Crises financières, accumulation de dette et défaut souverain

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Jury

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Financial crises, debt accumulation and sovereign default

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Résumé

Cette thèse contribue à la littérature sur le défaut souverain en offrant une nouvelle approche d'analyse, réconciliant les approches statistiques et structurelles. Avec comme fil rouge le lien entre crises financières, accumulation de dette et défaut souverain, ce travail répond à trois questions principales.

En premier lieu, quand les pays font-ils défaut ? En posant un simple regard sur les principales variables macroéconomiques et les composantes cycliques des défauts souverains, je montre que le défaut se produit quand le pays subit un retournement brutal de croissance, ajouté à un large choc discontinu sur son ratio de dette sur PIB, apporté en majorité par une crise de change ou une crise bancaire.

En second lieu, en quoi le risque souverain au sein d'une zone monétaire (par exemple la zone euro) diffère de celui d'une petite économie ouverte en change flexible, majoritairement décrit dans la littérature ? Je construis un modèle DSGE néo-keynésien dans lequel j'introduis du risque souverain ; je mets l'accent sur le rôle clé des comportements de consommation, à la fois dans la préférence pour l'union monétaire et dans la décision de défaut. Je regarde également l'efficacité de certaines politiques fiscales sur la réduction du risque souverain dans une zone monétaire.

Enfin, les instruments de politique monétaire ont-ils été efficaces pendant la crise pour réduire les taux souverains ? J'évalue la transmission de la politique monétaire de la BCE, à la fois conventionnelle et non-conventionnelle, aux taux et aux volumes d'émissions de titres souverains pour les quatre plus importantes économies européennes. Je montre que seule la transmission du taux directeur vers les taux souverains a été effective ; les instruments non-conventionnels ont eu des résultats contrastés et essentiellement sur les taux d'intérêt.

Mots clés : Dette souveraine ; Défaut souverain ; Modèle DSGE ; Comportements de consommation ; Union monétaire ; Assouplissement quantitatif.

Abstract

This thesis offers a new approach to sovereign default analysis, by tackling both statistical and the structural approaches to sovereign default. Starting from the link between financial crises, debt accumulation and sovereign default, it answers three main questions.
First, when do countries default ? Taking a simple look at macroeconomic variables and business cycles around default, I show that economic defaults occur when the country experiences a switch from a boom to a bust, combined with a large discontinuous shock on its debt-to-GDP ratio, brought mainly by a currency or a banking crisis.
Second, how sovereign risk in a monetary union (e.g. the Eurozone) differs from sovereign default risk in a small open economy usually described in default literature ? Constructing a New-Keynesian DSGE model with sovereign default risk, I exhibit the key role of habit persistence in the preference for a monetary union and the default decision. I am also able to test the efficiency of various policy tools on sovereign risk.
Third, have monetary policy tools been efficient to reduce sovereign spreads in the Eurozone ? I assess the transmission of ECB monetary policies, conventional and unconventional, to both interest rates and bond issuance for the four largest economies of the Euro area. The main result is that only the pass-through from the ECB rate to interest rates has been effective. Unconventional policies have had uneven effects and primarily on interest rates.

Keywords : Sovereign debt ; Sovereign default ; DSGE model ; Habit consumption ; Monetary union ; Quantitative easing.

À mes parents, Lucile, Matthieu

À Gilles

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Parfois les mots ne sont pas à la hauteur.

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son rappel incessant *d'aller d'aller jusqu'au bout, pour rendre les miens fiers.*

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Table des matières

Table des figures

Liste des tableaux

Chapitre 1

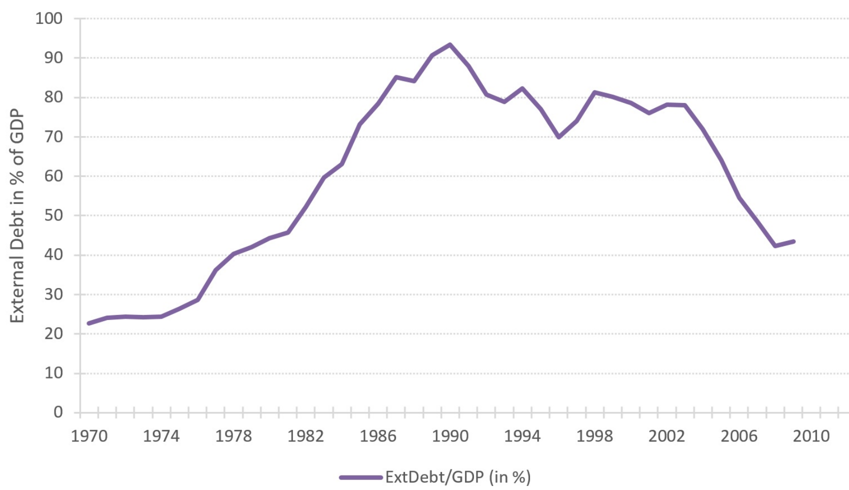
Introduction

On July 25th, 2017, Athens succeeded in issuing bonds (namely 3 billion euros of five-year bonds at 4.625% rate) with a view to testing the investors and with the prospect of returning on financial markets. Having defaulted in 2011, Greece has had no access to markets since 2010. The recent European debt crisis, and especially the Hellenic one, rekindles the debate upon sovereign debt sustainability, debt restructuring and the e*x-ante* and *ex-post* economic conditions of sovereign defaults. Indeed, the Greek crisis urges the academic profession to think back the default paradigm : after one hundred years of literature on sovereign defaults in emerging countries (talking about original sin, or bad administration of low-income countries), dogs did not bark when it came to threaten developed countries. All the puzzles the literature put aside all these years returned centre-stage : the simultaneity of default events with currency, banking and twin crises, the institution channel, the non-correlation of the output gap with debt distresses, etc. If the current crisis has stirred up interest in sovereign defaults in general, it has also put interest in stabilization measures aimed at preventing the occurrence of such events. Topics, such as contagion, suitable insolvency legislation, fiscal stabilisation or a workable assumption of joint liability in the context of the European Stability Mechanism (ESM), the European Financial Stability Facility (EFSF) and even Eurobonds, have made it onto the agenda. All of these issues put to test the notion of debt accumulation, sovereign default and the policies needed to cure or prevent from.

First, over time, the characteristics of sovereign debt have changed along several dimensions : the total amount of outstanding debt, the type of creditors (public versus private), the type of instruments (bonds, syndicated loans, concessional loans), the currency denomination, etc. We can first note that even if the utilisation of the term "external debt" is widely used to define public debt held by foreign creditors, it is very difficult to know in fact who owns a government's debt [1]. I will nonetheless use this global acceptance in the remaining of this thesis, as the exact definition of this word could be the subject of a thesis on its own. Figure 1.1 plots the evolution of external debt (all maturities) as a ratio of GDP. Figure 1.2 compares this evolution for advanced

1. See for instance Arslanalp and Tsuda [2014] for a study on foreign holdings of Greek debt

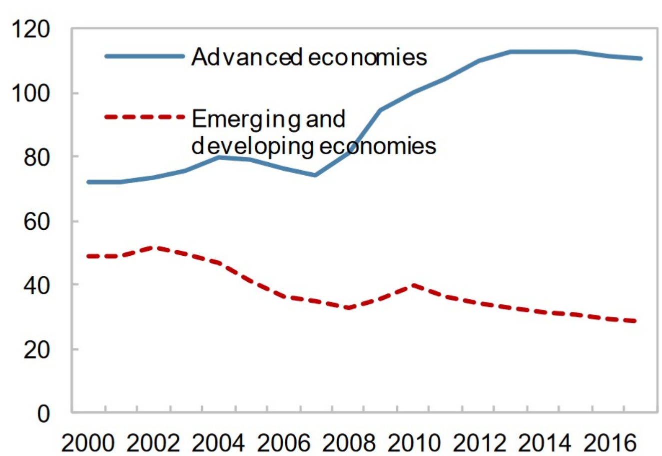
Figure 1.1 – Evolution of external debt - 1970-2010



Source : Cohen and Valadier (2011)

economies and emerging countries. Two main facts emerge from these pictures : first, the level of external debt decreases with the level of development (advanced countries face an external debt burden around 110% of their GDP in 2016 against 25% for emerging countries) ; second, there is a clear time pattern : sovereign debt has been on the rise from 1970 to the mid-1990s, and has declined since. This can be explained by the burst of the 1980s crisis, the different initiatives for debt reduction (like HIPC for instance), or by the development of domestic debt markets (see section 1.1.1 for this specific issue).

Figure 1.2 – General Government Gross Debt (percent of GDP)



Source : October 2016 WEO

Concerning sovereign defaults, we first have to note that there is no clear-cut definition of a sovereign default, which explains why there is no canonical list of default episodes. The general consensus is that a default is characterized when a country does not fully meet its contractual obligations towards its creditors. The most clear case of sovereign default is when a country (the sovereign) fails to honour some scheduled interest or principal payment. Events when syndicated bonds are rescheduled through some multilateral agreement such as those negotiated at the Paris Club or the London Club are also considered as defaults. Some authors, such as Kraay and Nehru [2006], also consider as being in default those countries that benefit from balance of payments support from the International Monetary Fund (IMF) or other multilateral financial institutions, in particular in the form of StandBy Arrangements and Extended Fund Facility ; the explanation behind that is that a country in need of external financial support would have been unable to meet its external obligations in the absence of such a support and would have defaulted. Cohen and Valadier [2011] extend this definition by naming a credit event when a country's sum of interest and principal arrears on long-term debt outstanding to all creditors is larger than 5% of the total debt outstanding. Once default events are identified, another issue is to measure the duration of the default episode, which can be either recorded when full payments are resumed, when an rescheduling agreement is reached, or when the country recovers its access to private financial markets. The 20th century was marked by many sovereign defaults, mainly by European, Latin American and African countries, culminating in the Latin America crisis of the 1980s, the Mexican crisis of 1994 and the Russian crisis of 1998. The 21st century started with one of the largest default in history with Argentina defaulting on 82 billion of dollars [2]. Over the period 1820–2004, Tomz and Wright [2007] document that 106 countries defaulted, making a total of 250 default episodes. Using a different methodology and restricting themselves to the recent era, Kraay and Nehru [2006] identify 94 episodes of debt distress over the period 1970–2001 [3].

Second, the literature on debt accumulation and sovereign default has long opposed accounting and statistical approaches to structural models of sovereign debt, and there lies the rub. Due to their non-convergence, the literature moved not so further, and we still do not know what is at stake when we ask about causality, common causes with other crises, or endogeneity. The hitherto preference has clearly been given to statistical models, because of their empirical tractability. Debt sustainability analysis made by the International Monetary Fund [2002, 2005] and the World Bank [2011] relies on the analysis of the current account, based on the simulation of macroeconomic variables such as primary surpluses, output growth and interest rate. They test whether the inter-temporal budget constraint holds in the long term under the assumed laws of motion and several shocks. Statistical models encompass regressions of a country's default probability on a series of explanatory variables. Most frequently, the latter include the debt-to-GDP (or to-GNI) ratio, the debt service, GDP or GDP growth, an index of the quality of institutions, and a measure of financial tension (Cohen and Valadier [2011]). On the other side, structural models following the seminal work of Eaton and Gersovitz [1981] study the microeconomic foundations at the root of a country's decision to default. This literature is paradoxically still young and includes Aguiar and Gopinath [2006], Arellano [2008], and more recently Cohen and Ville-

2. from Hatchondo et al. [2007a]

3. Other large default databases include those from Benjamin and Wright [2009], Borensztein and Panizza [2009], Cohen and Valadier [2011], Rose [2005]

mot [2012] and Mendoza and Yue [2012]. Contrary to corporate debt models, they emphasize the ability of a country to pay its debt, which is distinct from its willingness to pay. On the one hand, statistical models deliver relatively satisfactory predictions about countries' probabilities of default, based on the study of risk factors. Even though those determinants stem from a macroeconomic analysis of the current account, there is hardly any explicit mapping between statistical models of sovereign debt and macroeconomic theory. On the other hand, structural models have long been unable to jointly reproduce historical default probabilities and debt-to-GDP ratios. Sovereign default models with RBC features such as Mendoza and Yue [2012] deliver results that are closer to the stylized facts characterizing sovereign debt in market and emerging economies, yet without matching them with enough accuracy.

The aim of this thesis is to offer a new approach to sovereign default analysis, tackling both statistical and structural issues. Starting from the link between financial crises, debt accumulation and sovereign default, it answers three main questions.
First, when do countries default ? I construct a database using countries' business cycle phases in order to study debt distress inside a global macroeconomic trend. Taking a simple look at macroeconomic variables and business cycles around default, it turns out that default occurs when a country experiences a discontinuous growth shock (the large majority of defaults occurs in a downturn, defined as a peak to trough episode, whereas defaults exiting this downturn rule are rather non-economic defaults) and when it experiences a large discontinuous shock on its debt-to-GDP ratio (brought by a currency crisis through the denominator, or a banking crisis through the numerator : 71% economic defaults come along with another crisis).
Second, how sovereign risk in a monetary union (e.g. the Eurozone) differs from sovereign default risk in a small open economy usually described in default literature ? And therefore, are policy instruments (e.g. fiscal compact) useful for reducing default risk in a currency union ? Constructing a New-Keynesian DSGE model with sovereign default risk, I build a three-framework model (flexible change small open economy, small open economy in a currency union which exits the zone after a default, small open economy in a currency union which stays in the zone after a default) which is shown to be more robust and to better fit the data than the model of Aguiar and Gopinath [2006] and a full-fledged version of Cohen and Villemot [2012], which are simulated for various calibrations. I am able to exhibit the key role of habit persistence in the preference for a monetary union and the default decision. This model is also able to test the efficiency of various policy tools on sovereign risk.
Third, have monetary policy tools been efficient to reduce sovereign spreads in the Eurozone ? We assess the transmission of ECB monetary policies, conventional and unconventional, to both interest rates and lending volumes or bond issuance for three types of different economic agents through five different markets : sovereign bonds at 6-month, 5-year and 10-year horizons, loans to non-financial corporations and housing loans to households, during the financial crisis, and for the four largest economies of the Euro area. We look at three different unconventional tools : excess liquidity, longer-term refinancing operations and securities held for monetary policy pur-

poses following the decomposition of the ECB's Weekly Financial Statements. The main result is that only the pass-through from the ECB rate to interest rates has been effective. Unconventional policies have had uneven effects and primarily on interest rates.

1.1 Debt sustainability analysis and statistical models of default

As mentioned just before, structural models of sovereign debt differ from standard Debt Sustainability Analysis : while sovereign debt models study countries' decision to default based on micro-foundations (see section 1.2), Debt Sustainability Analysis relies on a macroeconomic analysis of countries' balance sheets and credits constraints.

1.1.1 Debt accumulation and debt sustainability analysis

First, there are many possible ways of theorizing the motives for a sovereign government to accumulate debt in general, and external debt in particular [4]. The first motive for debt is tax smoothing : in the context of fluctuating public spending and facing adverse economic shocks, the government tries to keep the tax rate as constant as possible, in order to minimize tax-related distortions. This implies that the government runs budget deficits and therefore accumulates debt when spending is high and, conversely, pays back its debt by running fiscal surpluses when spending is low.

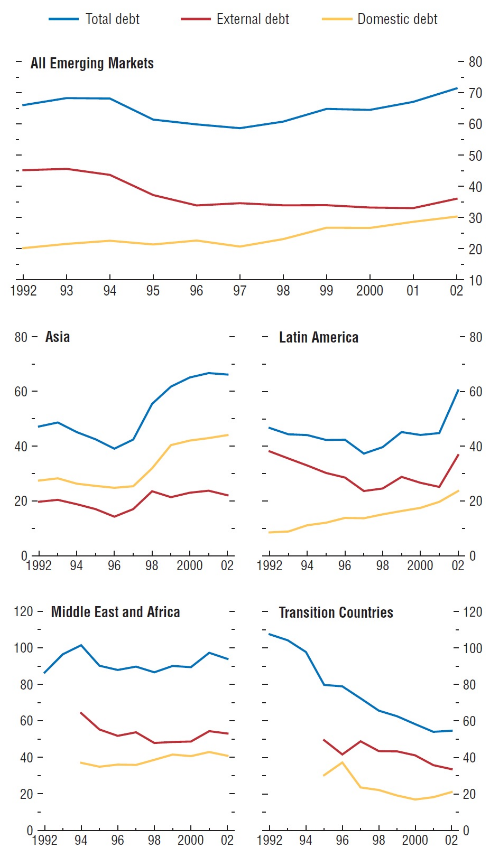
This theory though does not explain why a significant part of countries' debt comes from abroad, i.e. why government debt is for a large part external debt (see Figure 1.3). One possible explanation may be the underdevelopment of the domestic financial system and the scarcity of domestic capital, which must be particularly true for low-income countries. As documented by Reinhart et al. [2003], the case of middle-income countries is a bit different : between the beginning of the 1980s and the end of the 1990s, the domestic debt market has dramatically increased in many emerging countries (see Figure 1.3, in part because of the massive public bailouts of the financial system in the aftermath of the 1997–98 crisis), with the external debt market still remaining strong. Reinhart and Rogoff [2011a], also show that domestic debt has always accounted for a large part of the total public debt (with a peak in the 1950s, then a steady decrease until the 1990s, and more recently an upward trend).

Another fundamental reason for the accumulation of external debt by poor and emerging countries is given by Lucas [1990] with a model of international capital mobility : according to this model, we should observe a massive flow of capital from rich to poor countries in order to equalize marginal returns to capital ; this implies a surge in privately-owned external debt. But in practice, low-income countries' governments give some degree of public guarantee on private debt and sometimes even take the place of the private sector when it is failing. This may therefore

4. For a more detailed review on this issue, see Alesina and Perotti [1995]

explain the accumulation of external sovereign debt by poor countries [5].

FIGURE 1.3 – Public Debt in Emerging Market Economies (percent of GDP)



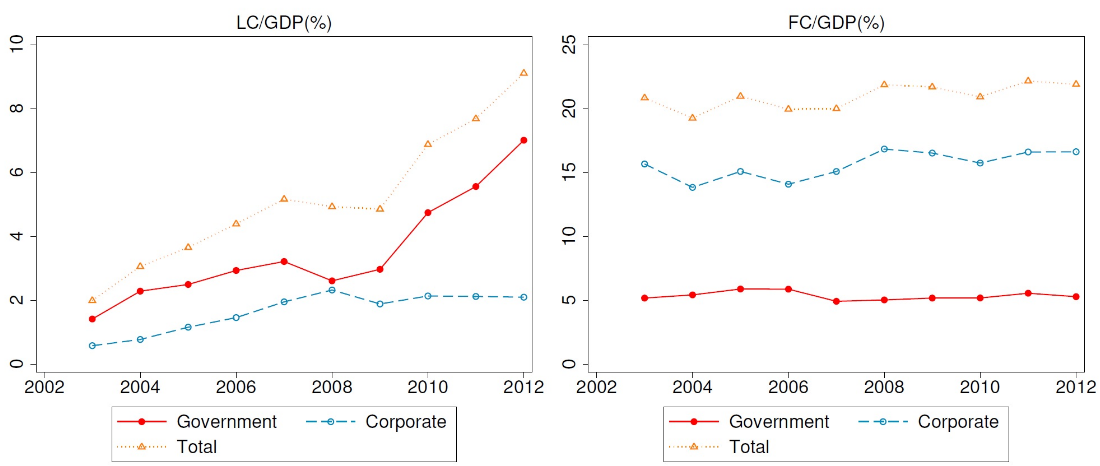
Source : International Monetary Fund

Last, these theories do not explain why emerging countries mostly issue their external debt in foreign currency. Indeed, the "original sin" refers in international finance literature to the fact that most emerging economies are not able to borrow abroad in their own currency. This concept, first introduced by Eichengreen et al. [2003], explains why virtually all developing countries had, in the 1990s, to borrow long term in a "strong currency" because creditors did not want to run the risk of being deprived of their investments. This theory builds also on the lack of monetary credibility to explain the predominance of foreign currency debt in international financial markets. A government's strategic debasement to inflate away the real value of debt can pose a significant obstacle to issuing local currency debt (Calvo [1978], Bohn [1990], Kydland and Prescott [1977]). Even if the situation has evolved since Eichengreen et al. [2003], namely thanks to the development of domestic bond markets in local currency since the early 2000s (Claessens et al. [2007]), the ability for a country to borrow in its own currency is a most efficient way of avoiding sovereign debt crisis (for instance, in spite of a debt-to-GDP ratio exceeding 200% of its

5. This however does not explain the Lucas paradox, which refers to the fact that national savings are too high in developing countries, relative to the optimum, that we can nonetheless see in Figure 1.3 for Asia. This is nonetheless another issue, that I do not tackle here since I focus on borrowing countries rather than creditors.

GDP, Japan keeps on borrowing heavily and easily without any sovereign risk content). Indeed, as Eichengreen et al. [2003] mentioned, the main problem with foreign-currency debt is the looming risk of currency mismatch, i.e. a liquidity issue when the country is unable to service its debt because it lacks foreign currency. This theory is still a prevailing phenomenon for a number of emerging economies, even though the recent studies by Du and Schreger [2013, 2015] find that the ability of emerging markets to borrow abroad in their own currency has been much improved in the last decade. Over a sample of 14 countries, they find that the cross-country mean of the share of external government debt in local currency has increased to around 60% (see Figure 1.4).

FIGURE 1.4 – External Debt/GDP by Currency and Sector in Selected Countries



Source : Du et al. [2014]. LC stands for Local Currency and FC stands for Foreign Currency. The countries in the sample are Brazil, Colombia, Hungary, Indonesia, Israel, South Korea, Malaysia, Mexico, Peru, Poland, Russia, South Africa, Thailand and Turkey.

Theoretical models also seize this currency issue. Jeanne [2003] presents models in which the unpredictability of monetary policy lead private firms to favor foreign currency borrowings in order to minimize their probability of default. Recently, Ottonello and Perez [2016] study the currency composition of sovereign debt in the dynamic general equilibrium model of a small open economy with a government with limited commitment to monetary and debt policy. Du et al. [2014] also study the currency composition of sovereign debt and find that a country with higher monetary credibility borrows more in local currency. They present a simple two period New-Keynesian model to show how credibility of monetary policy affects the currency composition of sovereign debt. More recently, Engel and Park [2017] build on the literature of the optimal contract arrangements between lenders and borrowers, and investigate how the optimal debt contract denominated in two currencies is constrained due to two types of commitment problem ; it features a government's endogenous default and debasement decisions.

The inter-temporal current account approach to sovereign debt

In the inter-temporal budget constraint approach, the country is solvent if and only if the discounted sum of consumption flows is equal to the discounted sum of output flows, minus the initial debt service. Equivalently, there exists a level of primary surplus making current debt sustainable given a path for the interest and the growth rates, computed from the debt law of motion. The main risk factors are deduced from this analysis.

Debt sustainability analysis is based on the implications of the one-period budget constraint of a representative country. Let C_t denote consumption, Q_t output, D_t the debt of period $t-1$ coming to maturity in t and L_t the amount lent by creditors to the country in t. The constraint writes :

$$C_t = Q_t + L_t - D_t$$

Assuming a constant interest rate r on risky debt, it is equivalent to :

$$C_t + (1+r)D_{t-1} = Q_t + D_t$$

Multiplying each constraint in period t by $\left(\frac{1}{1+r}\right)^t$ and summing over t gives the inter-temporal budget constraint :

$$\sum_{t=0}^{T}\left(\frac{1}{1+r}\right)^t C_t + (1+r)D_{-1} = \sum_{t=0}^{T}\left(\frac{1}{1+r}\right)^t Q_t + \left(\frac{1}{1+r}\right)^T D_T$$

Taking $T \longrightarrow \infty$ and using the transversality condition $\lim_{T\to\infty}\left(\frac{1}{1+r}\right)^T D_T = 0$, the constraint writes :

$$\sum_{t=0}^{\infty}\left(\frac{1}{1+r}\right)^t C_t = \sum_{t=0}^{\infty}\left(\frac{1}{1+r}\right)^t Q_t - (1+r)D_{-1}$$

The country is not solvent if the inter-temporal budget constraint does not hold. In this case, the current debt stock is not sustainable. The concepts of sustainability and solvency are distinct from that of illiquidity. The country can be illiquid but not insolvent, in the sense that the one-period budget constraint is violated, but the inter-temporal budget constraint holds in the long term (Roubini [2011]).

Debt sustainability in practice

Operationalizing the inter-temporal approach to sovereign debt requires to focus on the debt law of motion. It is denoted D_t, i_t denotes the interest rate bearing on this debt, P_t the primary surplus and g_t the growth rate of output. Lower case letters refer to variables normalized by output. It is straightforward to prove that the one-period $t+1$ budget constraint rewrites :

$$D_{t+1} - D_t = i_{t+1} D_t + P_{t+1}$$
$$\Rightarrow d_{t+1} = \frac{1 + i_{t+1}}{g_{t+1}} d_t p_{t+1}$$
$$\Rightarrow d_t = \sum_{k=0}^{\infty} \left(\prod_{s=0}^{k} \frac{1 + g_{t+1+s}}{1 + i_{t+1+s}} \right) p_{t+1+k}$$

substituting forward and using the transversality condition. The current debt stock must be consistent with the projected path of the primary surplus, the interest and growth rates. In a steady-state economy, assuming constant primary surplus and $0 < \frac{1+g}{1+i} < 1$, the primary surplus making the current debt level sustainable, for given interest rate and growth paths, is $p = \left(\frac{i-g}{1+g}\right)$. This is the prediction of static sustainability analysis : as pointed out by Sturzenegger and Zettelmeyer [2007], the uncertainty about the future paths of the interest and the growth rates makes it difficult to assess the optimal level of the primary surplus. Moreover, the current level of debt may be suboptimal with respect to the implications of a structural model, so that it may not be suitable to keep it constant. The static sustainability analysis is first used to compute the long-run primary surplus needed to ensure a constant level of public debt. Then the short to medium term dynamics of the economy leading to that primary surplus is simulated under various specifications of the paths of the interest rate, output growth and primary surpluses (Sturzenegger and Zettelmeyer [2007]). Alternatively, the dynamics of the variables featuring in the inter-temporal budget constraint are simulated under various specifications. Debt is then characterized as unsustainable if the inter-temporal budget constraint does not hold in the long run.

The literature is numerous on debt sustainability and related issues (interest rate, growth, etc.). Concerning the determination of an optimal level of debt, Yakita [2008] studies the sustainability of public deficits with a threshold of initial public debt which is increasing in the stock of public capital ; this determines a sustainable level of debt. Guimaraes [2007] follows this idea of debt sustainability by building a model that can determine the optimal level of debt which fluctuates with the productivity and shocks on international interest rates. More recently, Guzman and Lombardi [2017] assess the appropriate size of a debt relief in sovereign debt restructuring by restoring debt sustainability in a standard DSA model. In Chapter 2 of this thesis, I test the predictability power of current account surplus in determining sovereign crises and therefore the *ex ante* DSA efficiency in preventing credit events.

1.1.2 Macroeconomic variables around default time : an empirical puzzle

Statistical analyses of sovereign defaults study the empirical causes of debt crises. They regress a measure of debt crisis or technical default on a series of explanatory variables, including the debt-to-GDP or to-exports ratio, GDP growth (for instance, the recent controversy around Reinhart and Rogoff [2010]'s article put to test the correlation between crises and debt levels), the real exchange rate, a measure of openness and exports growth, the quality of institutions, the debt history of the country, a measure of liquidity, etc. Cohen and Valadier [2011] perform such an exercise with a logit model on the data of Kraay and Nehru [2006]. They argue that neither the "serial defaulter" theory of Reinhart et al. [2003] and Reinhart and Rogoff [2009], nor worldwide disruptions of economic activity can explain sovereign default. The latter owes much to the indebtedness of the country and the quality of its governance (as measured by the World Bank Country Policy and Institutional Assessment, CPIA), which respectively account for 50% and 25% of the risk factors. A refinement of this analysis consists in comparing the likelihoods of various statistical models, by using Bayesian methods to compute the posterior probability of the different models in the models space (Bayesian Model Averaging), as done in Chapter II of World Bank [2011]. Even though statistical models of sovereign debt can explain a non negligible fraction of the variation of debt distress events in the data, they are subject to various criticisms. First, their results must be interpreted cautiously because of endogeneity issues, due to possible omitted variable bias and reverse causality. Second, such models lack microeconomic foundations and do not allow to understand the drivers of a country's decision to default. Third, most analysis do not take into account the panel structure of the data, which may bias coefficient estimates and limit the explanatory power of the model. In Chapter 2, I extend the analysis of Cohen and Valadier [2011] and Kraay and Nehru [2006] by focusing on the cycle patterns of defaulters and putting new stylized facts centre stage.

The macroeconomic determinants of sovereign crises

Even if the literature tries to deal with the endogeneity issue (see Cohen and Villemot [2015]), the analysis of macroeconomic determinants of sovereign defaults can hardly be given a causal interpretation : these exercises are rather identifying the risk factors associated with such events.

Kraay and Nehru [2006] construct a panel dataset of default episodes across low- and middle-income countries over the period 1970–2001. They define a default as a substantial principal or interest payment arrears, debt relief received in the form of debt reduction or rescheduling by the Paris Club, or non-concessional balance of payment support by the IMF. They identify a total of 94 distress and 286 "normal times" episodes. Using a probit regression, they find that crises are more likely if the debt level is high (measured by debt-to-exports ratio and debt-service-to exports ratio), institutions are of poor quality (measured by the CPIA index) and real GDP growth is low. They posit that crises are more often triggered by liquidity than by solvency problems, since debt service-to-exports ratio is more significant than debt-to-exports ratio. They also explore the out of sample predictive power of their model : when the model is estimated using the three aforementioned explanatory variables in the pre-1990 sample, it is able to correctly forecast 84% of the episodes of the post-1990 sample. However, they show that depreciations in the real exchange rate, changes in the terms of trade, level of development are all statistically insignificant, which goes against simultaneity of currency with debt crises. Finally, the authors define a "safe" category depending on both level of growth and quality of institutions : a country with poor institutions and average growth reaches a debt distress probability of 25% with a 100% external debt-to-exports ratio, while a similar country but with good institutions reaches the threshold with a 300% ratio. Manasse et al. [2003] conduct a similar study and reach comparable conclusions : the risk of crisis is explained by measures of solvency (external debt-to-GDP ratio), measures of illiquidity (part of short term debt in overall external debt), low growth, current account imbalances and political uncertainty. Manasse and Roubini [2009] also derive "safe zones" and "danger zones" based on thresholds for external debt-to-GDP, inflation, growth, and some other macroeconomic indicators. In a recent article, Cohen and Villemot [2015] deal with the endogeneity between default and macroeconomic variables, namely growth. Using a slightly modified version of Kraay and Nehru [2006] database, they distinguish two types of sovereign crises : exogenous debt crises, which are the outcome of exogenous shocks (productivity growth), and endogenous debt crises, led by self-fulfilling items. They find that endogenous debt crises correspond in fact to a small minority of cases (between 6% and 12% of the crises). The likelihood of an exogenous debt crisis is driven by the debt-to-GDP ratio, the level of real income per capita and over-evaluation of the domestic currency.

