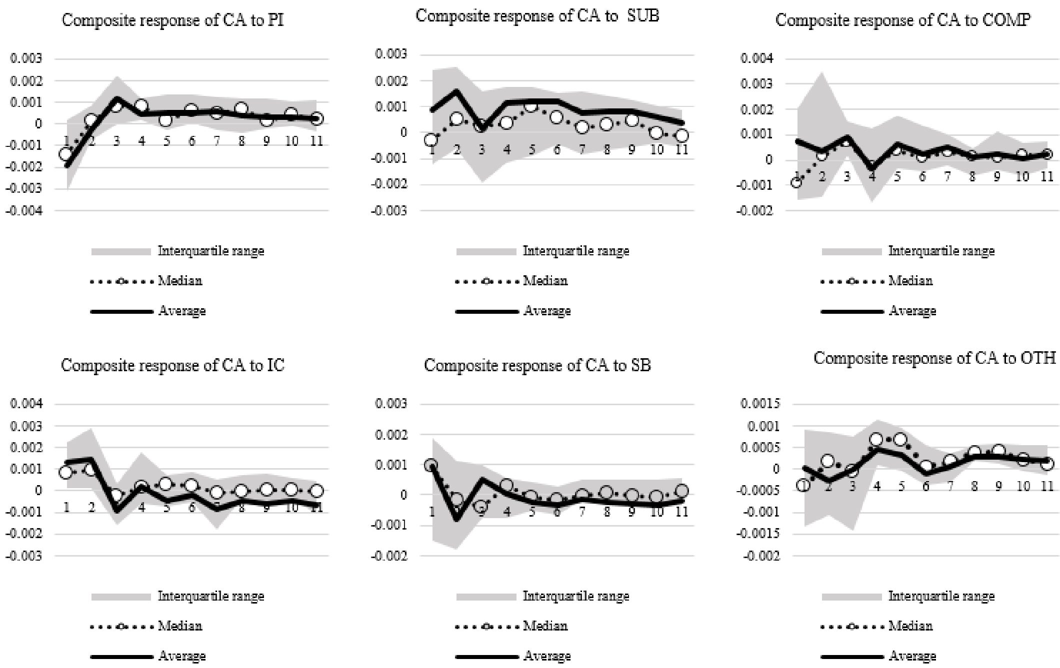
- On impact, the response of the CA to property income shocks is negative in all countries, except Austria and Belgium. The strongest decline is observed in Luxembourg (-0.015).[35] In the following quarters, the responses of Japan and Croatia get notably positive.
- The response to intermediate consumption is positive on impact in all countries, except Croatia and Sweden. The highest response is observed for Luxembourg. In the third quarter, the response in Luxembourg, and to a lesser extent Finland, gets negative.
- The response to subsidies on impact is positive in half of the cases (5 countries). The highest positive response is noted in Luxembourg. The response of Austria gets negative in the third quarter.
- It can be noted that for social benefits, the response is positive on impact in 4 out of the 10 countries (Japan, Belgium, Croatia and Luxembourg). The response in Luxembourg is particularly higher.[36] In addition, over the following periods, responses of Denmark and Finland get positive as well.
- Lastly, the response to compensation of employees is negative on impact in all countries, except Luxembourg, Belgium and Germany. In the following periods, responses of Denmark, Finland and Croatia get also positive.

[35] With a lower magnitude, a significant decline is also observed in Denmark (-0.004), Finland and Canada (both -0.003)

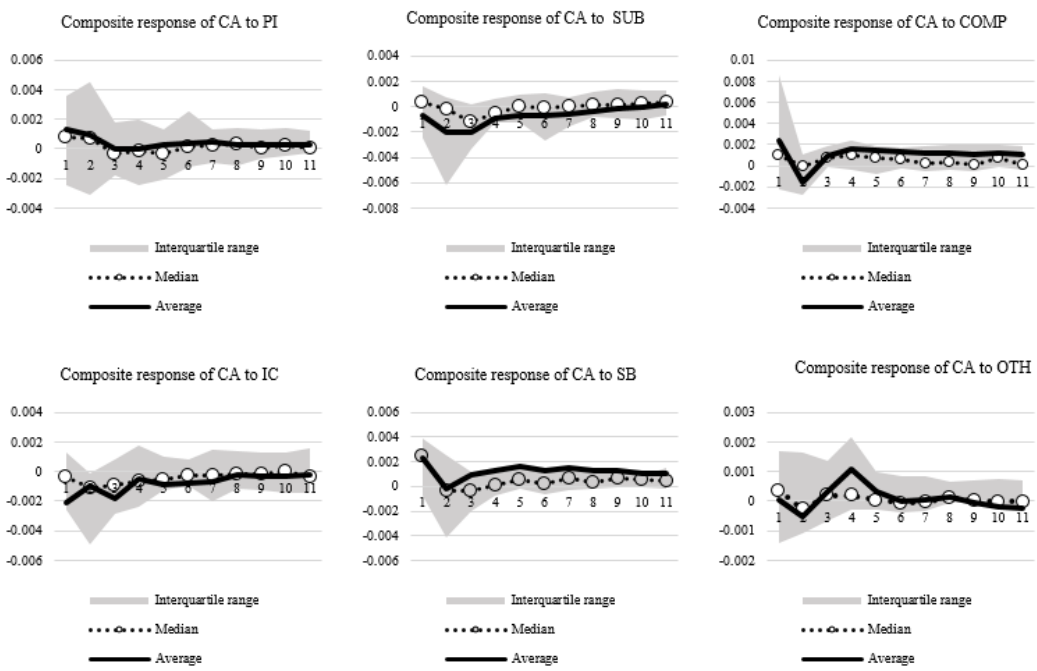
[36] An overall negative impact can be obtained if Luxembourg and Belgium are both removed

Appendix J: Quartile impulse responses of the CA to a one-unit composite shock to disaggregate government expenditures (by fiscal cyclicality group)

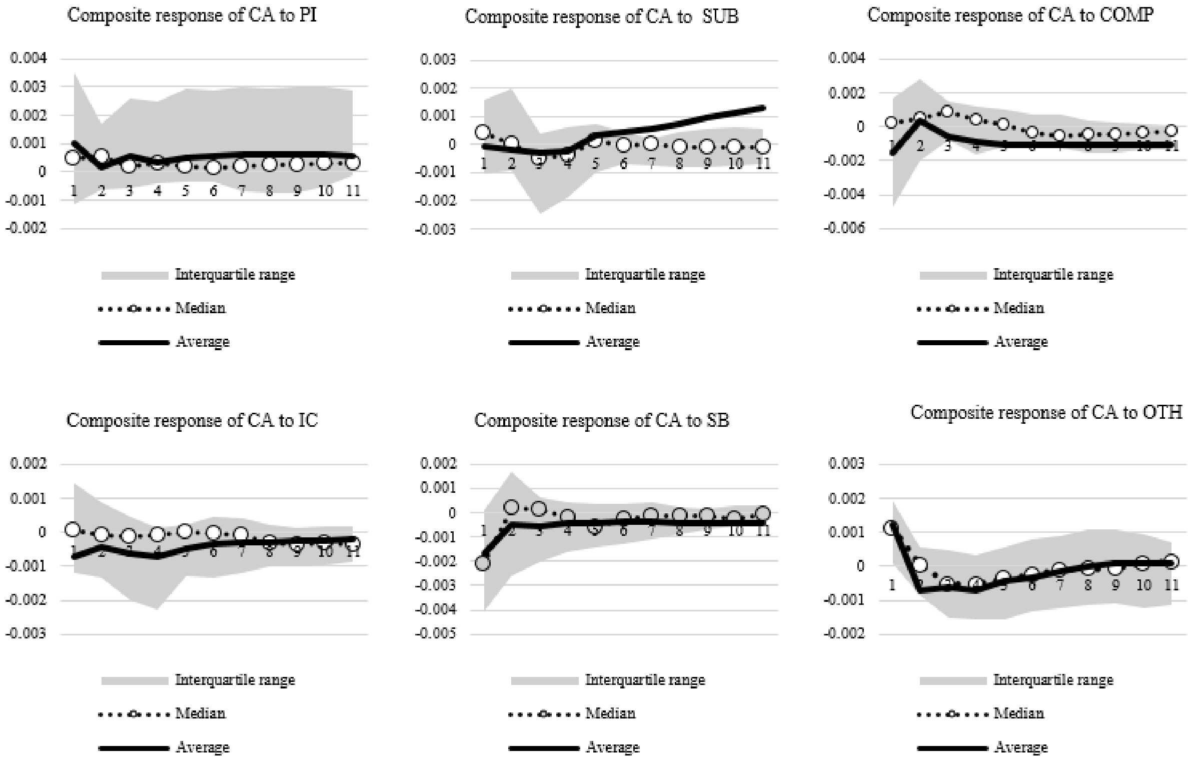
a. Group 1 (countercyclical)



b. Group 2 (acyclical)



c. Group 3 (procyclical)



Notes: CA= current account balance, PI= property income, SUB= subsidies, COMP= Compensation of employees, IC= intermediate consumption, SB= social benefits, OTH= Other expenditures. Data in domestic currency divided by GDP. Group 1 contains countries of the 1st tercile in terms of fiscal cyclicality (measure $<$ -0.09). Group 2 is the second tercile (acyclical economies with measure between -0.09 and 0.05) and Group 3 is the third tercile (procyclical economies with measure $>$0.05)

Chapter 3

Effects of fiscal stimulus policies on private consumption

3.1 Introduction

For a long time, monetary policy was considered as the primary tool to conduct stabilization policy. Then, the challenges it faced in the recent years brought the debate over the use of fiscal policy to the fore.[1] Yet, the understanding of fiscal policy effects on the economy is still insufficient. And although fiscal stimulus measures were undertaken during the Great Recession in many countries, fiscal policy effectiveness as an instrument for macroeconomic stabilization is still a matter of uncertainty.

Such an uncertainty is conspicuous in the disagreement prevailing in the literature on the fiscal multiplier, which extends to fiscal policy effects on GDP components such as private consumption. Nonetheless, recent developments of this literature give new hopes for a more efficient use of fiscal policy. More particularly, it has been recently found that fiscal multipliers can become large and above unity under some conditions. Usually this happens when a larger share of households has a non-optimizing behavior[2] or in exceptional circumstances that affect monetary policy or cause a situation of underutilization of resources (e.g., ZLB, long and deep recessions). A better understanding of the economy's behavior in these unusual cases has the potential to provide us with a better insight as to how to make stabilization policies more efficient.

In the present paper, I use a New-Keynesian model that includes rule-of-thumb consumers to analyze the effects of fiscal policy on private consumption at and outside the ZLB. The focus on private consumption is partly justified by the fact that it is usually the most significant component of output. Thereby, the disagreement over fiscal multipliers could be resulting from the varying effects on private consumption. This also makes it a critical element in devising successful fiscal stimulus measures or conducting fiscal consolidations. An additional reason to study consumption is the controversy around the direction and size of its reaction to fiscal policy in the theoretical and empirical literature. Lastly, consumers'

[1] This view on monetary policy has not always been the predominant one. Blinder et al. (2004) points out that during the 1960s, discretionary fiscal policy was cast in the lead role while central bank policies were considered as playing more of an accommodating role for fiscal policy. But then several theoretical and empirical works called into question the ability of fiscal policy to accomplish countercyclical stabilization (e.g., Ricardian equivalence), in addition to some practical challenges. In particular, one strong argument against the use of fiscal policy is the fact that lags in the implementation of adequate measures are typically too long to be useful for combatting recessions (which is not the case for monetary policy). As a result, a paradigm shift occurred in the 1980s in the literature, leading to the belief in the preeminence of monetary policy as a macroeconomic stabilization tool.

[2] In that case, they are less prone to act following the Ricardian equivalence principle.

behavior is often found to play a key role in the effectiveness of macroeconomic policy (e.g. Krusell and Smith (1996), Colciago (2011)).

The model I use is based on the benchmark of Smets and Wouters (2003) and is estimated in two versions. The first version (called "baseline model") includes rule-of-thumb consumers with two regimes (at and outside the ZLB) and fiscal policy based on lump-sum taxation; the second one (called "extended model") also includes rule-of-thumb consumers and the two regimes but adds distortionary taxation (on consumption, wages and capital income). Estimation of the model is based on Japanese quarterly data from 1980Q1 to 2020Q3, using a Markov-switching regimes approach. Japan is an interesting case of study for this topic because it experiences a very long ZLB episode with near-zero interest rates since the mid-1990s. In addition, as a drop in the aggregate consumption level occurred after the tax hikes of 2014 and 2019, devising optimal measures to boost demand is an important stake at present.

The main contributions of this research are as follows. Even after inclusion of the rule-of-thumb consumers, consumption does not respond positively to fiscal stimulus measures. This is explained, first, by the fact that Ricardian behavior remains prevalent in the model, irrespective of the share of non-Ricardian households. And this behavior is closely linked to lump-sum taxes that are kept in both versions of the model. Second, although consumption also tracks income more closely compared to the benchmark model of Smets and Wouters (2003) that does not have hand-to-mouth consumers,[3] real wages decline after most measures, thereby contributing negatively to consumption's response.

The inclusion of distortionary taxation is found to alter the model's behavior after a fiscal shock through movements of the different tax rates. In particular, the model with distortionary taxes shows that measures that affect the capital income tax generate positive effects over the long-run, through an increase in capital and inflation (at the ZLB or interest rates outside the bound).

No significant difference is found across regimes (outside and at the ZLB) in the model's behavior after a government spending increase or a capital income tax cut. But a difference between the two regimes can be seen after a cut in the consumption tax or the wage income tax. Outside the ZLB, both measures have negative effects on the economy. At the ZLB, both

[3] And also to models for Japan that are based on Smets and Wouters (2003) such as Iiboshi, Nishiyama, and Watanabe (2006).

policies have harmful effects in the short-run but the potential to yield better results over the long-run via an impact on investment through the expectations channel.

A comparison between the different fiscal policy measures indicates that a capital income tax cut is the most beneficial policy and also yields better results than a government spending increase. It has the disadvantage of increasing public debt more significantly. Finally, a variance decomposition analysis shows that labor supply and technology shocks are the most significant contributors to the variation of private consumption, whereas fiscal shocks play a small role.

The remainder of the paper is organized as follows. The next section presents an overview of the main literature on the relationship between fiscal policy, private consumption and output. The third section provides a description of the theoretical model. The fourth section shows a general depiction of the basic workings of the model based on a full calibration of its log-linearized version. The fifth section summarizes the main settings for the model's solution and estimation through a Markov-switching regimes approach, and discusses the main results. Finally, the last section summarizes the main points of the study.

3.2 Literature review

Although many macroeconomic models agree on a positive effect from government spending to output, different theoretical specifications give very different predictions of the magnitude of the fiscal multiplier.[4] Typically, analyses based on linearized models such as Smets and Wouters (2007), Cogan et al. (2010) tend to predict smaller multipliers while recent non-linear approaches yield higher multipliers under some conditions. Some examples include models that account for the Zero Lower Bound[5] (Eggertsson and Woodford (2003), Eggertsson and Krugman (2012), Christiano, Eichenbaum, and Rebelo (2011) and Woodford (2011)),[6]or changes in the business cycle reflected in the unemployment rate (Nakamura and Steinsson (2014)) or in financial frictions (Canzoneri et al. (2016), Fernández-Villaverde (2010)).

[4]Usually defined as the percentage change in GDP in response to a change in government spending equal to one percent GDP.

[5]In that case, the non-linearity is accounted for through the monetary policy rule.

[6]Higher multipliers result from an increase in inflation expectations when interest rates are held constant.

There is an even stronger disagreement in the literature regarding the impact on private consumption. Usually, negative or very small multipliers for consumption are found in analyses based on neoclassical models (Hall (2009)) and are considered to be the result of negative wealth effects. According to Galí, López-Salido, and Vallés (2007), consumers in neoclassical models (especially RBC models) act in a Ricardian fashion, as opposed to the traditional IS-LM frameworks. Therefore, an increase in government spending lowers the present-value of after-tax income thereby inducing a negative wealth effect that decreases consumption. In contrast, Keynesian models usually imply high multipliers for both output and consumption since the size of the multiplier mostly depends on the marginal propensity to consume. New Keynesian models on the other hand usually yield a negative response of consumption. Since they are constructed by adding rigidities to a neoclassical foundation, neoclassical effects tend to mute the Keynesian multiplier.

One way of increasing consumption's response in a New Keynesian model is the inclusion of rule-of-thumb (or non-Ricardian) consumers. That way, the marginal propensity to consume becomes much higher than it would be if consumers behaved optimally, and the Keynesian mechanism takes over. Rule-of-thumb consumers are individuals that do not borrow or save but consume their entire income. In practice, there are many factors that could explain this behavior; for instance: myopia, liquidity or borrowing constraints, lack of confidence in economic conditions, inability to form expectations in an uncertain context, etc. Some examples of models that yield higher multipliers after inclusion of non-Ricardian consumers in the literature include Galí, López-Salido, and Vallés (2007) and Coenen and Straub (2005).[7] However, in both cases, the authors stress the fact that the share of rule-of-thumb consumers has to be very high in order to alter the model's behavior. In addition, Galí, López-Salido, and Vallés (2007) state that it should be accompanied by a high value of the price stickiness parameter so that real wages increase and drive consumption up.

Still, the presence of rule-of-thumb consumers makes models more realistic especially that an extensive empirical and theoretical literature shows a strong dependence of consumption on current income (Hall (1978), Campbell and Mankiw (1989), Erceg, Guerrieri, and Gust (2005), López Salido and Rabanal (2006)). In addition, a proportion of households has no access to bank credit and is therefore unable to smooth consumption over the business

[7] Perotti (1999) also uses a model that assumes the coexistence of credit-constrained individuals and individuals with free access to credit, albeit with an opposite outcome (negative correlation in bad times).

cycle. Therefore, I include the assumption of the presence of rule-of-thumb consumers in this study. In addition, I introduce two other assumptions taken from the fiscal multiplier literature. These two assumptions usually make fiscal policy more effective in stimulating the economy even without resorting to widespread non-optimizing behavior.

The first additional assumption is the inclusion of lump-sum taxes in the fiscal rule specification. Usually, models featuring expenditures that are financed through distortionary taxes lead to low output multipliers, in comparison with those in which expenditures are financed through current or future lump-sum taxes.[8] The second assumption is the Zero Lower Bound on interest rates.[9] As both assumptions often lead to higher fiscal multipliers, they have the potential to make consumption more responsive to fiscal shocks in the model.

The model used in this chapter is estimated based on data for Japan over the period 1980Q1-2020Q3. A number of factors make Japan an interesting case for studying the economy's dynamics after fiscal shocks at the ZLB. One of these factors is the fact that Japan experiences a very long ZLB episode with interest rates being close to zero since the mid-1990s. Another one is that even within the low interest rates period, different patterns in interest rates movements can be found, resulting in separate episodes, each characterized by distinct macroeconomic conditions (e.g., different levels of inflation).

Evidence of fiscal policy effects in Japan in periods of low interest rates is mixed. For example, Ko and Morita (2013) found fiscal policy to be ineffective in stimulating consumption during the low interest rates period.[10] One explanation provided by the authors is a

[8] Fiscal policy effects also tend to be smaller if the increase of expenses is perceived by consumers as transitory rather than permanent (see Hall (2009), Ramey (2011), Baxter and King (1993)). In the latter case, consumers work more after the fiscal stimulus which generates a positive wealth effect; whereas in the former case, consumers simply smooth their labor and consumption by investing less. In other words, higher government spending leads to a reduction in investment instead of stimulating output.

[9] As stated before, the size of the multiplier is often found to be higher when accounting for markets failures: cases of high unemployment (Lee et al. (2020)), the presence of borrowing constraints (Canzoneri et al. (2016)) or liquidity constraints caused by the zero lower bound as monetary policy cannot be used to stimulate the economy. These factors reflect conditions that often occur during recessions and many empirical studies based on non-linear estimation methods show higher multiplier effects during recessionary episodes (e.g., Auerbach and Gorodnichenko (2012) and Auerbach and Gorodnichenko (2013), Batini, Callegari, and Melina (2012), Mittnik and Semmler (2012)).

[10] They followed an empirical approach using a MS-VAR model. Results showed the presence of four major structural changes in Japanese fiscal policy between the 1970s and the recent period. These break-points occurred in the mid-1970s (oil shock), early 1990s (recession), late 1990s (liquidity trap and slight recovery) and late 2000s (global recession and recovery). But fiscal policy appeared to be effective in stimulating consumption only during the first, second and fifth regime.

low expectations of future income increase by households, resulting from the sluggish economy.[11] In contrast, using the Jordà (2005) local projection method, Miyamoto, Nguyen, and Sergeyev (2018) reached the conclusion that a government spending increase crowds out private consumption and investment in the normal period and crowds them in during the ZLB period. They also found CPI inflation and expected inflation to respond positively and significantly at the ZLB, compared to the normal period.

Finally, incorporating non-linearities arising from the ZLB in DSGE models has become increasingly widespread in macroeconomic modelling and can be done following different methods. In this study, a regime-switching approach that builds on the contribution of Binning and Maih (2017) is adopted. Through this approach, perturbation methods can be applied to derive an approximated solution for the model.

3.3 Theoretical model

I consider a standard New-Keynesian DSGE model in the vein of Smets and Wouters (2003), augmented with rule-of-thumb consumers and an extended fiscal policy framework as in Coenen and Straub (2005), Galí, López-Salido, and Vallés (2007) and Iwata (2009). However, as opposed to these papers, money is not removed from the Ricardian households utility function and a quadratic form of capital adjustment costs is assumed. Two versions of the model are studied. The first version (called "baseline model") includes rule-of-thumb consumers with two regimes (at and outside the ZLB) and fiscal policy based on lump-sum taxation; the second one (called "extended model") also includes rule-of-thumb consumers and the two regimes but adds distortionary taxation (on consumption, wages and capital).