Instead of studying the determinants of actual crises, a string of the literature looks at the determinants of market perceptions of default risk. This includes either some non-market indicator (e.g. investors surveys) or market indicators (e.g. bond prices on the secondary market). Reinhart et al. [2003] examine the perception of default risk by investors and find that the debt-to-GNP ratio and the history of bad policies (hyperinflation, previous default episodes or restructuring) explain the history of rating. This may explain their "debt intolerance" theory, i.e. the idea that some countries have a structural tendency to default, independently of other economic or financial factors. This idea is however challenged by many authors and facts. Catao and Kapur [2004] find that the credit history variable of Reinhart et al. [2003] is actually only a proxy for macroeconomic volatility. In June 2017, Argentina succeeded in raising 2.75 billion of dollars with a 100-year issue yielding 7.9%, even though it has defaulted three times in the last 30 years, challenging once again the "debt intolerance" argument and advocating that past credit history may not hamper future credit rating. On the other hand, Credit Default Swaps (CDS) can be a good proxy for market perception of sovereign default risk. Many papers have studied their evolution during the recent Eurozone debt crisis and their link with bond prices. Among them, Palladini and Portes [2011] test the price discovery relationship between sovereign CDS premia and bond yield spreads and confirm that the two prices should be equal to each other in equilibrium. Moreover, they show that past values of CDS spreads help to forecast bond yield spreads. In another study, Delatte et al. [2014] test the linearity of sovereign risk pricing during bearish episodes, especially in the sovereign bond market of European peripheral countries during the crisis (2006-2012). They find that peripheral sovereign spreads were subject to significant non-linear dynamics, and that they have been priced above their historical values because of amplification effects. Some authors have also studied the dynamic relationship between emerging country spreads, domestic business cycle indicators and global macroeconomic indicators.

The difficulty with such issue is that there is probably double causality at work : the domestic macroeconomic situation impacts spreads via the perceived default risk, but external financing difficulties can also have a direct negative effect on economic conditions. Uribe and Yue [2006] tackle this endogeneity issue and show that country spreads are influenced by domestic output, domestic investment, the current account and the US real interest rate.

A close string of sovereign debt literature focuses on the term structure of sovereign interest rates, which is also decisive in the decision of default. Following Merton [1974], Duffie and Lando [2001] study the role of imperfect financial markets, which lead to imperfect information and impact on the term structure of credit spreads on corporate bonds. Both methodologies and results are useful to better understand market sentiments, contagion and multiple equilibria in the sovereign debt market. Yue [2010] studies the link between debt recovery rates and sovereign bond prices, which decrease with the level of debt. In a parallel literature, Cohen and Portes [1990] study the behaviour of secondary market prices for the debt of several LDCs (less-developed countries) and find that they are mostly driven by the Libor and "systemic risk". They also study the price of long-term debt relative to that of short-term debt and find that the price of short-term debt is only driven by local political risk. On the contrary, long-term debt payments reflect the country's resources ; the decision to service it is contingent upon servicing short-term debt and on "systemic risk".

Indeed, political factors also play a role in sovereign defaults. Hatchondo and Martinez [2009a] study a composite index which measures the risk of default related to political risk, independently of economic and financial risks (what we can call the risk of a "political default", i.e. the probability of having a government coming in power and repudiating the debt). Focusing on the Argentina default of 2001, this index suggests that the government was more creditor-friendly before the default than after : the authors conclude that this default episode was triggered by a political change rather than by economic or financial conditions. Conversely, the authors look at the examples of Russia in 1998 and Uruguay in 2003 and conclude that these defaults are likely not political ones. In Chapter 2, I put to test these "political defaults" and show that they come at a specific moment in the business cycle, which is different that the one at which come economic defaults.

Finally, there is an abundant literature on the simultaneous occurrence of banking and currency crises (the so-called "twin crises"). The macroeconomic determinants of banking and currency crises, leading in some cases to sovereign crises, are developed for instance by Gourinchas and Obstfeld [2012] : they show that domestic credit expansion and real currency appreciation have been the most robust and significant predictors of financial crises during the 20^{th} century ; for emerging economies in particular, higher foreign exchange reserves may reduce the probability of a subsequent crisis. However, the literature on simultaneous banking and debt crises, or currency and debt crises, is not so abundant. Kaminsky and Reinhart [1999] explore the link between banking and balance-of-payments crises, which are quite different from sovereign debt crises but their analysis is helpful for our issue. They find that banking crises help at predicting balance-of-payments crises, but the reverse is not true; they conclude that those two types of crises have common causes rather than a causal relationship. Reinhart [2002] shows that most sovereign defaults are associated with currency crises (but the reverse is not true), and preliminary evidence suggests that the causality goes from currency crises to debt crises. Conversely, Cohen and Valadier [2011] follow the definition of a twin crisis by Laeven and Valencia [2010] (sovereign + currency crises, or sovereign + banking crises, or currency + banking crises) and find that sovereign crises are rather crises of their own. Reinhart and Rogoff [2011b] show that banking crises often precede or accompany sovereign debt crises : banking crises often accompany currency crises (as documented by the twin crises literature, see Kaminsky and Reinhart [1999] or Laeven and Valencia [2010]), which in turn deteriorate the solvency indicators (e.g. ratio of a debt stock in foreign currency to GDP in domestic currency). These balance sheet effects lead, through currency mismatches, to a sovereign default. But the reverse causality may also be at work : Borensztein and Panizza [2009] document that sovereign defaults increase the probability of a banking crisis by 11%. Perez [2015] explores the mechanisms through which a sovereign default can disrupt the domestic economy via its banking system; in the same spirit, Gennaioli et al. [2014] or Coimbra [2013] test empirically the exposure of banks to public bonds and its effect on lending during sovereign defaults. In Chapter 2, I put to test the correlation between currency, banking and sovereign crises, trying to fill the gap left by the literature on such an issue.

The debt overhang debate

So far the analysis has focused on the effects and determinants of sovereign debt crises, but there is also a literature on the effect of excessive accumulation of external debt, independently of the occurrence of defaults and crises. This effect is known as the "debt overhang" effect, as coined by Sachs [1989] : the accumulation of external debt has a crowding out effect on investment because debt service reroutes resources out of the country to foreign creditors. Additionally, heavily indebted countries do not have strong incentives to implement good domestic policies, since a large share of the benefits from those will be captured by the foreign creditors. Krugman [1988] speaks of a "debt Laffer curve" about the relationship between the market value of the debt (expected repayments) and the face value of outstanding debt : for low levels of debt, face value and market value are almost equal because full repayment is expected; as face value increases, market value increases but not as fast, since a partial default is expected; after some threshold the debt burden becomes a strong disincentive for the country to implement the right policies and market value becomes a decreasing function of the face value. This theory paves the way for debt relief, namely the Heavily Indebted Poor Countries (HIPC) initiative, which has led to significant external debt reductions since 1996. Cohen [1993] tests empirically this "debt overhang" theory by studying the link between debt and investment and finds that, in the 1980s, there is no direct relationship between the stock of debt and investment, but that the service of the debt crowds out investment, which seems to confirm the debt overhang's investment channel.

As exemplified by the recent debate around Reinhart and Rogoff [2010], the empirical evidence for the "debt overhang" effect is subject to controversy. On one hand, several papers try to put in evidence such an effect. In a famous paper, Reinhart and Rogoff [2010] show that when external debt reached 60% of GDP, a country's annual growth declined by 2%, when external debt ratio reached 90%, GDP growth was cut by half ; the evidence for this 90%-debt threshold hypothesis provided support for pro-austerity policies in the aftermath of the global financial crisis. Patillo et al. [2011] estimate the non-linear relationship between debt and growth, and obtain the expected bell curve relationship : the overall effect of debt becomes negative around 35–40% of GDP, while the marginal effect of debt becomes negative at about 20%. Imbs and Rancière [2005] provide evidence in support of a debt Laffer curve à la Krugman, with a negative growth effect of debt when its present value reaches 40% of GDP, and with negative effects on investment and economic policies. Ruiz-Arranz et al. [2005] find a negative effect for intermediate levels of debt, but no effect for high levels which leads them to talk about "debt irrelevance", a zone in which the marginal effect of debt is zero. But all of these results have been roughly criticized. Depetris-Chauvin and Kraay [2005] argue that these results are contaminated by strong endogeneity problems. For instance, Presbitero [2008] finds that the debt-growth relationship is not statistically robust to several variables, for instance the quality of institutions. Moreover, most of these studies do not test for the impact of debt crises, and especially the cost of defaulting on growth (see further section 1.2.1). Last, Tomz and Wright [2007] confront these results with historical observations, from 1820 to 2004 : they find a surprisingly weak relationship between sovereign default and output. If defaults have happened in recessions, some countries have also defaulted in booms, which challenges further the debt-growth debate. I base my second chapter on such a result to find a new relationship between the country's position in the cycle and its default risk.

1.2 Sovereign default and its mechanisms : structural models of sovereign debt

The literature on quantitative dynamic macroeconomic models of sovereign default primarily improved in the wake of government crises in many Latin American countries over the past two decades. In such literature, a sovereign's decision on whether to service its debt or default is endogenised. Those models analysed the aspects of being "willing to repay debts".

Following Bulow and Rogoff [2015a], the literature on sovereign default can be divided into two rough branches :

— The "reputation" approach pioneered by Eaton and Gersovitz [1981] which builds on Hellwig [1977] ;

— The "direct punishments" approach of Bulow and Rogoff [1989a,b] which in turn builds on Cohen and Sachs [1986]. Bulow and Rogoff [1989a,b] make a difference between the rights in debtor country courts and in foreign creditor-country courts, which will be the stepping stone for debt contracts and debt renegotiation.

I will here focus on the first approach of modelling sovereign default.

1.2.1 The Eaton-Gersovitz reputation approach

Eaton and Gersovitz [1981] is the first paper that tries to encompass issues relevant to borrowing by foreign governments on international private capital markets. It is seen as a theoretical basis for the dynamic stochastic macro models that endeavour to portray government crises using numerical solutions. It provides the first theoretical analysis of borrowing by sovereign nations. The article distinguishes between the bankruptcy of an individual economic agent in a national economy and default by a government, and delimits the term "sovereign default" : in the case of an individual agent, bankruptcy reflects negative net worth ; bankruptcy laws provide an institutional framework defining this condition and creditors are compensated. The situation is quite different in the case of a sovereign and an international lending : unless private creditors are willing to coerce debtor governments into repaying loans, there is no explicit mechanism deterring a country from repudiating its external debt. Even without coercive methods of enforcing repayment, private creditors can take a number of retaliatory actions to penalize defaulting debtors, which the most important is exclusion from future borrowing (the creditors no longer trust the defaulting sovereign). Nevertheless, the threat of being excluded from future borrowing will not deter a country from defaulting if it plans to borrow for a period of time with no further intention of borrowing thereafter ; but the private creditors can anticipate this behaviour and would not lend to this sovereign. The basic Eaton-Gersovitz premise is the following : countries do want access to international capital markets because it allows them to smooth consumption, facing volatile output and fluctuating investment. They are reliable in repaying loans in booms because in a case of a switch, they need to keep their reputation as reliable debtors. In this framework, the sovereign borrows external debt and the repayments depend on consumption smoothing. At a certain point, the benefits to retaining market access do not justify rolling over debt : this is called the "incentive compatibility" constraint, which is most likely to be hit when repayments are large. If the country defaults on its repayments, it faces a permanent exclusion from capital markets and can no longer smooth its consumption across periods. The authors state also several assumptions which are crucial to understand the mechanisms of sovereign default, like the fact that the benefits of default increase with the size of the outstanding debt. They are also able to determine a maximum safe level of debt at which the costs just exceed the benefits of default, which is very close to public debt sustainability analysis. The model is detailed hereafter.

The canonical framework

The model features a small economy. Net output in period t, y_t is a random variable with a probability density function $g_t(y_t)$ for which there exists an maximum output $\bar{y} < \infty$. Output is not storable, so that

$$c_t = y_t + b_t - p_t$$

where c_t denotes consumption, b_t borrowing and p_t debt-service payments in period t.
The borrower's objective function is given by

$$E_0 \left[\sum_{t=0}^{\infty} \beta^t U(c_t - P_t) \right]$$

with $U' > 0, U'' < 0$ and $0 < \beta < 1$. P_t is a penalty imposed in case of default in addition to the embargo on future borrowing ; it may arise from a cut-off of aid or retaliatory interference by the creditors with commodity trade.

Debt matures in one period ; the repayment function is given by

$$d_{t+1} = R(b) = (1 + r_t)b_t$$

where d_{t+1} is debt service obligations in period $t + 1$ and r_t the interest rate at which b_t is contracted. In each period, the borrower chooses $b_t \in B_t$ and p_t where B_t is the set of loans available at period t. If $p_t < d_t$ so that debt payments fall short of debt obligations, $B_t = 0$ and the country is no longer allowed to borrow. Otherwise, if $p_t = d_t$, then $B_t = B(y_t, d_t)$.
The value of the objective function in t given a decision to default is

$$V^D(y_t) = E_t \left[\sum_{i=t}^{\infty} \beta^{i-t} U(y_i - P_i) \right]$$

It depends on the utility of having a penalty after default and on the level of output.
The value of the objective function in t given a decision to repay in t is

$$V^R(y_t, d_t) = \max_{b_t \in B_t} \left\{ U(y_t + b_t - d_t) + \beta E \max[V^R(y_{t+1}, d_{t+1}), V^D(y_{t+1})] \right\}$$

It depends on the utility of consumption today and the trade-off between the utility of repaying or not tomorrow. Default is then optimal whenever

$$V^D(y_t) > V^R(y_t, d_t)$$

The probability of default in t as anticipated in $t - 1$ is thus given by

$$\lambda(d_t) = P(V_t^D > V_t^R)$$

Eaton and Gersovitz [1981] also made some assumptions to characterize the lending behaviour. First, lenders are competitive and risk-neutral, which means that they effectively know the default probability. It results that they know the risk they take in lending to high-default-probability countries ; the price offered by creditors will depend on this probability. Second, lenders can lend to alternative borrowers safely and at interest rate r^*. They will compare the benefit they take from lending at risk-free rate and lending at a higher rate but with more risk ("arbitrage condition") ; thus, they will only make loans which guarantee them an expected rate of return at least as high as the market interest rate :

$$[1 - \lambda^*.R^*(b_t)]\, R^*(b_t) = (1 + r^*)b_t$$

Last, total loanable funds are bounded by $W_t < \infty$ so that $\max B_t \leq W_t$ (so-called "finiteness of world wealth" condition).

Several theoretical conclusions are made from this framework

- The probability of default in period t increases monotonically with debt service obligations, which means that the more a country has borrowed, the more it is likely to default.
- The set of available loans in period t is given by $[0, \bar{b_t}]$ for some $\bar{B}_t < \infty$. thus, there exists a threshold of debt emission per period.
- $R^*(b_t)$ is increasing (and convex) over $[0, \bar{b_t}]$. The more a country borrows, the more it will have to repay (since high debt implies high default probability, implying high interest rates).

These conclusions establish that the equilibrium borrowing in a credit market will be characterized by an upward-sloping curve for credit. If the sovereign cannot borrow b_t^* (equilibrium demand for credit), it will borrow the largest amount available $\bar{b_t}$.

1.2.2 Extensions to the canonical model

Some of the previous assumptions and conclusions are not sufficient to characterize the default decision. For instance, the threat of financial autarky is not sufficient to ensure a non-default equilibrium with sovereign debt if output fluctuations are deterministic. Indeed, if the country plans to borrow as long as net flows are positive and default immediately as soon as they become negative, creditors will anticipate the default and not lend in the first place. Sovereign lending can then exist only if there are additional default costs, other than financial autarky. In this case, if the cost becomes painful for the defaulter and is captured by the creditor, then the threat of punishment in the case of a default is credible and improves the country's incentives to repay.

Grossman and Van Huyck [1985] extend the analysis to allow for partial default and develop a model in which the sovereign never cares about any external threats but only maintaining its reputation for repayment. Most applied models add nonetheless a direct punishment cost, very much in the Cohen and Sachs [1986] tradition. In fact, in the empirical applications, it is typically the direct punishment and not the reputation component that drives the debt limits. Aguiar and Gopinath [2006] appear to be the first to make this point in a detailed calibrated model (for a recent application see Du et al. [2014]). They build a quantitative default model for a small open economy in which the defaulter faces both an exclusion from capital markets and an outright cost on its GDP (around 3%). They find that default can occur in equilibrium and improve the match between empirical observations and quantitative results. Namely, they account for the countercyclicality of interest rates, net exports and the positive correlation between interest rates and the current account. Arellano [2008] constructs a model in the spirit of Aguiar and Gopinath [2006] and emphasizes on an endogenous default cost ; she finds that default is more likely to occur in recession because, if the country is risk-averse, it is precisely when the non-contingent debt repayments are the most costly. Her model is able to replicate business cycles properties in Argentina (interest rates, consumption and output volatilities).

The cost of defaulting

As previously explained, the costs of defaulting play a key role in shaping the incentives and constraints of a country facing the choice of rolling-over or defaulting on its debt. They can be various and include post-default reputational concern (Cole and Kehoe [1995]) and direct sanctions from creditors (the most important of which are trade sanctions and exclusion from capital markets). Because debt distress events often go hand in hand with other types of economic disruptions such as banking and currency crisis (see Reinhart and Rogoff [2009, 2011a], or Chapter 2), the domestic political and financial consequences of default constitute a large part of default costs. The difficulty here comes from identifying and quantifying the costs actually incurred by the defaulter, because the literature agrees on the existence of a variety of different default costs [6]. This is a crucial task since theoretical sovereign debt models show that the magnitude of default costs have a direct impact on the amount of debt that a country can borrow (for instance Arellano [2008] accounts for larger default thresholds than Aguiar and Gopinath [2006] by endogenising the default costs). In the extreme case, if there is no cost to default, the country has no incentive to repay at all and so the markets would exclude it ex ante.

First, there is clear evidence that sovereign defaults hamper directly growth, even if strong endogeneity problem may arise in the relationship between the two. Taking this into account, Chuan and Sturzenegger [2005] estimate that default episodes cause a reduction of growth of 0.6 percentage points per year ; moreover, if the default coincides with a banking crisis, then the negative effect reaches 2.2 percentage points of growth. Similarly Borensztein and Panizza [2009] find that, on average, a default is associated with a decrease in growth between 1 and 1.2 percentage points per year, depending on the way the endogeneity problems are dealt with ; they find also that this negative impact is relatively fleeting because not significant after one year. In most sovereign default models (except Adam and Grill [2012]), the costs of default are calibrated at rather low values, around 3% of GDP. As pointed out by Cohen and Villemot [2012], this is the reason why most structural models are unable to generate default probabilities and debt-to-GDP ratios close to historical figures. Adam and Grill [2012] estimate at 6.1% the cost of defaulting for lenders from ex post returns on sovereign bonds, and use it to calibrate the overall costs of default at 10% or 20% in a social planner problem (including thus the cost for the country).

6. See Borensztein and Panizza [2009] for a summary of the various costs identified by the empirical literature

Arellano [2008] uses a flexible specification of default costs in order to increase the set of risky loans available and thus obtain higher default probabilities. She defines post-default output level at $97\%E(y)$ if output (y) is large and at $E(y)$ if output is low.

Second, the threat of exclusion from financial markets is a cost incorporated in most models of sovereign defaults. In an empirical paper on market access, Gelos et al. [2011] show that defaults are indeed always followed by a period of market exclusion. However, the authors show that this penalty is rather short-lived since the exclusion lasts 4.5 years. Using a different dataset, Alessandro et al. [2011] find similar results, but show that there is a great heterogeneity across countries concerning the duration of such an exclusion. Recently, Greece has been excluded from financial markets for seven years, Argentina for fifteen years. The literature also studies the impact of defaults on interest rates once the country has recovered market access. For example, Dell'Ariccia et al. [2006] show that Brady restructuring countries faced an increase in borrowing costs of about 15–50 basis points in the early 1990s, and of 50–100 basis points in the late 1990s following the Russian crisis. Borensztein and Panizza [2009] show that default has a direct negative impact on credit ratings and on interest rates but that these effects become not statistically significant after two or three years. Last, Cruces and Trebesch [2011] show that the interest rate spreads defaulting countries face after their return on capital markets are directly correlated with the size of the haircut during the default episode. Even if there is no broad consensus on this issue these empirical results acknowledge for a possibility of redemption after an exclusion from financial markets, which must be taken into account in theoretical modelling.

In Chapter 3, I introduce habit persistence as a possible *ex-ante* default cost, in the sense of a powerful deterrent from defaulting. Indeed, a high habit persistence reduces the speed of convergence at which public deficit may be reduced in order to avoid default, but also increases the need for consumption smoothing and therefore the need for access to capital markets. Associated with an exclusion from capital markets, consumption habits lower the default probability while increasing the default thresholds.

The need for discontinuity

The reputational approach to sovereign default has the undeniably attractive feature of only requiring modelling skills. But it suffers a number of rather fundamental empirical flaws, beyond the problem of rationalising realistically large costs. More specifically, the models described above fail at illustrating three stylized facts :

(1) The V-shaped dynamics of output around default events, as models account for both output losses, before and after the default event. As the Greek crisis has enlightened it, the crisis begins before the default decision, accelerates it and prompts an output loss which makes default desirable. The default decision is costly for the sovereign, but also frees the country from its debt services, which allows renewed growth.

(2) The negative correlation between interest rates on sovereign debt and output. There's

a need for a model in which, when a country is hit by a crisis, risk premia on its bonds increase, linked to its default probability and on the probability of sinking into the crisis.

(3) The disproportionately high government debt ratio when defaults take place. Most of previous models like Aguiar and Gopinath [2006] or Arellano [2008] (stochastic trends in output) are not able to replicate default with enough high probabilities and debt thresholds in accordance with today's debt levels.

Conventional DSGE models are usually unable to explain points (1) and (3) given that the sovereign defaults (if included in the models) follow an exogenous process. Besides, most of the literature on sovereign default cannot explain point (2) because the output is modelled exogenously. Cohen and Villemot [2012] tried though to reconcile these three patterns. They endogenise the process of output, in order to determine jointly equilibrium dynamics of output and sovereign default : a major crisis happens with probability p ; after entering such a crisis, default becomes a possibility for the sovereign, which faces higher interest rates on his debt. If a new large shock occurs, the sovereign will automatically default ; the risk premium and the probability of default become p, which is the probability that output falls again. They build their model upon a Lévy process of output, which may be decomposed into the sum of a Brownian motion, a linear drift, and a purely discontinuous process (Poisson). They find that the country will never default in a simple Brownian case, because of the continuous nature of growth. The country can continuously adjust to small shocks its debt level and never defaults. Nevertheless, when the economy is disrupted by a Poisson shock, default becomes a possibility with probability p per unit of time (i.e. the country will prefer to default if it experiences another Poisson shock).

1.2.3 Introducing the DSGE paradigm

Policy implication of sovereign default models relies on the specification of output fluctuations and costs of default. They respectively govern the ex ante and the ex post components of the output fall occurring at default time. Those models help at understanding the causes of default by offering a micro-founded description of the incentives and constraints faced by a representative country, but they have limited empirical tractability. The only way to test their validity in sample so far is to compare the model with the sample moments, as it is done in the Real Business Cycle (RBC) and Dynamic Stochastic General Equilibrium (DSGE) literature.

Business cycle models (RBC or DSGE models) are generally a suitable theory-based analytical tool for evaluating various policies, but they are rather reticent when it comes to issues related to sovereign defaults. Integrating sovereign default in such economic models is likely to be quite helpful for a micro-based discussion of the issues mentioned above, but also rises a dimensionality problem. Indeed, sovereign default models use recursive equilibrium solutions and are solved using value function iteration. Such a method limits the number of state variables to maximum three (usually two, output and debt, Na et al. [2015] add past inflation), which makes impossible the match with large scale business cycles models. Mendoza and Yue [2012] present a model that can be viewed as an initial step in this direction : they combine the literature on "sudden stops" with a sovereign default model in which the sovereign decides whether or not to default. They build a model in which the default probability and the level of domestic productivity interact (thanks to domestic and imported inputs) : lower productivity increases default probability and worsens financial conditions by generating larger public and private sector spreads ; this, in turn, worsens domestic productivity and increases more sharply the incentives to default.

The purpose of Chapter 3 is to build a DSGE model which incorporates sovereign risk and tackles the dimensionality problem in order to be able to still compare present value functions and derive government's decision to default. More precisely, I compute the default probabilities that would be implied in an DSGE model if the country was given the option to default in a similar fashion as in the canonical model. This is done without modifying the core of a New-Keynesian DSGE model (the possibility of a default is not endogenised *ex ante*) ; I rather compute an out-of-model default value function corresponding to what the country would get if it were to default ; then I test whether the value function of the DSGE model is greater or smaller than the default value function.

1.2.4 Self-fulfilling debt crises

The literature has also studied the theoretical possibility of self-fulfilling debt crises, i.e. crises that are triggered by self-fulfilling (pessimistic) beliefs about the ability or willingness of the sovereign country to roll-over its debt. These models depict the situation of a country whose fundamentals are sane enough to make it solvent if confronted to good market conditions, but whose default is precipitated by pessimistic creditors who ask for a high risk premium or refuse to lend in sufficient amounts. Technically, a model of self-fulfilling crises is a model with multiple equilibria : typically the model will sustain both a "good" equilibrium where lenders offer large credit at low rates, in which the country roll-overs its debts and follows its reimbursement schedule, and a "bad" equilibrium where lenders are pessimistic about the country's ability to repay, which precipitates the country into default because of bad market conditions. Both equilibria are compatible with rational expectations : in both cases, market expectations, whether bad or good, are realized in equilibrium. The bad or good equilibria are the outcome of a sunspot, independent of the country's fundamentals.

The first paper to examine self-fulfilling mechanisms in the context of a sovereign debt crisis is Calvo [1988]. He shows that the theoretical possibility of multiple equilibria lies in the interest rate : if lenders ask for the riskless interest rate, then the country is safe and is able to reimburse ; if lenders ask for a risk premium, the interest payments accumulate and debt becomes unsustainable : the country defaults. This effect can be qualified of a snowball effect, since the fear that debt becomes unsustainable directly makes it unsustainable. Several papers have showed how the snowball effect can be neutralized. Cohen and Portes [2006] show, in a simple two-period setting, that the snowball effect can be neutralized if creditors and the sovereign know ex ante that a socially efficient debt restructuring can be built up in case of default. Chamon [2007] also shows that multiple equilibria through the interest rate can be avoided if the timing of borrowing is modified : multiple equilibria arise if the country announces the amount that it wants to borrow today, and the investors reply with the interest rate they want to be applied tomorrow. If instead the country commits on the amount to be repaid tomorrow, and the investors reply with the interest rate they want to apply today, then multiple equilibria in the interest rate become impossible by construction. On the empirical side, Lorenzoni and Werning [2013] show that low and high interest rate equilibria may coexist ; "slow moving crises" are characterized by a high interest rate which lead to fast debt accumulation which validates in turn the default fears of investors and gives them a rationale for high interest rates (in opposition to "roll-over crises" which immediately leads to a default). Following the Eurozone debt crises, many other papers take stock of Calvo's work and provide multiple equilibria explanations to the credit event (see for instance Tamborini [2015], Nicolini et al. [2015] or Aguiar et al. [2016]).

Another type of self-fulfilling crises is studied by Cole and Kehoe [1995, 2000] and essentially focuses on liquidity crises. In this setting, close to the one of Diamond and Dybvig [1983] for bank runs, a government borrows from foreign investors and decides at every period to roll-over the debt or default. The mechanism is essentially linked to the average debt maturity : it has a maturity of one period so that, for high levels of indebtedness, the country cannot roll-over without contracting first a new loan. Therefore, if the country is not able to borrow enough at one period, it is likely to default because of a lack of liquidity even if it is fundamentally solvent. Cole and Kehoe show that a self-fulfilling zone arises : if creditors expect the country to default, then they refuse to refinance the debt and the country is indeed forced to default. This self-fulfilling mechanism disappears if maturity increases. Cohen and Villemot [2015] consider another possible type of self-fulfilling debt crisis, triggered by a confidence shock which can, by its own, damage the fundamentals of the country and create two equilibria.

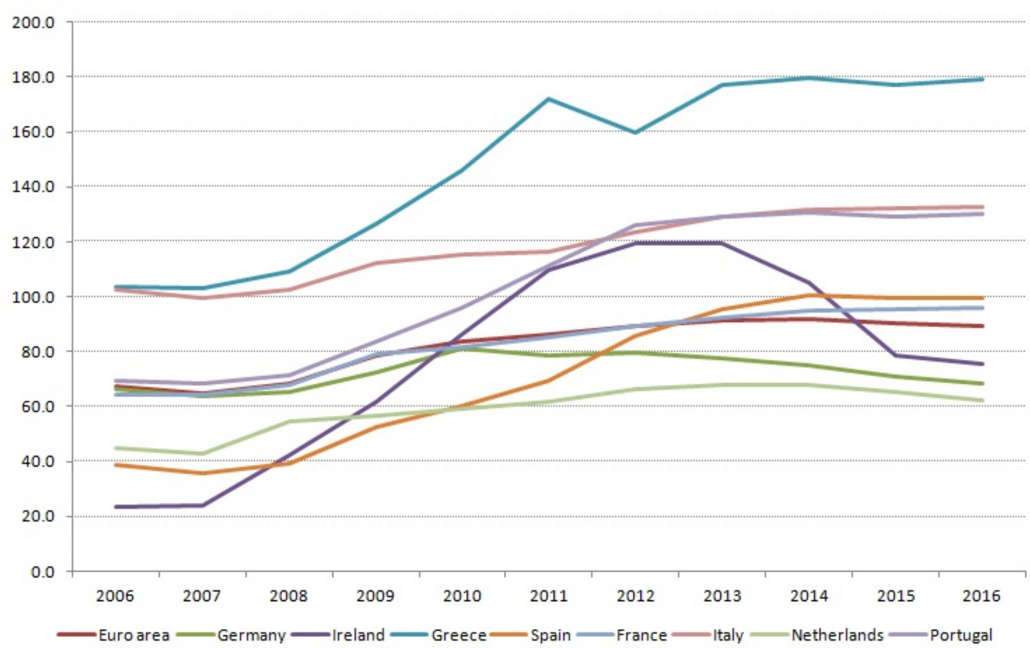
1.3 A focus on the Eurozone Debt Crisis

The literature on sovereign debt and defaults expounded so far mainly focused on emerging or low-income countries and small open economy frameworks. Nonetheless, starting in 2010, Europe has been hit by a sovereign debt crisis which has caused three of its members to be ousted from financial markets. Greece, Ireland and Portugal had to ask for the support of the other Eurozone countries to refinance their debt. Additionally, in the case of Greece, the eventual implementation of a nominal haircut of more than 50% was decided. In response to this unexpected crisis, Europe decided to impose a much stricter budgetary discipline, aiming for a near zero deficit rule. These events put to test the analyses and models traditionally used to understand sovereign default and many issues raise : how did the Eurozone suddenly become so vulnerable to sovereign risk ? Is the literature able to explain it ? Is Europe using the right policy tools to reduce default risk in its currency zone ?

1.3.1 The Eurozone Debt Crisis : 2009 - .

Initiated in the United States by the bursting of a real estate bubble (so-called "subprime" crisis) in 2007, the economic crisis that is affecting the Eurozone today is a public debt crisis. However, the merging of the financial crisis has nothing to do with a problem of public finances ; the level of sovereign debt surged after the crisis became systemic (public debt ratios in the Euro zone countries have only increased from the third quarter of 2008, see Figure 1.5). In average, the general government gross debt of advanced economies increased rapidly from 74 to 105 percent of GDP over 2007–11 (WEO statistics). What was then at the root of the Eurozone debt crisis that burst in 2009 ? The answer is not as straightforward as it may seem, partly due to the peculiar status of the Euro for its member States. As it has been underlined after the 2012 Greek debt workout, it was for the first time in nearly 80 years that a developed country had been forced to restructure the debt held by private creditors [7].

FIGURE 1.5 – EMU Countries' general govnerment debt (in % of GDP)



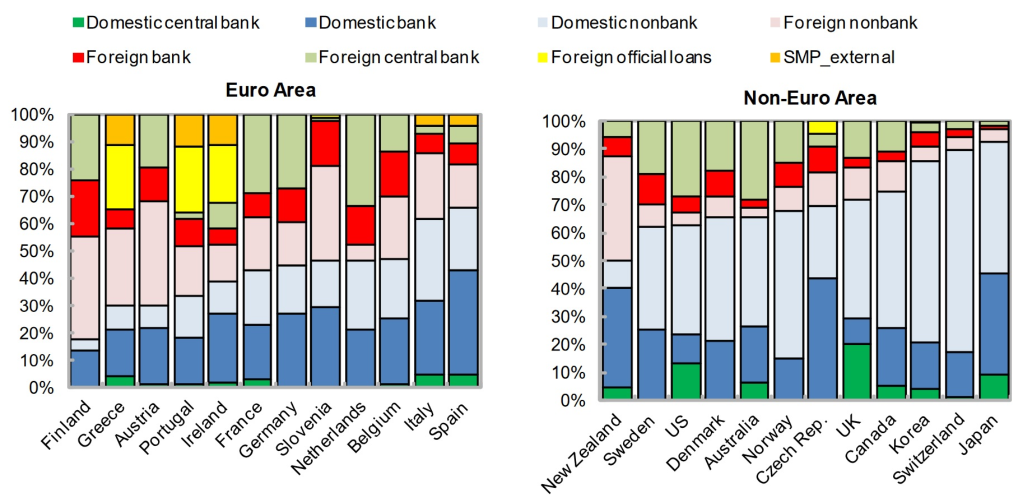
Source : Eurostat

What usually helps developed countries to avoid sovereign debt problems is their ability to implement countercyclical policies more easily than developing countries (Savona et al. [2015]) and to borrow in their own currency. Sovereign debt crisis in developing countries are triggered, at least in part, by liquidity issues (Roubini [2011]), all the more since they have a large external debt : even though these countries are solvent, if creditors refuse to lend more and then supply them with the external currency they need, it can prevent them from financing their external deficit and pay back their external debt. A temporary lack of cash, resulting in a default, can degrade a country's fundamentals, which ultimately make the country insolvent.

7. See for instance Allen & Overy [2012]

Based on a new dataset (which gathers 24 major advanced economies used to track 42 trillion of dollars of sovereign debt holdings on a quarterly basis over 2004-2011), Arslanalp and Tsuda [2014] examine how investors changed their holdings of advanced economy sovereign debt after the global financial crisis, including during the recent Euro area debt turmoil. For most advanced economies, they find a rising share of foreign investors in sovereign debt markets (see Figure 1.6) and a rising exposure of banks to own government debt after the global financial crisis, which might be at root of the Irish, Greek and Portuguese crises.

FIGURE 1.6 – Advanced Economies : Holders of Government Debt, end-2011 (percent of total)



Source : Arslanalp and Tsuda [2014]

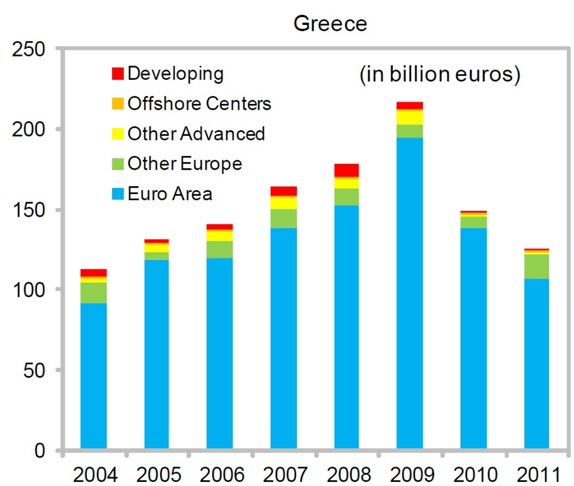
In the Eurozone, things are worth looking. Indeed, the Euro is a strange animal : bearing in mind that no country of the Euro area is capable of printing money and has no influence on the decisions of the European Central Bank (ECB), one may consider that Euro is like an external currency for its members. At the same time, the ECB acts as a lender of last resort for European banks, which have always been able to refinance even in the midst of the Euro crisis (see Chapter 4), and to a certain extent, there is some solidarity between the member states. This makes it difficult to assert that, for instance, Euro is for Greece what the Dollar was for Mexico in the 1980s. It makes it therefore more complex to analyse the causal links between macroeconomic environment and sovereign risk, and to apply the same considerations about external debt and its currency denomination than we did for emerging countries.

The Greek crisis...

Since the mid-1990s and up to 2009, Greece has voluntarily underestimated its public deficit. During fall 2009, the newly elected Greek government discovered that 2009 deficit was reaching 13.6% of GDP. Greece's creditors and international financial markets began to doubt Greece's ability to repay its debt, interest rates on Greek government bonds faded and Greece was forced to find a way to reduce its debt service while limiting its borrowing, with only very limited access to the bond markets (or even non-existent for long maturities).

In 2010, the public debt became unsustainable for the country and speculation about the default of Greece raised (it must be remembered that the latter had already defaulted four times since 1800). At this point, the majority of the public debt was held by Euro area external banks (see Figure 1.7), in particular French and German banks. Several forms of assistance has been provided by the Troika (IMF, ECB, European Commission) : haircut of almost 50% of the nominal debt (partial default), loans from the IMF and European governments, which were used to repay obligations and to fill the need for short-term public funding. These loans have been seen as a relief plan for Greece since they were a way to postpone the repayments to creditors and therefore to avoid a total default. This relief plan was granted provided the country was recovering : Greece had to regain growth to roll-over its debt and to reduce substantially its public deficit. The ECB also agreed to refinance Greek banks starting from Greek sovereign bonds taken as collateral.

FIGURE 1.7 – Foreign Holdings of Greece's Government Debt by Country of Origin, 2004–11



Source : Arslanalp and Tsuda [2014]

TABLE 1.1 – The Greek economy since the beginning of the sovereign crisis

	2008	2009	2010	2011	2012	2013	2014	2015
GDP Growth	-0.3	-4.3	-5.5	-9.1	-7.3	-3.2	0.7	-0.2
Unemployment rate	7.8	9.6	12.8	17.9	24.5	27.5	26.6	25
Government debt over GDP	117.4	134.7	128.4	110.7	167	181.7	179.8	
Public deficit over GDP	10.2	15.2	11.2	10.2	8.8	13	3.6	7.2

Source : OECD

From 2011, the country has plunged into recession (see Table 1.1) and the 2010 plan became no longer adequate. A second relief plan was signed in March 2012. The IMF loan was again subject to the same requirements as the first one : Greece had to improve its ability to raise taxes, cut public spending and introduce reforms that encourage employment and economic development. In July 2012, Mario Draghi delivered his famous speech : "Within our mandate, the ECB is ready to do whatever it takes to preserve the Euro. And believe me, it will be enough". The announcement of the OMT, a new debt buy-back program for the sub-program countries, drastically reduced interest rates on bonds in Europe ; the pressure on Greece fell temporarily. The two relief plans combined around 240 billion euros. In summer 2015, the loans granted in 2010 under the first aid plan reached maturity (1.55 billion euros from the IMF, 6.5 billion from the ECB) ; by deciding to default, Greece could be forced to leave the Euro zone ("Grexit"). In addition, the ECB decided at the same time to stop its loans to the Greek banks guaranteed by the government : the ECB didn't want to end up with less collateral than the loans it had already granted to Greek banks. A third aid plan has been unlocked (86 billion euros in tranches of 20 billion euros, the first of which in the autumn of 2015), in return for a series of measures to be set up in the country.

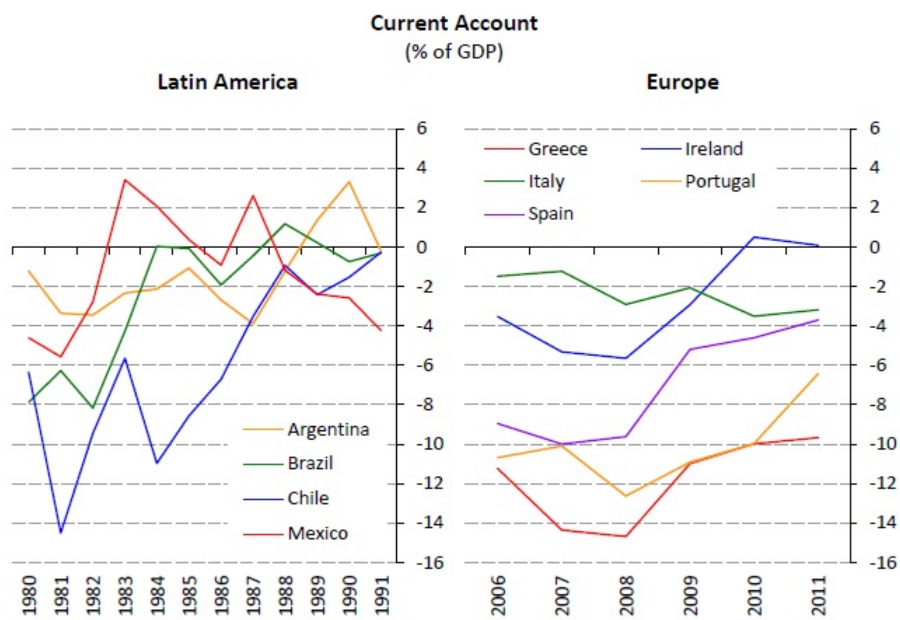
... A standard sovereign crisis ?

There are currently two conflicting views of the Eurozone Crisis and in particular the Greek crisis, in both policy and academic circles : it is either considered to be a sovereign debt crisis, or a balance of payments crisis. According to Baldwin and Giavazzi [2015], the Greek crisis is widely seen as a sovereign debt crisis, while those in Ireland, Portugal, and Spain are characterised as balance of payments crises. Hyppolite [2016] offers insight into the macroeconomic dynamics that preceded the crisis and finds that capital accumulation was artificially driven up by a real estate bubble, and was especially harmful because investments in overvalued assets were financed through external borrowing. According to him, the Greek crisis appears actually closer to a balance of payments crisis, thereby sharing strong similarities with the crises of other periphery countries. The key difference between them simply comes from to the relative involvement of the various economic sectors in domestic investment, and their financing through external borrowing : in Greece, the government was relatively more involved in this process than private sector. Hence, the crisis started as an external public – instead of private – debt crisis. However, Gourinchas et al. [2016] highlight the role of the sudden stop suffered by the private sector in the output drop, which suggests there may have been, before the crisis, broader harmful dynamics at play in the economy. They qualified the Greek crisis as one of the worst in history, comparing it to the "trifecta" crises – the combination of a sudden stop with output collapse, a sovereign debt crisis, and a lending boom/bust. They find that the decline in Greece's output, especially investment, has been deeper and more persistent than in almost any crisis on record over the period 1980-2010.

The Greek crisis also rekindled the liquidity vs. solvency debate. According to De Grauwe [2011], the crisis in Greece was not triggered by liquidity problems which would have led to a solvency crisis. On the contrary, the country entered a crisis only because it was insolvent. A liquidity crisis which is not accompanied by a solvency crisis can justify the intervention of institutions (such as the EU or the IMF), which substitutes themselves to the private creditors to extend financing to the country in crisis that should be theoretically temporary. But if a country is insolvent, there is no point in lending more to it without, at least, restructuring its debt. In the Greek case, financial assistance was conditional on implementing structural reforms, which makes not clear-cut whether the EMU countries underwent a "primary" liquidity crisis or a solvency crisis. As a consequence, there is a great temptation to resort to a political explanation of the Greek crisis, based solely on fiscal indiscipline.

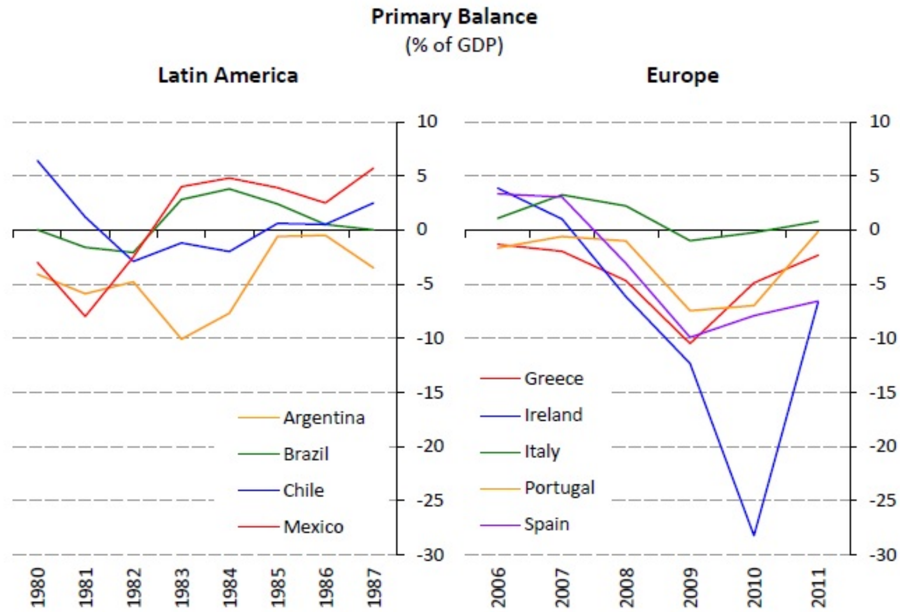
Last, according to Bulow and Rogoff [2015b], the outcome of the Greek crisis has much to do with the Eurozone management of the crisis and the fail in renegotiating : even though Greece started with a much higher ratio of debt to GDP than the Latin borrowers (see Figures 1.8 and 1.9), Greece was not forced to move from primary deficit to primary surplus almost overnight, compared to countries that did not have Greece's bargaining advantages (i.e. the major Latin American borrowers in the 1980s, with the exception of Argentina). This is because official creditor bailouts were much more forthcoming in the Greek case, which must have kept the country from defaulting on its debt and trying to wipe the state clean. All of these opposite views are difficult to reconcile, and thus Greece is willingly depicted as an "outlier" and the "exogenous trigger" of the Eurozone crisis.

Figure 1.8 – Current accounts of Latin America and Europe, 1980-2011



Source : Bulow and Rogoff [2015b]

FIGURE 1.9 – Primary balances of Latin America and Europe, 1980-2011



Source : Bulow and Rogoff [2015b]

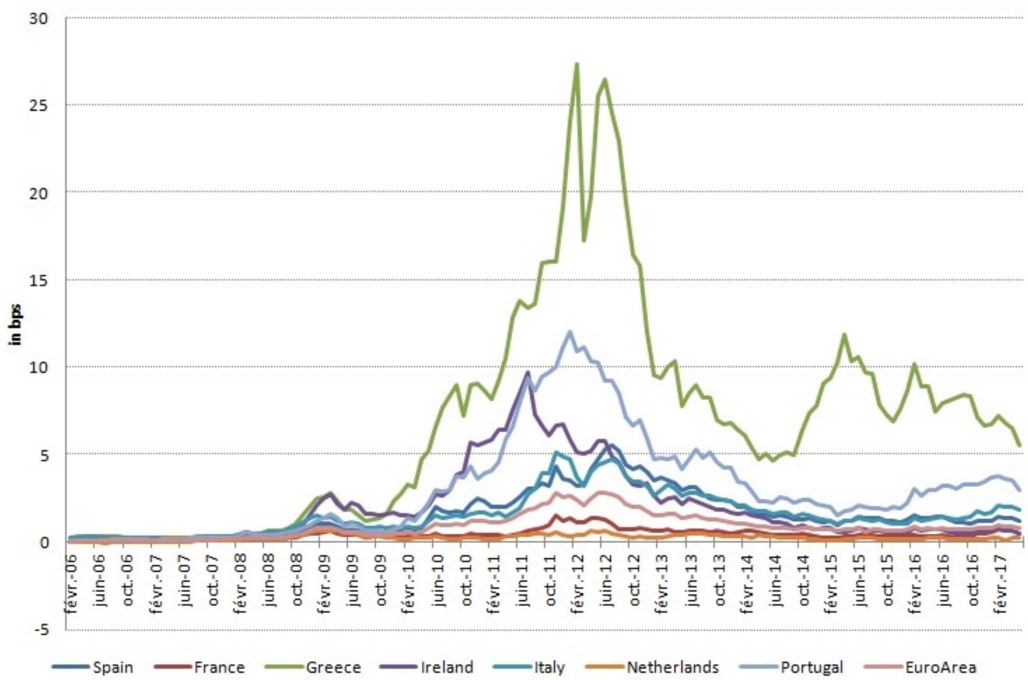
1.3.2 Policy implications and the role of monetary policy

Many fiscal and monetary policy implications can be drawn from the Eurozone debt crisis and its management from the various institutions at stake.

First, was fiscal consolidation a good way to reduce default risk in the Eurozone ? According to Blanchard [2015], the Eurozone had no choice to impose fast fiscal adjustment, and it was a good point to combine it with several relief plans. His argument is twofold : first, slower fiscal adjustment (less austerity), would have required even more financing with debt restructuring, and there was a political limit to what creditors could contribute. Second, "growth-killing structural reforms" combined with fiscal austerity have not necessary led to a recession, since a number of structural reforms were seen as necessary (reform of the tax administration, pensions, judicial system, etc.) and that inconsistent policies, insufficient reforms or weak banks would have even more contributed to a rise in default risk. Combined with relief plans, this fiscal austerity could achieve public debt sustainability. Conversely, Gourinchas et al. [2016] show that this unavoidable fiscal consolidation takes part in half of the drop in output, increasing the debt unsustainability. In Chapter 3, I test the two main measures of the fiscal compact (lower debt target and higher speed of adjustment) in New-Keynesian DSGE with sovereign default and compare their effect on sovereign risk in a country in the Eurozone and in a flexible-change small open economy.

Second, has the "whatever it takes" been effectively useful to reduce bonds interest rates in the Eurozone ? Several empirical papers have highlighted the role of shocks provided by political decisions on sovereign spreads (see Figure 1.10), in particular decisions taken by the European macroeconomic institutions (see Filbien et al. [2013]). Delatte et al. [2012] combine economic and political uncertainty variables to explain the sovereign bond yields in the Eurozone since the crisis. They find that the reforms set up by the European Economic institutions at the end of the spring 2010 created a switch regime in sovereign spreads but that ECB's communication on the sovereign bond crisis contributed to feeding it ; on the contrary, the meetings of the European Council contributed to lowering the spreads for the countries less affected by the crisis.

FIGURE 1.10 – EMU Countries' 10-year government bond spreads to Germany's



Source : ECB Database

More globally, many articles have studied the effect of conventional monetary policy in the Eurozone during the worldwide financial crisis [8]. For instance, Andries and Lecarpentier-Moyal [2012], Blot and Labondance [2013] and Belke et al. [2012] focus on the interest rate channel. Another string of literature assesses the effectiveness of unconventional measures : Altavilla et al. [2014], Ghysels et al. [2014] and Szczerbowicz [2015] focus on the effect of unconventional tools on interest rates ; Gambacorta and Marques-Ibanez [2011], Giannone et al. [2012] and Andrade et al. [2015] analyse more specifically the bank lending channel. The literature is much segmented indeed : analyses focus either on conventional or unconventional measures, either on interest rates or volumes, and only few focus on the sovereign bonds (e.g. Cordemans and de Sola Perea [2011]). In Chapter 4, I present further the literature on such issues and assess the monetary transmission of unconventional and conventional policies to sovereign interest rates and volumes during the Eurozone debt crisis.

8. See section 4.1 for a detailed review

Chapitre 2

When do countries default ?

2.1 Introduction

The sovereign debt crisis in Europe came as a surprise : the long history of sovereign defaults has been gathering mainly debt distresses in emerging or developing countries (see for instance Reinhart and Rogoff [2009] in their famous book, "This Time is Different"), and it seems to be a sink or swim time for sovereign default literature, which has to propose determinants of debt distresses in developed economies. Which lessons Europeans should retain in order to avoid further sovereign risk in the future ?

Structural models of sovereign default have hitherto focused on the output gap as the main trigger of debt distresses : in models such as Aguiar and Gopinath [2006] or Arellano [2008], transitory or permanent shocks to productivity lead the country to prefer defaulting rather than rolling-over its debt. These models nonetheless fail at replicating high default thresholds (see Table 2.1) :

TABLE 2.1 – Overview of mean debt-to-GDP ratios and default probabilities in the literature

Paper	Main feature	Mean debt-to-GDP (%, annual)	Default prob. (%, annual)
Arellano [2008]	Non-linear default cost	1	3.0
Aguiar and Gopinath [2006]	Shocks to GDP trend	5	0.9
Cuadra and Sapriza [2008]	Political uncertainty	2	4.8
Fink and Scholl [2011]	Bailouts	1	5.0
Yue [2010]	Endogenous recovery	3	2.7
Mendoza and Yue [2012]	Endogenous default cost	6	2.8
Hatchondo and Martinez [2009b]	Long-duration bonds	5	2.9
Benjamin and Wright [2009]	Endogenous recovery	16	4.4
Chatterjee and Eyigungor [2011]	Long-duration bonds	18	6.6

Note : For Aguiar and Gopinath [2006], we report results for their model II (with shocks to GDP trend). For Arellano [2008] and Aguiar and Gopinath [2006], the reported values come from Hatchondo et al. [2010] who re-simulate these models using more precise numerical techniques. For Hatchondo and Martinez [2009b], the reported values are those obtained for their default cost parameter equal to 20%.

What is at stake here has been answered by Tomz and Wright [2007] : looking at the relationship between economic output and sovereign defaults for the period 1820-2004, they find a surprisingly weak relationship between the two. Defaults do not necessarily occur in recessions : only 62% of them occurred during bad times (see results in Table 2.2, comparing the relationship between the two variables in data and as modelled in structural models).

Table 2.2 – The relationship between output and default - Tomz and Wright [2007]

	Historical data	Simulation	
		Transitory shocks	Permanent shocks
Mean deviation from trend (%)			
In first year of default	-1.6	-41.6	-7.4
In periods of default	-1.4	-25.7	-5.6
In last year of default	-1.3	-13.6	-4.5
In periods of non-default	0.2	0.0	0.4
Country years below trend (%)			
In first year of default	61.5	100.0	85.9
In periods of default	56.2	83.8	78.1
In last year of default	58.8	75.5	72.9
In periods of non-default	47.2	50.0	48.3

Source : Tomz and Wright [2007]

The theoretical answer to this striking stylized fact has been brought very recently by Cohen and Villemot [2012] and Serfaty [2015], who showed that defaults events are in fact triggered by two discontinuities : a discontinuity in level, brought by exogenous shocks (Cohen and Villemot [2012]) and a first order discontinuity, brought by a switch in growth trend (Serfaty [2015]).

Cohen and Villemot [2012] built a sovereign default model that embodies a Markov-Switching pattern which may lead to default. They base their theoretical inspiration on the Lévy stochastic processes, as defined in section 1.2.2 ; these processes can be roughly defined as the generalization of random walks to continuous time. More precisely, any stochastic process in continuous time with stationary and independent increments is a Lévy process. The Lévy-Itô decomposition states that any Lévy process is essentially the sum of two components : a Brownian process and a compound Poisson process. They demonstrate a key result : Brownian processes do not have the ability to generate defaults. Instead, they function as in deterministic models ; whatever the cost of default, the corresponding probability of default is zero. Default must depend on exogenous shocks, creating discrete jumps in the wealth of a nation. Such shocks are well-represented by a Markov switching process in the spirit of Hamilton's papers [1]. In their simulations, they show that a standard business cycle (such as observed say in the US) does not lead to default. It takes less frequent and more profound crises to trigger a debt crisis.

1. see for instance Hamilton [1989]

Serfaty [2015] shows that incorporating Markov-switching features in trend growth rather than in level produces even higher debt thresholds. In the following Table 2.3 adapted from Serfaty [2015], we present the outcome of one calibration, in the case when the probability of entry into a downturn is (only) 1% and when the probability of exit is 5% (each on a quarterly basis), which is in tune with the data pertaining to emerging countries. The calibrated model fits quite well the data at hand.

Table 2.3 – A Markov-Switching model of sovereign default

	Model (%, annual)	Data (%, annual)
Probability of default	3.0	3.0
Debt at default	83.5	80.0
Correlation between current account and GDP	-37	-89
Average spread	2.9	3.0

Note : Model in which the probability of entering a crisis is $p = 1\%$ and exiting it is $q = 5\%$ (quarterly)

The main goal of this chapter is to provide new stylized facts about debt distress events and to build new links with other types of crises (mainly currency and banking crises). We construct a database using countries' business cycle phases in order to study debt distress inside a global macroeconomic trend rather than at a date t. We want to answer and provide empirical foundations to the work of Tomz and Wright [2007], Cohen and Villemot [2012] and Serfaty [2015], and to answer the very simple question : when do countries default ? Taking a simple look at macroeconomic variables and business cycles around default, it turns out that default occurs when a country experiences a discontinuous growth shock : the large majority of defaults (60%) occurs in a downturn, defined as a peak to trough episode, whereas defaults exiting this downturn rule are rather non-economic defaults. When we focus on defaults in downturns, it turns out that 70% of them come along with another crisis (banking, currency or twin), which acts as a discontinuity on the debt-to-GDP ratio. Last, we perform a logit regression to compare defaults in booms and defaults in busts ; we find that defaults in booms cannot indeed be explained by macroeconomic variables. We conclude that countries default by a combination of three features, that are not sufficient by themselves. First, debt distresses happen mostly in peak-to-troughs and the switch, more than the output-gap itself, should be taken into account in sovereign default models (à la Hamilton [1989] for instance). Second, they mainly come along with other crises (banking or currency), which operate as huge discontinuous shocks on debt-to-GDP's denominator (currency crisis) or numerator (banking crisis). Last, if the countries' initial conditions (debt-to-GDP ratio for instance) are already quite high when they enter into the downturn, they face a high probability to default.

This paper is in line with a vast literature analysing the determinants of sovereign default, as previously exposed in the introduction (section 1.1.2). It is mainly inspired by the work of Kraay and Nehru [2006], who use a probit regression to find that crises are more likely if the debt level is high , institutions are of poor quality and real GDP growth is low. They test the out of sample predictive power of their model, which is able to correctly forecast 84% of the episodes of the post-1990 sample. We will use the same methodology in section 2.5. Cohen and Valadier [2011] improve their dataset and find that debt crises owe mostly to the debt level of the countries rather than other macroeconomic variables, but also to the quality of governance of the country (assessed by the Country Policy and Institutional Assessment index). In this chapter, we will show that the level of indebtedness has an impact only for default occurring during a downturn, whereas the quality of governance of the country may be the only driver of trough-to-peak defaults.

This chapter also takes stock of the literature on business cycles and its links with sovereign default. First, we will refer here to the Burns and Mitchell [1946]' definition of a business cycle : locating turning points in many series, each of which was a partial reflection of "economic activity", they define these turning points as specific cycles and use the information in these specific cycles to identify the reference cycle. It was the latter which was called the business cycle, and which is now used by the National Bureau of Economic Research. We will use the same definition. Regarding the link with sovereign defaults, Aguiar and Gopinath [2007] examine emerging markets business cycles and exhibit strong countercyclical current accounts, sudden stops in capital inflows and strong consumption volatility ; they conclude that these economies are subject to a substantial volatility in trend growth, which may cause some economic fluctuations painful enough to lead the country to default. In this chapter, we push on the analysis to disentangle the link between productivity level and default risk and emphasize on the switch from one regime (boom) to another (bust).

Last, this chapter put centre stage the debate about the simultaneity between currency, banking, twin crises and debt distresses. Most of the literature has only focused on the causal links between "twin" crises, that is to say banking and currency crisis ; only few add debt distress in their analysis. Indeed, Kaminsky and Reinhart [1999] define currency crises as balance-of-payment crises and explore the potential links with banking crises ; they find that currency events precede banking crises but that the reverse is not true. Rather than causal links between the two events, they prefer to posit common causes. In this chapter, we will address the same question but adding sovereign crises : which one precede the other ? Reinhart [2002] tests the connection between sovereign credit ratings and currency crises with a view to highlighting the strong link between defaults and currency shocks in emerging countries. She finds that these credit ratings fail at predicting currency events *per se* but that a fall in the country grade usually follows currency crises, which in turn increases the default risk.

The rest of the chapter is organized as follows. Section 2.2 presents the data, section 2.3 the arisen stylized facts, section 2.4 the sketch of a defaulting country vs. a non-defaulting country and section 2.5 the empirical strategy, results and multiplicity of equilibria. Section 2.6 concludes.