3.3.1 Baseline model

3.3.1.1 Households

There is a continuum of households indexed by $h \in (0, 1)$. This continuum includes two types of households: a share of $1 - \mu$ of households corresponds to Ricardian consumers, with unrestricted access to financial markets where they can trade government bonds and physical capital. The remaining μ households have no access to financial markets. Ricardian

[11] An investment crowding-out effect was also observed in the 2000s period. According to the authors this could be explained by the fact that a large share of public spending during this phase was made to bailout poorly productive, debt-ridden firms.

households maximize their intertemporal utility as follows:

$$E_0 \sum_{t=0}^{\infty} \beta^t U_t^R \tag{3.1}$$

Where β is the discount factor and the utility function is expressed by

$$U_t^R = \varepsilon_t^B \left(\frac{1}{1-\sigma_c} \left(C_t^R - H_t \right)^{1-\sigma_c} - \frac{\varepsilon_t^L}{1+\sigma_l} \left(L_t^R \right)^{1+\sigma_l} + \frac{\varepsilon_t^M}{1-\sigma_m} \left(\frac{M_t^R}{P_t} \right)^{1-\sigma_m} \right) \tag{3.2}$$

The external habit stock H_t is proportional to aggregate past consumption $H_t = hC_{t-1}$. The term σ_c represents relative risk aversion, σ_l is the inverse of the elasticity of work effort with respect to real wage and σ_m is the inverse of the elasticity of money holding with respect to the interest rate. The utility function includes three types of shocks that follow an AR(1) process: a preference shock $\ln\left(\varepsilon_t^B\right) = \rho_B \ln\left(\varepsilon_{t-1}^B\right) + \eta_t^B$, a shock to labor supply $\ln\left(\varepsilon_t^L\right) = \rho_L \ln\left(\varepsilon_{t-1}^L\right) + \eta_t^L$, and a money demand shock $\ln\left(\varepsilon_t^M\right) = \rho_M \ln\left(\varepsilon_{t-1}^M\right) + \eta_t^M$. Ricardian households intertemporal budget constraint is expressed by

$$\frac{M_t^R}{P_t} + \frac{B_t^R/R_t}{P_t} = \frac{M_{t-1}^R}{P_t} + \frac{B_{t-1}^R}{P_t} + Y_t^R - T_t^R - C_t^R - I_t^R \tag{3.3}$$

T_t^R are lump-sum taxes and I_t^R investment. As in Ireland (2001), it is assumed that in order to generate new units of capital, households must pay an adjustment cost, measured through the quadratic term $\frac{\Theta_k}{2}\left(\frac{K_{t+1}^R}{K_t^R} - 1\right)^2 K_t^R$. Households' real income is then given by

$$Y_t^R = w_t L_t^R + r_t^k K_t^R - \frac{\Theta_k}{2} \left(\frac{K_{t+1}^R}{K_t^R} - 1 \right)^2 K_t^R + Div_t^R \tag{3.4}$$

Where $r_t^k K_t^R$ represent total payments from supplying units of capital and Div_t^R dividends from firms of intermediate goods. The capital accumulation process is given by

$$K_{t+1}^R = (1-\delta) K_t^R + x_t I_t^R \tag{3.5}$$

Where δ is the rate of depreciation of capital with $0 < \delta < 1$ and x_t represents a shock to the marginal efficiency of investment and is expressed as $\ln(x_t) = \rho_x \ln(x_{t-1}) + \eta_t^x$.

On the other hand, Non-Ricardian households do not optimize their consumption decision and fully consume their labor income as follows

$$C_t^{NR} = w_t L_t^{NR} - T_t^{NR} \tag{3.6}$$

3.3.1.2 Labor markets

Wages are determined in the labor market by a continuum of unions acting as wage setters. The probability that a particular union changes its nominal wage in period t is constant and equal to $1 - \xi_w$. The households that cannot reoptimize their wages adjust based on past inflation

$$W_{h,t} = \left(\frac{P_{t-1}}{P_{t-2}}\right)^{\gamma_w} W_{h,\,t-1} \tag{3.7}$$

Where γ_w is the degree of wage indexation. The demand for labor is determined by

$$L_{h,t} = \left(\frac{W_{h,t}}{W_t}\right)^{-\frac{1+\lambda_{w,t}}{\lambda_{w,t}}} L_t \tag{3.8}$$

$\lambda_{w,t}$ a stochastic parameter representing the wage mark-up with $\lambda_{w,t} = \lambda_w + \eta_t^w$ and the shock η_t^w is assumed to be i.i.d. normal. Aggregate labor demand L_t and aggregate nominal wage W_t are given by Dixit-Stiglitz type aggregator functions as follows

$$L_t = \left[\int_0^1 (L_{h,t})^{\frac{1}{1+\lambda_{w,t}}} d\tau\right]^{1+\lambda_{w,t}} \tag{3.9}$$

$$W_t = \left[\int_0^1 (W_{h,t})^{\frac{-1}{\lambda_{w,t}}} d\tau\right]^{-\lambda_{w,t}} \tag{3.10}$$

The optimization problem leads to the following mark-up equation for the optimized wage (see Appendix A for more details)[12]

$$\frac{W_{h,t}^*}{P_t} E_t \sum_{i=0}^{\infty} (\beta\xi_w)^i \left[\Lambda_{t+i} \frac{\left({P_{t+i-1}}/{P_{t-1}}\right)^{\gamma_w}}{{P_{t+i}}/{P_t}} L_{h,t+i}\right] = E_t \sum_{i=0}^{\infty} (\beta\xi_w)^i \left(1 + \lambda_{w,t+i}\right) \varepsilon_{t+i}^B \varepsilon_{t+i}^L (L_{h,t+i})^{1+\sigma_l} \tag{3.11}$$

The aggregate nominal wage is given by

$$W_t = \left[(1 - \xi_w) \left(W_{h,t}^*\right)^{-\frac{1}{\lambda_{w,t}}} + \xi_w \left(\frac{P_{t-1}}{P_{t-2}}\right)^{\gamma_w} \left(W_{t-1}\right)^{-\frac{1}{\lambda_{w,t}}}\right]^{-\lambda_{w,t}} \tag{3.12}$$

[12] Λ_{t+i} can be interpreted as the Lagrange multiplier equivalent to the marginal utility of consumption.

Aggregate consumption is given by

$$C_t = (1-\mu)\, C_t^R + \mu C_t^{NR} \tag{3.13}$$

And aggregate labor

$$L_t = (1-\mu)\, L_t^R + \mu L_t^{NR} \tag{3.14}$$

With $L_t = L_t^R = L_t^{NR}$ at equilibrium. Aggregate lump-sum taxes are

$$T_t = (1-\mu)\, T_t^R + \mu T_t^{NR} \tag{3.15}$$

The fact that only Ricardian households hold government bonds, accumulate capital, invest and receive dividends implies the following aggregate expressions

$$B_t = (1-\mu)\, B_t^R \tag{3.16}$$

$$K_{t+1} = (1-\mu)\, K_{t+1}^R \tag{3.17}$$

$$I_t = (1-\mu)\, I_t^R \tag{3.18}$$

$$Div_t = (1-\mu)\, Div_t^R \tag{3.19}$$

3.3.1.3 Firms

Final goods sector

Firms produce the final good from bundled intermediate goods such that

$$Y_t = \left[\int_0^1 \left(y_t^j\right)^{\frac{1}{\left(1+\lambda_{p,t}\right)}} dj \right]^{1+\lambda_{p,t}} \tag{3.20}$$

Where y_t^j is the quantity of domestic intermediate goods j and $\lambda_{p,t}$ a stochastic parameter representing mark-up in goods market with $\lambda_{p,t} = \lambda_p + \eta_t^p$ and the shock η_t^p is assumed to be i.i.d. normal. Using the previous relation in the firms' profit maximization expression yields the following equation

$$y_t^j = \left(\frac{p_t^j}{P_t}\right)^{-\frac{1+\lambda_{p,t}}{\lambda_{p,t}}} Y_t \tag{3.21}$$

Replacing in the expression of the nominal value of the final good $p_t y_t = \int_0^1 p_t^j y_t^j dj$ leads to

$$P_t = \left[\int_0^1 \left(p_t^j \right)^{-\frac{1}{\lambda_{p,t}}} dj \right]^{-\lambda_{p,t}} \tag{3.22}$$

Intermediate goods

Intermediate goods' producers use the following production technology based on labor and capital services rent by households.

$$y_t^j = \varepsilon_t^a K_{j,t}^{\alpha} L_{j,t}^{1-\alpha} - \Phi \tag{3.23}$$

Φ are fixed costs of production and the technology shock is $\ln\left(\varepsilon_t^a\right) = \rho_a \ln\left(\varepsilon_{t-1}^a\right) + \eta_t^a$ Minimizing the total cost $W_t L_{j,t} + R_t^k K_{j,t}$ subject to the production technology yields the following expression

$$\frac{W_t L_{j,t}}{R_t^k K_{j,t}} = \frac{1-\alpha}{\alpha} \tag{3.24}$$

The firms' marginal costs correspond to

$$MC_t = \frac{{W_t}^{1-\alpha} {R_t^k}^{\alpha}}{\varepsilon_t^a \alpha^{\alpha} (1-\alpha)^{(1-\alpha)}} \tag{3.25}$$

Nominal profits are expressed as

$$\Pi_t^j = \left(p_t^j - MC_t \right) \left(\frac{p_t^j}{P_t} \right)^{-\frac{1+\lambda_{p,t}}{\lambda_{p,t}}} (Y_t) - MC_t \Phi \tag{3.26}$$

Based on a Calvo price setting model with partial indexation, a share of intermediate goods firms can re-optimize their price with a probability $1 - \xi_p$ to a new level $\tilde{p}_t^j$. The remaining share of firms index the price to the previous period's inflation with a probability ξ_p. The former category of firms chooses their price by solving the problem of maximization of future profits that will be generated by this optimal price.

$$E_t \sum_{i=0}^{\infty} \beta^i \rho_{t+i} \xi_p^i \left(p_{t+i}^j - MC_{t+i} \right) y_{t+i}^j = 0 \tag{3.27}$$

The expected profits are discounted using the rate $\beta\rho_t$ with $\rho_{t+i} = \frac{\lambda_{t+i}}{\lambda_t}\frac{1}{P_{t+i}}$

The first order condition is given by

$$E_t \sum_{i=0}^{\infty} \beta^i \xi_p^i \lambda_{t+i} y_{t+i} \left(\frac{\tilde{p}_t^j}{P_t} \frac{\left(P_{t-1+i}/P_{t-1}\right)^{\gamma_p}}{P_{t+i}/P_t} - \left(1+\lambda_{p,t+i}\right) mc_{t+i} \right) = 0 \tag{3.28}$$

And the aggregate price index is given by

$$\left(P_t\right)^{-\frac{1}{\lambda_{p,t}}} = \xi_p \left(P_{t-1} \left(\frac{P_{t-1}}{P_{t-2}} \right)^{\gamma_p} \right)^{-\frac{1}{\lambda_{p,t}}} + \left(1-\xi_p\right) \left(\tilde{p}_t^j\right)^{-\frac{1}{\lambda_{p,t}}} \tag{3.29}$$

3.3.1.4 Monetary policy

Monetary policy sets the gross nominal interest rate based on the following rule

$$R_t = \max \left\{ 1, R_{t-1}{}^{\phi_r} \left[\frac{\pi}{\beta} \left(\frac{\pi_t}{\pi} \right)^{\phi_\pi} \left(\frac{Y_t}{Y} \right)^{\phi_Y} \right]^{(1-\phi_r)} \right\} \tag{3.30}$$

Where ϕ_r captures the degree of interest rate smoothing, ϕ_π measures the response of monetary policy to inflation and ϕ_Y to output (both expressed as deviations from the steady state).

3.3.1.5 Fiscal policy

The government budget constraint is defined as

$$\frac{B_t/R_t}{P_t} + T_t = \frac{B_{t-1}}{P_t} + G_t \tag{3.31}$$

As in Gali et al. (2007), the fiscal policy rule is assumed to be as follows

$$t_t = \phi_b b_t + \phi_g g_t \tag{3.32}$$

With $t_t \equiv \left(T_t - T\right)/Y$, $g_t \equiv \left(G_t - G\right)/Y$, $b_t \equiv \left(\left(B_t/P_{t+1}\right) - \left(B/P\right)\right)/Y$ and the parameters ϕ_b and ϕ_g are positive coefficients. Government spending is assumed to follow an exogenously given AR(1) process

$$g_t = \rho_g g_{t-1} + \eta_t^g \tag{3.33}$$

3.3.1.6 Market equilibrium

The final goods market will be in equilibrium if production equals demand by households and the government such that

$$Y_t = C_t + G_t + I_t + \frac{\Theta_k}{2}\left(\frac{K_{t+1}}{K_t} - 1\right)^2 K_t \tag{3.34}$$

3.3.2 Extended model with an alternative fiscal rule

To assess the importance of the fiscal rule specification, I extend the baseline model by including distortionary taxation and additional rules in a subsequent step. In that case, the Ricardian household's budget constraint becomes

$$\frac{M_t^R}{P_t} + \frac{B_t^R/R_t}{P_t} = \frac{M_{t-1}^R}{P_t} + \frac{B_{t-1}^R}{P_t} + (1-\tau_{w,t})\, w_t L_t^R + (1-\tau_{k,t})\, r_t^k K_t^R - \frac{\Theta_k}{2}\left(\frac{K_{t+1}^R}{K_t^R} - 1\right)^2 K_t^R + (1-\tau_{k,t})\, Div_t^R + \tau_{k,t}\delta K_t^R - T_t^R - (1+\tau_{c,t})\, C_t^R - \frac{K_{t+1}^R - (1-\delta)\, K_t^R}{x_t} \tag{3.35}$$

Where $\tau_{c,t}$ $\tau_{w,t}$ and $\tau_{k,t}$ are consumption, labor and capital income taxes, respectively. Non-Ricardian households' budget constraint is

$$(1+\tau_{c,t})\, C_t^{NR} = (1-\tau_{w,t})\, w_t L_t^{NR} - T_t^{NR} \tag{3.36}$$

The government budget constraint becomes

$$\frac{B_t/R_t}{P_t} + T_t + \tau_{c,t}C_t + \tau_{k,t}Div_t + \tau_{w,t}w_tL_t - \tau_{k,t}\delta K_t + \tau_{k,t}r_t^kK_t = \frac{B_{t-1}}{P_t} + G_t \tag{3.37}$$

The fiscal rule is also changed. As in Kliem and Kriwoluzky (2014), government spending, transfers and consumption tax rate are assumed to respond to deviations of output and debt from their steady states. Labor and capital tax rates are assumed to respond to deviations of labor hours and investment, respectively, in addition to debt.

$$t_t = \rho_{tr}t_{t-1} + (1-\rho_{tr})\left(\rho_{try}\hat{Y}_t + \rho_{trb}b_{t-1}\right) + \eta_t^{tr} \tag{3.38}$$

$$\hat{\tau}_{c,t} = \rho_{ct}\hat{\tau}_{c,t-1} + (1-\rho_{ct})\left(\rho_{cty}\hat{Y}_t + \rho_{ctb}b_{t-1}\right) + \eta_t^{ct} \tag{3.39}$$

$$\hat{\tau}_{w,t} = \rho_{wt}\hat{\tau}_{w,t-1} + (1-\rho_{wt})\left(\rho_{wtl}\hat{L}_t + \rho_{wtb}b_{t-1}\right) + \eta_t^{wt} \tag{3.40}$$

$$\hat{\tau}_{k,t} = \rho_{kt}\hat{\tau}_{k,t-1} + (1-\rho_{kt})\left(\rho_{ktI}\hat{I}_t + \rho_{ktb}b_{t-1}\right) + \eta_t^{kt} \tag{3.41}$$

$$g_t = \rho_g g_{t-1} + \left(1-\rho_g\right)\left(\rho_{gy}\hat{Y}_t + \rho_{gb}b_{t-1}\right) + \eta_t^g \tag{3.42}$$

3.4 Model preliminary simulation with no binding constraint

3.4.1 Log-linearization of the baseline model around the steady state

In a first step, the model is log-linearized and the Ricardian and non-Ricardian consumption equations are combined (more details are provided in Appendix B). The resulting equations are as follows.

$$\Theta_k\hat{K}_t = (1+\beta)\,\Theta_k E_t\hat{K}_{t+1} - \beta\Theta_k E_t\hat{K}_{t+2} - \beta r^k E_t\hat{r}^k_{t+1} + \hat{R}_t - E_t\hat{\pi}_{t+1} + \beta(1-\delta)\,E_t\hat{x}_{t+1} - \hat{x}_t \tag{3.43}$$

$$\frac{C}{Y}\hat{C}_t = (1-\mu)\left[\frac{m}{Y\sigma_m}\left[\hat{\pi}_t + \frac{\beta}{1-\beta}\hat{R}_t - \frac{1}{1-\beta}\hat{R}_{t-1} - \left(\hat{\varepsilon}^B_t - \hat{\varepsilon}^B_{t-1}\right) - \left(\hat{\varepsilon}^M_t - \hat{\varepsilon}^M_{t-1}\right)\right] + \left[\hat{Y}_t - \frac{I}{Y}\hat{I}^R_t\right]\right] + \mu\left[\frac{\theta(1-\alpha)}{1+\lambda_p}\left(\hat{L}_t + \hat{w}_t\right) + \frac{b_t}{R} - b_{t-1}\right] - g_t \tag{3.44}$$

$$\frac{K}{Y}E_t\hat{K}_{t+1} = (1-\delta)\,\frac{K}{Y}\hat{K}_t + \frac{I}{Y}\hat{x}_t + \frac{I}{Y}\hat{I}_t \tag{3.45}$$

$$\hat{L}_t = -\hat{w}_t + \hat{r}^k_t + \hat{K}_t \tag{3.46}$$

$$\hat{Y}_t = \theta\left[\hat{\varepsilon}^a_t + \alpha\hat{K}_t + (1-\alpha)\,\hat{L}_t\right] \tag{3.47}$$

$$\hat{R}_t = \phi_r\hat{R}_{t-1} + (1-\phi_r)\left(\phi_\pi\hat{\pi}_t + \phi_Y\hat{Y}_t\right) \tag{3.48}$$

$$\frac{b_t}{R} = g_t\left(1-\phi_g\right) + b_{t-1}\left(1-\phi_b\right) \tag{3.49}$$

$$\hat{Y}_t = \frac{C}{Y}\hat{C}_t + g_t + \frac{I}{Y}\hat{I}_t \tag{3.50}$$

$$\hat{\pi}_t = \frac{\beta}{(1+\beta\gamma_p)}E_t\hat{\pi}_{t+1} + \frac{\gamma_p}{(1+\beta\gamma_p)}\hat{\pi}_{t-1} + \frac{\left(1-\beta\xi_p\right)\left(1-\xi_p\right)\left[\eta^p_t + \alpha\hat{r}^k_t + (1-\alpha)\,\hat{w}_t - \hat{\varepsilon}^a_t\right]}{\xi_p\left(1+\beta\gamma_p\right)} \tag{3.51}$$

$$\hat{w}_t = \frac{\beta}{(1+\beta)}E_t\hat{w}_{t+1} + \frac{1}{(1+\beta)}\hat{w}_{t-1} + \frac{\beta}{(1+\beta)}E_t\hat{\pi}_{t+1} - \frac{(1+\beta\gamma_w)}{(1+\beta)}\hat{\pi}_t + \frac{\gamma_w}{(1+\beta)}\hat{\pi}_{t-1} + \left[\hat{\varepsilon}_t^L + \sigma_l\hat{L}_t + \frac{\sigma_c}{(1-h)}\left(\hat{C}_t - h\hat{C}_{t-1}\right) + \eta_t^w - \hat{w}_t\right]\frac{(1-\beta\xi_w)(1-\xi_w)}{\xi_w(1+\beta)(1+\sigma_l)\left(\frac{1+\lambda_w}{\lambda_w}\right)} \tag{3.52}$$

$$\hat{\varepsilon}_t^B = \rho_B\hat{\varepsilon}_{t-1}^B + \hat{\eta}_t^B \tag{3.53}$$

$$\hat{\varepsilon}_t^L = \rho_L\hat{\varepsilon}_{t-1}^L + \hat{\eta}_t^L \tag{3.54}$$

$$\hat{\varepsilon}_t^M = \rho_M\hat{\varepsilon}_{t-1}^M + \hat{\eta}_t^M \tag{3.55}$$

$$\hat{x}_t = \rho_x\hat{x}_{t-1} + \hat{\eta}_t^x \tag{3.56}$$

$$\hat{\varepsilon}_t^a = \rho_a\hat{\varepsilon}_{t-1}^a + \hat{\eta}_t^a \tag{3.57}$$

$$g_t = \rho_g g_{t-1} + \eta_t^g \tag{3.58}$$

$$\lambda_{p,t} = \lambda_p + \eta_t^p \tag{3.59}$$

$$\lambda_{w,t} = \lambda_w + \eta_t^w \tag{3.60}$$

3.4.2 Baseline model calibration, simulation and basic mechanisms

I proceed with a preliminary simulation of the baseline model without any binding constraint to shed some light on the model's underlying mechanisms. This preliminary analysis is also useful to distinguish between results that are explained by the model specification and those that are explained by the data in later steps. The calibrated parameters are taken from the existing literature. The discount factor β is set to the value of 0.99, the elasticity of output with respect to capital α to 0.3, the depreciation rate of capital δ to 0.025. The steady-state ratios of consumption, investment and government spending over output are assumed to be respectively equal to 0.57, 0.2, 0.22 (corresponding to the average ratios calculated from collected data on Japan[13]). The steady-state ratio of money to output is taken as 0.9 (calculated based on average M2 to GDP over the period) and the ratio of capital to output is set to 2.2 as in previous similar studies.[14]

[13] See following section.

[14] See Watanabe (2009), Iwata (2009), Iiboshi, Nishiyama, and Watanabe (2006), Smets and Wouters (2003).

λ_w is set to the value of 0.5 and the share of non-Ricardian households to 0.35 (as in Iwata (2009)). The share of fixed costs over total production is considered equal to 0.45[15] and λ_p to 0.45.[16]. The capital adjustment cost parameter Θ_k is considered to be equal to 10 as in Ireland (2001) and the inverse of the elasticity of money holding with respect to the interest rate σ_M is set to 2 (Kuo and Miyamoto (2016)) To calibrate the remaining parameters, the posterior means obtained by Iiboshi, Nishiyama, and Watanabe (2006) from Japanese data are used (see Table 3.1). Finally, parameters of the fiscal rule are taken from Galí, López-Salido, and Vallés (2007) and those of the monetary policy rule from Smets and Wouters (2003).

Impulse response functions to a one standard deviation positive shock to government spending are shown on Figure 3.1. Based on zero steady state values, these preliminary results indicate that an increase in government spending induces a decline in consumption, investment, inflation, capital and real wages. At the same time, the shock generates a hike in labor supply and output and raises the public debt level. Most of these outcomes are in line with the model of Smets and Wouters (2003) and Iiboshi, Nishiyama, and Watanabe (2006) (for Japan).

From these responses and equation (3.44), it appears that the decline in private consumption is a direct consequence of a government spending crowding-out effect which manifests through higher taxes and higher public debt (both of which affect households' consumption through the budget constraint). The reduction in inflation (explained by lower wages) also negatively affects consumption through a positive change in money holdings, but this impact remains relatively weak in magnitude, even if the share of Ricardian households is increased. The positive effect of higher labor is offset by the decline in wages, resulting in an overall negative impact. This impact is also relatively small compared to that of government spending. But it can be increased if the parameters of the elasticity of output with respect to capital or the price markup are smaller or if the share of fixed costs in production is higher, since these parameters affect the steady state ratio of labor income over output. The effect of wages and labor also slightly increases with the share of non-Ricardian households (because consumption tracks income more closely).