2.2 Data

2.2.1 The debt distress database

We use a slightly modified version of Kraay and Nehru [2006]'s and Cohen and Valadier [2011]'s databases. The two are extended up to 2012 for GDP only, in order to be able to locate correctly in a business cycle defaults in the late 2000s [2]. Our concept of a debt crisis goes beyond the sheer case of a default to incorporate a broader range of situation, where the country experiences debt difficulties. More precisely, a debt distress event is defined as the union of three events :

— The sum of interest and principal arrears on long-term debt outstanding of a country is larger than 5% of total debt outstanding. This definition is not sufficient to define a default event since countries that are unable to service their external debt do not necessarily fall into arrears : they can receive a balance of payments support from the IMF (recognizing the third dot) or seek debt rescheduling from the Paris Club (recognizing the second dot)

— It receives support from the Paris Club (in a form of rescheduling or debt reduction) ;

— It receives balance of payments support by the IMF in the form of StandBy Arrangements or Extended Fund Facility, which depends on the quota the country gets from the IMF.

This definition allows to account for default episodes in a broader sense than outright default, and this is the main advantage of this dataset compared to other databases in literature (Benjamin and Wright [2009] use only debt restructuring outcomes, Borensztein and Panizza [2009] uses Standard and Poor's definition to gather strict defaults on sovereign bonds and bank loans whereas Rose [2005] only focus on debt restructuring brought by the Paris Club). Moreover, a default is defined at the intersection of one of these three events with the condition that one of this event has not occurred for at least three years : this enables to avoid double counting of those episodes when they last for several years and therefore to identify "real" debt distress episodes.

Using this definition of default events, we also look at their simultaneity with banking and currency crises. Following Cohen and Valadier [2011], currency crises are defined as follows (which differs from the definition of Kaminsky and Reinhart [1999] [3]) :

— the exchange rate against the US dollar has fallen by more than 30% compared to the previous year

— the rate of depreciation must be at least 10% greater than that of the previous year (to balance high inflation rates)

Systemic banking crises' definition also follows Cohen and Valadier [2011]'s, which includes a

2. Our dataset, thus, does not include Greek default in 2010

3. They construct a balance of payment index made of exchange rate changes and reserve changes and look at points above three standard deviations from mean

sharp increase in non-performing loans, a sharp decrease in banking capital, depressed asset prices, a sharp increase in real interest rates and a slowdown of capital flows.

The whole database gathers 176 countries, throughout the period 1970-2012, on an annual basis. Data description and descriptive statics are provided in Appendix (Tables A.1 to A.3, Figures A.1 and A.2).

2.2.2 Construction of cycles

The main goal of this chapter is to consider debt distresses as part of the business cycle of a country. We indeed have in mind that macroeconomic conditions bring a country to default in a certain phase of its business cycle rather than at a precise date t : if the country could have also defaulted at date $t-1$ or $t+1$ because of legal or political reasons, which blurs the macroeconomic analysis around default, it should not have defaulted in another phase of its cycle, since the macroeconomic conditions inside the phase are following broadly the same trend. Our point here is thus to situate defaults inside a business cycle phase and look at macroeconomic conditions at the beginning of it, answering the question : do initial conditions at the beginning of a bust (resp. boom) predict a debt distress inside this bust (resp. boom) ?

We construct cycles of the country using a method close to Harding and Pagan [2002]'s. Assuming business cycles have to be defined in terms of the turning points in the level of economic activity, we first apply an Hodrick-Prescott's filter on the country's GDP (in US dollars). This decomposition of time series allows us to keep only the cyclical component of our GDP series. We assume that the series y_t, for $t = 1, ..T$ (GDP, in log here, T is the number of observations) is made up of a trend component τ_t and a cyclical component c_t such that

$$y_t = \tau_t + c_t + \varepsilon_t$$

Given an adequately chosen λ (usually 1600 for quarterly data and 400 for annual data), there is a trend component that will solve

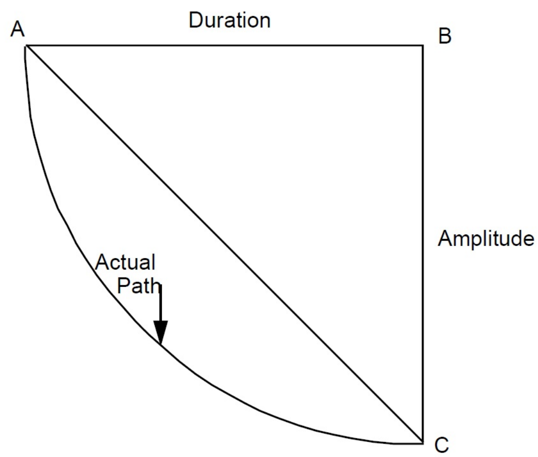
$$\min_{\tau_t} \left[\sum_{t=1}^{T} (y_t - \tau_t)^2 + \lambda \sum_{t=2}^{T-1} [(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})^2] \right]$$

We obtain the cyclical component by removing the so-found trend from the series. When series comprise missing values for a period of time, we apply the filter only around these holes (see in Appendix, Table A.4 to A.6).

The detection of any cycle is made by first isolating turning points in the series ; those dates are then used to mark out periods of expansions and contractions. First, the location of turning points has been done visually : in this way we were able to filter out “false turning points” i.e. movements which are either short lived or of insufficient amplitude. Then, these judgements have been transformed into an algorithm in order to compute cycles at a higher speed and to avoid human mistakes.

The best known algorithm for performing these tasks is set out by Bry and Boschan [1971]. They define a local peak (trough) as occurring at time t whenever $y_t \gtrless y_{t\pm k}$, $k = 1, \ldots, K$ where K is generally set to five. In their case, a phase must last at least six periods and a complete cycle should have a minimum duration of fifteen periods (months in their case). Other methods for identifying peak and troughs include the one of Wecker [1979] who defines a recession as at least two quarters of negative growth. In our case, we take Harding and Pagan [2002]'s method which computes the amplitude and duration of a cycle using a triangle (see Figure 2.1).

FIGURE 2.1 – Typical peak-to-trough



Source : Harding and Pagan [2002]

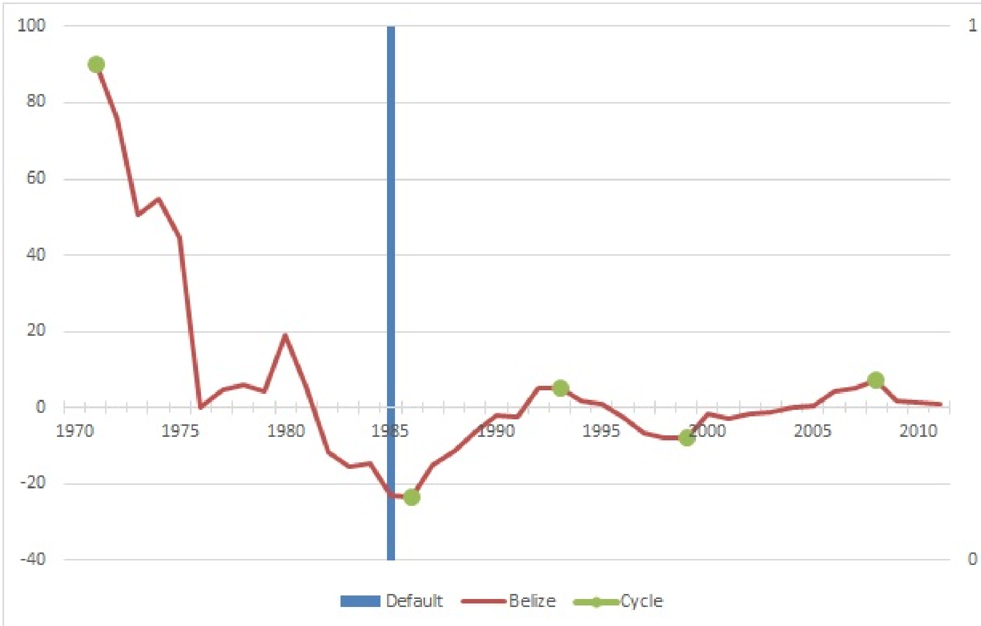
Figure 2.1 shows a typical peak-to-trough, with A being the peak and C the trough. The height of the triangle is the amplitude and the base is the duration. Knowing these two elements for any cycle of the country enables us to compute the area of the triangle, and thereby an approximation to the cumulated losses in output from peak to trough, relative to the previous peak. Setting an area threshold to avoid false turning points [4], we obtain the turning points of each country in our database. The cycles obtained are robust to several values of λ in the HP filter (100, 400 and 1600). Figure 2.2 illustrates how boom and bust episodes are identified for the case of Belize (GDP data from 1970 to 2011, default in 1985).

We build a database using only one cycle (a boom or a bust) per cell [5]. It gathers 1066 cycles, with 525 cells in bust (peak-to-troughs) and 541 cells in boom (trough-to-peaks). We chose to assign to those cells the initial values of macroeconomic variables, since we want to know if the default arising in the cycle can be explained by macroeconomic values at the top of the peak or

4. 15 in our case, in order to match with the visually located peaks and troughs

5. For instance, there are 5 cells for Belize : one bust from 1970 to 1986, one boom from 1987 to 1993, one bust from 1994 to 1999, one boom from 2000 to 2008, one bust from 2009 to 2011. The first bust is in debt distress.

FIGURE 2.2 – Belize's business cycles



at the deep of the trough. Our results are robust to values taken at the middle of the cycle or at the end of it.

2.3 Stylized facts and descriptive statics

2.3.1 General descriptive statics on debt distresses and other crises

The three-year rule capturing real debt distress episodes combined with our construction of business cycles enables us to find 131 cycles in debt distress in our new dataset. As shown in Table 2.4, the unconditional annual probability to experience a debt crisis during a boom or a bust stands at 12.3%. All of the defaults episodes are listed in Table 2.5.

TABLE 2.4 – Default and non-default events

Nb. of defaults	131	12.3%
Nb. of non-defaults	935	87.7%
Total	1066	100%

Source : Authors' analysis of data

We can recognize some familiar episodes, including the debt crises of the 1980s (Mexico, Bolivia, Brazil, etc.), Asian financial crises at the end of the 1990s (Thailand and Indonesia), Argentina's default event in 2000. There are also many sub-Saharan Africa's episodes, that we chose to keep in the descriptive statics regardless of their lack of market access, since they did not change much the stylized facts.

Table 2.5 – Distress episodes

Afghanistan	1981, 1986, 2005, 2011	Georgia	2001, 2008	Niger	1983, 1994, 2001
Albania	1998	Ghana	1983, 1996, 2001	Nigeria	1986, 2005
Algeria	1994	Greece	2004	Pakistan	1981, 1999, 2008
Argentina	1983, 2000	Grenada	1981, 2006	Panama	1985
Armenia	2009	Guatemala	1986	Paraguay	1987
Bangladesh	1981	Guinea	1979, 2001, 2008	Peru	1978, 1983
Belarus	2009	Guinea-Bissau	1982, 1987, 1995, 2001	Philippines	1976, 1984
Belize	1985	Guyana	1979	Romania	1982, 1991, 2009
Benin	1983, 2000	Haiti	1988, 2006	Rwanda	1998, 2002
Bolivia	1980, 1984, 2004	Honduras	1979, 1996, 2004	Sao Tome and P.	2000, 2005
Bosnia Herzegovina	2009	Hungary	2008	Senegal	1980
Brazil	1983, 1998	India	1982	Seychelles	1991, 2004
Burkina Faso	1991, 2000	Indonesia	1997	Sierra Leone	1976
Burundi	2004	Jamaica	1978	Slovak Rep.	2000
Cambodia	1995	Jordan	1989	Solomon Islands	1995, 2004
Cameroon	1986, 2001, 2006	Kazakhstan	1998	Somalia	1981
Central Africa	1973, 1994, 1998, 2007	Kenya	1980, 1992, 2000, 2004	Sri Lanka	1977, 2005, 2009
Chad	1995, 2001	Korea, Rep.	1997	Sudan	1977
Chile	1983	Kyrgyz Rep.	2002	Syrian Arab Rep.	1994
Comoros	2009	Latvia	2007	Tajikistan	1996
Congo, Dem. Rep.	1975	Lebanon	1984	Tanzania	1986
Congo, Rep.	1986	Liberia	1980	Thailand	1981, 1997
Costa Rica	1981	Macedonia	2000, 2007	Togo	1978, 2008
Cote d'Ivoire	1981, 2002, 2007	Madagascar	1981, 1997	Tunisia	1987, 1991
Djibouti	2000, 2008	Malawi	1980, 2001	Turkey	1978, 1995, 2000
Dominica	2006	Mali	1982, 1988, 1996, 2000	Turkmenistan	2000
Dominican Rep.	1983, 1990, 2004	Mauritania	1985, 1993, 2000	Uganda	1978, 1986
Ecuador	1983, 2000	Mauritius	1979, 1985	Ukraine	1995, 2008
Egypt, Arab Rep.	1977, 1987	Mexico	1983	Uruguay	1983, 1998, 2002
El Salvador	1990	Moldova	1999, 2003	Venezuela, RB	1985, 1990
Ethiopia	1981, 1992, 1997, 2001	Mongolia	2009	Vietnam	1989
Gabon	1987, 2004	Morocco	1980	Yemen, Rep.	2001
Gambia	1982, 2003, 2007	Nicaragua	1978, 1986	Zambia	1978, 1996
				Zimbabwe	1983, 2001

Source : Authors' analysis of data

In our dataset, year 2000 have been quite rough with thirteen sovereign defaults [6] (see in Appendix, Figure A.1), which is above the twelve defaults experienced in the early eighties. Six countries carry off the laurels of the serial defaulter, most of them sub-Saharan countries : Afghanistan, Central Africa, Ethiopia, Guinea-Bissau, Kenya and Mali. We can see that, except for those six, most countries experienced at most one or two episodes of defaults (see in Appendix, Figure A.2).

Table 2.6 – Currency, banking and twin crises

	Currency crisis		Banking crisis		Twin crisis	
Nb. of events	155	14.5%	101	9.5%	60	5.6%
Nb. of non-events	911	85.5%	965	90.5%	1006	94.4%
Total	1066	100%	1066	100%	1066	100%

Source : Authors' analysis of data

6. Argentina, Benin, Burkina Faso, Djibouti, Ecuador, Kenya, Macedonia, Mali, Mauritania, Sao Tome e Principe, Slovak Republic, Turkey, Turkmenistan

Regarding other potentially simultaneous crises, our definition allows 155 cycles in currency crisis over the period, 101 cycles experiencing a banking crisis, and 60 "twin" crisis cycles (in the sense of Kaminsky and Reinhart [1999], see Table 2.6). The simultaneity of currency, banking and sovereign crises is given by Table 2.7.

Table 2.7 – Simultaneity of crises

	Number	Percentage of defaults
Pure debt distress	68	52%
Mixed crises	63	48%
(among which)		
Sovereign + currency	28	21%
Sovereign + banking	10	8%
Sovereign + twin	25	19%

Source : Authors' analysis of data

Interestingly, we can see that almost half of sovereign debt crises come in parallel to a currency or a banking problem that creates or exacerbates the problem at hand. Additionally, almost one default over five is coming along with an exchange rate crisis : in 21% of cases, it comes with just an exchange rate crisis, while in 19%, it comes along a twin crisis (banking and currency crises altogether), and only 8% of events come with a banking crisis only. This is a good news for the Eurozone, as it allows to get rid of exchange rate crises (which are often a manifestation of the original sin problem analysed by Eichengreen et al. [2003]). The advent of a banking union is also a critical factor that will dampen sovereign risk in the future. These results are comparable with those of Cohen and Valadier [2011] but we exhibit more double or triple crises ; this has mainly to do with our larger definition of simultaneity, since we consider two crises simultaneous as they appear in the same cycle.

2.3.2 Business cycles and sovereign debt crises

We now analyse debt distress events in light of their position in the business cycle. Results are displayed in Table 2.8.

The first result is that 56% of defaults occur in a peak-to-trough. The business cycle position of debt distresses seems to be a strongly divisive hallmark : compared to Table 2.7 where half of defaults where linked to other crises, defaults occurring in busts are highly linked to other crises (in 70% of cases). The remaining 30% are pure public finance crises. Debt distresses in downturns are often simultaneous with an exchange rate crisis (30% of debt distresses in busts), or a twin crisis (30%) ; they come along with a banking crisis in 10% of cases.

Table 2.8 – Number of crises and position in the business cycle

	Trough-to-Peak (boom)	Peak-to-Trough (bust)	Total
All cases	525	541	1066
All crises (S+C+B)	111	163	274
Crises without debt distresses	53	90	143
(among which)			
Pure currency crises	25	52	77
Pure banking crises	21	10	31
Twin crises	7	28	35
Debt distresses	58	73	131
Pure sovereign crisis	46	22	68
Mixed crises	12	51	63
(among which)			
Sovereign + currency	6	22	28
Sovereign + banking	3	7	10
Sovereign + banking + currency	3	22	25

Source : Authors' analysis of the disaggregated database

On the contrary, defaults in booms are mostly pure sovereign crises (80% of cases). We took a closer look to defaults in trough-to-peaks. First, we chose to drop African countries in such situation : indeed, as sub-Saharan countries do not have access to financial markets, the default date is completely decorrelated from the date of the economic crisis ; defaults in no-market access countries defaults are another animal that we chose not to explore here. Clearing out no market-access countries, we get only 13 defaults occurring in booms. Moreover, we can see that these 13 remaining are always episodes linked to a non-economic factor :

— Elections, high political instability (Dominican Republic 1983, Moldova 2003, Georgia 2001, Haiti 2006, Honduras 1979 and 1996, Kyrgyz Republic 2002, Paraguay 1987, Solomon Islands 1995, Tunisia 1991)

— Wars, civilian conflicts (Guyana 1979, Lebanon 1984, Sri Lanka 2005)

It seems that, out of low market access countries, defaults in booms are never linked to an economic factor, leading us to posit that economic defaults always occur in peak-to-troughs. We will empirically test this theory in section 2.5. For this reason, we will for now on and for the rest of the chapter focus on the analysis of defaults in downturns.

Now looking at the duration of cycles in case of a debt distress, we see (Table 2.9) that cycles in debt distresses are much longer than non-defaulting countries', especially for the boom : this stylized fact gives a rationale to a Minskyan theory of sovereign defaults (see for instance Minsky [1977]), assuming that the roots of a debt crisis come along an upturn : in prosperous times, when sovereign cash flow rises beyond what is needed to pay off debt, a speculative euphoria may develop, and soon thereafter sovereign debt may exceed what the country can pay off from their incoming revenues, which in turn may produce a debt distress. Sovereign debt would be even higher when the boom lasts longer. Indeed, if we look at the probability of a switch from a boom to a bust, it reaches 7% for a non-defaulter against 4% for a defaulting country : this may explain why a country facing a relative high probability of a switch to be more prudent than the one quite confident in staying in the boom, which therefore accumulates more debt during the long boom and faces a larger shock when leaving the peak. We will empirically test this theory in section 2.5.

TABLE 2.9 – Duration of business cycles

	Trough-to-peak (boom)	Peak-to-trough (bust)
Defaulters	9.0	8.4
Non-defaulters	5.9	5.3
All countries	6.2	5.7

Source : Authors' analysis of data

2.3.3 Macroeconomic variables and default events

The means of key variables in debt distress and in normal times are listed in Table 2.10. First, we rediscover the differences between defaults in booms and defaults in busts [7] : the latter seem to be triggered by banking or currency crises, rather than by a public finance issue (the current account deficits for a defaulter and a non-defaulters in busts are very comparable, around 4.5% of GDP). It is exactly the opposite for defaults in booms, where other crises play almost no role whereas the debt distress comes along with a huge current account deficit (7.3%).

TABLE 2.10 – Means of key variables - All cycles, booms and busts

	All cycles		Trough-to-peaks		Peak-to-troughs	
Statistic	Default	Normal	Default	Normal	Default	Normal
Current account/GDP in %	−5.843	−4.042	−7.262	−3.824	−4.764	−4.295
Total debt service/exports	3.747	2.830	3.546	2.507	3.888	3.238
Debt/GDP in %	79.763	62.578	71.719	56.546	85.667	70.138
Debt/GDPppp in %	56.553	41.318	62.118	42.489	52.351	39.530
US GDP(HP filtered)	−2.320	113.979	2.471	187.475	−6.201	0.579
CPIA	2.988	3.117	2.937	3.128	3.025	3.105
Baa-US corporate spreads	0.235	2.036	0.204	1.986	2.105	0.183

Source : Authors' analysis of data

Second, we consider three specific variables that will become explanatory variables in our empirical strategy (section 2.5) : the present value of total future debt service obligations, expressed

7. Other descriptive statics about these variables are listed in Appendix, Table A.1 to A.3. We consider the mean as a good proxy for stylized facts as the distribution is squashed in it for the selected variables (see in Appendix, Figures A.3 to A.6)

as a share of current exports, World Bank's Country Policy and Institution Assessment (CPIA) index, which is used to measure the policy environment, and external debt ratio over GDP. We can see from Table 2.10 that there are substantial differences in the means of these variables for defaulters and non-defaulters : total debt service-to-exports ratio is one third as high in distress times (375%) as compared to normal times (283%), policy environment is quite substantially worse (a score of 2.9 and 3.2) and the external debt-to-GDP ratio, following debt service ratio, is substantially higher in the distress case (80% against 63%).

FIGURE 2.3 – Correlates of debt distress - Total debt service over exports, debt-to-GDP ratio, CPIA index

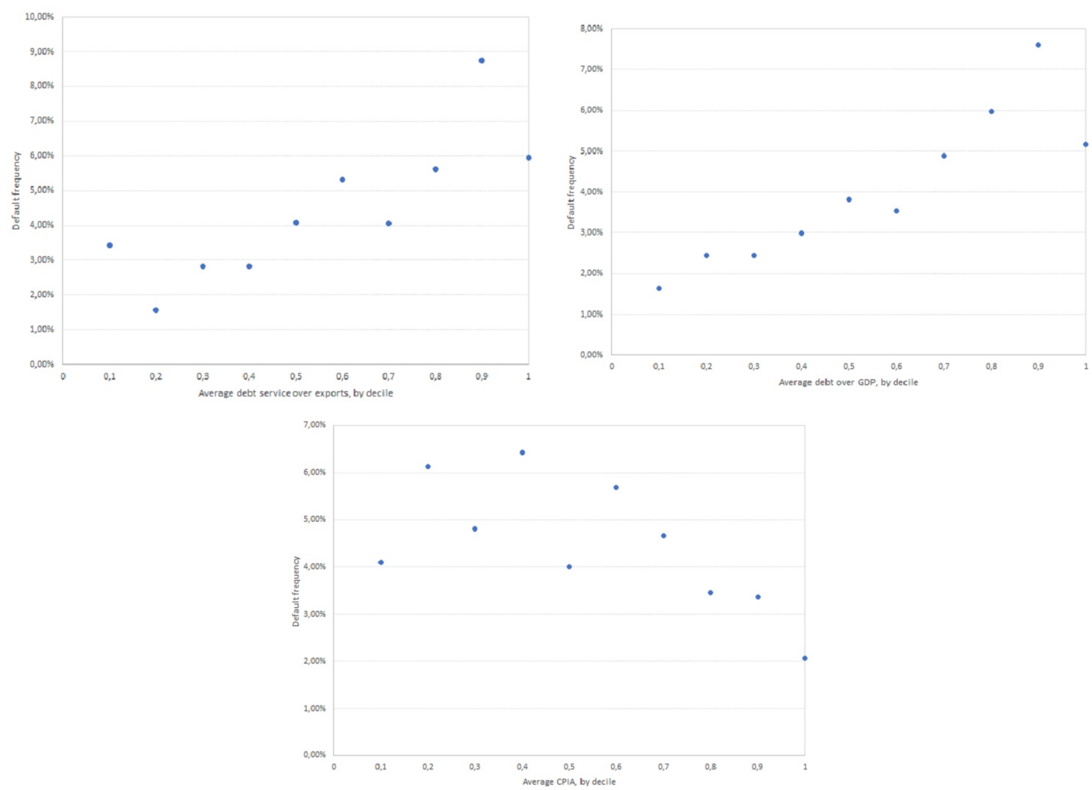


Figure 2.3 illustrates the bivariate relationships between the default probability and the three variables : as in Kraay and Nehru [2006], in each panel, the mean value of the variable is computed by deciles and plotted against the mean of the default frequency. We can see for instance that the top decile of total debt service-to-exports ratio leads to an unconditional default probability of 5.96%, whereas the bottom decile faces a probability at 3.44%. We exhibit a strong relationship between debt distress and the two debt ratios but also with policy performance : countries in the second decile of CPIA index face a default probability of 6.13% whereas countries in the top decile face a probability only of 2.04%. Last, regarding the correlation for debt-to-GDP and total debt service-to-exports ratios, we can relate the top decile's fall in default frequency to the debt irrelevance literature : as pointed by Ruiz-Arranz et al. [2005], a very high level of debt is less significant for sovereign defaults than intermediate levels and leads to a "debt irrelevance zone"

in which the marginal effect of debt is zero.

2.4 Sketch of a sovereign defaulter

We now look at the downturn of a defaulter versus a non-defaulter. More precisely, we look at typical macroeconomic variables that could explain a debt distress. In the following tables, GDP is measured in current dollar terms to be compared to the dollar-denominated debt. The values presented here correspond to the mean initial values at the beginning of the peaks or troughs, i.e. the means of the values assigned to cycles in our database. We only look here at defaults in peak-to-troughs, as we assume that defaults in booms are mainly non-economic defaults. The main goal here is to compare the downturn of a defaulter with a non-defaulter's in the same situation (i.e. both experiencing a currency crisis for instance), in order to understand why one country defaults and the other does not.

TABLE 2.11 – Defaulting vs. non-defaulting downturns, all cases

Defaulter	Peak	Trough	Bust (in pp)
Current account	-6.81	-1.77	+5.04
GDP (hp)	85.6	-32.3	-117.9
GDPppp (hp)	3.11	-0.18	-3.29
ExternalDebt/GDP	55.9	97.4	+41.5
ExternalDebt/GDP(ppp)	45.3	60.7	+15.4
ExternalDebt/Exports	317	339	+22

Non-defaulter	Peak	Trough	Bust (in pp)
Current account	-2.60	-3.21	-0.61
GDP (hp)	62	-60	-122
GDPppp (hp)	1.73	-0.65	-2.38
ExternalDebt/GDP	38.7	56.1	+17.4
ExternalDebt/GDP(ppp)	35	44.5	+9.5
ExternalDebt/Exports	231	257	+26

Source : Authors' analysis of data

Table 2.11 summarizes the sovereign crisis over the whole sample of events in downturns (73 debt distresses) and compares it to a non-defaulting bust. It shows that the deterioration of the debt burden is much more severe in relation to GDP for the defaulting country (measured in current dollars, +41.5 percentage points against +17.4)). It is also much more severe than in relation to the export base, reflecting an exchange rate problem (in volume, exports and output follow about the same path). Indeed, when we look at the deterioration of GDP expressed in purchase parity power, it is much less volatile than nominal GDP. This allows us to present the key role of the denominator in the discontinuity applied to the debt ratio : if sovereign debt is expressed in relation to nominal GDP, the discontinuity is clear-cut, whereas when it is epxressed in relation to nominal GDP, there is no discontinuity at work. Notice also that the defaulting country squeezes its current account problem over the course of the recession and makes a great effort to reduce debt between the boom. We can also see that the default country starts the downturn with a not so high debt-to-GDP ratio, below the 50% threshold deemed risky by the IMF, but still higher than the non-defaulting country. All macroeconomic variables are in worse conditions at the beginning of the downturn for a defaulting bust than for a non-defaulting one. In the light of Tomz and Wright [2007], we find that the output gap between the peak and the trough is not so different in the defaulting case than in the safe case, indicating that the relationship between output and default seems indeed to be quite weak. We also rediscover the result from Aguiar and Gopinath [2007], exhibiting that a defaulting country has a countercyclical current account, whereas non-defaulting sovereigns face a procyclical one.

All in all, two results emerge : first, the starting points are much more deteriorated in the defaulting case(debt-to-GDP ratio at 56% against 39%, current account at -6.81% against -2.60%) ; second, the deterioration during the downturn is worse in the debt distress case (debt-to-GDP ratio rises by +41.5pp for the defaulting country against +17.4pp for the non-defaulter), mainly due to a change issue (since the discontinuity does not appear in real terms). This result confirms the need for a discontinuity in level to trigger sovereign default. In the following subsections, we look closer at the different cases (default in a pure crisis, default concomitant with a currency crisis, banking crisis and then twin crisis) to see if this result is still at work.

2.4.1 Pure sovereign crises

We first focus on pure sovereign crises, that is cases of countries that experienced neither a currency or a banking shock at the time of their sovereign crisis (Table 2.12) ; they represent 30% of defaults in downturns.

TABLE 2.12 – Defaulting vs. non-defaulting downturns, no other crisis during the cycle

Defaulter	Peak	Trough	Bust (in pp)
Current account	-6.84	-2.00	+4.84
GDP (hp)	97	-23.5	-120.5
GDPppp (hp)	5.84	NA	NA
ExternalDebt/GDP	56.9	80.7	+23.8
ExternalDebt/GDP(ppp)	45.3	62.5	+17.2
ExternalDebt/Exports	331	333	+2

Non-defaulter	Peak	Trough	Bust (in pp)
Current account	-2.51	-3.40	-0.89
GDP (hp)	63.6	-62.7	-126.3
GDPppp (hp)	1.24	-1.38-2.62	
ExternalDebt/GDP	40.1	48.9	+8.8
ExternalDebt/GDP(ppp)	NA	NA	NA
ExternalDebt/Exports	229	190	-39

Source : Authors' analysis of data

During a pure debt distress, the current account seems to be in the heart of the crisis and the main factor of such a distress appears to be the inability of the country to adjust it sufficiently, since it starts at a very low level (-6.84%). That is the discontinuity we were looking for : the country starts at a worse point than a non-defaulter and experiences a harder deterioration (+23.8 percentage points of debt-to-GDP during the downturn against +8.8 for a safe country).

2.4.2 Banking, currency and twin crises

We now focus on default events coming along with other types of crises, namely banking, currency and twin crises, and we dress the sketch of a defaulting country vs. a safe country. Indeed, a speculative attack on the currency à la Obstfeld [1996] can be accompanied or followed by bank runs and by a period of high interest rates, as the central bank attempts to defend the peg ; the position of banks can be weakened further if the outstanding debt is denominated in foreign currency, leading to a sovereign debt crisis.

TABLE 2.13 – Defaulting vs. non-defaulting business cycles, banking crisis during the cycle

Defaulter	Peak	Trough	Bust (in pp)
Current account	-7.75	-2.86	+4.89
GDP (hp)	48.6	-26.1	-74.7
GDPppp (hp)	11.23	-1.70	-11.93
ExternalDebt/GDP	45.1	78	+32.9
ExternalDebt/GDP(ppp)	32	79.5	+47.5
ExternalDebt/Exports	250	275	+25

Source : Authors' analysis of data

In the banking crisis case (Table 2.13), there are only few data for the non-defaulters (as most banking crises come along with a currency or a sovereign crisis), so we will just look at the values for defaulters. The current account starts at a very low level, and unless the country makes a great effort to restore it during the downturn, the banking crisis effect on debt is stronger and makes the debt-to-GDP ratio increase. Debt over GDP in purchasing power parity increases more than the debt-to-GDP ratio, indicating a numerator effect in the case of banking crises.