The decline in consumption is strongly cushioned by the increase in output which enters the Ricardian households consumers' equation through dividends. And this increase in output

[15]As in Iiboshi, Nishiyama, and Watanabe (2006), Coenen and Straub (2005), Smets and Wouters (2003).

[16]Such that $1 + \lambda_p = 1 + \frac{\Phi}{Y}$, implying zero profits at the steady state.

is also a direct effect of higher government spending. In other words, this model shows that the increase in government spending only stimulates the consumption of households that own firms, through higher profits generated by the higher government demand. On the other hand, the decrease in investment is favorable for consumption since more income is available for Ricardian consumers, but it plays a limited role due to the small magnitude of the response.

Estimation of consumption's impulse response functions for different values of the share of rule-of-thumb consumers is shown on Figure 3.2. No matter the value of this parameter, response of consumption does not get positive. On the contrary, the decline in consumption is more marked when the parameter increases. This is unsurprising since the stimulating effect on the economy in this model mainly affects Ricardian households through firms' profits.

3.4.3 Basic workings of the extended model with distortionary taxation

I use the same calibration described previously to simulate the extended model with distortionary taxation. In addition, the steady state tax rates are set to the values $\tau_w = 0.32$, $\tau_c = 0.08$, $\tau_k = 0.61$.[17] At this stage, autoregressive parameters in the tax rules are set to 0.8[18] and the remaining parameters of the rules to 0.1.[19] The changes to the log-linearized model are included in Appendix C.

Figure 3.3 shows a comparison between the impulse responses in the extended version of the model and those of the baseline model. On impact, consumption decreases more strongly in the baseline model, but the opposite becomes true after two quarters. The primary reason for this is that the decline in the baseline model (as opposed to the second model) mainly results from the direct impact of government spending (through the fiscal rule). Therefore, this response weakens as spending converges to the steady state. Conversely, based on the aggregate consumption equation of the second model (equation (3.179) in Appendix C), consumption's decline is mainly driven by the declining wages (a direct effect on income and to a lesser extent an indirect effect through lower inflation).

As before, the increase in output in the extended version is mainly a result of the increase in government spending since both consumption and investment decline (the same shock is applied in both models). The slight difference in output response results from a higher

[17] Taken from Iwata (2009).
[18] Drygalla, Holtemöller, and Kiesel (2020), Iwata (2009), Kliem and Kriwoluzky (2014).
[19] Prior means in Iwata (2009).

response of labor in the extended model. Another reason is that government spending converges more rapidly to the steady state in the baseline model compared to the extended model. Finally, lump-sum taxes and tax rates gradually increase after the spending shock. They all contribute equivalently to the debt repayment except the capital income tax rate which increases with a smaller amount compared to the other taxes. The divergence of capital in the baseline model, although not observed in the extended model, is consistent with the response in the benchmark model of Smets and Wouters (2003) and also in Iiboshi, Nishiyama, and Watanabe (2006).

3.5 Markov-Switching Bayesian approach

I then proceed with the model estimation through Bayesian methods using Japanese data from 1980 Q1 to 2020 Q3. Since Japan experiences a long ZLB episode during the period of study (nominal interest rates have been close to zero since 1995 Q3), relying on non-linear solution and estimation techniques is necessary.

3.5.1 Solution methodology

Binning and Maih (2016) provide a brief description of the main solution approaches to solve non-linear DSGE models and which include: extended path solutions, piecewise-linear solutions, anticipated shocks, projection methods and regime-switching methods. In the present study, the regime-switching model approach is adopted. Based on Maih (2015), the regime-switching dynamic stochastic general equilibrium model (RS-DSGE) model can be expressed as follows.

$$E_t \sum_{r_{(t+1)}=1}^{h} \pi_{r_t,r_{t+1}} (\Omega_t) \tilde{d}_{r_t} (\nu) = 0 \tag{3.61}$$

$\tilde{d}_{r_t} : \mathbb{R}^{(n_\nu)} \rightarrow \mathbb{R}^{(n_d)}$ is a $n_d x1$ vector of possibly non-linear functions of their argument ν

The variable r_t corresponds to the regime at time t

$\pi_{r_t,r_{t+1}} (\Omega_t)$ is the transition probability for going from regime r_t at time t to regime r_{t+1} in the following period. It depends on the information set at time t represented by Ω_t. The special case where transition probabilities are constant is referred to as the Markov-Switching DSGE model.

The argument ν represents a n_ν vector that includes the stacked vectors of the following categories of variables: static variables (s_t), forward-looking variables (f_t), predetermined variables (p_t), variables that are both predetermined and forward looking (b_t), shocks (ε_t) and switching parameters appearing with a lead in the model ($\theta_{r_{t+1}}$).

For $d_{r_t,r_{t+1}}$, a $n_d x1$ vector such that $d_{r_t,r_{t+1}} \equiv \pi_{r_t,r_{t+1}}(\Omega_t)\tilde{d}_{r_t}$, the objective function becomes

$$E_t \sum_{r_{t+1}=1}^{h} d_{r_t,r_{t+1}}(\nu) = 0 \tag{3.62}$$

It is assumed that if agents have information for all or some of the shocks k periods ahead of time, then the state variables vector z_t can be expressed as a $n_z x1$ vector that contains the variables (p_{t-1}), (b_{t-1}), a perturbation parameter σ, the present shock and k future shocks, with $n_z = n_p + n_b + (k+1)\,n_\varepsilon + 1$. This is an important distinction with the traditional approach based on "news shocks", usually included in the system by adding additional terms to the law of motion of the shock process. Another difference is that anticipated shocks are considered as structural shocks and therefore can be related to other parts of the system.

For $y_t(r_t)$ being the $n_y x1$ vector of all endogenous variables with $n_y = n_s + n_p + n_b + n_f$, the solution would be expressed as a function of the state variables, in the following form

$$y_t(r_t) \equiv \begin{bmatrix} s_t(r_t) \\ p_t(r_t) \\ b_t(r_t) \\ f_t(r_t) \end{bmatrix} = \Im^{r_t}(z_t) \equiv \begin{bmatrix} S^{r_t}(z_t) \\ P^{r_t}(z_t) \\ B^{r_t}(z_t) \\ F^{r_t}(z_t) \end{bmatrix} \tag{3.63}$$

To solve the model, a perturbation method is used to approximate the decision rules above. To do so, the vector y_t is decomposed to isolate the predetermined from the forward-looking components. Similarly the vector z_t is also partitioned so that all variables of the system can be expressed in terms of the state variables vector z_t. Thus, the vector ν becomes

$$\nu = \begin{pmatrix} \lambda_{bf}\Im^{r_{t+1}}(z_{t+1}(z_t)) \\ \Im^{r_t}(z_t) \\ m_p z_t \\ m_b z_t \\ m_{\varepsilon,0} z_t \\ \theta_{r_{t+1}} m_\sigma z_t \end{pmatrix} \tag{3.64}$$

Where λ_{bf} is the matrix that selects the variables b and f and m_g refers to a $n_g x n_z$ matrix that selects the g type variables from the state variatbles vector z_t. The objective function therefore becomes

$$E_t \sum_{r_{t+1}=1}^{h} d_{r_t,r_{t+1}} \left(v\left(z_t, u\right)\right) = 0 \tag{3.65}$$

Using this expression, successive Taylor approximations around an approximation point can be performed up to higher orders to find the perturbation solutions. Several algorithms to solve the approximated problem are discussed in Maih (2015) and Farmer, Waggoner, and Zha (2011). In the present study, the model is solved using a functional iteration algorithm that offers the advantage of converging fast when a solution is found.[20]

3.5.2 Calibration, prior specification and data

Bayesian estimation of the model is based on the following quarterly macroeconomic series: output, private consumption, private investment, nominal interest rate, labor hours and real hourly wage. Data for the first three series are obtained from the database of the Cabinet Office and divided by the labor force. Labor hours are calculated based on the series of aggregate weekly labor hours for non-agricultural industries obtained from the Portal Site of Official Statistics of Japan. Real wages are calculated based on real wage indices from the monthly labor survey of the Ministry of Health, Labor and Welfare and the value of real hourly wage at 2020Q3 taken from statistics of the Japan Institute for Labor Policy and Training. The short-term nominal interest rates correspond to the overnight call rates taken from the Bank of Japan database. All variables are transformed to logarithms and detrended using a one-sided Hodrick-Prescott filter,[21] except the interest rate, that is detrended without log-transformation.

As is usual in the literature, the parameter values of β, α, δ, λ_p, λ_w, Θ_k and the ratios over output are fixed, using the calibration values of the previous section. The prior distributions for estimated parameters are reported on Table 3.3. In setting these values, I follow similar studies based on variants of Smets and Wouters (2003) for Japan such as Iiboshi, Nishiyama, and Watanabe (2006), Iwata (2009) and Watanabe (2009). All standard deviations of shocks are assumed to follow an inverted gamma distribution with degrees of freedom equal to two.

[20] The mfi algorithm implemented in the Rationality In Switching Environments (RISE) Toolbox.

[21] Non-causal filters such as the two-sided HP or Baxter-King filters are not used since they take future values to construct present data.

The distribution of autoregressive parameters is on the other hand assumed to follow a beta distribution with mean 0.8 and standard error 0.1. Prior of the inverse of the elasticity of money holding with respect to the interest rate σ_M is set based on Kuo and Miyamoto (2016) and the standard error of money demand shock ${\eta_t}^M$ from Kano (2019). Priors for the fiscal rule parameters are taken from Coenen and Straub (2005) in the case of the baseline model, and from Iwata (2009) in the case of the extended model.

Priors for the monetary policy rule in the first regime are taken from Smets and Wouters (2003). At the ZLB, parameters of the monetary rule are more difficult to obtain. I therefore decide to keep the same type of probability distribution as in the first regime but set estimates of the mean and standard deviation based on a regression model. This necessitates a definition of the ZLB period. Looking at interest rates data, it can be noted that interest rates have been almost steadily declining since 1991Q3.[22] But despite this decline, interest rates were not close to zero in the first quarters of the 1991Q3-2020Q3 period. Within this period, one major drop occurred in 1995Q3 when interest rates went below 1%. They then stayed below this level for the remaining part of the sample period. For this reason, many studies define the ZLB period as the entire period that follows this drop, and which is characterized by interest rates that are within the unit interval (in percentage). For example, all the post-1995Q4 period is chosen as the ZLB period in Miyamoto, Nguyen, and Sergeyev (2018), Borağan Aruoba, Cuba-Borda, and Schorfheide (2018) and Adjemian and Juillard (2010). On the other hand, Hayashi and Koeda (2014) follow a different approach and define the ZLB as the period where interest rates are below the critical rate of 0.05%.[23]

In the present study, the chosen period to estimate the model is 1995Q3-2016Q1 (the remaining quarters are excluded because interest rates are negative). One difficulty that arises from the choice of this period is the changing behavior of inflation (see Figure 3.4). More specifically, the long deflationary period imposes a negative relationship between interest rates and inflation, which in reality does not apply to the whole low interest rates period. To overcome this problem, a threshold regression approach is adopted. That way, it is possible to distinguish between different patterns of relationships between the interest rate and the

[22] By applying a Zivot-Andrews unit root test over the whole data series, I also find one breakpoint at 1992Q1.

[23] This corresponds to the rate below which bank reserves in Japan are greater than required reserves (and often several times greater). Based on this definition, the ZLB corresponds to the following episodes: March 1999 - July 2000, March 2001 - June 2006, and December 2008 to the end of the period of study (2014).

monetary rule variables depending on the interest rate level.[24] Results of this regression are reported on Table 3.2. Prior means of the monetary rule parameters are set based on an average of these coefficients. Finally, the Markov process is defined based on constant transition probabilities for which the prior is defined as on Table 3.3.

3.5.3 Results

3.5.3.1 Estimation settings and smoothed probabilities

Estimation of the posterior distribution is based on a stochastic optimizer with 1000 iterations. After multiple runs of the optimization procedure, the estimation result with the highest log marginal data density (Laplace approximation) is selected. This corresponds to a value of -1465 for the baseline model and -1346 for the extended model. In a subsequent step, the Metropolis-Hastings algorithm is applied with 1000 parameter draws from the distribution (in addition to a ratio of 0.1 burnin). Finally, impulse response functions are constructed based on random parameter draws (300 replications) from the MCMC simulation.

Then, the smoothed probabilities are calculated to detect the timing of regime shifts. These probabilities are plotted on Figure 3.5 along with the time series of short-term nominal interest rates. It can be noted that regime 1 switches abruptly at the following dates: 2001Q3-2006Q1, 2009Q3-2011Q2, 2011Q4-2015Q4 and 2016Q3-2018Q2. These shifts suggest that the second regime represents all periods with interest rates below 0.10. There are however two main exceptions. First, the model does not capture the period 1999Q2-2000Q2 in which interest rates are also below the 0.1 threshold. Second, there is a regime change that occurs during the low interest-rates period, at 2016Q2, when interest rates turn negative. Conversely, the model perfectly captures the period 2001Q3-2006Q1 where interest rates are in most quarters close to or below 0.001, with probabilities of being in regime 1 that are close to zero for this entire interval. To conclude, the timing of these shifts suggests that regime 1 corresponds to a period where interest rates are unbounded whereas regime 2 is the ZLB period.

[24] The most common approach in estimating the monetary policy rule is an IV tobit regression (e.g., Kiesel and Wolters (2014), Kim and Mizen (2010), Kato and Nishiyama (2005)) since the variable of short-term interest rates is left-censored. However, the threshold regression approach is chosen in this study; first because no significant differences are obtained in the estimated coefficients compared to a tobit regression for the selected short time span, and second because the relationship between variables may differ across the different periods of low interest rates.

3.5.3.2 Parameters' posterior mode estimates

Estimated posterior modes are provided on Tables 3.3 and 3.4. The estimated parameter of rule-of-thumb consumers appears as lower than the prior mean in the baseline model and higher in the extended model. The parameter of Calvo price stickiness has a small value in both models,[25] suggesting a higher price flexibility than expected. In the extended model, estimates for the fiscal rules are close to the prior in the case of consumption, wage income and capital income tax rates. Conversely, the parameters of response of government spending to deviations in output and public debt are extremely small. This implies that budget adjustments made after an increase in public debt are mainly made through tax rates and not government spending. Response of lump-sum taxes to public debt is also relatively smaller than the prior mean. Finally, among fiscal rule variables, lump-sum taxes show the least persistence.

3.5.3.3 Impact of a government spending shock

I then apply a positive shock to government spending. Although a shock of the same magnitude is applied in both the baseline and extended models (+0.34), there are some differences in terms of responses between both. For example, there is almost no difference between variables' reaction at and outside the ZLB in the baseline model (Figure 3.6), but a slight difference can be seen between both regimes in the extended model (Figure 3.7). Nonetheless, the response of consumption on impact is negative in all cases. Even at the ZLB, the model does not produce the crowding-in effect of consumption that has been discussed in some previous studies. It can however be noted that in the extended model, consumption's reaction gets positive over the long-run (after 6 quarters outside the ZLB and 5 at the ZLB). The shape of consumption's response in this case suggests an impact from tax rate adjustments that follow the spending increase (see Figure 3.8).

The aggregate consumption equations[26] are used to uncover the main contributors to consumption's response. In the baseline model, the decline in consumption (about -0.11), both at and outside the ZLB, is found to be mainly a direct crowding-out effect of government spending (through higher taxes and public debt). This decline is mitigated by a higher output

[25]This parameter is considered by Galí, López-Salido, and Vallés (2007) as an important factor to generate an increase in real wages (if it is sufficiently high) and thereby a positive response in consumption.

[26]Equation (3.44) in section 3.4 for the baseline model and equation (3.179) in Appendix C for the extended model.

and an increase in labor that offsets the effect of falling real wages (overall positive effect of labor income). In the extended model, consumption drops by 0.12 after the shock in both regimes. This effect results essentially from the increase in lump-sum taxes (negative transfers) and a decline in wages. In particular, it can be seen that the path of consumption closely tracks real wages' response.

Turning to output, a positive reaction is observed in all cases (+0.269 outside the ZLB and +0.266 at the ZLB in the baseline model and +0.31 outside the ZLB and +0.35 at the ZLB in the extended version). The fiscal multiplier on impact is relatively higher in the extended model, especially at the ZLB (where it slighlty exceeds unity with a value of 1.03). This positive response is mostly explained by the government spending increase itself which raises aggregate demand. The higher aggregate demand also induces higher labor, which plays a significant role in explaining output through the production function.

One important distinction between the baseline and the extended model is a different response of capital, investment, inflation and interest rates. Inflation (at the ZLB) and interest rates (outside the bound) respond positively in the extended model as opposed to the baseline model. At the same time, there is almost no difference between the two models in the responses of the rental rate of capital and real wages. This implies that the difference in the reaction of inflation at the ZLB is not explained by the marginal cost and can only be attributed to different inflation's expectations or parameter estimates. It is true that the estimated parameter of the degree of partial indexation of price γ_p is lower in the extended model while Calvo price stickiness ξ_p is slightly higher but this difference is not sufficient in explaining the opposite sign of inflation's response. Therefore, different inflation's response is mainly due to different expectations. The positive response of capital in the second model is also affected by higher expectations, in addition to a higher steady state of the rental rate of capital[27] and more particularly the impact of the capital income tax.[28] The difference between capital's evolution at and outside the bound is explained by the difference in the evolution of the tax rate in both regimes. On the other hand, the path of investment is mainly explained by capital.

Based on these results, I conclude that the fiscal rule specification plays an important role in determining the model's response to fiscal shocks. In a model that does not account for

[27] Impact of the steady state capital income tax rate.

[28] Capital is a predetermined variable in the model and therefore positively affected by the tax rate at time t.

distortionary taxation, a crowding-out effect of investment is obtained, which is consistent with the main findings of Smets and Wouters (2003) and Iiboshi, Nishiyama, and Watanabe (2006). But the presence of taxes alters this impact by affecting the path of the model's variables. The increase in capital in the extended model has a positive effect on the economy since it eventually leads to an increase in consumption and wages although their immediate response to the spending increase is negative.

Overall, the way consumption reacts to government spending in both the baseline and extended model suggests that Ricardian behavior remains important even after inclusion of rule-of-thumb consumers. Such a conclusion is corroborated by the model's response to a contractionary fiscal policy (a reduction of government spending) as shown on Figure 3.10. It can be seen from the figure that private consumption responds positively to a cut in government spending. And the shape of this response reveals its relationship with the movement of lump-sum taxes (Figure 3.9). To sum up, consumption appears to be driven by two key factors in both models: lump-sum taxes and real wages. Real wages play a negative role in this model because they decline after the positive government spending shock, but they can be increased in the long-run if there is a positive accumulation of capital, in which case they contribute to boosting consumption. Finally, output's response is strongly linked to labor.

3.5.3.4 Effects of tax cut policies

I then simulate different tax cuts and compare their outcomes. In case of a consumption income tax cut (see Figure 3.11), there is a slight difference between the model's behavior outside and at the ZLB. In the first regime, consumption increases on impact. On the other hand, there is a small drop in output and interest rates. In the second regime, consumption also increases on impact but declines after two quarters to go up again before the tenth quarter. Response of output is negative and more acute than in the first regime. Finally, as interest rates are bounded, a deflationary response is caused by the shock, which further depresses the economy.

A similarity can be observed between consumption's response and the response of real wages. On impact, there is a slight increase of wages and consumption in both regimes resulting from the lower consumption tax. Then the path of both variables is negatively affected by the increase in other taxes. Both variables rise again as taxes converge to their steady states. Therefore, movements in both variables correspond to the inverse of those of taxes which follow a hump-shaped pattern.

Overall, it appears that this policy is ineffective. First, it causes a drop in labor (and thereby in output). Second, even the immediate positive response of consumption is extremely small. This can be justified by the parameterization of the model. The parameters that determine the impact of a consumption tax are small (especially compared to other taxes). The consumption tax rate steady state value is 0.08 (compared to 0.61 for the capital income tax). The steady state ratio of consumption over output is 0.57 (compared to 2.2 for capital). The estimated posterior mode for the standard deviations of shocks is also smaller compared to other taxes. Third, the immediate positive effect of the tax cut on consumption is offset by the negative effect of other tax increases. Finally, at the ZLB, this policy is even more detrimental in the short-run because of the negative reaction of inflation.

Although a consumption tax cut is inefficient in stimulating the economy, it is not as disadvantageous in the short-run as a wage income tax cut (Figure 3.12). A wage income tax cut causes a drop in consumption and output both at and outside the ZLB. The behavior of interest rates and inflation is the same as in the consumption tax cut. There is a negative response of labor, capital and investment on impact, causing the decline in output.

Nevertheless, in the long-run, at the ZLB, the impact of both consumption tax and wage income tax cuts becomes positive. This can be justified by an increase in investment after the second quarter which increases the capital stock and inverts the response of inflation, real wages, consumption and output. The higher investment is linked to the increase in capital income tax rate which is more marked at the ZLB. The model specification implies that a future increase in the capital income tax rate has a negative effect on present capital, but a present increase has a positive effect because of the expected decrease of the tax.

The most advantageous policy in all tax cut policies is a capital income tax cut (Figure 3.13). Although it causes a drop in consumption on impact, consumption tends to increase over time both at and outside the ZLB. The response of output is positive over the whole simulation period. One main driver of these dynamics is the jump in investment that follows the policy, which is accompanied by higher labor. Over time, there is a positive accumulation of capital, which induces a progressive decline in the rental rate of capital. As opposed to the previous tax cuts, inflation's response is positive at the ZLB. Still, this inflationary effect does not significantly alter the model's behavior which stays almost the same across both regimes.

Finally, one can remark that successful policies are those that increase inflation (at the ZLB or interest rates outside the bound) and generate higher investment. Capital accumulation plays an important role by shifting wages and production upward.

3.5.3.5 Comparison between policies of a government spending increase and a capital income tax cut

I compare between the effect of a government spending increase and a capital income tax cut. Plots are reported on Figure 3.14. On impact, many responses are almost at the same level for both measures (consumption, output, labor, rental rate of capital, real wages and interest rates). However, after a few quarters, a capital income tax cut has a better stimulating effect on the economy than a government spending increase. This mainly results from the higher increase in investment and the ensuing capital accumulation which shifts the economy's productive potential upward, resulting in a higher level of output. This process also leads to a substantial increase in real wages over the long run, which eventually decreases labor. However, one negative aspect of this measure is that it generates a higher level of debt compared to a government spending increase. As a result, tax rates also increase more significantly to repay the debt, as shown on Figure 3.15.

3.5.3.6 Variance decomposition of private consumption

Based on the extended model, I calculate the variance decomposition of private consumption, output, investment and real wages to detect what structural shocks drive these variables. Results are shown in Table 3.5 with various horizons (short-run: one quarter, medium-run: 10 quarters and long-run: 20 quarters).