When defaults are simultaneous with currency crises (Table 2.14), we can see that the default country starts the peak with a huge debt-over-GDP ratio (70.8% against 42.2% in the safe case). The deterioration of the debt ratio is comparable in the default and non-default cases, even if the crisis (in terms of output gap) is more severe in the safe case, which may explain why the safe country exhibits a +35.7 percentage points increase in its debt-to-GDP ratio whereas the defaulting country faces a +23.8pp increase.

TABLE 2.14 – Defaulting vs. non-defaulting business cycles, currency crisis during the cycle

Defaulter	Peak	Trough	Bust (in pp)
Current account	-5.50	-2.63	+2.87
GDP (hp)	50	-35.6	-85.6
GDPppp (hp)	11.10	NA	NA
ExternalDebt/GDP	70.8	94.6	+23.8
ExternalDebt/GDP(ppp)	49	63.8	+14.8
ExternalDebt/Exports	300	300	+0
Non-defaulter	**Peak**	**Trough**	**Bust (in pp)**
Current account	-3.2	-3.92	-0.72
GDP (hp)	64.8	-38.1	-102.9
GDPppp (hp)	0.86	-0.46	-1.32
ExternalDebt/GDP	42.2	77.9	+35.7
ExternalDebt/GDP(ppp)	27	40	+13
ExternalDebt/Exports	300	355	+55

Source : Authors' analysis of data

TABLE 2.15 – Defaulting vs. non-defaulting business cycles, twin crisis during the peak-to-trough

Defaulter	Peak	Trough	Bust (in pp)
Current account	-4.00	-0.47	+3.53
GDP (hp)	35	-39.5	-74.5
GDPppp (hp)	1.01	-8.30	-9.31
ExternalDebt/GDP	44	116.7	+72.7
ExternalDebt/GDP(ppp)	87	78.6	-8.4
ExternalDebt/Exports	NA	NA	NA
Non-defaulter	**Peak**	**Trough**	**Bust (in pp)**
Current account	-3.33	0.11	+3.44
GDP (hp)	17.3	-35.2	-52.5
GDPppp (hp)	11.97	-2.63	-14.60
ExternalDebt/GDP	24	67.8	+43.8
ExternalDebt/GDP(ppp)	NA	NA	NA
ExternalDebt/Exports	300	456	+156

Source : Authors' analysis of data

Last, when we look at the twin crises case (Table 2.15), which means a currency crisis coupled with a banking crisis, it seems to confirm our intuition. First, the output gap is smaller than in the other cases and should not explain the crisis. Second, the defaulting country starts the downturn with a debt-to-GDP ratio 20pp higher than the non-defaulter. Third, the deterioration during the bust is almost two times worse for a defaulter : its external debt ratio goes from 44% to 116.7% against 24% to 67.8% for a non-defaulter. This table clearly illustrates the discontinuity in level at work in debt distresses.

2.5 A log-likelihood estimation of debt crises : can cycles predict debt crises ?

This section confirms the importance of business cycles' phase in default events and the need for discontinuity : although the debt burden and the simultaneity with other crises are key in driving debt distress during downturns, none of these variables are significant for default events in booms. This section finds also the length of the previous cycle as a significant determinant of debt distresses, which hints to a Minskyan theory of sovereign defaults.

2.5.1 Theoretical background

To model the probability of sovereign debt default, we use the following the model :

$$p[y_{c,y} = 1] = F(\beta' X_{c,y})$$

where $y_{c,y}$ is an indicator variable that takes the value of one for sovereign default episodes of country c at year y. $F(x) = \frac{e^x}{1+e^x}$, with $F(-\infty) = 0$ and $F(\infty) = 1$, is the cumulative distribution function of the logistic distribution. $X_{c,y}$ is a vector of determinants of sovereign default, and β is a vector of parameters to be estimated.

Parameters are estimated by maximizing the log-likelihood with respect to $(\beta_0, \beta_1, ..., \beta_n)$. Such estimates are consistent and asymptotically normally distributed.

The likelihood is given by :

$$L(\beta) = L(Y_1 = y_1; Y_2 = y_2; ...; Y_N = y_N) = \prod_{i=1}^{N} \Big[F(X_i\beta)\Big]^{y_i} \Big[1 - F(X_i\beta)\Big]^{1-y_i}$$

And the log-likelihood :

$$\log(L(\beta)) = \sum_{i=1}^{N} \Big[y_i \log(F(X_i\beta)) + (1 - y_i) \log(1 - F(X_i\beta))\Big]$$

We are looking for a vector β such that $\hat{\beta} = \arg\max_\beta \log(L(\beta))$. It corresponds to β such that $\frac{\partial \log(L(\beta))}{\partial \beta} = 0$. The first order conditions arising from these equation are non-linear and non-analytic. Therefore, we have to obtain the Maximum-Likelihood estimates using numerical optimization methods. Here we use the Newton-Raphson iterative method.

2.5.2 Benchmark estimation

We run a logit regression to explain the risk of a debt distress during a cycle. The core specification considers five explanatory variables. The first one is the occurrence of a banking crisis during the same phase of the business cycle (peak-to-trough or trough-to-peak) as the default event, measured by a dummy. The second one is a dummy variable which equals one if the country experiences a simultaneous currency crisis during the phase in which the default occurs. The third one is the country's Country Policy and Institution Assessment index, used to measure the country's policy environment. The fourth one is total debt service over exports, which is a useful summary of the debt burden, measuring the country's ability to repay debt in a short horizon. The last one is a year-fixed variable which measures the spread between the yield of corporate bonds in the US rate Baa by Moody's and the yield of 10-year US Treasury bonds in order to proxy for worldwide financial shocks.

Table 2.16 – Benchmark model - Aggregated data

	default.cycle		
	UpsAndDowns	Ups	Downs
CPIA index	−0.093	−0.389	0.154
	(0.188)	(0.263)	(0.300)
currency crisis	0.838***	0.262	0.929**
	(0.305)	(0.716)	(0.462)
banking crisis	0.656**	−0.332	1.020**
	(0.319)	(0.681)	(0.412)
total debt service / exports	1.646**	0.264	3.882***
	(0.666)	(0.924)	(1.274)
Baa US corporate spreads	0.387	0.175	0.665
	(0.260)	(0.351)	(0.431)
Constant	−2.634***	−0.821	−4.598***
	(0.821)	(1.054)	(1.418)
Observations	367	202	165
Log Likelihood	−175.755	−90.223	−77.702
Akaike Inf. Crit.	363.510	192.447	167.404

Note : Numbers in parentheses are standard errors. *p<0.1 ; **p<0.05 ; ***p<0.01

Table 2.16 reports the core specification. The observations for all countries and all cycles show that the debt burden (measured by total debt service over exports) and simultaneity of other crises (banking or currency) are all highly significant predictors of debt distresses. Being in a currency crisis increases the log odds ($\frac{p}{1-p}$) in favour of default by 0.84. Moreover a unit increase in the debt service to export ratio increases the log odds in favour of default by 1.65. The striking results is that these determinants are highly significant only for default in peak-to-troughs, whereas none of these variables are significant for default in a trough-to-peak (boom), which cannot be explained by any economic variables in our database. Countries with high debt burdens and which experience a banking or a currency crisis given a bust are significantly more likely to experience a default event in the same peak-to-trough, but this is not true for countries defaulting during a boom. For a country in a downturn, a unit increase in the debt service to export ratio increases the log odds in favour of default by 3.88, whereas being in a banking crisis increases the log odds in favour of default by 1.02. Holding constant the other variables at the median for continuous variable, and at the mean for binary exogenous variables, moving the debt service to export ratio from the 25th percentile to the 75th percentile increases the probability of sovereign default from 10% to 14%. Likewise, moving from no currency crisis (resp. banking) to the occurrence of one increases the probability of default from 9% (resp. 10%) to 19% (resp. 18%).

In order to formally test Tomz and Wright [2007]'s result, we add the deviation from trend of GDP volume and the output gap between the two turning points of a cycle ; none of these variables entered significantly in the regression, attesting that output is not so relevant in determining default.

Table 2.17 – With Previous Cycle Length Regression Results - Aggregated data

	default.cycle		
	UpsAndDowns	Ups	Downs
Previous cycle length	0.113***	0.152**	0.108**
	(0.034)	(0.062)	(0.045)
CPIA	−0.123	−0.480*	0.201
	(0.197)	(0.277)	(0.321)
currency crisis	0.902***	0.247	1.048**
	(0.319)	(0.744)	(0.479)
banking crisis	0.361	−0.239	0.540
	(0.348)	(0.716)	(0.457)
total debt service / exports	1.669**	0.056	4.252***
	(0.678)	(0.972)	(1.337)
Baa US corporate spreads	0.236	−0.046	0.502
	(0.270)	(0.372)	(0.446)
Constant	−2.957***	−1.055	−5.165***
	(0.855)	(1.099)	(1.496)
Observations	367	202	165
Log Likelihood	−169.985	−87.355	−74.309
Akaike Inf. Crit.	353.971	188.709	162.618

Note : Numbers in parentheses are standard errors. *p<0.1 ; **p<0.05 ; ***p<0.01

Table 2.17 tests a Minskyan theory of sovereign default : we add in the regression the length of the previous cycle. It seems to be highly significant, for both defaults in booms or busts : a country experiencing a long cycle is more likely to default after the growth-regime switch. Surprisingly, adding a measure of the cycle length in the regression makes policies (measured by the CPIA index) significant for default in booms, this variable becoming the only significant determinant of default events in trough-to-peaks. It also makes the significance of banking crises disappear for both default events.

2.5.3 Multiplicity of equilibria

Two types of multiple equilibria arise from our analysis. The first one concerns the collusion between the switch and the default ; the second one the simultaneity of currency/banking crises and the debt distress.

In order to prevent from the multiplicity of equilibria between the default and the switch, we compute the average default year in the cycle. First, we find that countries default in average in the middle of the cycle, 5.4 years after the trough or 5 years after the peak. Second, we look at the distribution of defaults, and we find that 31 countries default however on the first year of the cycle. The multiplicity of equilibria is thus an issue for 18% of crises, and could be disentangled by a model à la Cohen and Villemot [2015] : using a circular dependency in order to exhibit self-fulfilling features in default events, they find that multiple equilibria correspond in fact to a small minority of cases, between 6% and 12% of the crises. We nonetheless test these stylized facts by regressing the switch probability from a boom to a bust on significant variables for debt distresses. Results are reported in Table 2.18 and show that a higher debt ratio at the end of the boom increases the probability of a reversal only by 9%.

TABLE 2.18 – Probability of a switch - Marginal effects

	switch
currency crisis	-0.04***
	(0.008)
banking crisis	-0.02**
	(0.009)
total debt service / exports	0.09***
	(0.026)
Baa US corporate spreads	-0.02***
	(0.009)
Constant	-1.61***
	(0.363)
Observations	1467
Akaike Inf. Crit.	1200.3

Note : Numbers in parentheses are standard errors. *p<0.1 ; **p<0.05 ; ***p<0.01

Regarding the possible collusion between default events and other crises, we first look back at Table 2.8 : we can see that more than half of other crises in downturns occur without a sovereign crisis (90 over 163), limiting the potential causality from debt distresses to other crises. Second, as the recession is comparable between a defaultable and a non-defaultable bust, we remember that 70% of defaults in downturns come along with other crises : it seems as they act as an important trigger of default events, and the multiplicity of equilibria between the two is not an issue here.

Nonetheless, a solution to purge the multiplicity from the regression would be to re-write the likelihood incorporating self-fulfilling mechanisms. This can be done as in Cohen and Villemot [2015] : our empirical framework would be written by three simultaneous equations ; since they exhibit some circular dependency, there would be an identification issue :

$$d_{i,t} = X^d_{i,t-1}\eta^d + c_{i,t}X^{d,c}_{i,t-1}\eta^{d,c} + \epsilon^d_{i,t} \tag{2.1}$$

$$c_{i,t} = X^c_{i,t-1}\eta^c + \delta_{i,t}X^{c,\delta}_{i,t-1}\eta^{c,\delta} + \epsilon^c_{i,t} \tag{2.2}$$

$$\delta_{i,t} = 1_{\{X^\delta_{i,t-1}\eta^\delta + d_{i,t}X^{\delta,d}_{i,t-1}\eta^{\delta,d} + \epsilon^\delta_{i,t} > 0\}} \tag{2.3}$$

where i indexes countries, t time, $d_{i,t}$ is total debt service over exports, $c_{i,t}$ is a dummy indicating a currency crisis and $\delta_{i,t}$ a dummy indicating a debt crisis ; $X^d_{i,t-1}, X^c_{i,t-1}, X^\delta_{i,t-1}, X^{d,c}_{i,t-1}, X^{c,\delta}_{i,t-1}, X^{\delta,d}_{i,t-1}$ are row vectors of exogenous variables and $\eta^d, \eta^{d,c}, \eta^c, \eta^{c,\delta}, \eta^\delta, \eta^{\delta,d}$ column vectors of parameters, $\epsilon^d_{i,t}, \epsilon^c_{i,t}, \epsilon^\delta_{i,t}$ are exogenous shocks. Equation (2.1) reflects the debt dynamics equation, which depends on the occurrence of a currency crisis, depicted by equation (2.2), which in turn depends on the occurrence of a default crisis, depicted by equation (2.3). The circular dependency of these three variables is precisely the possibility of multiple equilibria we want to model. Estimating the self-fulfilling effect between currency and default events is at stake, in order to better assess the causality between the two ; this part is for now still work in progress.

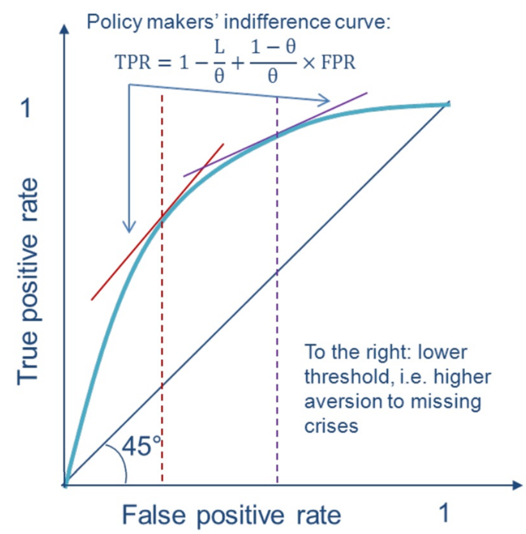
2.5.4 Predicting default events

As a last step, we want to know if the parsimonious set of variables that we found to be determinants of sovereign debt defaults is apt to perform prediction of defaults events and to provide early-warning signs of debt distresses. In particular, we want to assess the out-of-sample predictive power of the model. Hence, we randomly choose 80% of the observations and carry out a baseline estimation. The model is then tested on the 20% remaining observations to assess the model accuracy at predicting successfully the true default outcome variable. This operation is performed 500 times while accuracy below the 10^{th} decile and above the 90^{th} decile are removed to lessen the impact of samples with too many or too few default episodes compared to the whole dataset. We then define a threshold over which the predicted probability conditional on the observed data is deemed a default event. As common in the literature, we could use the unconditional probability of sovereign default in our full sample as a threshold, that is to say 2.4% (hence a threshold of at 97.6%), for the non-aggregated sample. But since this unconditional probability is very low because our sample is very biased in favour of non-default events, we use instead 0.5 as a threshold. On average (among our 500 random training and testing samples), the accuracy of our model to predict the right outcome is 96%. This provides an interesting insight into the model's ability to perform predictions.

However, albeit intuitive, accuracy is very sensitive to class imbalances, which makes it quite unsuitable in our case. By construction, a model that would always yield a non-defaults outcome would be 97.6% accurate on average. Instead, we use the Area Under the Receiver Operating

Characteristic (AUROC) methodology to assess the prediction aptitude of our model. This methodology, unlike accuracy, is unaffected by class imbalances. Another reason to use AUROC to assess the predictive power of our model is to take into account the trade-off between type-I errors and type-II errors. Since the two outcomes cannot be discriminated perfectly, there is a trade-off between failing to predict a default (type-I errors) and predicting a default that will not occur (type-II errors) for all binary indicators. Hence, the unconditional probability, or any other arbitrary threshold, may not be ideally suited whatever the policy-makers preferences. If the threshold is too high, few defaults will be correctly identified, but few will be incorrectly signalled (more type-I errors and fewer type-II errors) ; with low thresholds, many defaults will be correctly identified but many false signals will arise.

FIGURE 2.4 – AUROC methodology



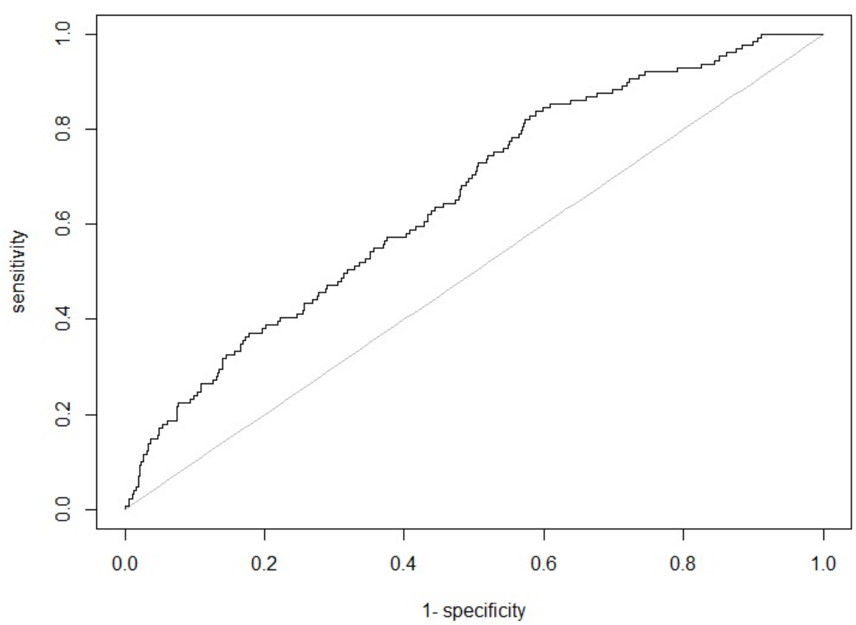
Source : Detken et al. [2014]

For each threshold we can compute the true positive rate (true positive/(true positive + false negative)) and the false positive rate (false negative/(false positive + true negative) [8]. Intuitively the true positive rate corresponds to the proportion of positive data points that are correctly considered as positive with respect to all positive data points. In other words, the higher the hit ratio, the fewer positive data points will be missed. Regarding the false positive rate, the higher the ratio, the more negative data points will be misclassified. The Receiver Operating Characteristic (ROC) curve plots the noise ratio (false positive rate, i.e. type II errors) against the signal ratio (true positive rate, i.e. the complements of type I errors) for every possible threshold value. We can then compute the Area Under the Receiver Operating Characteristic (AUROC) curve, which is a typical performance measure to visualize the trade-off between sensitivity (true positive rate) and 1-specificity (false positive rate) in a binary classifier (see Figure 2.4).

8. True Positive = we correctly predict that the class is 1 ; False Positive = we incorrectly predict that the class is 1 ; True negative = we correctly predict that the class is 0 ; False negative = we incorrectly predict that the class is negative 0

Lowe and Borio [2002] and Borio and Drehmann [2011] argue that policy-makers may care more about not missing a crisis because the cost is higher than that of a false alarm. However, more often than not, the preferences of policy-makers between type-I and type-II errors are unobservable. The main interest of the AUROC analysis is that it is robust to different policy-makers' preferences. On Figure 2.4, the red indifference curve corresponds to a policy-maker that cares more about avoiding wrong signals than missing a crisis. Conversely, the purple indifference curve corresponds to a policy-maker that cares more about avoiding missing crisis than getting a wrong signal. A specific utility function leads to a specific trade-off between type-I and type-II errors, and the ROC is an intuitive way to map all the potential trade-off related to the whole set of preferences. This is the reason why the AUROC methodology has become a common evaluation criterion in economics, e.g. Jorda et al. [2011] and Drehmann and Juselius [2014].

FIGURE 2.5 – Area Under the ROC Curve



A model with good predictive ability should have an AUC closer to 1 (1 is ideal) than to 0.5 (the 45 degree line represents the ROC curve of a random predictor). The Area Under the Roc Curve for our model is 0.66 (see Figure 2.5), which is a reasonable result that confirms that our model is ideally suited for forecasting default events based on a parsimonious set of variables.

2.6 Conclusion

In this chapter, we have provided new stylized facts about debt distress events in order to know precisely when do countries default. We have provided rationale for three main papers in the literature. First, we have answered to Tomz and Wright [2007], attesting that the relationship between default events and output gap is weak and non-significant. Second, we have brought some empirical intuition to Cohen and Villemot [2012] and Serfaty [2015]' theories by showing that defaults do need two types of discontinuity to occur, which are necessary but not sufficient by their own to trigger a default.

We have indeed shown that a default needs a first order discontinuity : the large majority of defaults (56%) occurred in a downturn, defined as a peak to trough episode. This result confirms the findings of Serfaty [2015]. Moreover, we found that defaults exiting this downturn rule were rather non-economic defaults. We performed a logit regression to compare defaults in booms and defaults in busts ; we found that defaults in booms cannot indeed be explained by macroeconomic variables. Furthermore, we showed that defaults are also speeden up by additional crises : when we focus on defaults in downturns, it turns out that 71% of them come along with another crisis (banking, currency or twin), which create discontinuity in level (at the denominator or at the numerator of the debt-to-GDP ratio), confirming the thesis of Cohen and Villemot [2012]. We have also shown that exogenous shocks during a downturn were still not sufficient to create default : the country must start the downturn with a relatively high debt-to-GDP ratio. The combination of bad initial conditions and discontinuous shocks like an exchange rate crisis worsens the deterioration of economic conditions during the downturn, which, in turn, leads the country to a debt distress and a sovereign default.

We conclude that a sovereign default is due to a combination of three features, that are necessary but not sufficient by themselves : they happen mostly in peak-to-troughs and the switch, more than the output-gap itself, should be taken into account in sovereign default models ; they mainly come along with other crises (banking or currency), which operate as huge discontinuous shocks and worsens the downturn (the banking crisis increases the numerator of the debt-to-GDP ratio, the currency crisis reduces the denominator) ; last, if initial conditions (debt-to-GDP ratio for instance) are already quite high, the downturn will create a debt distress.

Our analysis of mainly emerging markets crises allows us to draw a few implications for sovereign risk within the Eurozone. First, one of the key driver of sovereign crises being the exchange rate risk, one may ascertain that Eurozone crises are bound to be much less frequent than the corresponding risk in emerging markets. Second, although less important when they come on their own, banking crises are a key factor to be accounted for, with the goal of the banking union currently in the making to allow banking and sovereign risk to be decorrelated. Third, sovereign risk occur in downturns, but owe much to the disconnect between GDP and exports growth during that period. Besides the exchange rate risk, the issue of fiscal consolidation in bad times rather than in good times may be one of the cause of the problem. The key challenge of sovereign risk management is to engineer debt consolidation in good times, rather than too late, when the downturn starts.

Annexe A

Data and descriptive statics

Table A.1 – Descriptive statics key variables - All cycles

Statistic	N	Mean	St. Dev.	Min	Max
Banking crisis	7,525	0.123	0.329	0	1
Currency crisis	7,525	0.152	0.359	0	1
Current account/GDP	4,812	−4.100	9.305	−132.796	53.234
Total debt service / exports	3,831	2.869	4.612	0.000	92.690
Debt/GDP	3,924	63.291	70.589	0.230	1,080.000
Debt/GDPppp	1,182	42.264	39.433	0.000	507.640
US GDP(HP filtered)	7,525	111.181	9,489.200	−7,974.239	822,881.300
CPIA	3,029	3.111	0.758	0.600	5.500
Baa US corporate spreads	3,776	2.039	0.493	1.080	3.190

Table A.2 – Descriptive statics key variables - Booms

Statistic	N	Mean	St. Dev.	Min	Max
banking crisis	4,537	0.055	0.229	0	1
currency crisis	4,537	0.053	0.224	0	1
Current account/GDP	2,568	−3.914	9.782	−132.796	39.578
total debt service / exports	2,114	2.540	4.484	0.000	92.690
Debt/GDP	2,161	57.030	65.682	0.230	832.610
Debt / GDP PPP	702	43.384	42.148	0.000	507.640
US GDP (HP filtered)	4,537	184.172	12,217.760	−7,974.239	822,881.300
CPIA	1,634	3.121	0.774	0.600	5.500
Baa US corporate spreads	2,202	1.990	0.490	1.080	3.190

Table A.3 – Descriptive statics key variables - Busts

Statistic	N	Mean	St. Dev.	Min	Max
Banking crisis	2,988	0.227	0.419	0	1
Currency crisis	2,988	0.303	0.460	0	1
Current account/GDP	2,244	−4.313	8.724	−75.256	53.234
otal debt service / exports	1,717	3.274	4.735	0.000	68.650
Debt/GDP	1,763	70.966	75.488	0.240	1,080.000
Debt / GDP PPP	480	40.625	35.066	0.000	183.800
US GDP (HP filtered)	2,988	0.353	333.259	−4,227.004	16,755.570
CPIA	1,395	3.100	0.738	1.000	5.375
Baa US corporate spreads	1,574	2.108	0.488	1.080	3.190

Figure A.1 – Number of defaults by year

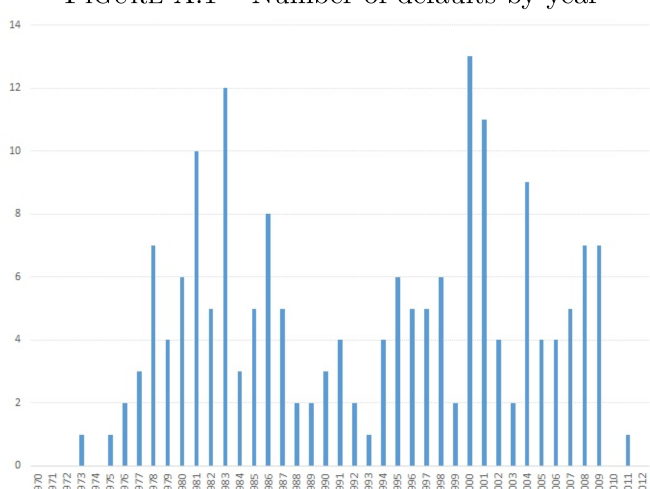


Figure A.2 – Number of defaults by country

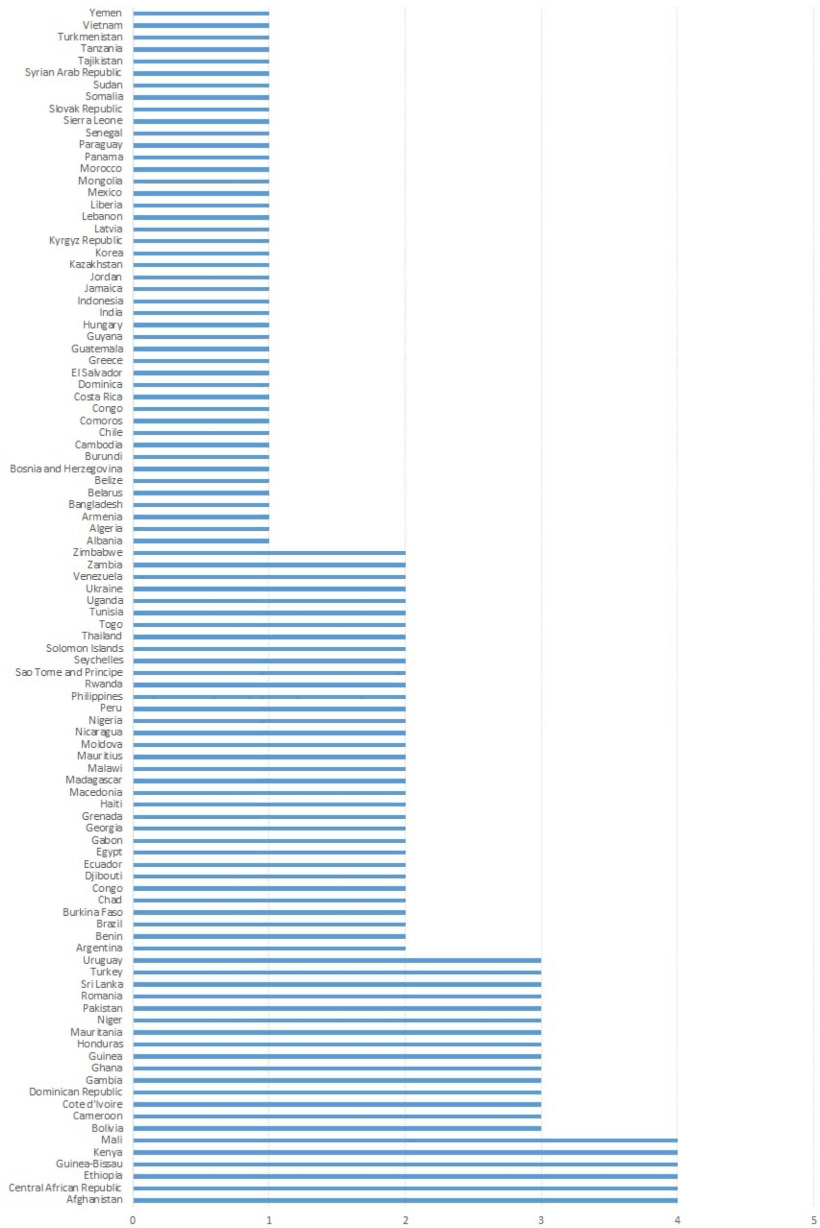


Table A.4 – Availability of data and defaults (1)