One significant difference between the obtained results and those of the benchmark model of Smets and Wouters (2003) is that preference shocks are not found to be the main drivers of consumption. Conversely, labor supply shocks and technology shocks contribute significantly to the variance of this variable in both regimes, especially in the first period. In addition, the decomposition also shows that the respective shares of shocks to the marginal efficiency of investment and capital income tax shocks progressively grow over time, in both regimes. The main difference between both regimes lies in the fact that lump-sum taxes play a much more important role in the variation of private consumption at the ZLB than outside it. Finally, Sugo and Ueda (2007) that used a model close to Smets and Wouters (2003) for

Japan[29] also found consumption to be mainly driven by technology shocks, but the weight of preference shocks was not as insignificant in their model as in the present model.

Overall, fiscal shocks do not affect private consumption significantly. In comparison, they contribute more notably in variations of output and investment. As shown in Table 3.5, output is significantly affected by wage income tax rate fluctuations, in addition to government spending (in the short-run), capital income tax rate shocks (over the long-run), and also lump-sum taxes at the ZLB. In the case of the investment variable, there is a significant contribution of the capital income tax shock (in addition to lump-sum taxes at the ZLB). Finally, the variance decomposition of consumption is closer to the one of real wages. Real wages' variation is mainly explained by a technology shock, a shock to the mark-up in goods market, a shock to the marginal efficiency of investment (over the long-run) and lump-sum taxes at the ZLB.

Figure 3.16 shows the response of private consumption to the shocks that contribute the most to its variance. It can be seen that an exogenous positive technology shock generates a positive and high response in consumption.[30] On the other hand, a labor supply shock generates a small negative response, which is consistent with Iiboshi, Nishiyama, and Watanabe (2006). It is important to note that this shock is accompanied by a decrease in labor hours.[31] A shock to the marginal efficiency of investment has a positive and progressively growing impact on consumption (hump-shaped). Finally, response of consumption to a negative shock to lump-sum taxes is negative at the ZLB.

3.6 Conclusion

In this paper, I study the effects of fiscal shocks on private consumption through a standard new Keynesian model that includes rule-of-thumb consumers and the ZLB on interest rates. A Markov-switching approach is used for the estimation. In addition, to assess the importance of the fiscal rule specification, findings from a baseline model with lump-sum taxes are compared with those from an extended model with distortionary taxation.

[29] Sugo and Ueda (2007) made two main modifications: they used actual capital utilization rate data for estimation, and they incorporated a negative correlation between capital utilization rates and rental costs of capital.

[30] A technology shock also induces a positive response in output and a negative response in public debt.

[31] It affects the model through the wage equation.

Results indicate that the presence of Non-Ricardian consumers is not sufficient to reduce the weight of Ricardian behavior which still plays a major role in shaping consumption's response. The presence of Non-Ricardian consumers does however strengthen the dependence of consumption on wage fluctuations. The inclusion of distortionary taxation also alters the model's behavior through movements in the tax rates.

It is particularly noted that successful fiscal policies are those that increase investment and inflation (at the ZLB) or interest rates (outside the bound). Investment plays a fundamental role in the model as it affects the economy's production level through the capital accumulation process.

There is no significant difference between the model's behavior at and outside the ZLB after a government spending increase or a capital income tax cut. But a difference across regimes can be observed after a consumption tax or a wage income tax cut. Outside the ZLB, both measures have a negative impact on the economy. At the ZLB, both policies have harmful effects in the short-run but the potential to yield better results over the long-run. A comparison between the different policies indicates that a capital income tax cut is the most beneficial measure because of its stimulating impact on investment. Nonetheless, it generates a much higher level of public debt which causes future tax hikes.

Finally, a variance decomposition of private consumption reveals that it is mainly driven by shocks to the labor supply and technology shocks. At the ZLB, shocks to lump-sum taxes are also found to play an important role. Among these shocks, a technology shock is the one that generates the highest positive response in consumption.

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Tables

TABLE 3.1: Calibration of baseline model

Parameter		Calibration	Smets and Wouters (2003)*
Structural parameters			
Habit of consumption	h	0.795	0.592
Inverse of elasticity of work effort	σ_L	2.077	2.503
Relative risk aversion of Ricardian households	σ_c	1.912	1.391
Inverse of the elasticity of money holding with respect to the interest rate	σ_M	2	——
Share of fixed cost in production +1 $\left(1+\frac{\Phi}{Y}\right)$	θ	1.45	1.417
Share of non-Ricardian consumers	μ	0.35	——
Degree of partial indexation of price	γ_p	0.579	0.477
Degree of partial ind. of wage	γ_w	0.581	0.728
Calvo price stickiness	ξ_p	0.791	0.905
Calvo wage stickiness	ξ_w	0.275	0.742
Policy Parameters			
Response of monetary policy to inflation	ϕ_π	1.70	1.688
Autoregressive coefficient of interest rate	ϕ_r	0.80	0.956
Response of monetary policy to output gap	ϕ_Y	0.125	0.098
Fiscal rule parameter with respect to debt	ϕ_b	0.33	——
Fiscal rule par. with respect to government spending	ϕ_g	0.10	——
Shock persistence			
Autoregressive parameter of preference shock	ρ_B	0.214	0.838
Autoregressive parameter of labor supply shock	ρ_L	0.406	0.881
Autoregressive parameter of shock to the marginal efficiency of investment	ρ_x	0.933	0.913
Autoregressive parameter of technology shock	ρ_a	0.818	0.811
Autoregressive parameter of government spending shock	ρ_g	0.793	0.943
Autoregressive parameter of a money demand shock	ρ_M	0.800	——

* Posterior mean

TABLE 3.2: Threshold regression estimation of the monetary policy rule using Japanese data over the period 1995Q3-2016Q1

IR threshold	**<0.001**			**<0.01**			**<0.1**			**Average**
	Coeff	S.E.	P-value	Coeff	S.E.	P-value	Coeff	S.E.	P-value	Coeff
ϕ_r	0.28***	$5x10^{-15}$	0	0.33***	0.02	0	0.58**	0.18	0.0021	0.40
ϕ_π	-0.001***	$3x10^{-18}$	0	-0.001***	0.0003	0	0.012	0.008	0.13	0.003
ϕ_y	0.00003***	$6x10^{-18}$	0	0.0013*	0.0005	0.017	0.015*	0.006	0.02	0.005

*** p<0.001, **p<0.01, *p<0.05

TABLE 3.3: Prior distributions and posterior mode of parameters for the Markov-switching baseline model estimation

Parameter	Distribution	Prior mean	Standard deviation	Posterior Mode	Mode SD
Structural parameters					
h	beta	0.795	0.1	0.624	0.082
σ_l	gamma	2	0.375	2.251	0.947
σ_c	gamma	1.5	0.2	2.078	0.708
σ_M	gamma	2	0.5	1.452	0.939
θ	gamma	1.45	0.25	1.613	0.471
μ	beta	0.2	0.05	0.100	0.041
γ_p	beta	0.75	0.15	0.819	0.083
γ_w	beta	0.75	0.15	0.823	0.189
ξ_p	beta	0.75	0.15	0.011	0.069
ξ_w	beta	0.75	0.15	0.018	0.122
Fiscal Policy Parameters					
ϕ_b	Inverse gamma	0.1	2	0.034	0.179
ϕ_g	normal	0.1	0.05	0.099	0.075
Shock persistence					
ρ_B	beta	0.8	0.1	0.998	0.270
ρ_L	beta	0.8	0.1	0.295	0.201
ρ_x	beta	0.8	0.1	0.990	0.054
ρ_a	beta	0.8	0.1	0.846	0.186
ρ_g	beta	0.8	0.1	0.745	0.132
ρ_M	beta	0.8	0.1	0.931	0.067
Standard deviation of shocks					
η_t^B	Inverse gamma	0.2	2	10.000	0.791
η_t^L	Inverse gamma	1	2	6.962	1.155
η_t^x	Inverse gamma	0.1	2	8.545	2.960
η_t^a	Inverse gamma	0.4	2	0.888	0.868
η_t^g	Inverse gamma	0.3	2	0.339	0.099
η_t^p	Inverse gamma	0.15	2	0.050	3.149
η_t^w	Inverse gamma	0.25	2	0.084	0.470
η_t^M	Inverse gamma	0.5	2	10.000	0.543
Switching Monetary Policy Parameters					
Regime 1					
ϕ_π	normal	1.7	0.1	1.790	0.201
ϕ_r	beta	0.8	0.1	0.571	0.111
ϕ_Y	normal	0.125	0.05	0.120	0.097
Regime 2					
ϕ_π	normal	0.003	0.001	0.006	0.001
ϕ_r	beta	0.4	0.1	0.857	0.224
ϕ_Y	normal	0.005	0.001	0.005	0.002
Transition probabilities					
TP (1 to 2)	beta	0.005	0.15	0.030	0.161
TP (2 to 1)	beta	0.005	0.15	0.247	0.239

TABLE 3.4: Prior distributions and posterior mode of parameters for the Markov-switching extended model estimation

Parameter	Distribution	Prior mean	Standard deviation	Posterior Mode	Mode SD
Structural parameters					
h	beta	0.795	0.1	0.490	0.111
σ_l	gamma	2	0.375	1.602	0.348
σ_c	gamma	1.5	0.2	1.817	0.236
σ_M	gamma	2	0.5	4.563	0.552
θ	gamma	1.45	0.25	1.999	0.151
μ	beta	0.2	0.05	0.422	0.036
γ_p	beta	0.75	0.15	0.488	0.202
γ_w	beta	0.75	0.15	0.564	0.183
ξ_p	beta	0.75	0.15	0.036	0.076
ξ_w	beta	0.75	0.15	0.011	0.079
Fiscal Policy Parameters					
ρ_{tr}	beta	0.8	0.1	0.217	0.126
ρ_{ct}	beta	0.8	0.1	0.853	0.172
ρ_{wt}	beta	0.8	0.1	0.771	0.130
ρ_{kt}	beta	0.8	0.1	0.847	0.146
ρ_{try}	normal	0.1	0.05	0.102	0.048
ρ_{cty}	normal	0.1	0.05	0.100	0.105
ρ_{wtl}	normal	0.1	0.05	0.102	0.047
ρ_{ktI}	normal	0.1	0.05	0.098	0.081
ρ_{gy}	normal	0.1	0.05	-0.026	0.047
ρ_{trb}	normal	0.1	0.05	0.068	0.106
ρ_{ctb}	normal	0.1	0.05	0.092	0.051
ρ_{wtb}	normal	0.1	0.05	0.110	0.100
ρ_{ktb}	normal	0.1	0.05	0.096	0.063
ρ_{gb}	normal	0.1	0.05	0.005	0.076
Shock persistence					
ρ_B	beta	0.8	0.1	0.846	0.153
ρ_L	beta	0.8	0.1	0.333	0.196
ρ_x	beta	0.8	0.1	0.874	0.088
ρ_a	beta	0.8	0.1	0.357	0.130
ρ_g	beta	0.8	0.1	0.704	0.064
ρ_M	beta	0.8	0.1	0.917	0.174
Standard deviation of shocks					
η_t^B	Inverse gamma	0.2	2	0.067	0.886
η_t^L	Inverse gamma	1	2	4.523	1.879
η_t^x	Inverse gamma	0.1	2	6.084	1.089
η_t^a	Inverse gamma	0.4	2	0.687	1.083
η_t^g	Inverse gamma	0.3	2	0.338	1.007
η_t^p	Inverse gamma	0.15	2	0.049	2.938
η_t^w	Inverse gamma	0.25	2	0.083	2.414
η_t^M	Inverse gamma	0.5	2	6.749	1.906
η_t^{tr}	Inverse gamma	0.1	2	6.405	0.472
η_t^{ct}	Inverse gamma	0.1	2	0.033	0.808
η_t^{wt}	Inverse gamma	0.1	2	0.057	3.370
η_t^{kt}	Inverse gamma	0.4	2	6.024	1.197
Switching Monetary Policy Parameters					
Regime 1					
ϕ_π	normal	1.7	0.1	1.694	0.073
ϕ_r	beta	0.8	0.1	0.694	0.106
ϕ_Y	normal	0.125	0.05	0.102	0.057
Regime 2					
ϕ_π	normal	0.003	0.001	0.003	0.003
ϕ_r	beta	0.4	0.1	0.799	0.178
ϕ_Y	normal	0.005	0.001	0.005	0.001
Transition probabilities					
TP (1 to 2)	beta	0.005	0.15	0.057	0.209
TP (2 to 1)	beta	0.005	0.15	0.217	0.058

TABLE 3.5: Forecast error variance decomposition of consumption, output, investment and real wages at various horizons (extended model)

Private consumption

		Regime 1			Regime 2 (ZLB)		
		t=1	t=10	t=20	t=1	t=10	t=20
Labor supply shock	η_t^L	0.65	0.31	0.19	0.44	0.25	0.14
Technology shock	η_t^a	0.25	0.12	0.08	0.14	0.08	0.04
Shock to mark-up in goods markets	η_t^p	0.05	0.01	0.01	0.01	0.00	0.00
Wage mark-up shock	η_t^w	0.03	0.01	0.01	0.02	0.01	0.00
Shock to the marg. effic. of inv.	η_t^x	0.01	0.49	0.48	0.02	0.29	0.25
Government spending shock	η_t^g	0.01	0.01	0.01	0.01	0.01	0.01
Capital income tax shock	η_t^{kt}	0.00	0.04	0.21	0.00	0.06	0.19
Lump-sum taxes shock	η_t^{tr}	0.00	0.01	0.02	0.31	0.29	0.35
Wage-income tax shock	η_t^{wt}	0.00	0.00	0.00	0.00	0.00	0.00
Money demand shock	η_t^M	0.00	0.00	0.00	0.04	0.02	0.01
Consumption tax shock	η_t^{ct}	0.00	0.00	0.00	0.00	0.00	0.00
Preference shock	η_t^B	0.00	0.00	0.00	0.00	0.00	0.00

Output

		Regime 1			Regime 2 (ZLB)		
		t=1	t=10	t=20	t=1	t=10	t=20
Wage-income tax shock	η_t^{wt}	0.32	0.17	0.10	0.29	0.14	0.11
Technology shock	η_t^a	0.28	0.18	0.12	0.09	0.07	0.05
Shock to the marg. effic. of inv.	η_t^x	0.16	0.13	0.12	0.09	0.07	0.07
Government spending shock	η_t^g	0.09	0.06	0.04	0.04	0.03	0.03
Capital income tax shock	η_t^{kt}	0.07	0.38	0.56	0.04	0.20	0.31
Shock to mark-up in goods markets	η_t^p	0.05	0.02	0.01	0.01	0.01	0.00
Wage mark-up shock	η_t^w	0.04	0.02	0.01	0.02	0.01	0.01
Labor supply shock	η_t^L	0.01	0.01	0.01	0.00	0.01	0.00
Lump-sum taxes shock	η_t^{tr}	0.01	0.03	0.02	0.35	0.40	0.36
Money demand shock	η_t^M	0.00	0.00	0.00	0.04	0.03	0.03
Preference shock	η_t^B	0.00	0.00	0.00	0.02	0.04	0.03
Consumption tax shock	η_t^{ct}	0.00	0.00	0.00	0.00	0.00	0.00

Investment

		Regime 1			Regime 2 (ZLB)		
		t=1	t=10	t=20	t=1	t=10	t=20
Shock to the marg. effic. of inv.	η_t^x	0.65	0.82	0.89	0.43	0.60	0.70
Capital income tax shock	η_t^{kt}	0.30	0.16	0.10	0.18	0.12	0.09
Lump-sum taxes shock	η_t^{tr}	0.03	0.01	0.00	0.26	0.22	0.16
Technology shock	η_t^a	0.01	0.01	0.00	0.02	0.00	0.00
Government spending shock	η_t^g	0.00	0.00	0.00	0.00	0.00	0.00
Money demand shock	η_t^M	0.00	0.00	0.00	0.02	0.01	0.01
Preference shock	η_t^B	0.00	0.00	0.00	0.08	0.03	0.02
Shock to mark-up in goods markets	η_t^p	0.00	0.00	0.00	0.00	0.00	0.00
Labor supply shock	η_t^L	0.00	0.00	0.00	0.00	0.00	0.00
Wage mark-up shock	η_t^w	0.00	0.00	0.00	0.00	0.00	0.00
Wage-income tax shock	η_t^{wt}	0.00	0.00	0.00	0.00	0.02	0.02
Consumption tax shock	η_t^{ct}	0.00	0.00	0.00	0.00	0.00	0.00

Real wages

		Regime 1			Regime 2 (ZLB)		
		t=1	t=10	t=20	t=1	t=10	t=20
Technology shock	η_t^a	0.51	0.22	0.12	0.32	0.16	0.09
Shock to mark-up in goods markets	η_t^p	0.46	0.17	0.09	0.27	0.11	0.06
Wage-income tax shock	η_t^{wt}	0.01	0.01	0.00	0.00	0.01	0.02
Shock to the marg. effic. of inv.	η_t^x	0.01	0.54	0.62	0.00	0.37	0.45
Government spending shock	η_t^g	0.00	0.00	0.00	0.00	0.00	0.00
Capital income tax shock	η_t^{kt}	0.00	0.07	0.16	0.00	0.06	0.14
Wage mark-up shock	η_t^w	0.00	0.00	0.00	0.00	0.00	0.00
Lump-sum taxes shock	η_t^{tr}	0.00	0.00	0.00	0.16	0.13	0.14
Labor supply shock	η_t^L	0.00	0.00	0.00	0.00	0.00	0.00
Preference shock	η_t^B	0.00	0.00	0.00	0.13	0.08	0.05
Money demand shock	η_t^M	0.00	0.00	0.00	0.11	0.07	0.04
Consumption tax shock	η_t^{ct}	0.00	0.00	0.00	0.00	0.00	0.00

Figures

FIGURE 3.1: Baseline model's response to a government spending positive shock in the absence of a binding constraint

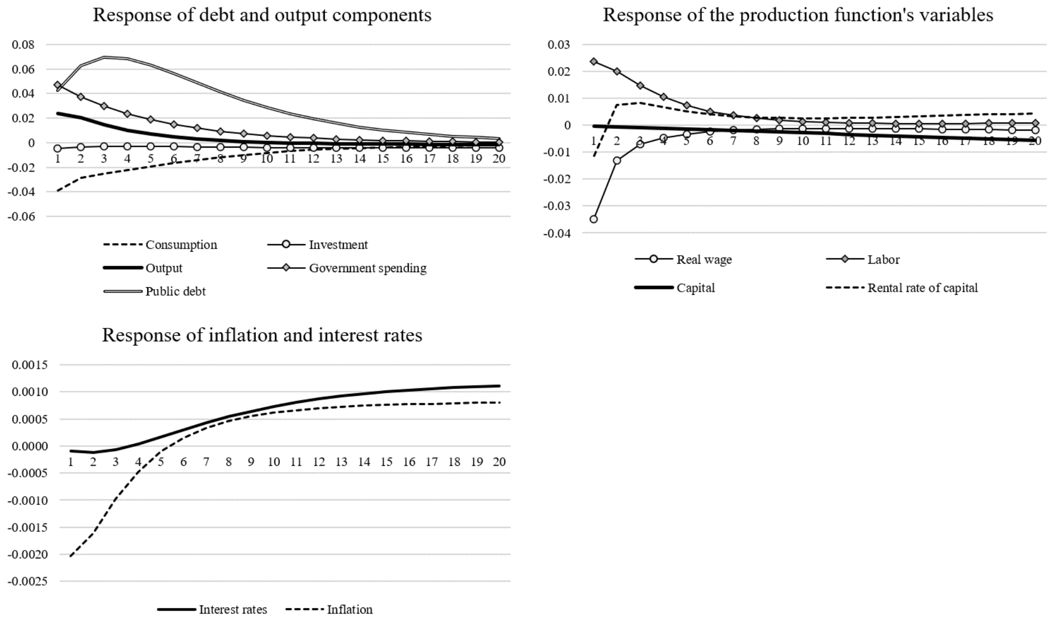


FIGURE 3.2: Response of consumption to a government spending shock for different values of the share of rule-of-thumb consumers (calibrated baseline model)

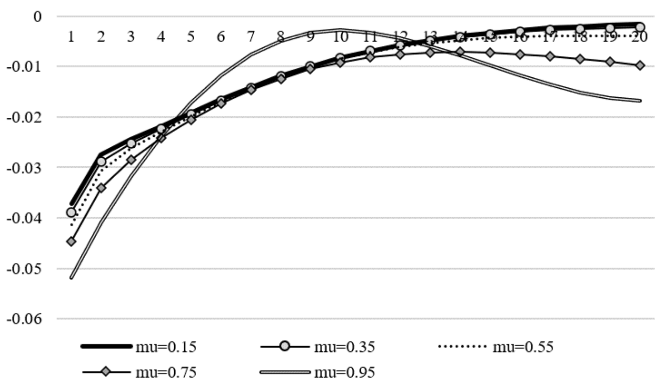


FIGURE 3.3: Response to a positive government spending shock in the baseline and extended model (fully calibrated model with no binding constraint)