	GDP data slots	Default years
Afghanistan	1970-1981, 2001-2008, 2010-2011	1981, 1986, 2005, 2011
Albania	1984-2011	1998
Algeria	1970-2011	1994
Angola	1985-2011	
Argentina	1970-2011	1983, 2000
Armenia	1990-2011	2009
Australia	1970-2011	
Austria	1970-2011	
Azerbaijan	1990-2011	
Bahamas, The	1970-2011	
Bangladesh	1970-2011	1981
Barbados	1970-2011	
Belarus	1990-2011	2009
Belgium	1970-2011	
Belize	1970-2011	1985
Benin	1970-2011	1983, 2000
Bhutan	1981-2011	
Bolivia	1970-2011	1980, 1984, 2004
Bosnia and Herzegovina	1994-2011	2009
Botswana	1970-2011	
Brazil	1970-2011	1983, 1998
Brunei Darussalam	2010-2011	
Bulgaria	1980-2011	
Burkina Faso	1970-2011	1991, 2000
Burundi	1970-2011	2004
Cambodia	1970-1974, 1993-2011	1995
Cameroon	1970-2011	1986, 2001, 2006
Canada	1970-2011	
Cape Verde	1986-2011	
Central African Republic	1970-2011	1973, 1994, 1998, 2007
Chad	1970-2011	1995, 2001
Chile	1970-2011	1983
China	1970-2011	
Colombia	1970-2011	
Comoros	1970-2011	2009
Congo, Dem. Rep.	1970-2011	1975
Congo, Rep.	1970-2011	1986
Costa Rica	1970-2011	1981
Cote d'Ivoire	1970-2011	1981, 2002, 2007
Croatia	1990-2011	
Cyprus	1980-2011	
Czech Republic	1990-2011	
Denmark	1970-2011	
Djibouti	1985, 1987-2009	2000, 2008
Dominica	1977-2011	2006
Dominican Republic	1970-2011	1983, 1990, 2004
Ecuador	1970-2011	1983, 2000
Egypt, Arab Rep.	1970-2011	1977, 1987
El Salvador	1970-2011	1990
Equatorial Guinea	1970-1977, 1985-2011	
Eritrea	1992-2011	
Estonia	1987-2011	
Ethiopia	1981-2011	1981, 1992, 1997, 2001
Fiji	1970-2011	
Finland	1970-2011	
France	1970-2011	
Gabon	1970-2011	1987, 2004
Gambia, The	1970-2011	1982, 2003, 2007
Georgia	1990-2011	2001, 2008
Germany	1970-2011	
Ghana	1970-2011	1983, 1996, 2001
Greece	1970-2011	2004
Grenada	1977-2011	1981, 2006
Guatemala	1970-2011	1986

Table A.5 – Availability of data and defaults (2)

	GDP data slots	Default years
Guinea	1986-2011	1979, 2001, 2008
Guinea-Bissau	1970-2011	1982, 1987, 1995, 2001
Guyana	1970-2011	1979
Haiti	1991-2011	1988, 2006
Honduras	1970-2011	1979, 1996, 2004
Hungary	1970-2011	2008
Iceland	1970-2011	
India	1970-2011	1982
Indonesia	1970-2011	1997
Iran, Islamic Rep.	1970-1990, 1993-2009	
Iraq	1970-1989, 1997-2002, 2004-2011	
Ireland	1970-2011	
Israel	1970-2011	
Italy	1970-2011	
Jamaica	1970-2011	1978
Japan	1970-2011	
Jordan	1970-2011	1989
Kazakhstan	1990-2011	1998
Kenya	1970-2011	1980, 1992, 2000, 2004
Kiribati	1970-2011	
Korea, Rep.	1970-2011	1997
Kyrgyz Republic	1990-2011	2002
Lao PDR	1984-2011	
Latvia	1987-2011	2007
Lebanon	1988-2011	1984
Lesotho	1970-2011	
Liberia	1970-2011	1980
Libya	1990-2009	
Lithuania	1990-2011	
Luxembourg	1970-2011	
Macedonia, FYR	1990-2011	2000, 2007
Madagascar	1970-2011	1981, 1997
Malawi	1970-2011	1980, 2001
Malaysia	1970-2011	
Maldives	1980-2011	
Mali	1970-2011	1982, 1988, 1996, 2000
Malta	1970-2011	
Mauritania	1970-2011	1985, 1993, 2000
Mauritius	1976-2011	1979, 1985
Mexico	1970-2011	1983
Moldova	1990-2011	1999, 2003
Mongolia	1981-2011	2009
Morocco	1970-2011	1980
Mozambique	1980-2011	
Namibia	1980-2001, 2003-2011	
Nepal	1970-2011	
Netherlands	1970-2011	
New Zealand	1970-2011	
Nicaragua	1970-2011	1978, 1986
Niger	1970-2011	1983, 1994, 2001
Nigeria	1970-2011	1986, 2005
Norway	1970-2011	
Oman	1970-2011	
Pakistan	1970-2011	1981, 1999, 2008
Panama	1970-2011	1985
Papua New Guinea	1970-2011	
Paraguay	1970-2011	1987
Peru	1970-2011	1978, 1983
Philippines	1970-2011	1976, 1984
Poland	1985-2011	
Portugal	1970-2011	
Qatar	1970-2011	
Romania	1987-2011	1982, 1991, 2009
Russian Federation	1989-2011	

Table A.6 – Availability of data and defaults (3)

	GDP data slots	Default years
Rwanda	1970-2011	1998, 2002
Samoa	1982-2011	
Sao Tome and Principe	2001-2011	2000, 2005
Saudi Arabia	1970-2011	
Senegal	1970-2011	1980
Serbia	1997-2011	
Seychelles	1970-2011	1991, 2004
Sierra Leone	1970-2011	1976
Singapore	1970-2011	
Slovak Republic	1982-2011	2000
Slovenia	1990-2011	
Solomon Islands	1971-2011	1995, 2004
Somalia	1970-1990	1981
South Africa	1970-2011	
Spain	1970-2011	
Sri Lanka	1970-2011	1977, 2005, 2009
St. Kitts and Nevis	1970-2011	
St. Lucia	1970-2011	
St. Vincent and the Grenadines	1970-2011	
Sudan	1970-2011	1977
Suriname	1970-2010	
Swaziland	1970-2011	
Sweden	1970-2011	
Switzerland	1970-2011	
Syrian Arab Republic	1970-2010	1994
Tajikistan	1990-2011	1996
Tanzania	1988-2011	1986
Thailand	1970-2011	1981, 1997
Togo	1970-2011	1978, 2008
Tonga	1975-2011	
Trinidad and Tobago	1970-2011	
Tunisia	1970-2011	1987, 1991
Turkey	1970-2011	1978, 1995, 2000
Turkmenistan	1987-2011	2000
Uganda	1970-2011	1978, 1986
Ukraine	1987-2011	1995, 2008
United Arab Emirates	1973-2011	
United Kingdom	1970-2011	
United States	1970-2011	
Uruguay	1970-2011	1983, 1998, 2002
Uzbekistan	1990-2011	
Vanuatu	1979-2011	
Venezuela, RB	1970-2011	1985, 1990
Vietnam	1985-2011	1989
Yemen, Rep.	1990-2011	2001
Zambia	1970-2011	1978, 1996
Zimbabwe	1970-2011	1983, 2001

Figure A.3 – Distribution of key macroeconomic variables (1) - Current account over GDP and debt-to-exports ratio

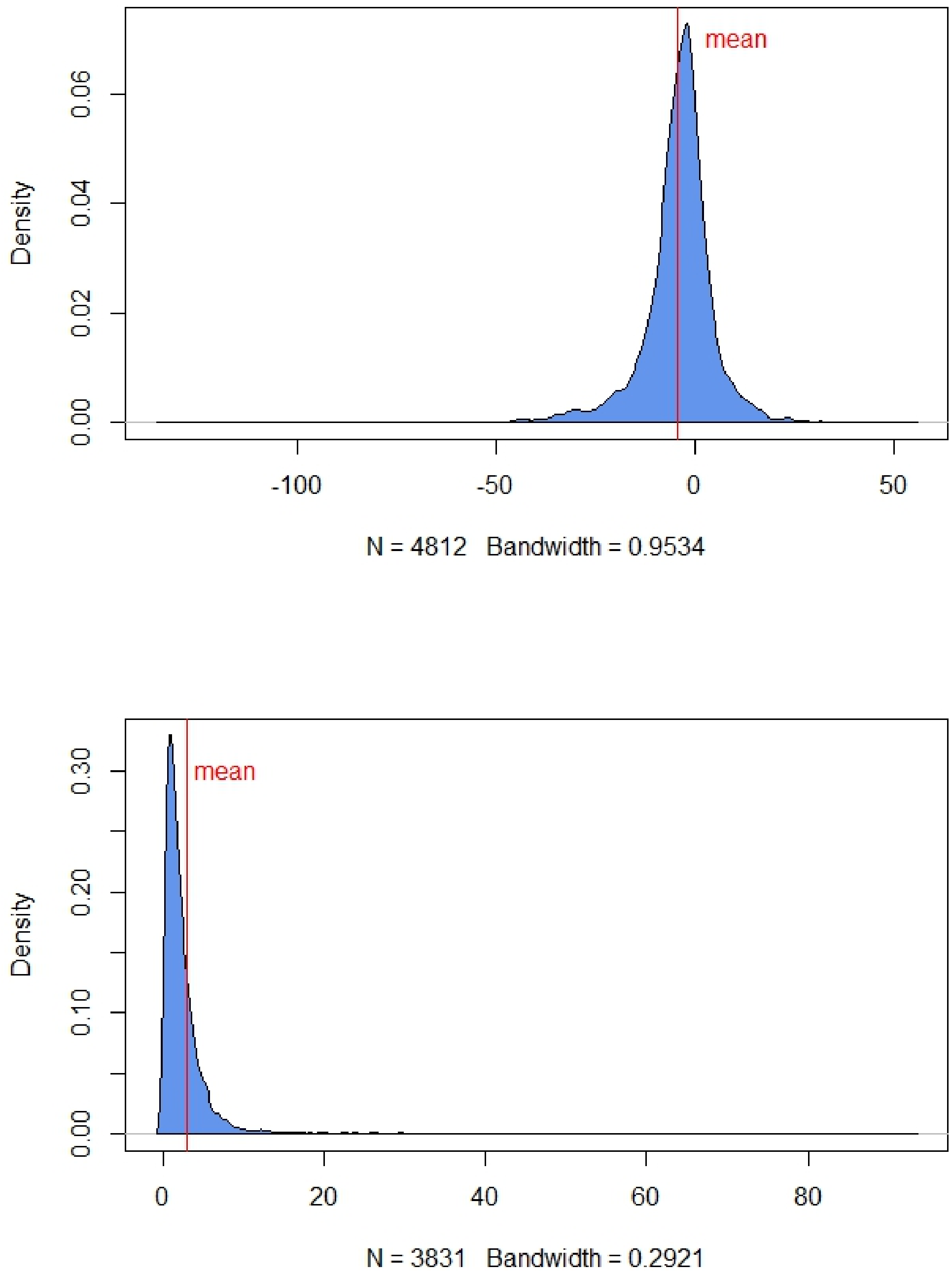
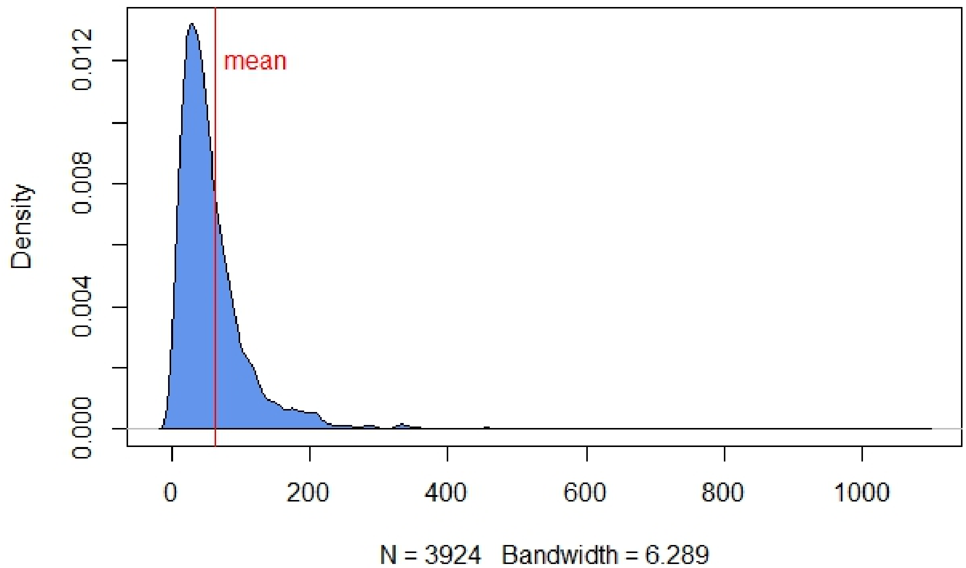


Figure A.4 – Distribution of key macroeconomic variables (2) - Debt-to-GDP ratio and debt-to-GDP in purchase power parity ratio



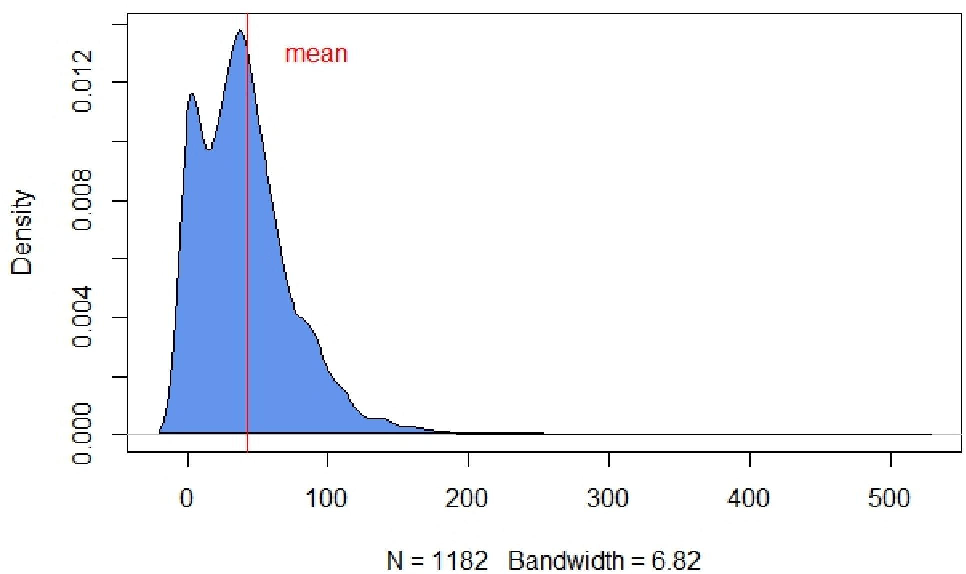


Figure A.5 – Distribution of explanatory variables for defaulters and non-defaulters (1)

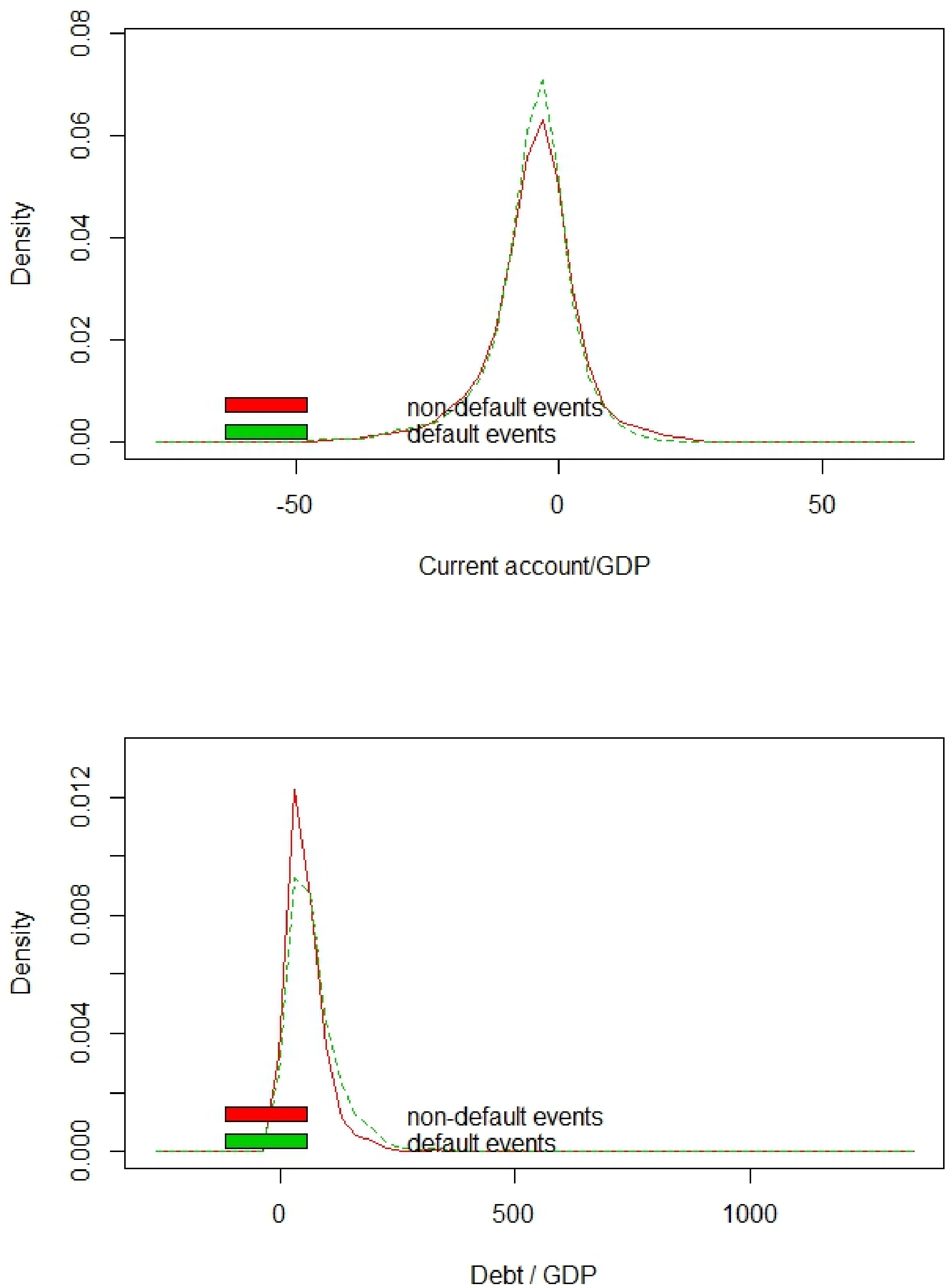
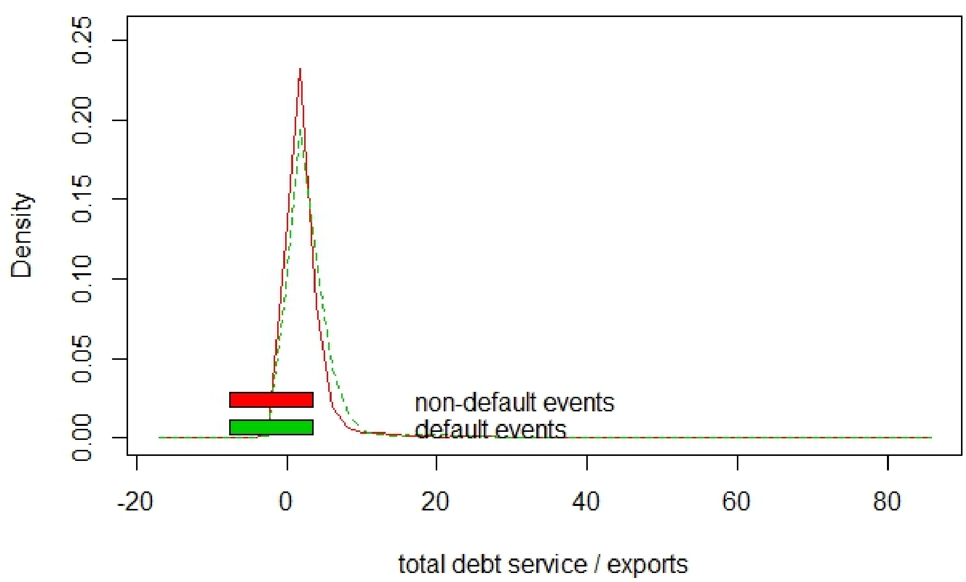


Figure A.6 – Distribution of explanatory variables for defaulters and non-defaulters (2)



Chapitre 3

Schäuble versus Tsipras : A New-Keynesian DSGE for the Eurozone Debt Crisis

3.1 Introduction

The Eurozone has experienced a major sovereign debt crisis past 2009. Greece, then Ireland and Portugal lost their access to the financial markets and had to request financial assistance from the other Eurozone countries. Then it was the turn of Spain, and to a lesser extent of Italy (in the summer of 2011) to experience huge spikes in their financing rates. Greece eventually wrote down more than 50% (in face value term) of its public debt.

What happened ? Two shocks of a different nature actually hit the Eurozone countries which came under stress. The Greek shock resulted from the sudden discovery of a major deficit of the public sector in 2009. After many revisions, it reached the almost unprecedented level of 15.5% of GDP. The speed at which such a deficit could be brought down to normal was clearly finite and became the root of Greece's problems. In the case of Ireland, the issue was more straightforward. The banking crisis saddled with debt a country which was viewed as perfectly solvent (respecting all the criteria of the Maastricht treaty with honours). Here a major unexpected shock on debt created the crisis.

Although relatively simple to describe and analyse in retrospect, these two polar cases do not fit well the literature on sovereign debt. For one thing, in most models, the primary surplus is a "control variable", i.e. one that government can monitor at will. Clearly, as the Greek case demonstrated, there are limits to the speed at which the primary deficit can be contracted. Although these costs to adjust the primary surplus can be taken into account in a model à la Arellano [2008] by introducing an adjustment cost on any debt changes, in our model preferred habit will reduce endogenously the speed of adjustment. One contribution of this paper is to model explicitly how these limits can be accounted for.

Another dimension of the Eurozone crisis is the discontinuous break in the debt-to-GDP ratio. Because of the banking crisis, the Irish government suffered from a huge jump in its public debt. This changed the dynamics of debt accumulation, in ways standard models do not usually account for. Usually the debt build results from a country (willingly) running excessive deficits. The risk of a discrete jump is another feature that we want to embed in our model.

We analyse a simple DSGE model in the spirit of Smets and Wouters [2003]. We analyse how the risk of default evolves, in each of three polar cases : in a flexible exchange rate regime, in a Eurozone case (fixed exchange rate, with full capital mobility) where the country switches to a flexible economy if it defaults, and in a Eurozone case where the country stays in the zone whatever happens. We calibrate how much unexpected debt or deficit a Eurozone country can take. We discuss the impact of a certain rigidity of the economy, namely the degree of habit consumption, as it increases the persistence of a shock. We then analyse the speed at which the debt can be reduced.

Our main results are the following. The risk of default is larger within the Eurozone than in the pure flexible exchange rate system. Perhaps surprisingly, the key parameter driving this result is consumption habit. As it rises, the benefit, in a fixed exchange rate system, of regaining control of its domestic monetary policy rises, and so does the risk of default. Nonetheless, there is a key difference between the two Eurozone cases : since the fixed rate is preferred to flexible change when habit formation is pretty high, the country that must leave the monetary zone in case of default won't default. We thus can write a "Schäuble" theorem : in a monetary union and in case of large habit formation, if you give a country the choice between (i) default and leave the zone and (ii) default and stay in the union, it will always choose (ii), default and stay. If habit formation is low, the opposite law appears. We also find that decreasing the public debt target does decrease default risk but only if the country does not face the exit threat ; increasing the speed of convergence has no effect on default risk if the degree if rigidity, namely habit persistence, in high, which is actually the case in the Eurozone.

The paper is organized as follows : we first present the model framework (section 3.2), then present the calibration and benchmark results (section 3.3), and then analyse the sensitivity of our results to habit formation and policy tools (section 3.4). Section 3.5 concludes.

3.2 Quantifying default risk in a DSGE model

The main objective of this model is to bring the literature on sovereign default and DSGE models back together : although models of default à la Eaton and Gersovitz [1981] allow value function comparison and endogenise the default decision, they cannot afford more than two state variables ; on the other hand, DSGE models are unable to endogenise the default decision, and are therefore forced to introduce sovereign spreads as a proxy for sovereign risk.

In line with Mendoza and Yue [2012] who solve an RBC model with fully endogenous default, and with Villemot [2012] who solves a RBC model with default frequencies, we propose another strategy for filling the gap between these two classes of models by introducing default risk in a more complex New-Keynesian DSGE model : we compute an out-of-model value function corresponding to the one the country must face in case of default and compare it to the one the country faces in the DSGE model without default. In this way, we can compute an *ex-post* default probability, at the cost of an approximation : the risk of default is not internalized by agents before it has materialized.

3.2.1 Greece before the Euro : a small-open economy model with flexible exchange rate (FLEX)

We first analyse a simple small open economy model in a flexible exchange rate regime, which can be though as representing a European country before the introduction of the Euro. We will be able to compare the default thresholds for such a framework with the one of a country in a monetary union (see section 3.2.2).

Preferences

There is a continuum of households indexed by i. Every household i maximizes a utility function with goods and labour over an infinite horizon.

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u^i(C_t^i, H_t, L_t^i) \tag{3.1}$$

where β is the discount factor. Consumption is relative to a time-varying external habit variable :

$$u^i(C_t^i, H_t, L_t^i) = \log(C_t^i - H_t) - \varphi \frac{(L_t^i)^{1+\sigma_L}}{1+\sigma_L} \tag{3.2}$$

where φ disutility of labour, σ_L represents the inverse elasticity of work effort w.r.t. real wage (Frisch elasticity), C_t^i is consumption of household i and L_t^i its labour force. $H_t = hC_{t-1}$ represents external consumption habit, with h the habit persistence rate. Indeed, following Hall [1978], Flavin [1981] and Hall and Mishkin [1982], consumers do not smooth out consumption as much as predicted by the Life Cycle Permanent Income Hypothesis. Current consumption seems to be excessively sensitive to current ; lagged income and changes in consumption can be explained by averages of past innovations to income. This observation is known as the excess sensitivity puzzle of consumption. Another striking fact about aggregate consumption behaviour is that shifts in aggregate income cause relatively small shifts in aggregate consumption ; the explanation is that consumption is determined by permanent income rather than current income. This anomaly, known as "Deaton's paradox" (Deaton [1992]), is explained by the fact that consumption is slow to adjust to innovations in income in the sense that changes in consumption are related to averages of previous innovations. In our case, we expect habit persistence to have several effects on default and preference for a currency zone, that we explicit in section 3.2.3.

Households rent capital to firms and decide how much to invest. They also can buy public bonds in domestic currency. The budget constraint for each household i writes :

$$B_t^i + C_t^i = \frac{R_{t-1} + \Delta_{t-1}}{\pi_t} B_{t-1}^i + Y_t^i - I_t^i - \tau_t C_t \tag{3.3}$$

Where B_t are the real holdings of government bonds, $\pi_t = 1 + \frac{P_t}{P_{t-1}}$ is the inflation rate, τ_t the tax rate on consumption (which allows to skip the issue of capital taxation), R_t the (gross) nominal interest rate, π_t the gross inflation rate, I_t the investment decision. R_t is the gross nominal return on bonds and D_t being the real external debt (see Government section). $\Delta_t = \Psi\left(e^{D_t - \bar{D}} - 1\right)$ is a default risk premium, $\bar{D}$ is the external debt target, equal to zero in case of default. Indeed, following Schmitt-Grohé and Uribe [2003], if domestic residents have only access to a risk-free bond whose rate is exogenously determined abroad, the steady-state of the model would depend on initial conditions, and mainly on the country's initial net foreign asset position, making the equilibrium dynamics possess a random walk component. By introducing a debt-elastic interest-rate premium (here an interest rate which increases with the country's net foreign debt), Schmitt-Grohé and Uribe [2003] show that this device induces stationarity and makes the model converge easily. We will introduce the same risk premium in the uncovered interest parity equation, for the same reasons [1].

Their revenues write :

$$Y_t^i = (w_t^i L_t^i + A_t^i) + (r_t^k z_t^i - \psi(z_t^i))K_{t-1}^i + Div_t^i \tag{3.4}$$

where z_t is the capital utilization rate and $\psi(z_t) = \gamma_1(z_t - 1) + \frac{\gamma_2}{2}(z_t - 1)^2$ a cost-adjustment function. Div_t^i represents the dividends from firm's profits. A_t^i are the net cash inflow from participating in state-contingent securities (Arrow-Debreu) : following Christiano et al. [2001], we assume that there exists domestic state-contingent securities that insure households against variations in household specific labour income. As a result, the first component in the household's income will be equal to aggregate labour income.

1. The parameters Ψ and ϑ are calibrated so as to match Schmitt-Grohé and Uribe [2003]'s value for the budget constraint risk premium and to be as little as possible for the UIP equation. Our agenda for research includes the incorporation of our simulated default events to endogenize these risk premia.

Consumption and savings behaviour Maximization of preferences with respect to consumption and holdings of bonds gives the following first-order condition (Euler condition) :

$$\mathbb{E}_t\left[\beta\left(\frac{C_t-H_t}{C_{t+1}-H_{t+1}}\frac{1-\tau_t}{1-\tau_{t+1}}\right)\frac{R_t+\Delta_t}{\pi_{t+1}}\right]=1 \tag{3.5}$$

Labor supply and wage setting Labor is differentiated across households, so there's a monopoly power over wages that become sticky à la Calvo [1983]. Wages can be optimally adjusted after some random "wage-change signal" (see Kollman [1997]) : with probability $1-\xi_w$, the household i set a new nominal wage $\tilde{w}_t$.There is also partial indexation of wages on past inflation :

$$w_t^i=\pi_{t-1}^{\chi_w}w_{t-1}^i \tag{3.6}$$

where χ_w is the degree of wage indexation (if 0, non-optimized wages, remain constant).

Cost minimization from the wage aggregator gives :

$$\max_{L_t^i} w_t^iL_t^i-\int_0^1 w_t^jL_t^jdj$$

which is

$$\max_{L_t^i}\left(\int_0^1 L_{t,j}^{\frac{\eta-1}{\eta}}dj\right)^{\frac{\eta}{\eta-1}}-\int_0^1 w_t^jL_t^jdj$$

The first order condition gives

$$\frac{\eta}{\eta-1}\frac{\eta-1}{\eta}L_{t,i}^{\frac{\eta-1}{\eta}-1}\left(\int_0^1 L_{t,j}^{\frac{\eta-1}{\eta^l}}dj\right)^{\frac{\eta}{\eta-1}-1}W_t-w_t^i)=0$$

$$w_t^i=L_{t,i}^{\frac{-1}{\eta}}\left(\int_0^1 L_{t,j}^{\frac{\eta-1}{\eta}}dj\right)^{\frac{1}{\eta-1}}W_t$$

$$\left(\frac{w_t^i}{W_t}\right)^{-\eta}=L_t^i\left(\int_0^1 L_{t,j}^{\frac{\eta-1}{\eta}}dj\right)^{\frac{-\eta}{\eta-1}}$$

The demand for labor is thus given by :

$$L_t^i=\left(\frac{w_t^i}{W_t}\right)^{-\eta}L_t$$

Where $L_t=\left(\int_0^1(L_t^i)^{\frac{\eta-1}{\eta}}di\right)^{\frac{\eta}{\eta-1}}$ is the aggregate labour demand, $W_t=\left(\int_0^1(w_t^i)^{1-\eta}di\right)^{\frac{-1}{\eta-1}}$ the aggregate nominal wage and η the elasticity of substitution between labour varieties.

Households face the demand for labor. We suppose that they change their wage at date t but no longer between t and $t+j$. They thus have to maximize :

$$\max_{w_t^i} \sum_{j=0}^{\infty} (\beta \xi_w)^j \left[log(C_{t+j}^i - hC_{t+j-1}^i) - \frac{(L_{t+j}^i)^{1+\phi}}{1+\phi} \right]$$

$$s.t. \quad L_{t+j}^i = \left(\frac{w_t^i}{W_{t+j}} \right)^{-\eta} L_{t+j}$$

the demand for labor at date $t+j$ with the wage optimized at date t only, and subject to the budget constraint at date $t+j$ but with the wage optimized at date t only.

We obtain the following mark-up equations (reallocation of wages) :

$$\frac{\tilde{w}_t}{w_t} \mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \xi_w^j \left(\frac{\pi_t^{\chi_w}}{\pi_{t+j}} \right) \frac{\eta - 1}{\eta} \frac{L_{t+j}^i}{(C_{t+j}^i - H_{t+j})(1 - \tau_{t+j})} = \mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \xi_w^j \varphi (L_{t+j}^i)^{(1+\sigma_L)} \tag{3.7}$$

The nominal wage at time t of a household m that is allowed to change its wage set so that the present value of the marginal return of working is a mark-up over the present value of the marginal cost (of working).

At equilibrium, each household that can choose $\tilde{w}_t^i$ will choose the same wage and the same supply of labor. By the law of large number, we thus obtain the law of motion of the aggregate wage index :

$$1 = \xi_w \left(\frac{\pi_{t-1}^{\chi_w} W_{t-1}}{\pi_t W_t} \right)^{1-\eta} + (1 - \xi_w) \left(\frac{\tilde{w}_t}{W_t} \right)^{1-\eta} \tag{3.8}$$

Investment and capital accumulation Households choose the capital stock K_t, investment I_t and the utilization rate z_t in order to maximize their preferences. The capital accumulation equation is given by

$$K_t = (1-\delta) K_{t-1} + \left[1 - S \left(\frac{I_t}{I_{t-1}} \right) \right] I_t \tag{3.9}$$

Where $S\left(\frac{I_t}{I_{t-1}}\right) = \frac{\kappa_I}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2$ is an adjustment cost function (equals 0 in steady-state, where there is constant I).

We obtain the following first-order conditions for capital (Tobin's q), investment and capital utilization rate :

$$\begin{aligned}
\mathbb{E}_t \left[\frac{1}{\beta} \left(\frac{C_{t+1} - H_{t+1}}{C_t - H_t} \frac{1 - \tau_{t+1}}{1 - \tau_t} \right) \right] q_t &= q_{t+1}(1-\delta) + z_{t+1} r_{t+1}^k - \psi(z_{t+1}) && (3.10) \\
q_t \left[1 - S \left(\frac{I_t}{I_{t-1}} \right) \right] - 1 &+ \beta \mathbb{E}_t q_{t+1} \left(\frac{C_t - H_t}{C_{t+1} - H_{t+1}} \frac{1 - \tau_t}{1 - \tau_{t+1}} \right) S' \left(\frac{I_{t+1}}{I_t} \right) \frac{I_{t+1}^2}{I_t^2} \\
&= q_t S' \left(\frac{I_t}{I_{t-1}} \right) \frac{I_t}{I_{t-1}} && (3.11) \\
r_t^k &= \psi'(z_t) && (3.12)
\end{aligned}$$

Technologies and firms

The country produces a unique final good Y_t, which is produced using a continuum of intermediate goods $y_{j,t}$. Those intermediate goods are produced using labour L_t, imported materials M_t and capital $z_t K_{j,t-1}$, each in a single monopolistic firm. The final good is consumed by the households.

Final-good sector The final good is produced using the following technology :

$$Y_t = \left(\int_0^1 y_{j,t}^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}} \tag{3.13}$$

The final good is indeed determined by a Dixit-Stiglitz aggregator that combines a continuum of differentiated intermediate inputs $y_{j,t}$ for $j \in [0,1]$.

Intermediate goods producers Each intermediate (domestic) good is produced using the following technology :

$$y_{j,t} = A_t (z_t K_{j,t-1})^{\alpha_K} M_t^{\alpha_M} L_{jt}^{1-\alpha_K-\alpha_M} \tag{3.14}$$

where A_t is an AR(1) productivity shock following $\log(A_t) = \rho_A \log(A_{t-1}) + \varepsilon_t^A$.

Because of perfect competition in the final good market, aggregate prices write

$$P_t = \left(\int_0^1 p_{j,t}^{1-\epsilon} dj \right)^{\frac{1}{1-\epsilon}} \tag{3.15}$$

where $p_{j,t}$ is the price in t of the intermediate good y_j. Cost minimization leads to

$$\frac{w_t L_t}{r_t z_t K_{t-1}} = \frac{1-\alpha_K-\alpha_M}{\alpha_K} \tag{3.16}$$

$$\frac{\varepsilon_t M_t}{r_t z_t K_{t-1}} = \frac{\alpha_M}{\alpha_K} \tag{3.17}$$

Where $\varepsilon_t = E_t \dfrac{P_t^*}{P_t}$ is the real exchange rate (E_t being the nominal exchange rate) and the price of imported materials. The firms' marginal cost is given by

$$MC_t = \frac{1}{A_t} W_t^{1-\alpha_K-\alpha_M} r_t^{\alpha_K} \varepsilon_t^{\alpha_M} \left[\frac{1}{\alpha_K}^{\alpha_K} \frac{1}{\alpha_M}^{\alpha_M} \frac{1}{1-\alpha_K-\alpha_M}^{1-\alpha_K-\alpha_M} \right] \tag{3.18}$$

Thus, nominal profits can write

$$\Pi_{j,t} = (p_{j,t} - MC_t) y_{j,t} \tag{3.19}$$

As in Calvo [1983], prices can be optimally adjusted after some random price-change signal : with probability $1-\xi_p$, the intermediate firm j sets a new nominal price $\tilde{p}_{j,t}$. Optimal price inflation becomes thus $\tilde{\pi}_{j,t}$. We also allow partial indexation for non-optimized prices with rate $\chi_p : P_t = \pi_{t-1}^{\chi_p} P_{t-1}$

Profit optimization by producers that are allowed to re-optimize their prices at time t results in the following first-order condition :

$$\frac{\tilde{\pi}_{j,t}}{\pi_t}\mathbb{E}_t\sum_{i=0}^{\infty}\beta^i\xi_p^i\left(\frac{y_{j,t+i}}{(C_{t+i}-H_{t+i})(1-\tau_{t+i})}\right)\left(\left(\frac{\pi_t^{\chi_p}}{\pi_{t+i}}\right)-MC_{t+i}\frac{\epsilon}{\epsilon-1}\right)=0 \tag{3.20}$$

The price set by the firm j at time t is a function of expected future marginal costs. The price will be a mark-up over these weighted marginal costs. If prices are perfectly flexible ($\xi_p = 0$), the mark-up in period t becomes $\frac{\epsilon}{\epsilon-1}$.

We obtain the law of motion of the aggregate price index :

$$1=\xi_p\left(\frac{\pi_{t-1}^{\chi_p}}{\pi_t}\right)^{1-\epsilon}+(1-\xi_p)\left(\frac{\tilde{\pi}_{j,t}}{\pi_t}\right)^{1-\epsilon} \tag{3.21}$$

Exports Following Aoki et al. [2015], exports are given by $X_t = \varepsilon_t^{\iota} Y_t^*$ with Y_t^* an exogenous parameter for foreign demand following $(Y_t^* - 1) = \rho_Y(Y_{t-1}^* - 1) + \varepsilon_t^Y$.

Government

The government raise taxes $T_t = \tau_t C_t$. Public expenditures G_t are exogenous and follow an AR(1) process $G_t - \bar{G} = \rho_G(G_{t-1} - \bar{G}) + \varepsilon_t^G$.

The primary surplus in real terms is given by

$$P_t^{sur} = T_t - G_t \tag{3.22}$$

The government can sell bonds to households (B_t) in domestic currency which return $R_t + \Delta_t$ next period and bonds to foreign investors (D_t) in foreign currency which return $R_t^* + \Delta_t$ next period, where R_t^* is the foreign gross nominal interest rate.

Interests on debt at date t are given by

$$Int_t=\left(\frac{R_{t-1}+\Delta_{t-1}}{\pi_t}-1\right)B_{t-1}+\left(\frac{R_{t-1}^*+\Delta_{t-1}}{\pi_t}-1\right)\frac{E_t}{E_{t-1}}D_{t-1}$$

The government faces the following budget constraint :

$$B_t+D_t+\tau_t C_t=\frac{R_{t-1}+\Delta_{t-1}}{\pi_t}B_{t-1}+\frac{R_{t-1}^*+\Delta_{t-1}}{\pi_t}\frac{E_t}{E_{t-1}}D_{t-1}+G_t \tag{3.23}$$

All variables are expressed in real terms and in domestic goods ; the return on D_t being obviously affected by the currency position.

The public deficit and the debt target are determined by the following fiscal rule :

$$P_t^{sur} - Int_t = \alpha_B \left(B_{t-1} + \frac{E_t}{E_{t-1}} D_{t-1} - \overline{BD}_t \right) \tag{3.24}$$

where $\overline{BD}_t$ is the total debt target and α_B the control force. They are the two Maastricht tools we want to test the efficiency in section 3.4.2. The balance of payment is given by :

$$D_t = \frac{R_{t-1}^* + \Delta_{t-1}}{\pi_t} \frac{E_t}{E_{t-1}} D_{t-1} + \varepsilon_t M_t - X_t \tag{3.25}$$

Last, the choice of the real exchange rate is determined by the uncovered interest parity equation :

$$(R_t + \Delta_t) = \mathbb{E}_t \left(R_t^* \frac{E_{t+1}}{E_t} \right) + \vartheta \left(e^{(D_t - \bar{D})} - 1 \right) \tag{3.26}$$

Where $\vartheta \left(e^{(D_t - \bar{D})} - 1 \right)$ is a risk premium à la Schmitt-Grohé and Uribe [2003].

Market equilibrium

— The final goods market is in equilibrium if production minus exports equals demand by households for consumption and investment and by the government (note that Y_t measures aggregate production, GDP would be obtained by subtracting imports) :

$$Y_t - X_t = C_t + G_t + I_t + \psi(z_t) K_{t-1} \tag{3.27}$$

— **Capital markets** : the demand for capital by intermediate goods producers equals the supply of capital by households

— **Labour markets** : firms' demand for labour equals labour supply at the wage level set by the households

— **Interest rate** : Monetary policy decisions are made thanks to a Taylor rule. In the capital market, government debt is held by domestic investors and foreign investors at rates $R_t + \Delta_t$ and $R_t^* + \Delta_t$.

  We can write the following Taylor rule, with $\bar{R}$ the long-term (gross) interest rate :

$$\frac{R_t}{\bar{R}} = \left(\frac{R_{t-1}}{\bar{R}} \right)^{\rho_\pi} \left(\frac{\pi_t}{\bar{\pi}} \right)^{r_\pi (1-\rho_\pi)} \tag{3.28}$$

— **Default risk** : With the satellite model, we quantify the sovereign risk in the core model. The country defaults on its external debt ; this assumption is motivated by the empirical literature on the original sin, which documents that virtually all of the debt issued by emerging countries is denominated in foreign currency (see for instance Eichengreen et al. [2003]). In the recent Greek case, collective action clauses and priority creditors makes the Greek external debt (bilateral loans from Eurozone countries) gathering 21% of total debt, the remaining being hold by the European Stability Mechanism (56%), the International Monetary Fund (13%) and the European Central Bank (10%).

3.2.2 A small-open economy with fixed exchange rate : the Schäuble and Tsipras models

Two other versions of the model involve a country which is part of a monetary union. The nominal exchange rate is now fixed. The real exchange rate becomes $\frac{\varepsilon_t}{\varepsilon_{t-1}} = \frac{\pi_t^*}{\pi_t}$ with π_t^* the inflation in the rest of the monetary union.

The framework is almost the same, except that the monetary policy is exogenous :

$$R_t = R_t^*$$

with R_t^* the foreign interest rate. Here, we thus do not take into account the global monetary policy of the central bank on the small open economy in the currency zone.

In a first version of this monetary union model, the country stays in a fixed-exchange rate regime after a default (Tsipras). In a second one, the country is back to a full flexible regime after a default (Schäuble). In this latter case, we nonetheless do not take into account the debt denomination issue after exit and neither the regain in debt monetization or devaluation possibility (as seen in Na et al. [2015]), since our assets here are reduced to sovereign debt. The possibility of exiting the zone is not internalized by agents (as it can be in Kriwoluzky et al. [2015] [2]). Note here that these two cases represent an extreme simplification of the Greek case (in case of a Grexit or not), since we do not incorporate private debt, banking system, financial frictions, relief plans, etc. In particular, this type of modelling does not solve the financial flows equation in the Eurozone.

3.2.3 Habit persistence and preference for fixed exchange rate

In our framework, there is a key difference in terms of welfare between being part of a currency union or being in a flexible exchange rate regime, which will base our results concerning sovereign default (see Table 3.1). In our setting, a trade-off monetary rule vs. change rule operates : in a flexible exchange rate regime, even with an optimal monetary policy, the country cannot eliminate a noise on the exchange rate which lowers the welfare. Even if the monetary rule in a monetary union is suboptimal, the agents will prefer to face a fixed exchange rate.

2. They develop a model of a small open economy part of a currency union and find that fiscal policy is not sustainable and that agents expect a regime change ; debt revaluation, behaviour of interest rates and risk denomination are issues developed in their paper

TABLE 3.1 – Welfare comparisons and moments of simulated variables - $h = 0.85$

	Welfare	External debt	Output
Flexible regime	$J_r = -800.2$	$\bar{D} = 0.23$	$\bar{Y} = 2.70$
		$\sigma(D) = 0.75$	$\sigma(Y) = 1.93$
Monetary union	$J_r = -799.6$	$\bar{D} = 0.23$	$\bar{Y} = 2.70$
		$\sigma(D) = 0.61$	$\sigma(Y) = 1.89$

Nonetheless, the contradiction of this result with the intuition of models à la Casas et al. [2016] can be explained through the habit persistence parameter h, set at 0.85 in our setting (against 0 in traditional small open economy models of fixed vs. flexible exchange rate). As shown in Table 3.2, flexible change is preferred when habit persistence is low.

TABLE 3.2 – Welfare comparisons and moments of simulated variables - $h = 0.25$

	Welfare	External debt	Output
Flexible regime	$J_r = -177.9$	$\bar{D} = 0.17$	$\bar{Y} = 1.85$
		$\sigma(D) = 1.32$	$\sigma(Y) = 2.77$
Monetary union	$J_r = -178.4$	$\bar{D} = 0.16$	$\bar{Y} = 1.86$
		$\sigma(D) = 1.11$	$\sigma(Y) = 2.74$

This result has two main explanations. First, when external habit persistence is strong, an exogenous shock on the agents' revenue becomes almost permanent : agents drop consumption smoothing, do not borrow anymore and invest more in government bonds, which makes B_t rise and D_t, external debt, falls. But second, strong habit persistence makes wealth cut by hW_{-1} : agents feel poorer, so they invest less in government bonds, and this is why D_t actually rises with h (see Tables 3.1 and 3.2), whereas B_t shrinks. In this case, agents have little leeway when adverse shocks occur : when a negative shock occurs, it has less impact on agents' welfare since h is large and the shock will hit them in a lagged and smoothed way (more persistence). As the agents feel poorer, debt is less volatile and agents come through the crisis easier. The possibility of more adverse shocks (in particular through the exchange rate channel) outside the monetary union makes agents prefer monetary union rather than flexible regime when habit persistence is strong : Tsipras does better than Schäuble. This result is reversed when habit persistence is low, as in most small open economy models (where it is set to 0) : adverse shocks arrive with enough intermittence and agents have enough leeway to face exogenous shocks so that the country will prefer an optimal monetary policy rule, in a flexible setting, rather than a sub-optimal one in a fixed exchange rate setting.

3.2.4 Modelling the implied default risk : the satellite model

For all three models, we consider a satellite model whose purpose is to quantify the risk of default in the core model (*i.e.* before default) and compute a default frequency. Indeed, because of algorithmic and computational limits, it is not possible to introduce endogenous default risk in such a model. Using a satellite model allows us to quantify an implied risk of default delivered by our DSGE model, at the cost of some approximation : default in this model is not endogenous, as incorporating the default risk would raise the dimensionality of the model one step too high. In particular, there is no endogenous risk premium here, which is calibrated and *ad hoc*. Agents are totally myopic towards the risk of default, which comes as a "MIT shock". Nonetheless, it allows us to compute default probabilities on simulated paths.

As in the canonical endogenous default model à la Aguiar and Gopinath [2006], we assume that, after a default on its external debt, a penalty is imposed on the country in the form of a proportional cost to production, and that the country remains in financial autarky for eternity [3] ; as a consequence, the country forgoes all the benefits, in the form of additional investment finance and consumption smoothing, offered by borrowing abroad.

Post-default production is defined as :

$$Y_t^d = (1 - \lambda_Q)Y_t \tag{3.29}$$

where λ_Q governs the magnitude of the default cost. As $D_t = 0$ after default (since the country has defaulted on external debt and lost its access to financial markets), the government budget constraint becomes :

$$B_t + T_t = \frac{R_{t-1} + \Delta_{t-1}}{\pi_t} B_{t-1} + G_t \tag{3.30}$$

In all three cases (Flex, Schäuble, Tsipras), the financial autarky in the satellite model implies that external debt remains zero, which in particular means that the trade balance must be equilibrated at all times (imports must be matched by imports). In the Flex and Schäuble cases, the country has control over its monetary policy (through a Taylor rule), and the nominal exchange rate plays the role of the adjustment device.

In a nutshell, exchange rate and monetary regimes after default are the following :
- Flexible case : the model does not change after default, the country remains in a flexible exchange rate regime and has its own independent monetary policy.
- Schäuble case : the country goes back to a flexible exchange rate regime after default, and hence regains its independent monetary policy.
- Tsipras case : the country remains in the monetary union after default (and hence adjustment through the exchange rate is not possible) and in financial autarky (and hence adjustment through external debt is no longer possible). In the modelling, something has thus to give in, and I choose to make adjustment through the nominal interest rate, which is not fixed by the ECB because of autarky but neither freely adjustable through a Taylor rule. Another possibility (to be explored) is to allow adjustment through prices by drop-

3. This is a strong and simplifying assumption ; incorporating a probability of redemption is on agenda for future research

ping the fiscal rule ; this solution may be more realistic since it implies import rationing from the default country.

The core model and the satellite model are self-contained and do not depend on the other one. The comparison of the value function of the core model J^r with that of the satellite model J^d delivers the implicit default probability :

$$\begin{aligned} J^d(K_{t-1}, A_t, B_{t-1}, H_t, R_{t-1}, \pi_{t-1}, \varepsilon_{t-1}, \Delta_{t-1}) &= \max_{C_t, L_t, K_t, B_t} \{u(C_t, L_t, H_t) \\ &+ \beta E_t J^d(K_t, A_{t+1}, B_t, H_{t+1}, R_t, \pi_t, \varepsilon_t, \Delta_t) \end{aligned} \tag{3.31}$$

$$\begin{aligned} J^r(K_{t-1}, A_t, B_{t-1}, D_{t-1}, H_t, R_{t-1}, \pi_{t-1}, \varepsilon_{t-1}, \Delta_{t-1}) &= \max_{C_t, L_t, K_t, B_t, D_t} \{u(C_t, L_t, H_t) \\ &+ \beta E_t J^r(K_t, A_{t+1}, B_t, D_t, H_{t+1}, R_t, \pi_t, \varepsilon_t, \Delta_t) \end{aligned} \tag{3.32}$$

The model is solved in the following way :

— The core model is solved and we compute the value function J^r corresponding to the non-default case : this computation gives us a mean debt-to-GDP ratio and a simulation path of 10 000 periods for all the model variables.

— The satellite model is solved and we compute the value function J^d corresponding to the post-default model.

— We compare J^r and J^d on the 10 000 simulation points, which enables us to compute the default probability (percentage of periods in which $J^r - J^d < 0$. The default threshold is the level of external debt for which $J^r = J^d$, for the state variables evaluated at their steady-state value.

The results show how often the country would default ex-post in the model (default frequency).

3.3 Calibration and benchmark results

We base our calibration on [Smets and Wouters, 2003] for the DSGE inputs, Mendoza and Yue [2012] for the international economics inputs and on Aguiar and Gopinath [2006] for the default specificities. Consequently, the external debt target $\bar{D}$ is calibrated as to match the default threshold obtained by Aguiar and Gopinath [2006], which is approximately 30% quarterly. Table 3.3 summarizes the calibration.

This calibration is quite standard for both default and New-Keynesian DSGE models. As in Smets and Wouters [2003], we calibrate consumption habit around 0.8 for the Euro area. Our discount factor β must be high in order to keep a targeted inflation around 2% in annual terms. We also calibrate the total debt target $\overline{BD}_t$ and the speed of convergence α_B to match Maastricht criteria : a debt target ratio at 60% annual and 20 years needed to get back to it. The parameters linked to the risk premium directly come from Schmitt-Grohé and Uribe [2003].

TABLE 3.3 – Benchmark calibration of the model (all specifications)

Parameter	Symbol	Value
Consumption habit	h	0.85
Discount factor	β	0.995
Capital utilization, linear term	γ_1	0.035
Capital utilization, quadratic term	γ_2	0.001
Capital share in output	α_K	0.3
Imported materials share in output	α_M	0.15
Capital depreciation rate	δ	0.025
Capital adjustment cost parameter	κ_I	1
Elasticity of substitution between labour varieties	η	3
Elasticity of substitution between good varieties	ϵ	9
Labour disutility parameter	φ	5.89
Inverse Frisch elasticity	σ_L	2.4
Wage indexation parameter	χ_w	0.763
Calvo parameter for wages	ξ_w	0.737
Price indexation parameter	χ_p	0.469
Calvo parameter for prices	ξ_p	0.908
Steady-state inflation	$\bar{\pi}$	1.005
Steady-state gross nominal interest rate	$\bar{R}$	$\bar{\pi}/\beta \simeq 1.01$
Total debt target	$\overline{BD}_t$	$2.4Y_t$
Back to equilibrium debt targets (fiscal rule)	α_B	1/80
Government expenditures target in AR(1) process	$\bar{G}$	$0.18\bar{Y}$
Standard deviation of TFP shock ε_t^A	σ_A	$\exp(-3.97)$
Standard deviation of government expenditures shock ε_t^G	σ_G	$\exp(-2.16)$
Standard deviation of foreign demand shock ε_t^Y	σ_Y	$\exp(-4.12)$
Persistence of TFP process	ρ_A	0.9
Persistence of government expenditures process	ρ_G	0.9
Persistence of foreign demand process	ρ_Y	0.9
Interest smoothing coefficient in Taylor rule	ρ_π	0.85
Feedback coefficient to inflation in Taylor rule	r_π	1.5
Foreign nominal gross interest rate	R_t^*	$\bar{\pi}/\beta \simeq 1.01$
Risk premium in uncovered interest parity	ϑ	0.001
Price elasticity of exports demand	ι	1
Schmitt-Grohé parameter for risk premium Δ_t	Ψ	0.007742
External debt target	$\overline{D}$	$0.3\bar{Y}$
Loss of output in autarky (% of GDP)	λ_Q	0.03

Note : Quarterly frequency

Note that $\bar{R}$, β, $\bar{\pi}$ and $\bar{\Delta}$ at steady-state must satisfy the Euler equation :

$$\beta \frac{\bar{R} + \bar{\Delta}}{\bar{\pi}} = 1 \tag{3.33}$$

In the benchmark calibration, we set $\bar{R} = \bar{\pi}/\beta$ which implies $\Delta = 0$ at steady-state and therefore $D = \bar{D}$.

The first results arise from welfare comparisons in the core and post-default models (see Table 3.4, steady-states in the two models are the same for standard variables). Post-default seems to be preferred in a monetary union, bringing stability for output. The explanations brought in section 3.2.3 are strengthened after a default.

TABLE 3.4 – Welfare comparisons and moments of simulated variables - $h = 0.85$

CORE MODEL

	Welfare	External debt	Consumption	Output
Flexible regime	$J_r = -800.2$	$\bar{D} = 0.23$	$\bar{C} = 0.19$	$\bar{Y} = 2.70$
		$\sigma(D) = 0.75$	$\sigma(C) = 0.25$	$\sigma(Y) = 1.93$
Monetary union	$J_r = -799.6$	$\bar{D} = 0.23$	$\bar{C} = 0.19$	$\bar{Y} = 2.70$
		$\sigma(D) = 0.61$	$\sigma(C) = 0.25$	$\sigma(Y) = 1.89$

SATELLITE MODEL

	Welfare	External debt	Consumption	Output
Flexible regime	$J_d = -838.7$	$\bar{D} = 0$	$\bar{C} = 0.18$	$\bar{Y} = 2.66$
		$\sigma(D) = 0$	$\sigma(C) = 0.24$	$\sigma(Y) = 2.73$
Monetary union	$J_d = -810.5$	$\bar{D} = 0$	$\bar{C} = 0.19$	$\bar{Y} = 2.63$
		$\sigma(D) = 0$	$\sigma(C) = 1.39$	$\sigma(Y) = 0.60$

Regarding default occurrences and debt thresholds, we can see that the default threshold is very high in either the flexible, Tsipras and Schäuble models, and consequently the implicit default probability is almost zero (Table 3.5). These results are much more realistic than standard default models, even if these results owe to the fact that the country does not internalize the risk of default and its corresponding cost, and should therefore not be taken at face value. Nonetheless, internalizing the risk of default would then increase little to the default frequency results (except if the country were to deliberately seek to default, which is unlikely) [4].

TABLE 3.5 – Default probabilities and debt thresholds - Flexible, Schäuble and Tsipras models

	Default probability	Default threshold (at SS)
Baseline	0.2%	55.8%
Schäuble regime	0.0%	92.3%
Tsipras regime	2.88%	91.5%

Note : Annual frequency

In the Tsipras model instead, there is a positive risk of default, which is the outcome of the fact that default is not too costly : defaulting while maintaining the fixed exchange rate regime

4. Note that default as a “MIT shock” is actually non-existent in the Schäuble case

(barring only the ability to borrow) is not as costly as in the other cases. The reason has to do with the fact that the country regains its monetary policy while keeping the stability brought by the fixed regime.

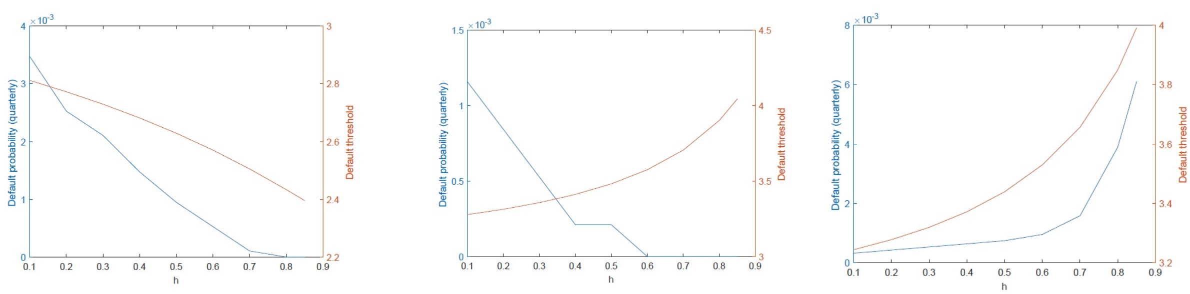
3.4 Sensitivity analysis

The results obtained on the benchmark calibration are driven by three key parameters : the total debt target in fiscal rule $\overline{BD}_t$, the level of consumption habit h and the speed of convergence in fiscal rule α_B. Let us analyse the sensitivity of our results to these parameters.

3.4.1 Consumption habits

First, we take a close look to sensitivity with respect to consumption habit in our three benchmarks models. Figure 3.1 summarizes the results of such a sensitivity exercise when h ranges from 0.1 to 0.85 (its benchmark value), while keeping other parameters constant.

FIGURE 3.1 – Default probabilities and debt thresholds on baseline calibration - Sensitivity with respect to consumption habit



a) Flexible model b) Schäuble model c) Tsipras model

Consumption habit has a remarkable influence on the risk of default. In the Flexible model, a high degree of habit raises the default threshold and lowers the default probability. In the Tsipras model the opposite effect emerges. A higher degree of consumption habit simultaneously raises the debt ceiling and the risk of default. Finally the Schäuble model is a combination of both cases. Higher consumption habit means more debt and less default risk.

The intuition behind these results comes as follows. The higher the consumption habit parameter h, the lower the volatility of consumption (almost three times higher in the low h case than in the high h scenario, for all models). As h rises, two conflicting forces operate. As the desired $\sigma(c)$ falls, the debt is reduced to stabilize consumption. But on the other hand, a higher stock of debt service hampers the ability to respond to a (large) negative shock on GDP. This is why all combinations are possible. Rising debt threshold *cum* rising default risk, declining debt threshold *cum* declining risk or rising debt and declining risk. See Carré et al. [2015] for further insight on why debt threshold and default risk are not necessarily correlated. Specifically, *ceteris paribus*, default, when it reduces the number of instruments is less likely for large h values. The reason why this is not the case in the Tsipras case is, as we indicated earlier, that default allows the country to regain full control of its monetary policy without having to pay the consequences of exchange rate volatility. Default then becomes more likely when h rises. Schäuble is the worst of both cases, so that the risk of default does decline as in the Flexible model, but sustainable debt is also higher as the cost of default becomes even higher.