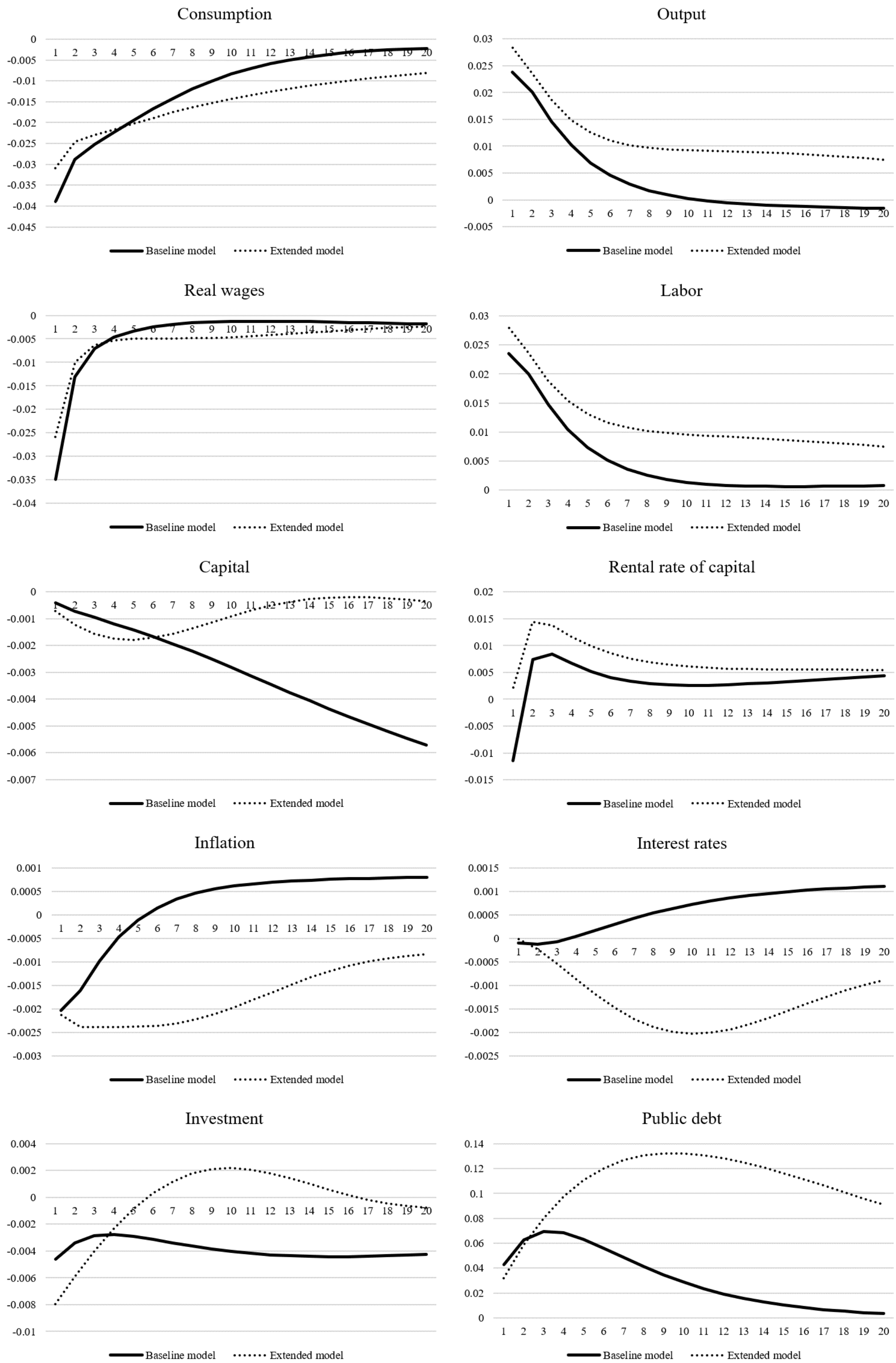


FIGURE 3.4: CPI inflation and interest rates over the period of study

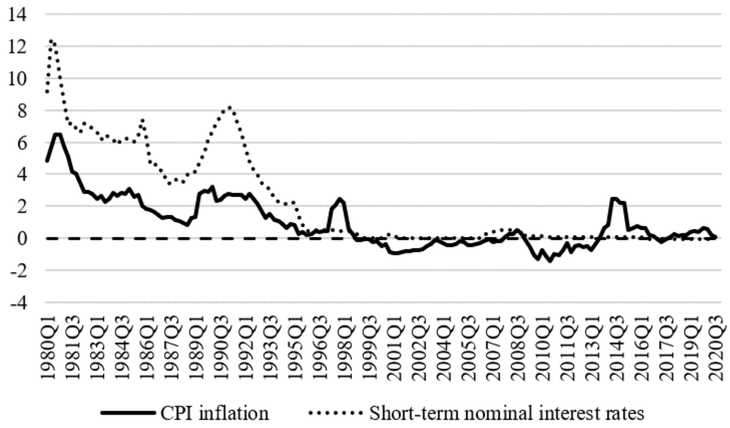


FIGURE 3.5: Interest rates Vs smoothed probabilities of an unbounded interest rates regime

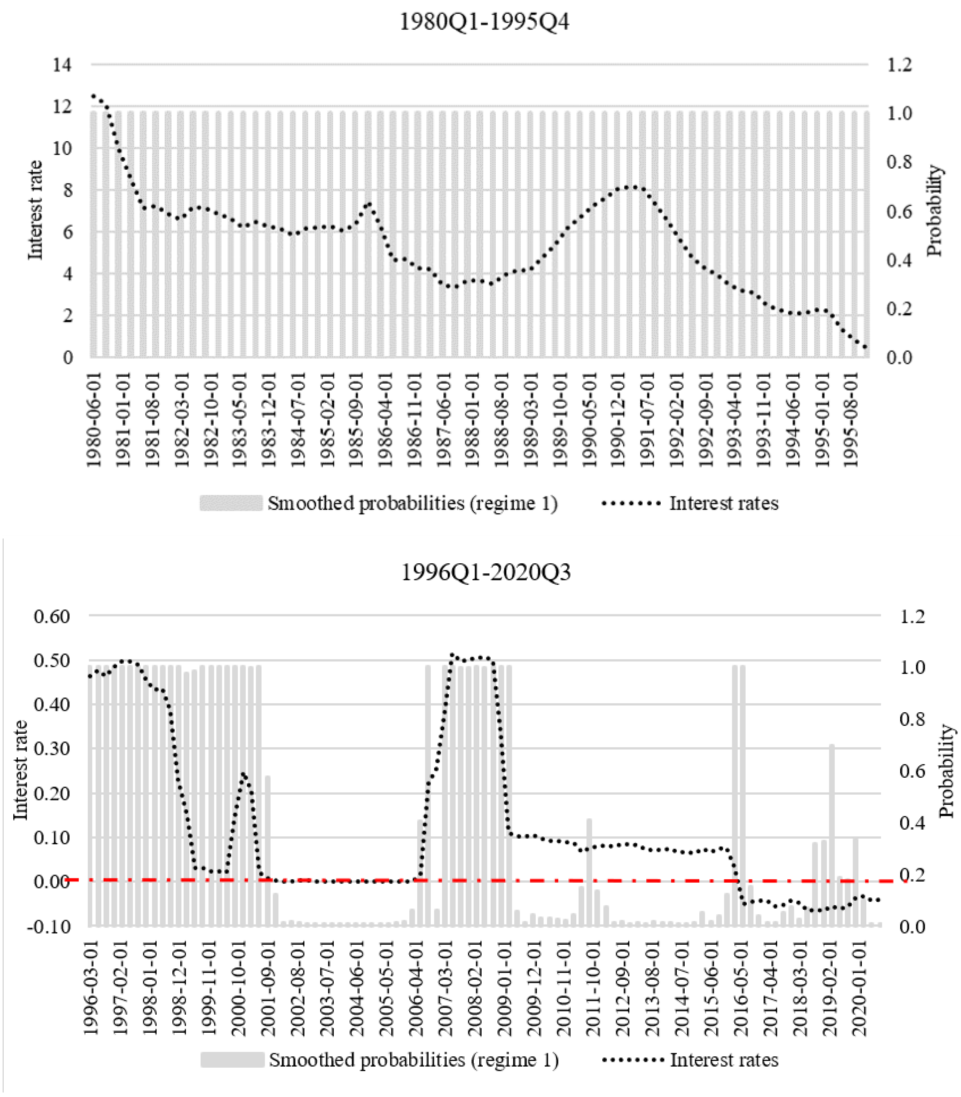


FIGURE 3.6: Response to a positive government spending shock in the baseline model (regime-switching)

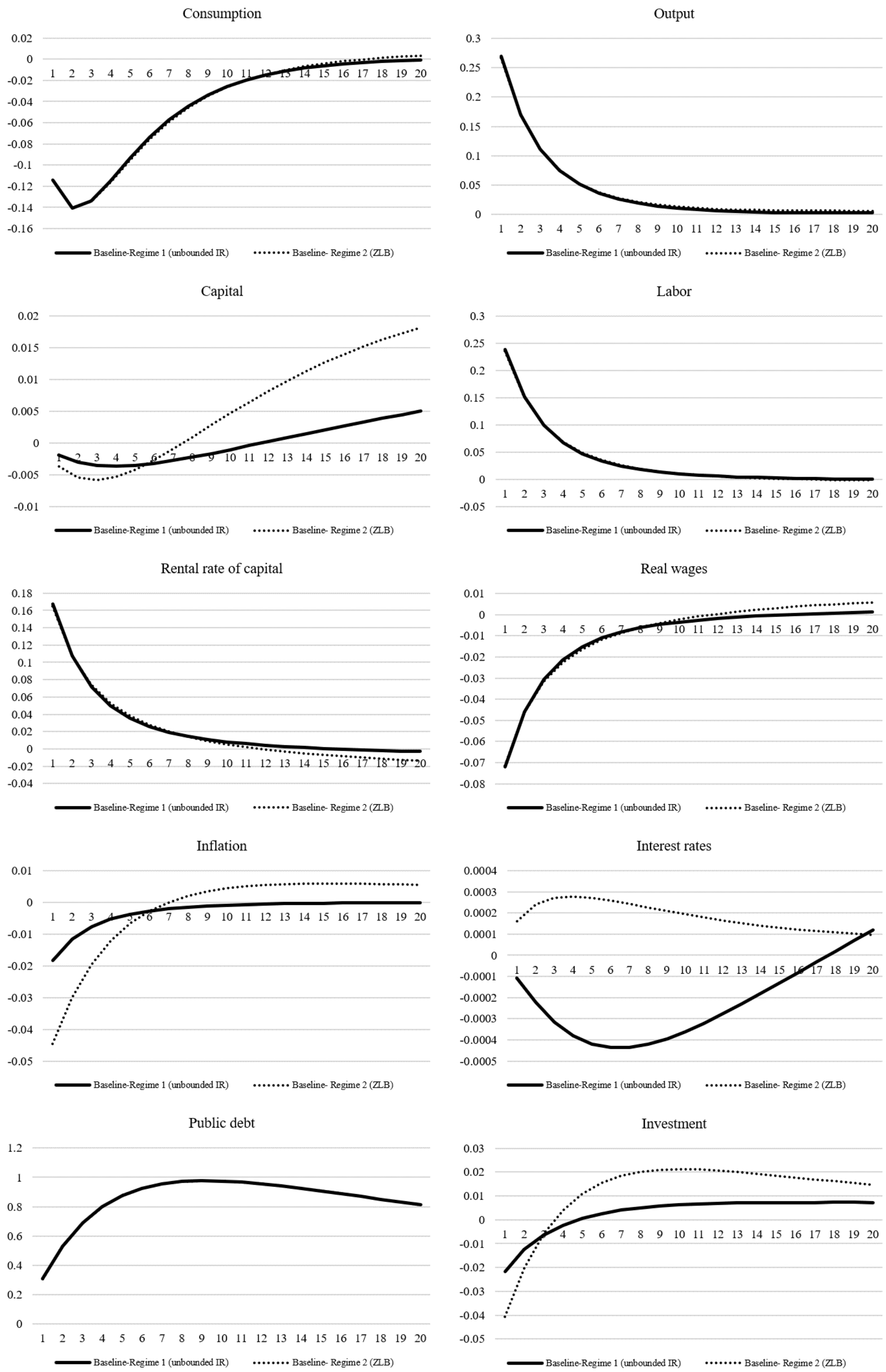


FIGURE 3.7: Response to a positive government spending shock in the extended model (regime-switching)

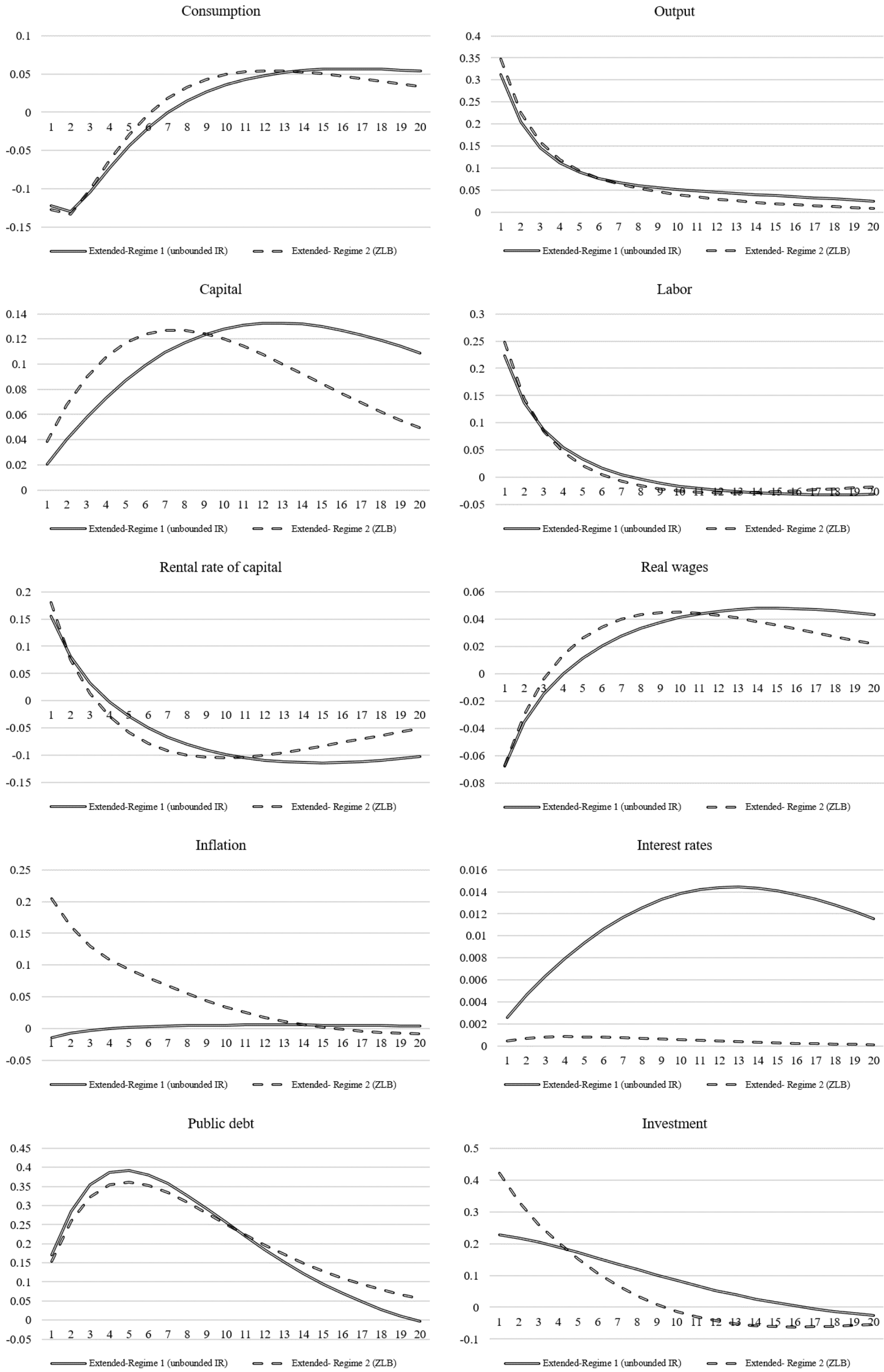


FIGURE 3.8: Lump-sum taxes and tax rate adjustments after a positive government spending shock in the extended model (regime-switching)

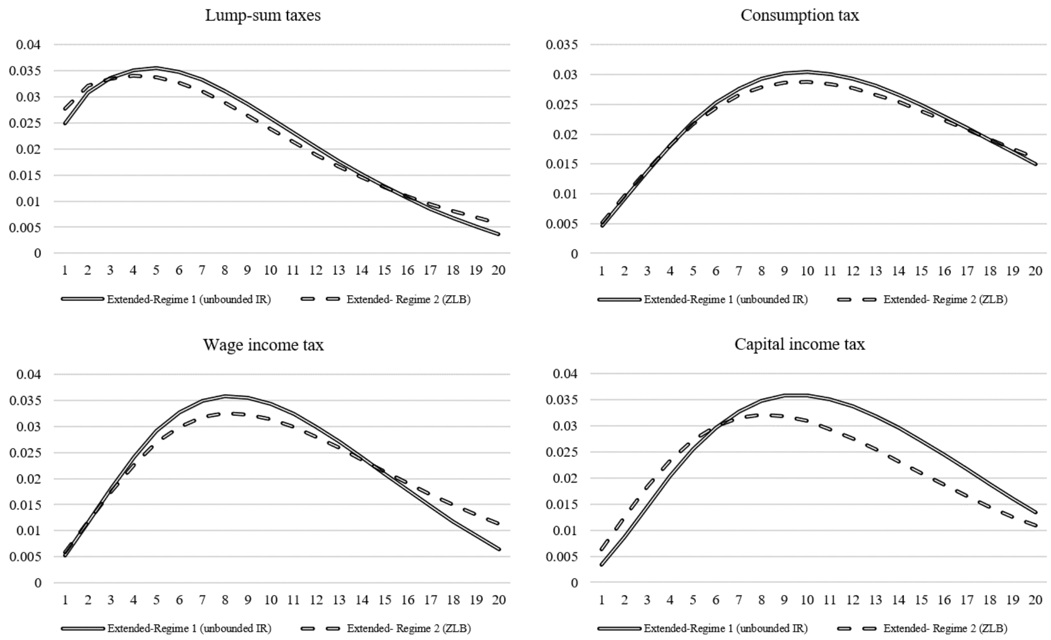


FIGURE 3.9: Lump-sum taxes and tax rate adjustments after a negative government spending shock in the extended model (regime-switching)

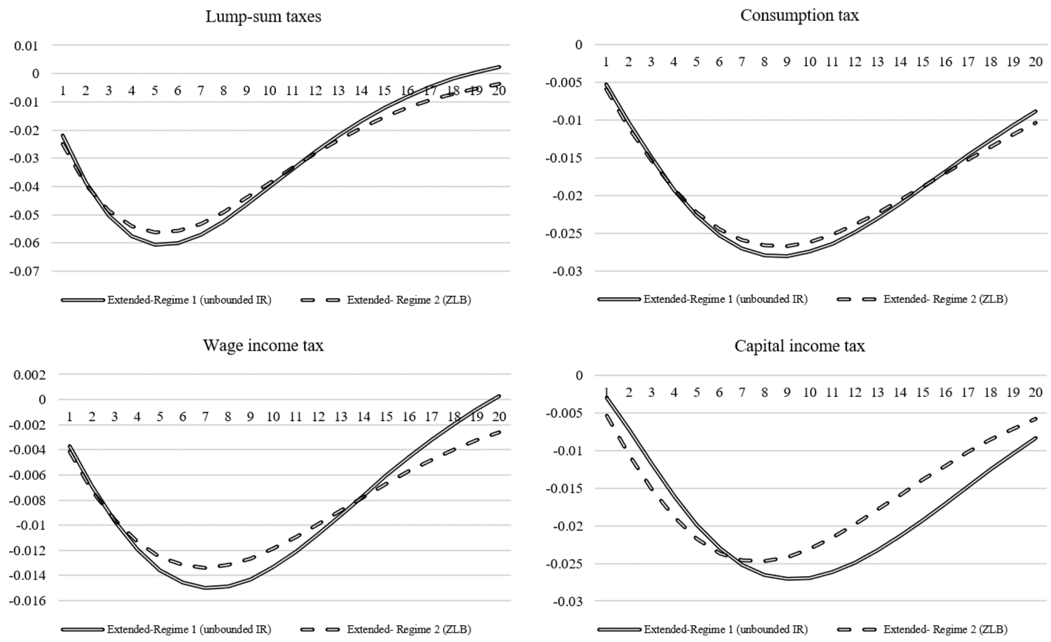


FIGURE 3.10: Response to a negative shock to government spending (regime-switching)

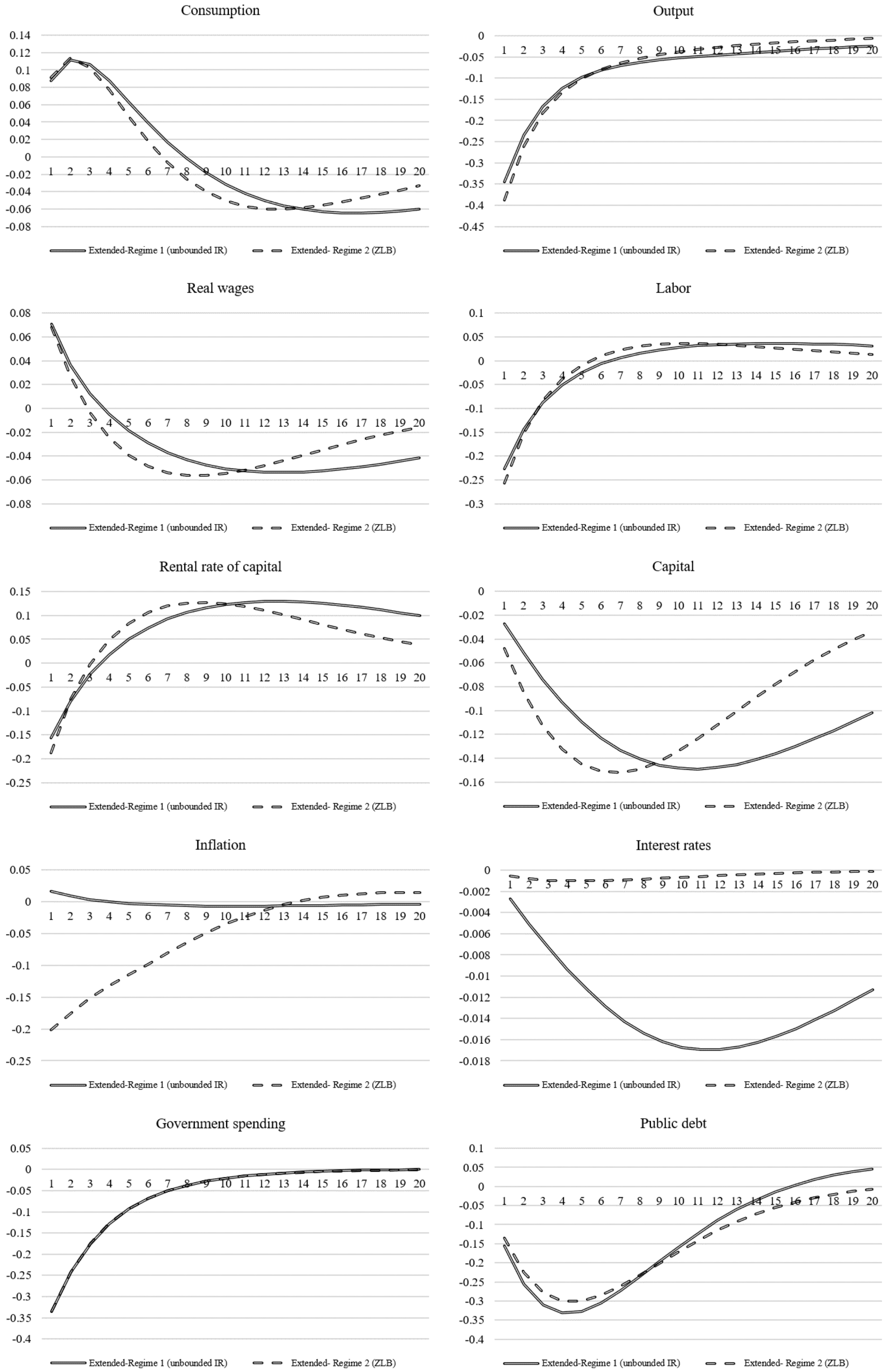


FIGURE 3.11: Response to a negative shock to the consumption tax rate (regime-switching)

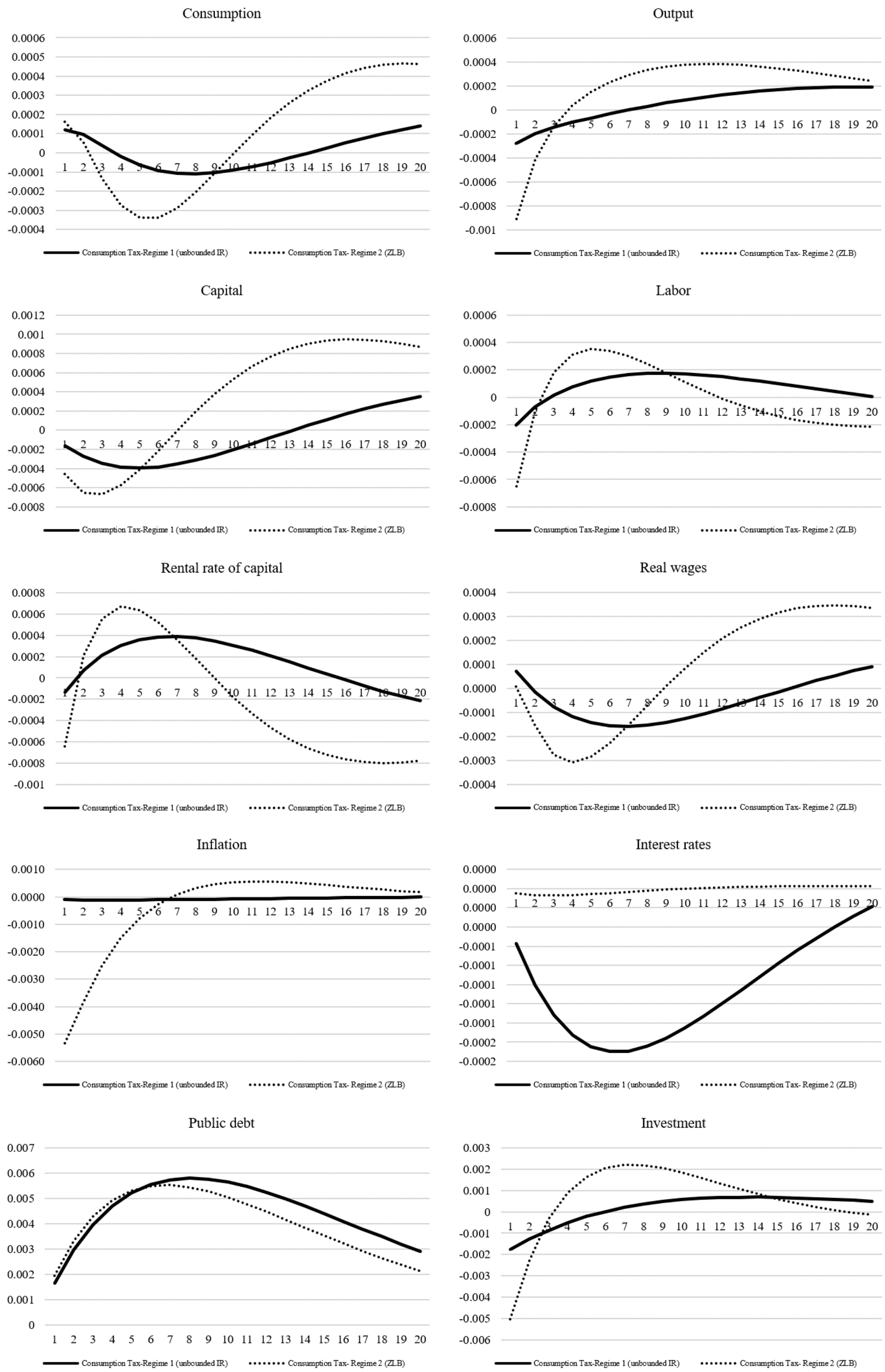


FIGURE 3.12: Response to a negative shock to the wage income tax rate (regime-switching)

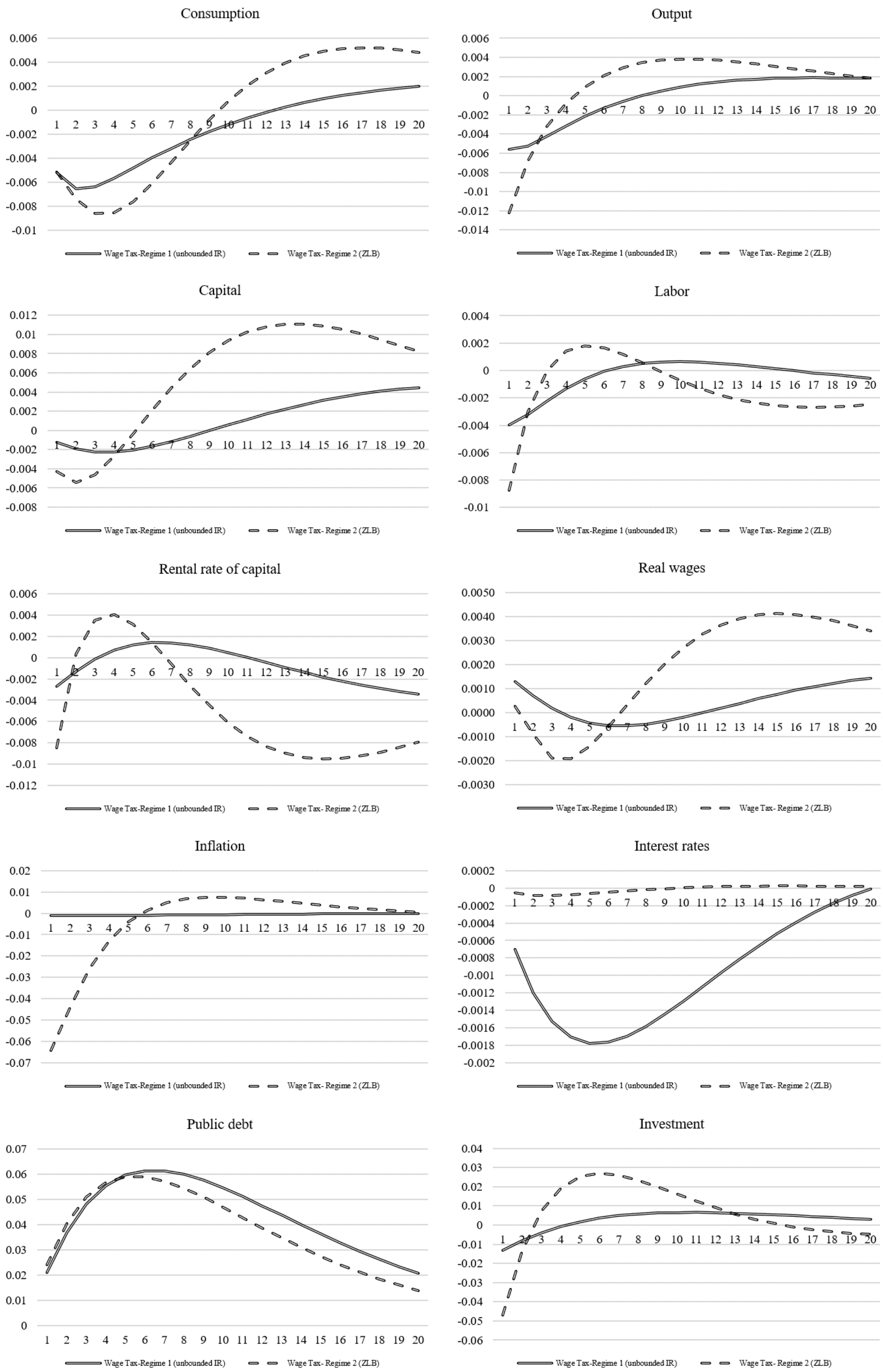


FIGURE 3.13: Response to a negative shock to the capital income tax rate (regime-switching)

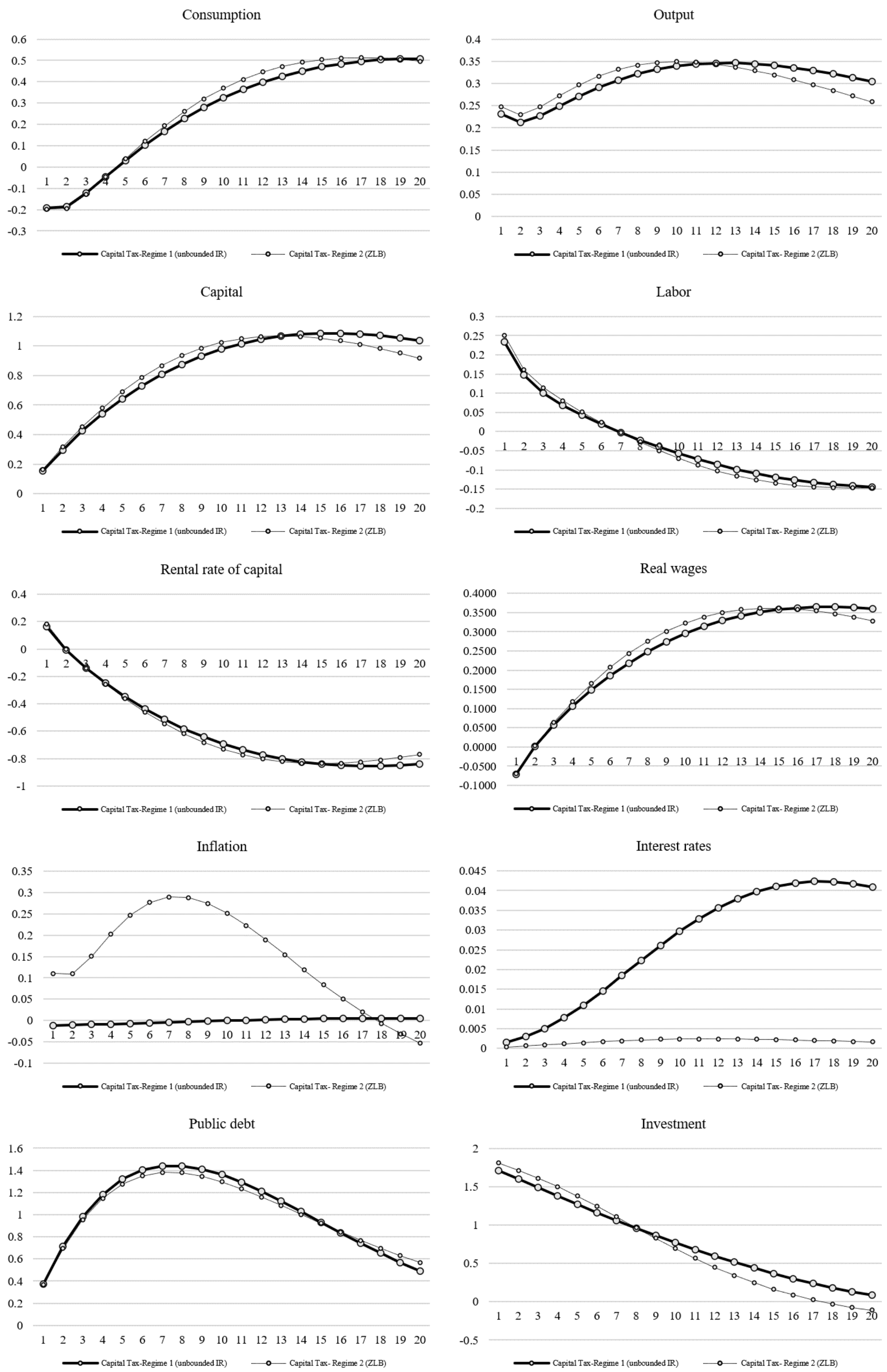


FIGURE 3.14: Comparison between a government spending increase measure and a capital income tax cut

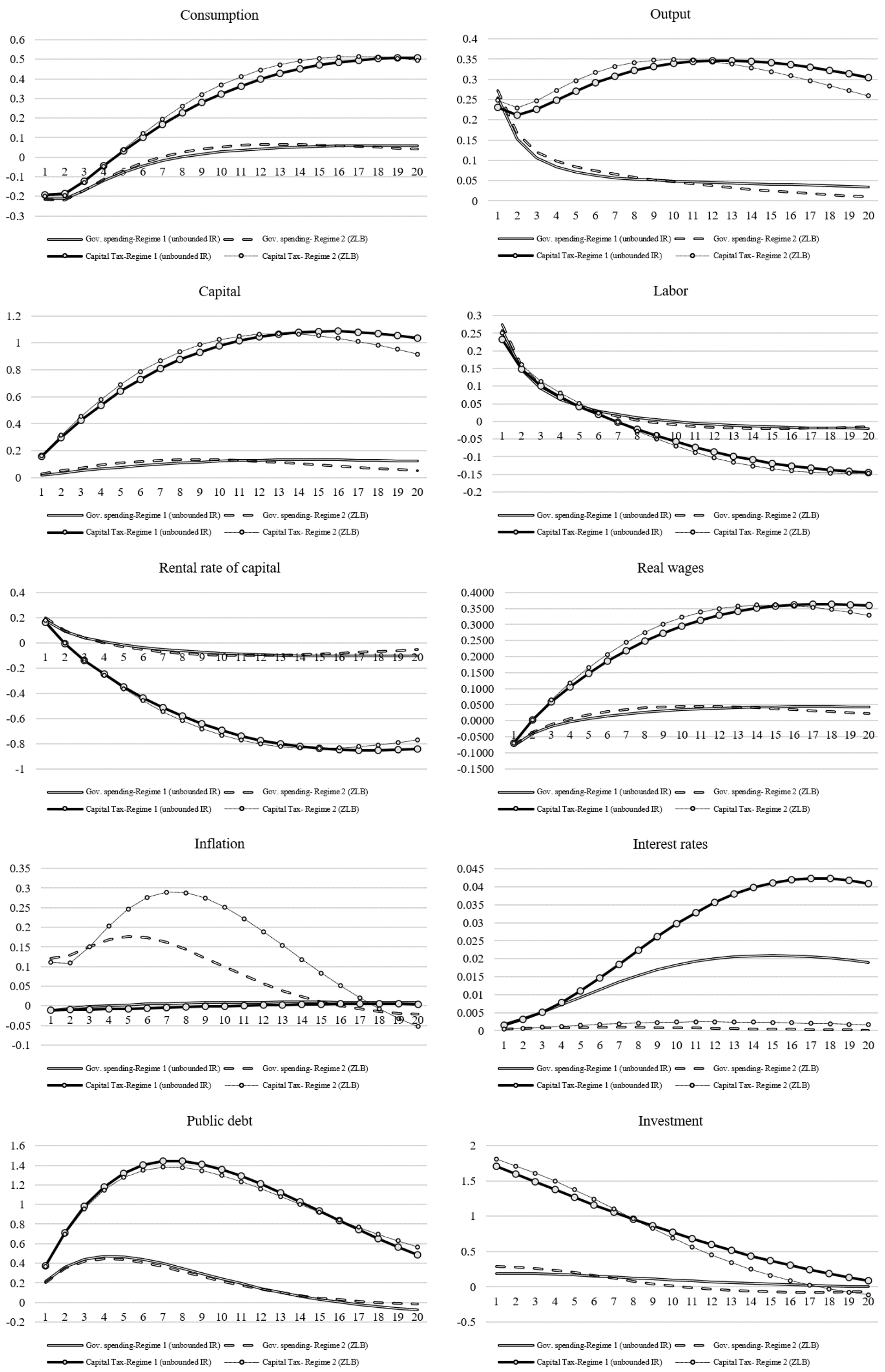


FIGURE 3.15: Spending and tax adjustments after a government spending increase and a capital income tax cut

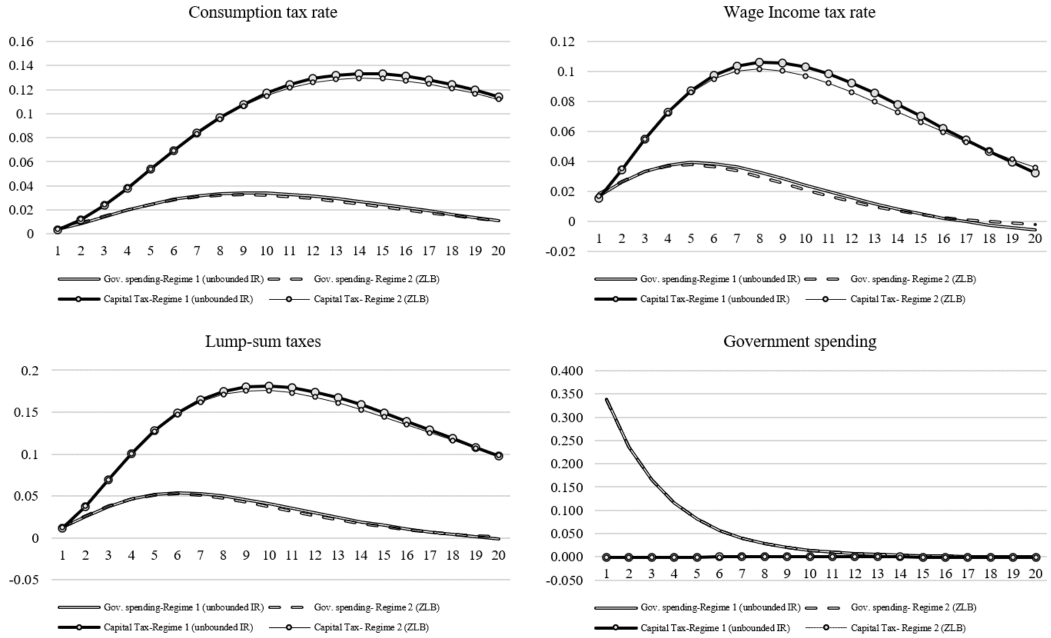
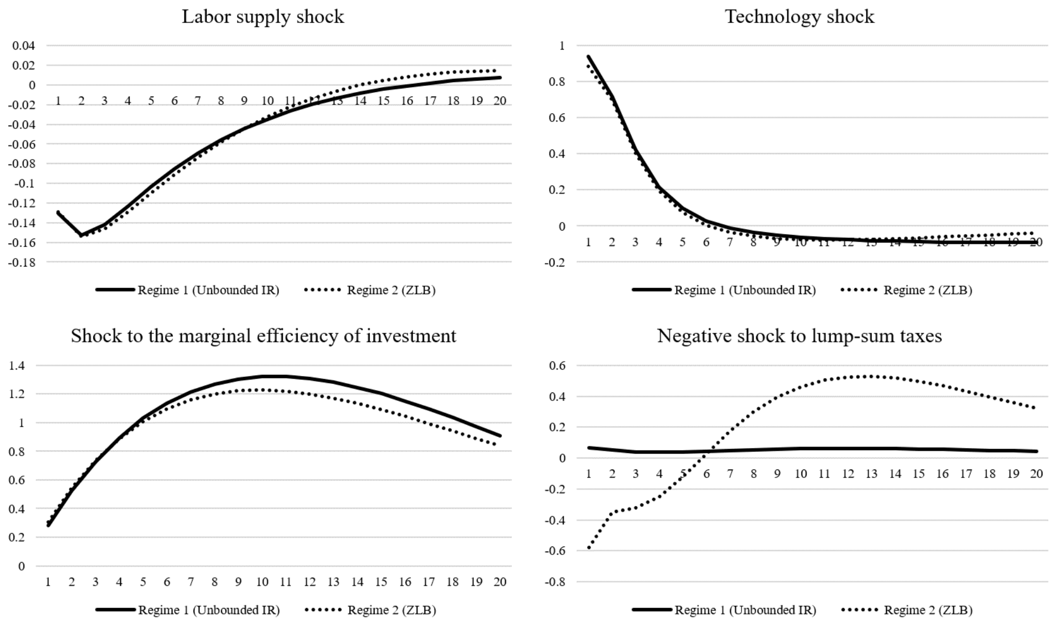


FIGURE 3.16: Response of private consumption to various shocks (extended model)



Appendix A: Baseline model summary

Households

The households' optimization problem is as follows

Maximizing utility

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\varepsilon_t^B \left(\frac{1}{1-\sigma_c} \left(C_t^R - H_t \right)^{1-\sigma_c} - \frac{\varepsilon_t^L}{1+\sigma_l} \left(L_t^R \right)^{1+\sigma_l} + \frac{\varepsilon_t^M}{1-\sigma_m} \left(\frac{M_t^R}{P_t} \right)^{1-\sigma_m} \right) \right] \tag{3.66}$$

s.c.

$$\frac{M_t^R}{P_t} + \frac{B_t^R / R_t}{P_t} = \frac{M_{t-1}^R}{P_t} + \frac{B_{t-1}^R}{P_t} + w_t L_t^R + r_t^k K_t^R - \frac{\Theta_k}{2} \left(\frac{K_{t+1}^R}{K_t^R} - 1 \right)^2 K_t^R + Div_t^R - T_t^R - C_t^R - \frac{K_{t+1}^R - (1-\delta) K_t^R}{x_t} \tag{3.67}$$

Setting the Lagrangien as

$$L = E_t \sum_{t=0}^{\infty} \beta^t \left[\varepsilon_t^B \left(\frac{1}{1-\sigma_c} \left(C_t^R - H_t \right)^{1-\sigma_c} - \frac{\varepsilon_t^L}{1+\sigma_l} \left(L_t^R \right)^{1+\sigma_l} + \frac{\varepsilon_t^M}{1-\sigma_m} \left(\frac{M_t^R}{P_t} \right)^{1-\sigma_m} \right) - \lambda_t \left(\left[\frac{M_t^R}{P_t} + \frac{B_t^R}{R_t P_t} + C_t^R + \frac{\Theta_k}{2} \left(\frac{K_{t+1}^R}{K_t^R} - 1 \right)^2 K_t^R + \frac{K_{t+1}^R - (1-\delta) K_t^R}{x_t} \right] - \left[\frac{M_{t-1}^R}{P_t} + \frac{B_{t-1}^R}{P_t} + w_t L_t^R + r_t^k K_t^R + Div_t^R - T_t^R \right] \right) \right] \tag{3.68}$$

The following first order conditions are obtained

$$\frac{dL}{dC_t^R} : \lambda_t = \frac{\varepsilon_t^B}{\left(C_t^R - H_t \right)^{\sigma_c}} \tag{3.69}$$

$$\frac{dL}{dM_t^R} : \left(\frac{M_t^R}{P_t} \right)^{\sigma_m} \left[\lambda_t - \beta E_t \lambda_{t+1} \frac{P_t}{P_{t+1}} \right] - \varepsilon_t^B \varepsilon_t^M = 0 \tag{3.70}$$

$$\frac{dL}{dB_t^R} : \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \frac{P_t}{P_{t+1}} = \frac{1}{R_t} \tag{3.71}$$

$$\frac{dL}{dK_{t+1}^{R}}:\ \lambda_t\left[\frac{1}{x_t}+\Theta_k\left(\frac{K_{t+1}^{R}}{K_t^{R}}-1\right)\right]=\beta E_t\lambda_{t+1}\left[\frac{(1-\delta)}{x_{t+1}}+\frac{\Theta_k}{2}\left(\left(\frac{K_{t+2}^{R}}{K_{t+1}^{R}}\right)^2-1\right)+r_{t+1}^{k}\right] \tag{3.72}$$

$$\frac{dL}{d\lambda_t}:\ \frac{M_t^R}{P_t}+\frac{B_t^R/R_t}{P_t}+C_t^R+\frac{\Theta_k}{2}\left(\frac{K_{t+1}^{R}}{K_t^{R}}-1\right)^2K_t^R+\frac{K_{t+1}^{R}-(1-\delta)K_t^R}{x_t}=\frac{M_{t-1}^R}{P_t}+\frac{B_{t-1}^R}{P_t}+w_tL_t^R+r_t^kK_t^R+Div_t^R-T_t^R \tag{3.73}$$

Combining conditions 3.69 to 3.71

$$\left[\left(C_t^R-H_t\right)^{\sigma_c}\varepsilon_t^M\right]^{1/\sigma_m}=\frac{M_t^R}{P_t}\left(1-\frac{1}{R_t}\right)^{1/\sigma_m} \tag{3.74}$$

As stated in the model description, the capital accumulation process is given by

$$K_{t+1}^R=(1-\delta)K_t^R+x_tI_t^R \tag{3.75}$$

And shocks are expressed as

$$\ln\left(\varepsilon_t^B\right)=\rho_B\ln\left(\varepsilon_{t-1}^B\right)+\eta_t^B \tag{3.76}$$

$$\ln\left(\varepsilon_t^L\right)=\rho_L\ln\left(\varepsilon_{t-1}^L\right)+\eta_t^L \tag{3.77}$$

$$\ln\left(\varepsilon_t^M\right)=\rho_M\ln\left(\varepsilon_{t-1}^M\right)+\eta_t^M \tag{3.78}$$

$$\ln(x_t)=\rho_x\ln\left(x_{t-1}\right)+\eta_t^x \tag{3.79}$$

The non-ricardian consumers budget constraint is given by

$$C_t^{NR}=w_tL_t^{NR}-T_t^{NR} \tag{3.80}$$

Aggregate variables

$$C_t=(1-\mu)C_t^R+\mu C_t^{NR} \tag{3.81}$$

$$L_t=(1-\mu)L_t^R+\mu L_t^{NR} \tag{3.82}$$

With $L_t = L_t^R = L_t^{NR}$ at equilibrium.

$$T_t = (1-\mu)\, T_t^R + \mu T_t^{NR} \tag{3.83}$$

$$B_t = (1-\mu)\, B_t^R \tag{3.84}$$

$$K_{t+1} = (1-\mu)\, K_{t+1}^R \tag{3.85}$$

$$I_t = (1-\mu)\, I_t^R \tag{3.86}$$

$$Div_t = (1-\mu)\, Div_t^R \tag{3.87}$$

Wage equation

Unions choose the wage that maximizes the utility of future periods as follows

$$\max E_t \sum_{i=0}^{\infty} (\beta\xi_w)^i \left[\Lambda_{t+i} \frac{W_{h,t+i}}{P_{t+i}} L_{h,t+i} - \frac{\varepsilon_{t+i}^B \varepsilon_{t+i}^L}{1+\sigma_l} (L_{h,t+i})^{1+\sigma_l} \right] \tag{3.88}$$

Where Λ_{t+i} can be interpreted as the Lagrange multiplier equivalent to the marginal utility of consumption. In other words, the expression shows the gain in utility of consumption based on labor with wage $W_{h,t+i}$minus the disutility of labor, provided that the chosen wage is kept for infinity. Since

$$W_{h,t} = \left(\frac{P_{t-1}}{P_{t-2}} \right)^{\gamma_w} W_{h,\, t-1} \tag{3.89}$$

Then

$$W_{h,t+i} = \prod_{s=1}^{i} \left(\frac{P_{t+s-1}}{P_{t+s-2}} \right)^{\gamma_w} W_{h,\, t} \tag{3.90}$$

Where γ_w is the degree of wage indexation. The demand for labor is

$$L_{h,t+i} = \left(\frac{W_{h,t+i}}{W_{t+i}} \right)^{-\frac{1+\lambda_{w,t+i}}{\lambda_{w,t+i}}} L_{t+i} \tag{3.91}$$

Replacing in 3.88 and deriving the first order condition with respect to wage yields the expression

$$E_t \sum_{i=0}^{\infty} (\beta\xi_w)^i \left[\Lambda_{t+i} \frac{\prod_{s=1}^{i} \left(\frac{P_{t+s-1}}{P_{t+s-2}} \right)^{\gamma_w}}{P_{t+i}} L_{h,t+i} - \frac{\varepsilon_{t+i}^B \varepsilon_{t+i}^L \left(1+\lambda_{w,t+i}\right)}{W_{h,t}^*} (L_{h,t+i})^{1+\sigma_l} \right] = 0 \tag{3.92}$$

Thus

$$\frac{W_{h,t}^*}{P_t}E_t\sum_{i=0}^{\infty}(\beta\xi_w)^i\left[\Lambda_{t+i}\frac{\left(P_{t+i-1}/P_{t-1}\right)^{\gamma_w}}{P_{t+i}/P_t}L_{h,t+i}\right]=E_t\sum_{i=0}^{\infty}(\beta\xi_w)^i\left(1+\lambda_{w,t+i}\right)\varepsilon_{t+i}^B\varepsilon_{t+i}^L(L_{h,t+i})^{1+\sigma_l} \tag{3.93}$$

Or

$$\frac{W_{h,t}^*}{P_t}E_t\sum_{i=0}^{\infty}(\beta\xi_w)^i\left[U_c'\frac{\left(P_{t+i-1}/P_{t-1}\right)^{\gamma_w}}{P_{t+i}/P_t}L_{h,t+i}\right]=E_t\sum_{i=0}^{\infty}(\beta\xi_w)^i\left(1+\lambda_{w,t+i}\right)L_{h,t+i}U_L' \tag{3.94}$$

Where U_c' is the marginal utility of an additional unit of consumption and U_L' the marginal disutility of labor. The aggregate nominal wage is given by

$$W_t=\left[(1-\xi_w)\left(W_{h,t}^*\right)^{-\frac{1}{\lambda_{w,t}}}+\xi_w\left(\frac{P_{t-1}}{P_{t-2}}\right)^{\gamma_w}(W_{t-1})^{-\frac{1}{\lambda_{w,t}}}\right]^{-\lambda_{w,t}} \tag{3.95}$$

Firms

Final goods profits maximization problem leads to the relation

$$y_t^j=\left(\frac{p_t^j}{P_t}\right)^{-\frac{1+\lambda_{p,t}}{\lambda_{p,t}}}Y_t \tag{3.96}$$

Replacing in the expression of the nominal value of the final good $p_t y_t=\int_0^1 p_t^j y_t^j dj$, leads to

$$P_t=\left[\int_0^1\left(p_t^j\right)^{-\frac{1}{\lambda_{p,t}}}dj\right]^{-\lambda_{p,t}} \tag{3.97}$$

The production technology for intermediate goods firms is

$$y_t^j=\varepsilon_t^a K_{j,t}^{\alpha}L_{j,t}^{1-\alpha}-\Phi \tag{3.98}$$

Φ are fixed costs of production and the technology shock is $\ln\left(\varepsilon_t^a\right)=\rho_a\ln\left(\varepsilon_{t-1}^a\right)+\eta_t^a$

Minimizing the total cost $W_tL_{j,t}+R_t^kK_{j,t}$ subject to the production technology yields the following expression

$$\frac{W_tL_{j,t}}{R_t^kK_{j,t}}=\frac{1-\alpha}{\alpha} \tag{3.99}$$

The firms' marginal costs correspond to

$$MC_t = \frac{{W_t}^{1-\alpha} {R_t^k}^{\alpha}}{\varepsilon_t^a \alpha^\alpha (1-\alpha)^{(1-\alpha)}} \tag{3.100}$$

Profits are expressed as

$$\Pi_t^j = \left(p_t^j - MC_t\right) \left(\frac{p_t^j}{P_t}\right)^{-\frac{1+\lambda_{p,t}}{\lambda_{p,t}}} (Y_t) - MC_t \Phi \tag{3.101}$$

Price setting equation

The first order condition is given by

$$E_t \sum_{i=0}^{\infty} \beta^i \xi_p^i \lambda_{t+i} y_{t+i} \left(\frac{\tilde{p}_t^j}{P_t} \frac{(P_{t-1+i}/P_{t-1})^{\gamma_p}}{P_{t+i}/P_t} - \left(1+\lambda_{p,t+i}\right) mc_{t+i} \right) = 0 \tag{3.102}$$

And the aggregate price index is given by

$$(P_t)^{-\frac{1}{\lambda_{p,t}}} = \xi_p \left(P_{t-1} \left(\frac{P_{t-1}}{P_{t-2}}\right)^{\gamma_p} \right)^{-\frac{1}{\lambda_{p,t}}} + \left(1-\xi_p\right) \left(\tilde{p}_t^j\right)^{-\frac{1}{\lambda_{p,t}}} \tag{3.103}$$

Monetary and fiscal authorities

Monetary policy sets the gross nominal interest rate based on

$$R_t = \max\left\{ 1, {R_{t-1}}^{\phi_r} \left[\frac{\pi}{\beta} \left(\frac{\pi_t}{\pi}\right)^{\phi_\pi} \left(\frac{Y_t}{Y}\right)^{\phi_Y} \right]^{(1-\phi_r)} \right\} \tag{3.104}$$

The government budget constraint

$$\frac{B_t/R_t}{P_t} + T_t = \frac{B_{t-1}}{P_t} + G_t \tag{3.105}$$

The fiscal policy rule

$$t_t = \phi_b b_t + \phi_g g_t \tag{3.106}$$

The government spending process

$$g_t = \rho_g g_{t-1} + \eta_t^g \tag{3.107}$$

Goods market equilibrium

The final goods market equilibrium condition

$$Y_t = C_t + G_t + I_t + \frac{\Theta_k}{2}\left(\frac{K_{t+1}}{K_t} - 1\right)^2 K_t \tag{3.108}$$

Appendix B: log-linearization of the baseline model with lump-sum taxes

Steady States

In the absence of shocks, the economy converges to the steady state. Then $\eta_t^B = \eta_t^L = \eta_t^M = \eta_t^x = \eta_t^a = 0$, implying that $\varepsilon^B = \varepsilon^L = \varepsilon^M = x = \varepsilon^a = 1$

Also

$$R = \frac{1}{\beta} \tag{3.109}$$

$$r^k = \frac{1}{\beta} - 1 + \delta \tag{3.110}$$

It is assumed that the debt level is null at the steady state and that the budget is balanced

$$B = 0 \tag{3.111}$$

$$T = G \tag{3.112}$$

The real marginal cost is equivalent to

$$mc = \frac{1}{1 + \lambda_p} \tag{3.113}$$

This leads to

$$\frac{wL}{Y} = \frac{(1-\alpha)}{1+\lambda_p}\left(1 + \frac{\Phi}{Y}\right) = \frac{(1-\alpha)}{1+\lambda_p}\theta \tag{3.114}$$

Where $\theta = 1 + \frac{\Phi}{Y}$

Real dividends relative to output at the steady state can be expressed as

$$\frac{Div}{Y} = 1 - mc\theta = \frac{1 + \lambda_p - \theta}{1 + \lambda_p} \tag{3.115}$$

As in Gali et al (2007), steady state consumption is assumed to be the same across all households

$$C = C^R = C^{NR} \tag{3.116}$$

And as stated before

$$L = L^R = L^{NR} \tag{3.117}$$

Log-linearized model excluding prices and wages equations

Letters with a hat represent the log-linearized variables around the steady state, i.e.$\hat{X}_t = \ln(X_t) - \ln(X) \approx \frac{X_t - X}{X}$

The log-linearization of 3.69 and 3.71 give the following relations

$$\hat{\lambda}_t = \hat{\varepsilon}_t^B - \frac{\sigma_c}{(1-h)}\left(\hat{C}_t^R - h\hat{C}_{t-1}^R\right) \tag{3.118}$$

$$\hat{R}_t = E_t\hat{\pi}_{t+1} + \hat{\lambda}_t - \hat{\lambda}_{t+1} \tag{3.119}$$

Combining the above relations yields the following expression for log-linear consumption of Ricardian households

$$\hat{C}_t^R = \frac{h\hat{C}_{t-1}^R}{(1+h)} + \frac{E_t\hat{C}_{t+1}^R}{(1+h)} - \frac{(1-h)}{\sigma_c(1+h)}\left(\hat{R}_t - E_t\hat{\pi}_{t+1} + E_t\hat{\varepsilon}_{t+1}^B - \hat{\varepsilon}_t^B\right) \tag{3.120}$$

The same expression can also be obtained by combining the log-linearized 3.70 and 3.74

$$\sigma_m\hat{m}_t + \frac{1}{(1-\beta)}\left(\hat{\lambda}_t - \beta E_t\hat{\lambda}_{t+1} + \beta E_t\hat{\pi}_{t+1}\right) = \hat{\varepsilon}_t^B + \hat{\varepsilon}_t^M \tag{3.121}$$

$$\frac{\sigma_c}{\sigma_m(1-h)}\left(\hat{C}_t^R - h\hat{C}_{t-1}^R\right) + \frac{1}{\sigma_m}\hat{\varepsilon}_t^M = \hat{m}_t + \frac{\hat{R}_t}{\sigma_m(R-1)} \tag{3.122}$$

The expression of consumption for non-Ricardian consumers is

$$\hat{C}_t^{NR} = \frac{L^{NR}w}{C^{NR}}\left(\hat{w}_t + \hat{L}_t^{NR}\right) - \frac{Y}{C^{NR}}t_t^{NR} \tag{3.123}$$

Or

$$\hat{C}_t^{NR} = \frac{(1-\alpha)}{1+\lambda_p}\theta\frac{Y}{C}\left(\hat{w}_t + \hat{L}_t^{NR}\right) - \frac{Y}{C}t_t^{NR} \tag{3.124}$$

Where $t_t^{NR} = \frac{T_t^{NR} - T^{NR}}{Y}$. Aggregate consumption is given by

$$\hat{C}_t = (1-\mu)\,\hat{C}_t^R + \mu \hat{C}_t^{NR} \tag{3.125}$$

Log-linearization of 3.72

$$\Theta_k \hat{K}_t = (1+\beta)\,\Theta_k E_t \hat{K}_{t+1} - \beta \Theta_k E_t \hat{K}_{t+2} - \beta r^k E_t \hat{r}_{t+1}^k + \hat{R}_t - E_t \hat{\pi}_{t+1} + \beta\,(1-\delta)\,E_t \hat{x}_{t+1} - \hat{x}_t \tag{3.126}$$

Log-linearization of 3.73

$$\begin{aligned} &\frac{m}{Y}\left[\hat{m}_t^R - \hat{m}_{t-1}^R\right] + \frac{b_t}{R} - b_{t-1} + \frac{C}{Y}\hat{C}_t^R + \frac{I}{Y}\hat{I}_t^R + t_t^R - \frac{Div}{Y}\widehat{Div}_t \\ = &\left(\frac{C}{Y} + \frac{I}{Y} + \frac{T^R}{Y} - \frac{Div}{Y}\right)\frac{1}{wL^R + r^k K}\left[wL^R\left(\hat{w}_t + \hat{L}_t^R\right) + r^k K\left(\hat{r}_t^k + \hat{K}_t\right)\right] \end{aligned} \tag{3.127}$$

Dividends are equivalent to real profits from firms of intermediate goods, therefore

$$Div_{j,\,t} = \left(1 - mc_{j,t}\right) Y_{j,t} - mc_{j,t}\Phi \tag{3.128}$$

This leads to

$$\widehat{Div}_t = \frac{\lambda_p}{1+\lambda_p-\theta}\hat{Y}_t - \frac{\theta}{1+\lambda_p-\theta}\widehat{mc}_t \tag{3.129}$$

Replacing in the above expression yields

$$\begin{aligned} \frac{m}{Y\sigma_m}&\left[\frac{\sigma_c}{1-h}\left(\hat{C}_t^R - (1+h)\,\hat{C}_{t-1}^R + h\hat{C}_{t-2}^R\right) + \left(\hat{\varepsilon}_t^M - \hat{\varepsilon}_{t-1}^M\right) - \frac{\beta}{1-\beta}\left(\hat{R}_t - \hat{R}_{t-1}\right)\right] \\ &+ \frac{b_t}{R} - b_{t-1} + \frac{C}{Y}\hat{C}_t^R + \frac{I}{Y}\hat{I}_t^R + t_t^R - \left[\frac{\lambda_p}{1+\lambda_p}\hat{Y}_t - \frac{\theta}{1+\lambda_p}\widehat{mc}_t\right] \\ &= \left(\frac{\theta}{1+\lambda_p}\right)\left[(1-\alpha)\left(\hat{w}_t + \hat{L}_t^R\right) + \alpha\left(\hat{r}_t^k + \hat{K}_t\right)\right] \end{aligned} \tag{3.130}$$

With

$$\widehat{mc}_t = (1-\alpha)\,\hat{w}_t + \alpha \hat{r}_t^k - \hat{\varepsilon}_t^a \tag{3.131}$$

Simplifying

$$\frac{C}{Y}\hat{C}_t^R = \frac{m}{Y\sigma_m}\left[\left(-\hat{\varepsilon}_t^B + \hat{\varepsilon}_{t-1}^B\right) - \left(\hat{\varepsilon}_t^M - \hat{\varepsilon}_{t-1}^M\right) + \hat{\pi}_t + \frac{\beta}{1-\beta}\hat{R}_t - \frac{1}{1-\beta}\hat{R}_{t-1}\right] + \left[-\frac{b_t}{R} + b_{t-1} - \frac{I}{Y}\hat{I}_t^R - t_t^R\right] + \left[\frac{\lambda_p}{1+\lambda_p}\hat{Y}_t - \frac{\theta}{1+\lambda_p}\widehat{mc}_t\right] + \left(\frac{\theta}{1+\lambda_p}\right)\left[(1-\alpha)\left(\hat{w}_t + \hat{L}_t^R\right) + \alpha\left(\hat{r}_t^k + \hat{K}_t\right)\right] \quad (3.132)$$

Or

$$\frac{C}{Y}\hat{C}_t^R = \frac{m}{Y\sigma_m}\left[\left(-\hat{\varepsilon}_t^B + \hat{\varepsilon}_{t-1}^B\right) - \left(\hat{\varepsilon}_t^M - \hat{\varepsilon}_{t-1}^M\right) + \hat{\pi}_t + \frac{\beta}{1-\beta}\hat{R}_t - \frac{1}{1-\beta}\hat{R}_{t-1}\right] + \left[-\frac{b_t}{R} + b_{t-1} - \frac{I}{Y}\hat{I}_t^R - t_t^R\right] + \left[\frac{\lambda_p}{1+\lambda_p}\hat{Y}_t\right] + \left(\frac{\theta}{1+\lambda_p}\right)\left[(1-\alpha)\hat{L}_t^R + \alpha\hat{K}_t + \hat{\varepsilon}_t^a\right] \quad (3.133)$$

Replacing in the aggregate consumption equation

$$\frac{C}{Y}\hat{C}_t = (1-\mu)\left[\frac{m}{Y\sigma_m}\left[\left(-\hat{\varepsilon}_t^B + \hat{\varepsilon}_{t-1}^B\right) - \left(\hat{\varepsilon}_t^M - \hat{\varepsilon}_{t-1}^M\right) + \hat{\pi}_t + \frac{\beta}{1-\beta}\hat{R}_t - \frac{1}{1-\beta}\hat{R}_{t-1}\right] + \left[-\frac{b_t}{R} + b_{t-1} - \frac{I}{Y}\hat{I}_t^R - t_t^R\right] + \left[\frac{\lambda_p}{1+\lambda_p}\hat{Y}_t\right] + \left(\frac{\theta}{1+\lambda_p}\right)\left[(1-\alpha)\hat{L}_t^R + \alpha\hat{K}_t + \hat{\varepsilon}_t^a\right]\right] + \mu\left[\frac{(1-\alpha)}{1+\lambda_p}\theta\left(\hat{w}_t + \hat{L}_t^{NR}\right) - t_t^{NR}\right] \quad (3.134)$$

Using the fiscal rule

$$\frac{C}{Y}\hat{C}_t = (1-\mu)\left[\frac{m}{Y\sigma_m}\left[\left(-\hat{\varepsilon}_t^B + \hat{\varepsilon}_{t-1}^B\right) - \left(\hat{\varepsilon}_t^M - \hat{\varepsilon}_{t-1}^M\right) + \hat{\pi}_t + \frac{\beta}{1-\beta}\hat{R}_t - \frac{1}{1-\beta}\hat{R}_{t-1}\right] + \left[\frac{\lambda_p}{1+\lambda_p}\hat{Y}_t - \frac{I}{Y}\hat{I}_t^R\right] + \left(\frac{\theta}{1+\lambda_p}\right)\left[(1-\alpha)\hat{L}_t^R + \alpha\hat{K}_t + \hat{\varepsilon}_t^a\right]\right] + \mu\left[\frac{\theta(1-\alpha)}{1+\lambda_p}\left(\hat{w}_t + \hat{L}_t^{NR}\right) + \frac{b_t}{R} - b_{t-1}\right] - g_t \quad (3.135)$$

Aggregate labor is given by

$$\hat{L}_t = (1-\mu)\hat{L}_t^R + \mu\hat{L}_t^{NR} \quad (3.136)$$

Replacing in the expression

$$\frac{C}{Y}\hat{C}_t = (1-\mu)\left[\frac{m}{Y\sigma_m}\left[\hat{\pi}_t + \frac{\beta}{1-\beta}\hat{R}_t - \frac{1}{1-\beta}\hat{R}_{t-1} - \left(\hat{\varepsilon}_t^B - \hat{\varepsilon}_{t-1}^B\right) - \left(\hat{\varepsilon}_t^M - \hat{\varepsilon}_{t-1}^M\right)\right] + \left[\frac{\lambda_p}{1+\lambda_p}\hat{Y}_t - \frac{I}{Y}\hat{I}_t^R\right] + \left(\frac{\theta}{1+\lambda_p}\right)\left[\alpha\hat{K}_t + \hat{\varepsilon}_t^a\right]\right] + \mu\left[\frac{\theta(1-\alpha)}{1+\lambda_p}\hat{w}_t + \frac{b_t}{R} - b_{t-1}\right] + \frac{\theta(1-\alpha)}{1+\lambda_p}\hat{L}_t - g_t \tag{3.137}$$

The following equation for aggregate consumption is obtained

$$\frac{C}{Y}\hat{C}_t = (1-\mu)\left[\frac{m}{Y\sigma_m}\left[\hat{\pi}_t + \frac{\beta}{1-\beta}\hat{R}_t - \frac{1}{1-\beta}\hat{R}_{t-1} - \left(\hat{\varepsilon}_t^B - \hat{\varepsilon}_{t-1}^B\right) - \left(\hat{\varepsilon}_t^M - \hat{\varepsilon}_{t-1}^M\right)\right] + \left[\hat{Y}_t - \frac{I}{Y}\hat{I}_t^R\right]\right] + \mu\left[\frac{\theta(1-\alpha)}{1+\lambda_p}\left(\hat{L}_t + \hat{w}_t\right) + \frac{b_t}{R} - b_{t-1}\right] - g_t \tag{3.138}$$

Log-linearization of the capital accumulation equation 3.75, the labor demand equation 3.99 and firms production function gives

$$\frac{K}{Y}\hat{K}_{t+1} = (1-\delta)\frac{K}{Y}\hat{K}_t + \frac{I}{Y}\hat{x}_t + \frac{I}{Y}\hat{I}_t \tag{3.139}$$

$$\hat{L}_t = -\hat{w}_t + \hat{r}_t^k + \hat{K}_t \tag{3.140}$$

$$\hat{Y}_t = \theta\left[\hat{\varepsilon}_t^a + \alpha\hat{K}_t + (1-\alpha)\hat{L}_t\right] \tag{3.141}$$

The monetary policy equation when the ZLB is not binding

$$\hat{R}_t = \phi_r\hat{R}_{t-1} + (1-\phi_r)\left(\phi_\pi\hat{\pi}_t + \phi_Y\hat{Y}_t\right) \tag{3.142}$$

Based on a zero debt level at the steady state and a balanced budget, the following expression holds

$$b_t = R\left(g_t + b_{t-1} - t_t\right) \tag{3.143}$$

Using the fiscal rule 3.106 leads to

$$\frac{b_t}{R} = g_t\left(1-\phi_g\right) + b_{t-1}\left(1-\phi_b\right) \tag{3.144}$$

The condition for a non-explosive debt path is $R(1-\phi_b) < 1$ leading to $\phi_b > 1 - \frac{1}{R}$

The final goods market equilibrium condition is given by

$$\hat{Y}_t = \frac{C}{Y}\hat{C}_t + g_t + \frac{I}{Y}\hat{I}_t \tag{3.145}$$

Log-linearized inflation equation

From log-linearization of

$$(P_t)^{-\frac{1}{\lambda_{p,t}}} = \xi_p \left(P_{t-1} \left(\frac{P_{t-1}}{P_{t-2}} \right)^{\gamma_p} \right)^{-\frac{1}{\lambda_{p,t}}} + (1-\xi_p) \left(\tilde{p}_t^j \right)^{-\frac{1}{\lambda_{p,t}}} \tag{3.146}$$

The following expression is obtained

$$\hat{P}_t = \xi_p \left(\hat{P}_{t-1} + \gamma_p \hat{\pi}_{t-1} \right) + (1-\xi_p)\, \tilde{p}_t^j \tag{3.147}$$

Thus

$$\tilde{p}_t^j = \frac{\hat{P}_t - \xi_p \left(\hat{P}_{t-1} + \gamma_p \hat{\pi}_{t-1} \right)}{(1-\xi_p)} \tag{3.148}$$

Log-linearization of 3.102 yields

$$E_t \sum_{i=0}^{\infty} \beta^i \xi_p^i \left(\frac{\lambda_p}{(1+\lambda_p)} \hat{\lambda}_{p,t+i} + \widehat{mc}_{t+i} + \hat{P}_{t+i} - \gamma_p \hat{P}_{t+i-1} \right) = E_t \sum_{i=0}^{\infty} \beta^i \xi_p^i \left(\tilde{p}_t^j - \gamma_p \hat{P}_{t-1} \right) \tag{3.149}$$

Or

$$E_t \sum_{i=0}^{\infty} \beta^i \xi_p^i \left(\frac{\lambda_p}{(1+\lambda_p)} \hat{\lambda}_{p,t+i} + \widehat{mc}_{t+i} + \hat{P}_{t+i} - \gamma_p \hat{P}_{t+i-1} \right) = \frac{1}{1-\beta\xi_p} \left(\tilde{p}_t^j - \gamma_p \hat{P}_{t-1} \right) \tag{3.150}$$

The difference between this expression at time t+i and t+i+1 gives

$$\frac{\lambda_p}{(1+\lambda_p)} \hat{\lambda}_{p,t} + \widehat{mc}_t + \hat{P}_t - \gamma_p \hat{P}_{t-1} = \frac{1}{1-\beta\xi_p} \left[\left(\tilde{p}_t^j - \gamma_p \hat{P}_{t-1} \right) - \beta\xi_p \left(\tilde{p}_{t+1}^j - \gamma_p \hat{P}_t \right) \right] \tag{3.151}$$

Replacing with the expression of $\tilde{p}_t^j$ and simplifying yields

$$\frac{\lambda_p}{(1+\lambda_p)} \hat{\lambda}_{p,t} + \widehat{mc}_t = \frac{1}{(1-\beta\xi_p)(1-\xi_p)} \left[\hat{\pi}_t \left(\xi_p + \beta\xi_p\gamma_p \right) - \beta\xi_p E_t \hat{\pi}_{t+1} - \xi_p \gamma_p \hat{\pi}_{t-1} \right] \tag{3.152}$$

Replacing with the expression of $\widehat{mc}_t$ and simplifying, the inflation equation is as follows

$$\hat{\pi}_t = \frac{\beta}{(1+\beta\gamma_p)} E_t \hat{\pi}_{t+1} + \frac{\gamma_p}{(1+\beta\gamma_p)} \hat{\pi}_{t-1} + \frac{(1-\beta\xi_p)(1-\xi_p)\left[\eta_t^p + \alpha \hat{r}_t^k + (1-\alpha)\hat{w}_t - \hat{\varepsilon}_t^a\right]}{\xi_p(1+\beta\gamma_p)} \tag{3.153}$$

Log-linearized wage equation

From

$$\frac{W_{h,t}^*}{P_t} E_t \sum_{i=0}^{\infty} (\beta\xi_w)^i \left[\Lambda_{t+i} \frac{\left(P_{t+i-1}/P_{t-1}\right)^{\gamma_w}}{P_{t+i}/P_t} L_{h,t+i}\right] = E_t \sum_{i=0}^{\infty} (\beta\xi_w)^i (1+\lambda_{w,t+i})\, \varepsilon_{t+i}^B \varepsilon_{t+i}^L (L_{h,t+i})^{1+\sigma_l} \tag{3.154}$$

The linearized version is

$$\begin{aligned} E_t \sum_{i=0}^{\infty} (\beta\xi_w)^i \left[\sigma_l \hat{L}_{h,t+i} - \hat{\Lambda}_{t+i} + \hat{P}_{t+i} - \gamma_w \hat{P}_{t+i-1} + \frac{\lambda_w}{1+\lambda_w}\hat{\lambda}_{w,t+i} + \hat{\varepsilon}_{t+i}^B + \hat{\varepsilon}_{t+i}^L\right] \\ = E_t \sum_{i=0}^{\infty} (\beta\xi_w)^i \left[\hat{W}_{h,t}^* - \gamma_w \hat{P}_{t-1}\right] \end{aligned} \tag{3.155}$$

Since

$$\hat{\Lambda}_t = \hat{\varepsilon}_t^B - \frac{\sigma_c}{(1-h)}\left(\hat{C}_t - h\hat{C}_{t-1}\right) \tag{3.156}$$

And

$$\hat{L}_{h,t+i} = -\left(\frac{1+\lambda_w}{\lambda_w}\right)\left(\hat{W}_{h,t+i}^* - \hat{W}_{t+i}\right) + \hat{L}_{t+i} \tag{3.157}$$

And

$$\hat{W}_{h,t+i} = \gamma_w\left(\hat{P}_{t+i-1} - \hat{P}_{t-1}\right) + \hat{W}_{h,t} \tag{3.158}$$

By replacing in the linearized relation and calculating the difference between this expression at time t+i and time t+i+1, the following equation is obtained

$$\begin{aligned} \left[\hat{\varepsilon}_t^L + \sigma_l \hat{L}_t + \frac{\sigma_c}{(1-h)}\left(\hat{C}_t - h\hat{C}_{t-1}\right) + \left(\frac{1+\lambda_w}{\lambda_w}\right)\hat{\lambda}_{w,t} + \sigma_l\left(\frac{1+\lambda_w}{\lambda_w}\right)\hat{W}_t\right] \frac{(1-\beta\xi_w)}{1+\sigma_l\left(\frac{1+\lambda_w}{\lambda_w}\right)} \\ = \hat{W}_{h,t}^* - \beta\xi_w \hat{W}_{h,t+1}^* - \gamma_w \hat{P}_{t-1} + \gamma_w \hat{P}_t + \gamma_w(1-\beta\xi_w)\hat{P}_{t-1} - \frac{(1-\beta\xi_w)}{(1+\sigma_l)\left(\frac{1+\lambda_w}{\lambda_w}\right)}\hat{P}_t \end{aligned} \tag{3.159}$$

Also (from 3.95)

$$\hat{W}^*_{h,t} = \frac{\hat{W}_t - \xi_w\left(\hat{W}_{t-1} + \gamma_w \hat{\pi}_{t-1}\right)}{1-\xi_w} \tag{3.160}$$

Replacing in the above expression and simplifying, the real wage equation is

$$\begin{aligned}\hat{w}_t = &\frac{\beta}{(1+\beta)}E_t\hat{w}_{t+1} + \frac{1}{(1+\beta)}\hat{w}_{t-1} + \frac{\beta}{(1+\beta)}E_t\hat{\pi}_{t+1} - \frac{(1+\beta\gamma_w)}{(1+\beta)}\hat{\pi}_t + \frac{\gamma_w}{(1+\beta)}\hat{\pi}_{t-1} \\ &+ \left[\hat{\varepsilon}^L_t + \sigma_l\hat{L}_t + \frac{\sigma_c}{(1-h)}\left(\hat{C}_t - h\hat{C}_{t-1}\right) + \eta^w_t - \hat{w}_t\right]\frac{(1-\beta\xi_w)(1-\xi_w)}{\xi_w(1+\beta)(1+\sigma_l)\left(\frac{1+\lambda_w}{\lambda_w}\right)}\end{aligned} \tag{3.161}$$

The dynamic system also includes

$$\hat{\varepsilon}^B_t = \rho_B\hat{\varepsilon}^B_{t-1} + \hat{\eta}^B_t \tag{3.162}$$

$$\hat{\varepsilon}^L_t = \rho_L\hat{\varepsilon}^L_{t-1} + \hat{\eta}^L_t \tag{3.163}$$

$$\hat{\varepsilon}^M_t = \rho_M\hat{\varepsilon}^M_{t-1} + \hat{\eta}^M_t \tag{3.164}$$

$$\hat{x}_t = \rho_x\hat{x}_{t-1} + \hat{\eta}^x_t \tag{3.165}$$

$$\hat{\varepsilon}^a_t = \rho_a\hat{\varepsilon}^a_{t-1} + \hat{\eta}^a_t \tag{3.166}$$

$$g_t = \rho_g g_{t-1} + \eta^g_t \tag{3.167}$$

$$\lambda_{p,t} = \lambda_p + \eta^p_t \tag{3.168}$$

$$\lambda_{w,t} = \lambda_w + \eta^w_t \tag{3.169}$$

Appendix C: log-linearization of the extended model with distortionary taxation

Based on the modified Ricardian households budget constraint

$$\begin{aligned}\frac{M^R_t}{P_t} + \frac{B^R_t/R_t}{P_t} = &\frac{M^R_{t-1}}{P_t} + \frac{B^R_{t-1}}{P_t} + (1-\tau_{w,t})\,w_t L^R_t + (1-\tau_{k,t})\,r^k_t K^R_t - \frac{\Theta_k}{2}\left(\frac{K^R_{t+1}}{K^R_t} - 1\right)^2 K^R_t \\ &+ (1-\tau_{k,t})\,Div^R_t + \tau_{k,t}\delta K^R_t - T^R_t - (1+\tau_{c,t})\,C^R_t - \frac{K^R_{t+1} - (1-\delta)\,K^R_t}{x_t}\end{aligned} \tag{3.170}$$

Equations 3.69, 3.72, 3.73 and 3.74 become

$$\frac{dL}{dC_t^R} : \lambda_t = \frac{\varepsilon_t^B}{(1+\tau_{c,t})\left(C_t^R - H_t\right)^{\sigma_c}} \tag{3.171}$$

$$\frac{dL}{dK_{t+1}^R} : \lambda_t \left[\frac{1}{x_t} + \Theta_k \left(\frac{K_{t+1}^R}{K_t^R} - 1\right)\right] = \beta E_t \lambda_{t+1} \left[\frac{(1-\delta)}{x_{t+1}} + \frac{\Theta_k}{2}\left(\left(\frac{K_{t+2}^R}{K_{t+1}^R}\right)^2 - 1\right) + (1 - E_t\tau_{k,t+1}) E_t r_{t+1}^k + E_t \tau_{k,t+1}\delta\right] \tag{3.172}$$

$$\frac{dL}{d\lambda_t} : \frac{M_t^R}{P_t} + \frac{B_t^R/R_t}{P_t} + T_t^R + (1+\tau_{c,t}) C_t^R + \frac{K_{t+1}^R - (1-\delta) K_t^R}{x_t} + \frac{\Theta_k}{2}\left(\frac{K_{t+1}^R}{K_t^R} - 1\right)^2 K_t^R = \frac{M_{t-1}^R}{P_t} + \frac{B_{t-1}^R}{P_t} + (1-\tau_{w,t}) w_t L_t^R + (1-\tau_{k,t}) r_t^k K_t^R + (1-\tau_{k,t}) Div_t^R + \tau_{k,t}\delta K_t^R \tag{3.173}$$

$$\left[\left(C_t^R - H_t\right)^{\sigma_c} \varepsilon_t^M\right]^{1/\sigma_m} = \frac{M_t^R}{P_t}\left(\frac{R_t - 1}{R_t (1+\tau_{c,t})}\right)^{1/\sigma_m} \tag{3.174}$$

The steady state rental rate of capital is

$$r^k = \frac{1-\beta}{\beta(1-\tau_k)} + \delta \tag{3.175}$$

As the government budget is balanced at the steady state, then

$$\frac{G}{Y} = \frac{T}{Y} + \tau_c \frac{C}{Y} + \tau_k \left(1 - \frac{\theta}{(1+\lambda_p)} + \frac{K(1-\beta)}{Y\beta(1-\tau_k)}\right) + \tau_w \frac{\theta(1-\alpha)}{(1+\lambda_p)} \tag{3.176}$$

The log-linearized Ricardian households consumption equation becomes

$$\hat{C}_t^R = \frac{h\hat{C}_{t-1}^R}{(1+h)} + \frac{E_t\hat{C}_{t+1}^R}{(1+h)} - \frac{(1-h)}{\sigma_c(1+h)}\left(\hat{R}_t - E_t\hat{\pi}_{t+1} + E_t\hat{\varepsilon}_{t+1}^B - \hat{\varepsilon}_t^B + \frac{\tau_c}{1+\tau_c}\left(\hat{\tau}_{c,t} + E_t\hat{\tau}_{c,t+1}\right)\right) \tag{3.177}$$

For non-Ricardian households

$$\hat{C}_t^{NR} = \frac{(1-\tau_w)(1-\alpha)\theta Y}{(1+\tau_c)(1+\lambda_p) C^{NR}}\left(\hat{w}_t + \hat{L}_t^{NR}\right) - \frac{\tau_w(1-\alpha)\theta Y}{(1+\tau_c)(1+\lambda_p) C^{NR}}\hat{\tau}_{w,t} - \frac{Y}{(1+\tau_c) C^{NR}} t_t^{NR} - \frac{\tau_c}{1+\tau_c}\hat{\tau}_{c,t} \tag{3.178}$$

The equation of aggregate consumption is therefore

$$\mu\tau_c\frac{C}{Y}\hat{C}_t = (1-\mu)\left[\frac{m}{Y\sigma_m}\left[\hat{\pi}_t + \frac{\beta}{1-\beta}\hat{R}_t - \frac{1}{1-\beta}\hat{R}_{t-1} - \left(\hat{\varepsilon}_t^B - \hat{\varepsilon}_{t-1}^B\right) - \left(\hat{\varepsilon}_t^M - \hat{\varepsilon}_{t-1}^M\right)\right]\right] \\ -\mu t_t - \mu\frac{\tau_w(1-\alpha)\theta}{(1+\lambda_p)}\hat{\tau}_{w,t} - \mu\frac{\tau_c C}{Y}\hat{\tau}_{c,t} + \mu\hat{w}_t\frac{(1-\tau_w)(1-\alpha)\theta}{(1+\lambda_p)} \tag{3.179}$$

Equation 3.126 becomes

$$\Theta_k\hat{K}_t = (1+\beta)\Theta_k E_t\hat{K}_{t+1} - \beta\Theta_k E_t\hat{K}_{t+2} - \beta(1-\tau_k)r^k E_t\hat{r}^k_{t+1} - \beta\left(\delta - r^k\right)\tau_k E_t\hat{\tau}_{k,t+1} \\ +\hat{R}_t - E_t\hat{\pi}_{t+1} + \beta(1-\delta)E_t\hat{x}_{t+1} - \hat{x}_t \tag{3.180}$$

Based on a zero-debt level at the steady state and a balanced budget, the log-linearized government budget constraint is

$$t_t + \tau_c\frac{C}{Y}\hat{C}_t + \tau_k\frac{Div}{Y}\widehat{Div}_t - \tau_k\frac{\delta K}{Y}\hat{K}_t + \tau_c\frac{C}{Y}\hat{\tau}_{c,t} + \tau_w\frac{wL}{Y}\hat{\tau}_{w,t} + \tau_k\frac{(Div - \delta K + r^k K)}{Y}\hat{\tau}_{k,t} \\ +\left(\tau_w\frac{(1-\alpha)}{\alpha}\right)\frac{wL}{Y}\left(\hat{w}_t + \hat{L}_t\right) + \tau_k\frac{r^k K}{Y}\left(\widehat{r^k}_t + \hat{K}_t\right) = g_t + b_{t-1} - \frac{b_t}{R_t} \tag{3.181}$$

Or

$$t_t + \tau_c\frac{C}{Y}\hat{C}_t + \tau_k\left[\frac{\lambda_p}{1+\lambda_p}\hat{Y}_t - \frac{\theta}{1+\lambda_p}\left((1-\alpha)\hat{w}_t + \alpha\hat{r}^k_t - \hat{\varepsilon}^a_t\right)\right] - \tau_k\frac{\delta K}{Y}\hat{K}_t + \tau_c\frac{C}{Y}\hat{\tau}_{c,t} + \tau_w\frac{(1-\alpha)}{1+\lambda_p}\theta\hat{\tau}_{w,t} \\ +\tau_k\left[\frac{1+\lambda_p-\theta}{1+\lambda_p} + \frac{1-\beta}{\beta(1-\tau_k)}\frac{K}{Y}\right]\hat{\tau}_{k,t} + \left(\tau_w\frac{(1-\alpha)}{\alpha} + \tau_k\right)\frac{\alpha\,\theta}{1+\lambda_p}\left(\hat{w}_t + \hat{L}_t\right) = g_t + b_{t-1} - \frac{b_t}{R} \tag{3.182}$$

The real wage equation becomes

$$\hat{w}_t = \frac{\beta}{(1+\beta)}E_t\hat{w}_{t+1} + \frac{1}{(1+\beta)}\hat{w}_{t-1} + \frac{\beta}{(1+\beta)}E_t\hat{\pi}_{t+1} - \frac{(1+\beta\gamma_w)}{(1+\beta)}\hat{\pi}_t + \frac{\gamma_w}{(1+\beta)}\hat{\pi}_{t-1} \\ +\left[\hat{\varepsilon}^L_t - \frac{\tau_w}{(1-\tau_w)}\hat{\tau}_{w,t} + \sigma_l\hat{L}_t + \frac{\sigma_c}{(1-h)}\left(\hat{C}_t - h\hat{C}_{t-1}\right) + \eta^w_t - \hat{w}_t\right]\frac{(1-\beta\xi_w)(1-\xi_w)}{\xi_w(1+\beta)(1+\sigma_l)\left(\frac{1+\lambda_w}{\lambda_w}\right)} \tag{3.183}$$

Conclusion

In this thesis, I attempted to study effects of fiscal policy on inflation, the current account balance and private consumption using different theoretical and empirical approaches. At the end of this research, I reach several important conclusions. The first one is that effects of fiscal policy on the price level are closely linked with the stance of monetary policy. As discussed in the first chapter, fiscal policy is less likely to generate inflation when monetary policy is based on targets. On the other hand, budget deficits tend to be inflationary when there is no solid national monetary policy framework (e.g., dollarized Latin American economies).

Another notable result of this research is that cyclicality contributes significantly to shaping the interactions between fiscal policy and external balances. More specifically, the negative relationship between government spending and the current account (CA) that is sometimes reported in the literature is found to hold only in countries with a countercyclical fiscal policy and a procyclical CA. Studies based on traditional regression methods may show a negative relationship in a panel setting, especially if they rely on pooled estimates. But the result in the present study is based on an econometric approach that takes better account of the heterogeneity within the sample. The negative response in this particular group is explained essentially by a negative response of the CA to property income shocks, in almost all the group's countries.

The panel analysis based on disaggregate fiscal data shows substantial discrepancies between countries in terms of the relationship between the CA and spending components. Results from a country by country investigation reveal that subsidies and property income are the government spending categories that are more likely to affect the CA. In particular, property income expenditures affect the CA more markedly in economies where sovereign credit risk is perceived as relatively high by international markets.

Finally, the study of fiscal stimulus effects on consumption through a New-Keynesian model based on Japanese data led to the following conclusions. The inclusion of rule-of-thumb consumers is not sufficient to yield a positive response of consumption to fiscal stimulus measures. This is explained by two reasons. First, Ricardian behavior remains dominant in the model, irrespective of the value of the share of non-Ricardian consumers. In particular, consumption's response is closely linked to the response of lump-sum taxes (even after inclusion of distortionary taxes). Second, although consumption also tracks income more closely (compared to models without non-Ricardian households), real wages decline after most measures, thereby contributing negatively to the response of consumption.

The introduction of distortionary taxation alters the model's behavior over the long-run through the different movements in tax rates. In particular, shocks that affect the capital income tax rate tend to lead to positive effects over the long-run through an increase (or expected increase) in capital. Higher capital significantly improves the economy by shifting its productive capacity upward. This is also the same reason why a capital income tax cut is found to be the most optimal fiscal stimulus measure for both consumption and output. Lastly, the variance decomposition analysis shows that consumption is strongly affected by labor supply and technology shocks. Overall, supply-side shocks are found to contribute more to economic fluctuations than demand-side shocks.