Additionally, explanations given in section section 3.2.3 matter even more when a default choice has to be made (see Table 3.6)

TABLE 3.6 – Welfare comparisons and moments of simulated variables - $h = 0.25$

CORE MODEL

	Welfare	External debt	Output
Flexible regime	$J_r = -177.9$	$\bar{D} = 0.17$	$\bar{Y} = 1.85$
		$\sigma(D) = 1.32$	$\sigma(Y) = 2.77$
Monetary union	$J_r = -178.4$	$\bar{D} = 0.16$	$\bar{Y} = 1.86$
		$\sigma(D) = 1.11$	$\sigma(Y) = 2.74$

SATELLITE MODEL

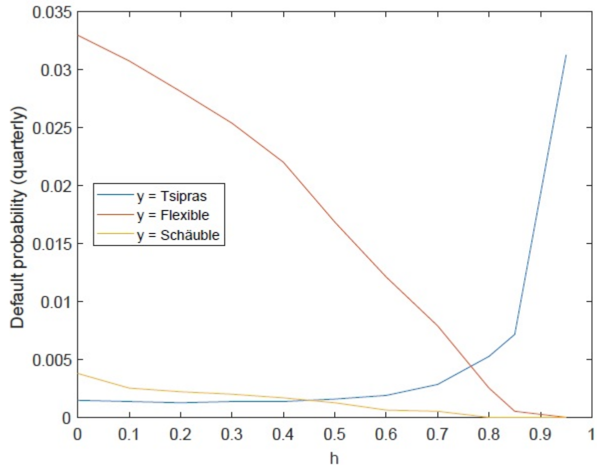
	Welfare	External debt	Output
Flexible regime	$J_d = -192.3$	$\bar{D} = 0$	$\bar{Y} = 1.83$
		$\sigma(D) = 0$	$\sigma(Y) = 3.88$
Monetary union	$J_d = -178.9$	$\bar{D} = 0$	$\bar{Y} = 1.80$
		$\sigma(D) = 0$	$\sigma(Y) = 0.46$

This lets us to derive a theorem, illustrated by Figure 3.2 :

Schäuble Theorem

In a monetary union and if habit formation is sufficiently high ($h > 0.45$), if you give a country the choice between (i) default and leave the zone and (ii) default and stay in the union, it will always choose (ii), default and stay. This results is reversed in case of low habit persistence ($h < 0.45$).

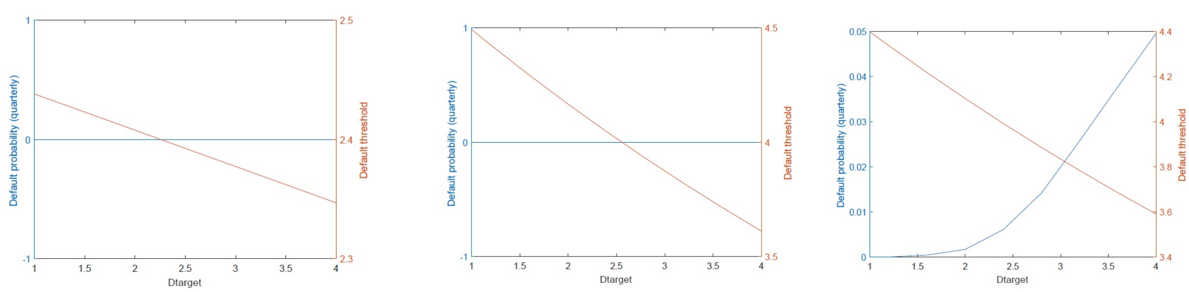
Figure 3.2 – Defaults probabilities and habit formation



3.4.2 Maastricht tools

We now analyse the sensitivity of the default risk to the aggregate debt targets (domestic and external together, see Figure 3.3). We find the same kind of qualitative opposition between the three regimes. Raising the long run debt target does not raise (in the range that is considered) default risk in both Flexible and the Schäuble model, but does so in the Tsipras case. The intuition is the same as in the previous section. With a large habit parameter (0.85 here), the Eurozone country is more likely to default, as it seeks to regain its monetary instrument. The larger the debt ceiling the more likely it will choose to do so. The flexible and the Schäuble models generate no default, *ceteris paribus*, because of the fear the additional instability brought by the flexible exchange rate regime when it is not compensated by an access to financial markets.

Figure 3.3 – Default probabilities and debt thresholds - Sensitivity with respect to total debt target



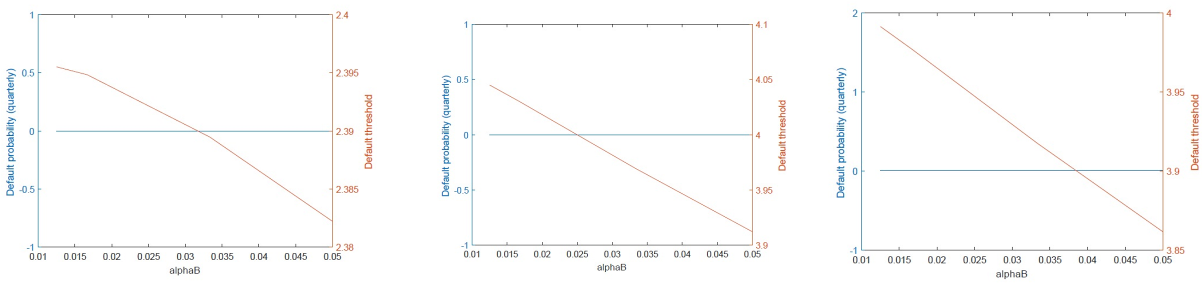
a) Flexible model

b) Schäuble model

c) Tsipras model

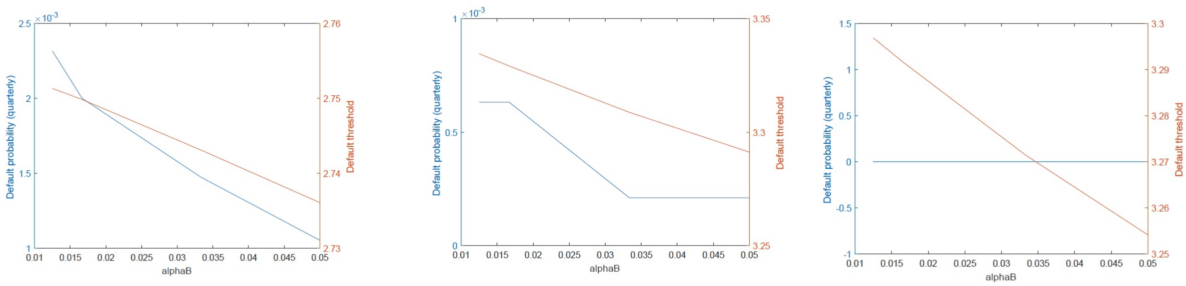
As a last exercise, we present sensitivity results to the speed of convergence in the fiscal rule, α_B. Results are presented in Figures 3.4 and 3.5. For large consumption habits ($h = 0.85$), in all cases, a fast speed of convergence does not change the default probability but reduces the debt threshold.

FIGURE 3.4 – Default probabilities and thresholds with high consumption habits ($h = 0.85$) - Sensitivity with respect to speed of convergence



a) Flexible model b) Schäuble model c) Tsipras model

FIGURE 3.5 – Default probabilities and thresholds with low consumption habits ($h = 0.25$) - Sensitivity with respect to speed of convergence



a) Flexible model b) Schäuble model c) Tsipras model

With low consumption habits (Figure 3.5), raising the speed of fiscal convergences reduces the default risk in flexible and Schäuble models but does not affect it in the Tsipras case. Indeed, rising up the speed of convergence limits the risk that the country will err in the side of too much debt, as it is very volatile, and hence reduces the risk of default in the Flexible and Schäuble regimes. Nonetheless, we can see that the quantitative effect is very small, so this result has to be qualified; furthermore, with weak fiscal instruments, the risk of default is larger for large habit persistence in Flexible and Schäuble cases and may explain why tougher fiscal rules are here needed. In the actual Greek case, i.e. Tsipras framework, increasing the speed of convergence has no effect on default risk.

3.5 Conclusion

Calibrating a New-Keynesian DSGE and using the comparison of two value functions to compute an implicit default probability, we have compared the robustness of a small Eurozone in a fixed exchange rate model to a flexible rate economy. The model that we have presented highlights the critical differences between a small open economy within the Eurozone and a flexible exchange rate economy. Furthermore, analysing the role of consumption habit persistence in three frameworks (a flexible case, a Schäuble case where the country goes out of the monetary union if it defaults, and a Tsipras case where the country stays in the monetary union even if it defaults), we were able to find a Schäuble theorem : in a monetary union and if habit formation is sufficiently high, if you give a country the choice between (i) default and leave the zone and (ii) default and stay in the union, it will always choose (ii), default and stay. This result is reversed in case of low habit persistence. This can be explained by both stability brought by the Eurozone in terms of currency noise and persistence in negative shocks brought by large habit parameters, which make the country like even more the stability.

For the conventional set of parameters the risk of default is larger in the Eurozone case when the country can maintain its fixed exchange rate regime after defaulting. Even if our setting simplifies drastically what effectively happened, this is somehow what happened to Greece : leaving the Eurozone and simultaneously losing access to the financial markets, on the other hand, would have been too costly.

Last, we have shown that the impact of fiscal policies may change from one framework to the other : a fast speed of consolidation in fiscal rules can help preventing defaults, but only if habit persistence is low and in flexible and "Grexit" framework. In the Greek case (Tsipras), this model thus show that imposing a faster speed of fiscal convergence was not relevant for preventing the country from another default.

Two main issues can extend this work : first, we could incorporate the possibility of redemption after default, which is more realistic than our forever exclusion from borrowing (as recently showed by the Greek re-entry on financial markets). Second, we could allow default on total debt rather than on external debt only ; this would allow us to calibrate the model for other Eurozone countries where domestic debt is majority (Italy for instance).

Annexe B

The Flexible model

Figure B.1 – Impulse response functions for the FLEX model - Productivity

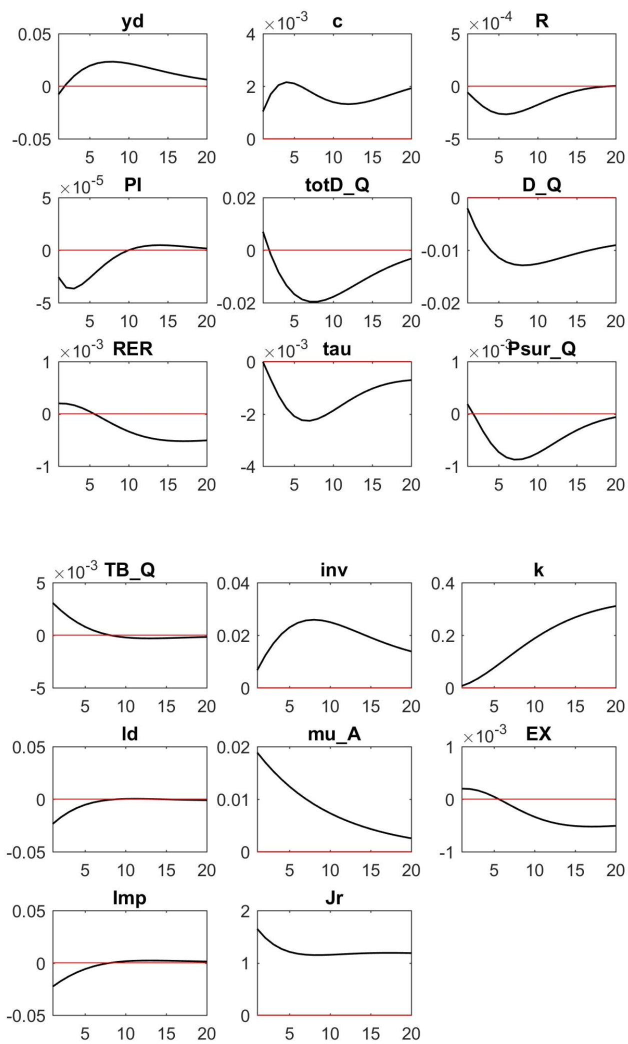


Figure B.2 – Impulse response functions for the FLEX model - Foreign demand

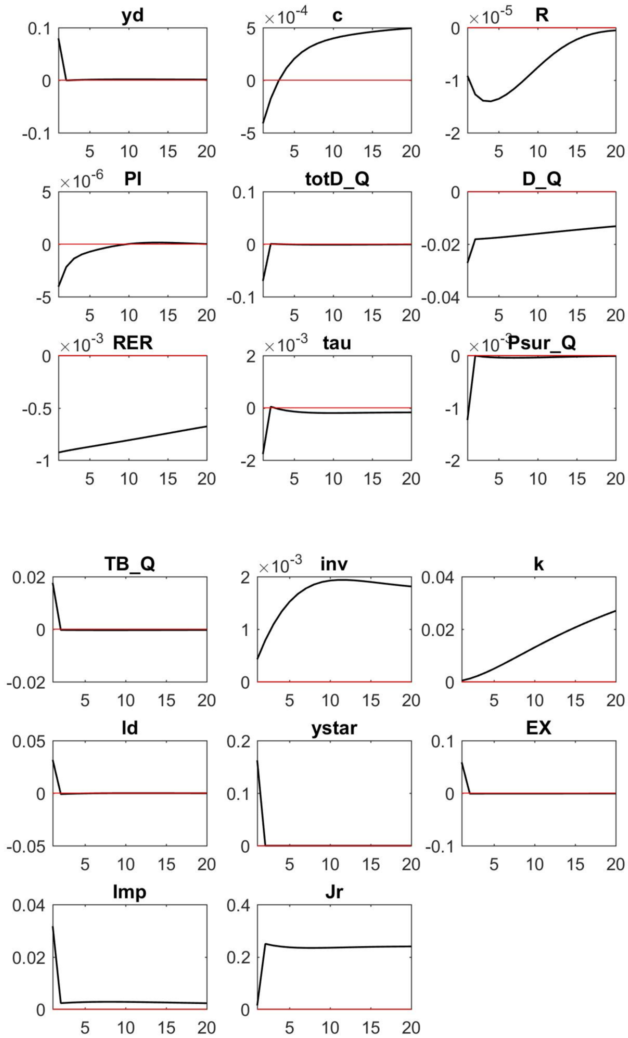
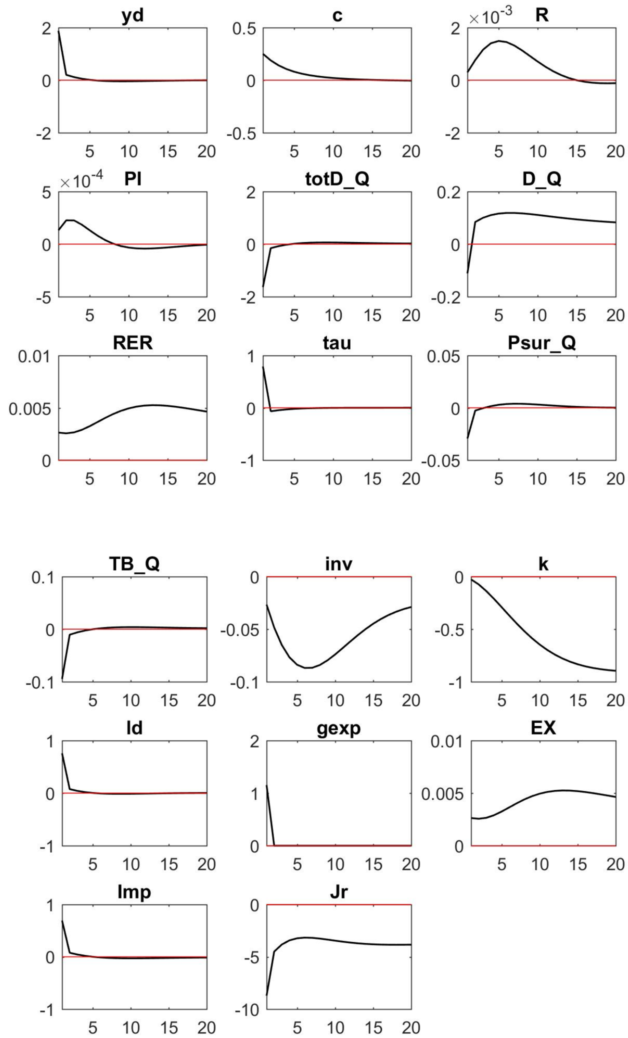


Figure B.3 – Impulse response functions for the FLEX model - Government expenditures



Annexe C

The Schäuble model

Figure C.1 – Impulse response functions for the Schäuble model - Productivity

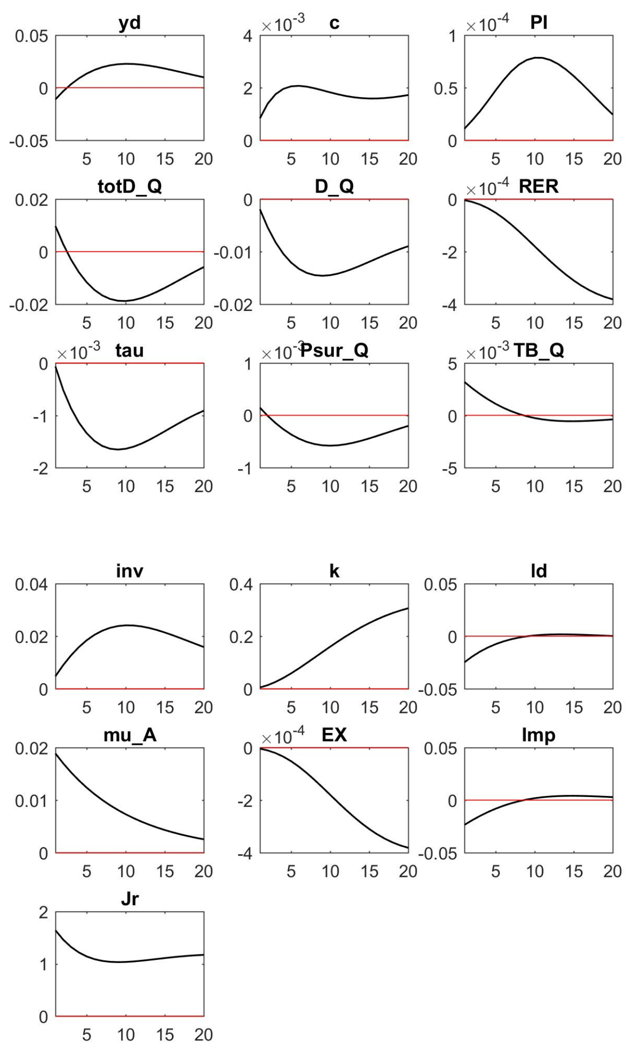


Figure C.2 – Impulse response functions for the Schäuble model - Foreign demand

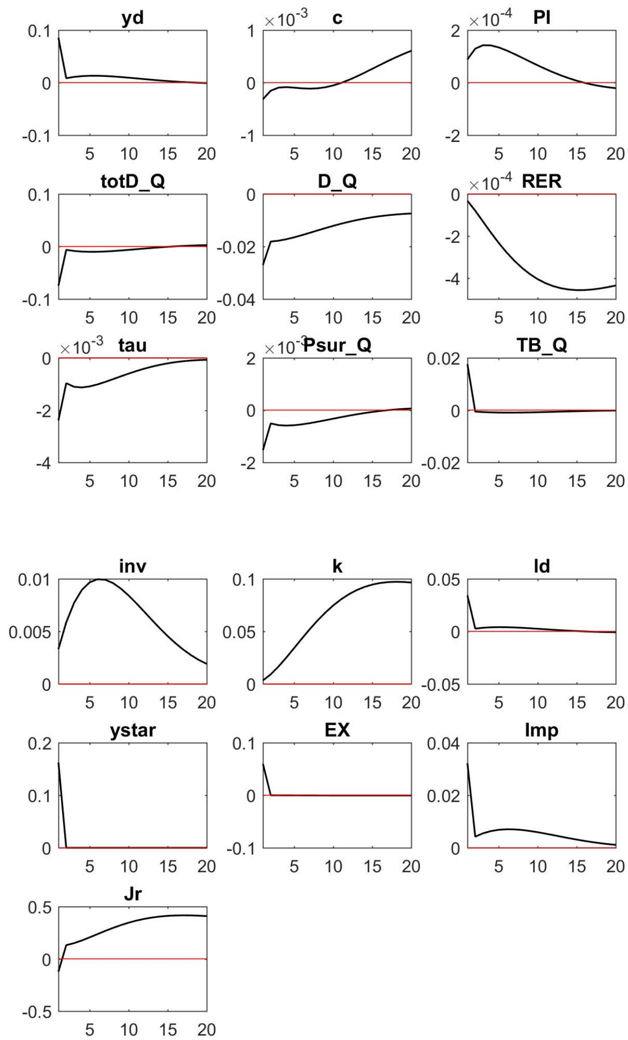
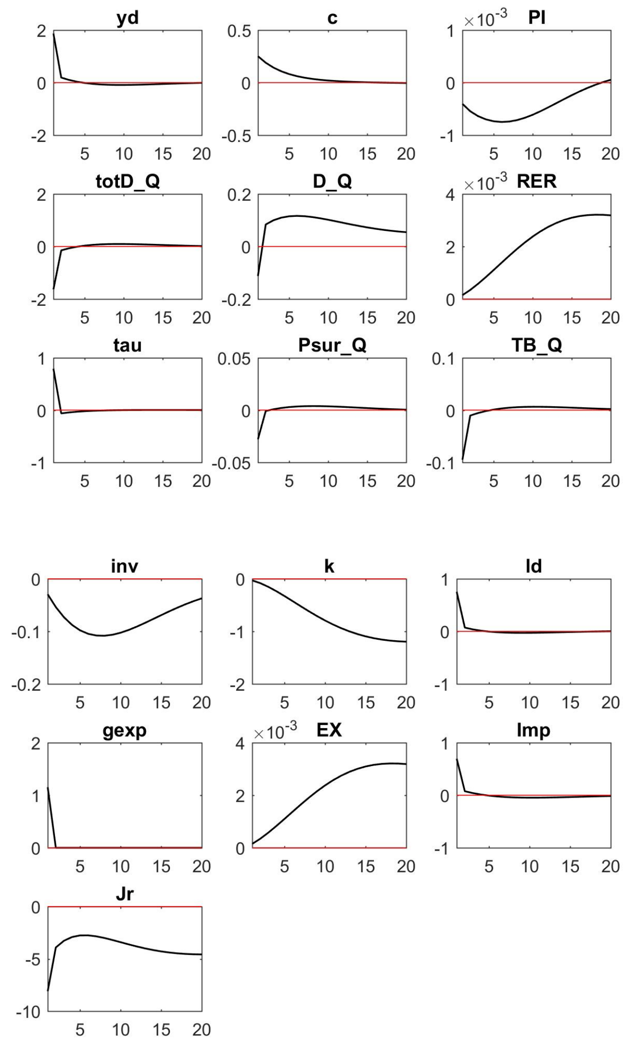


Figure C.3 – Impulse response functions for the Schäuble model - Government expenditures



Annexe D

The Tsipras model

Figure D.1 – Impulse response functions for the Tsipras model - Productivity

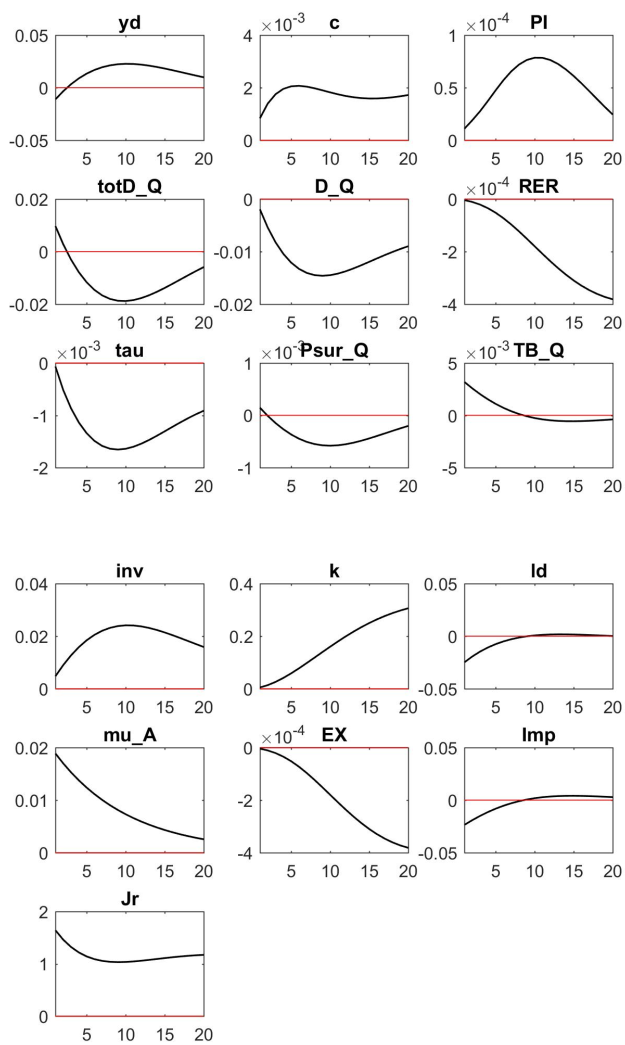


FIGURE D.2 – Impulse response functions for the Tsipras model - Foreign demand

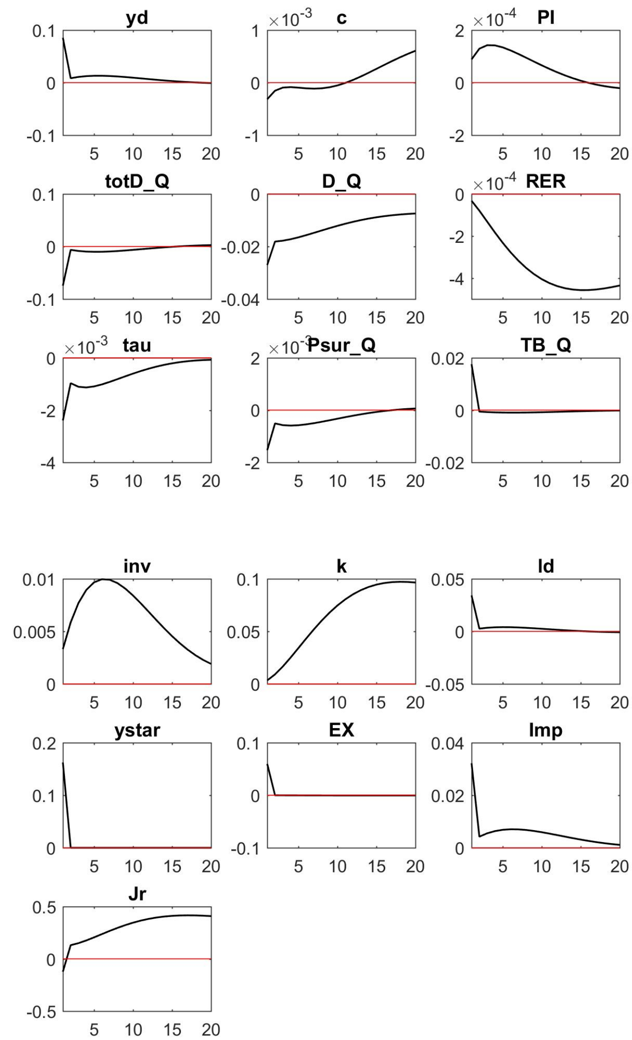
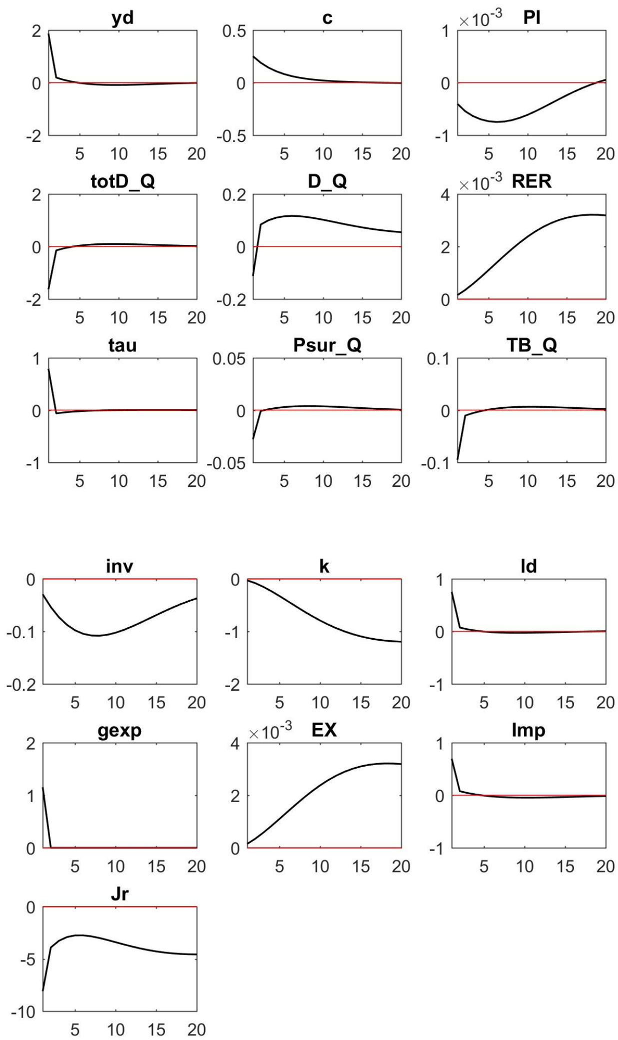


Figure D.3 – Impulse response functions for the Tsipras model - Government expenditures



Chapitre 4

The effect of ECB monetary policies on interest rates and volumes

This chapter gathers the works written with Jérôme Creel and Paul Hubert. It is now published in *Applied Economics*.

4.1 Introduction

This paper aims at establishing the effects of conventional and unconventional ECB monetary policies on both interest rates and volumes in the four largest economies of the Eurozone during the global financial crisis. So far, the literature has been rather segmented and we adopt a comprehensive empirical framework by looking at a fine decomposition of conventional and unconventional policy tools, by assessing their effect on different markets – government, non-financial corporations and households –, in different countries and on different outcome variables. This issue is topical since Mario Draghi, chairman of the ECB, justified the implementation of some of the unconventional policy tool – the Outright Monetary Transactions - by the disruption of the ECB monetary policy transmission to the real economy in some Eurozone countries. The question also matters theoretically. Unconventional monetary policies should be neutral (apart from signalling effects) except if there is some market segmentation over the following two dimensions : along the term structure (short and long term maturities are not perfect substitutes as there are duration preferences) or between countries (there is a home bias in debt holding or risk aversion to some country specific loans or debts). This is the irrelevance result of Eggertsson and Woodford [2003] in perfect financial markets. However, there has been strong empirical evidence against this neutrality in the most recent literature.

One of the pioneering studies about the monetary transmission mechanism is Bernanke and Blinder [1992] showing that the pass-through from the policy rate to lending and deposit interest rates is expected to be positive, whereas the pass-through to lending and deposits volumes is expected to be negative. Before the recent financial crisis, many studies have focused on the monetary transmission mechanism in the Eurozone. Degryse and Donnay [2001] with a SVAR, De Bondt [2005] with a vector error-correction model, Sorensen and Werner [2006] with a cross-country analysis, and Kleimeier and Sander [2006b] with expected and unexpected monetary policy impulses, assess the pass-through from the policy rate to money market rates or bank interest rates. The literature on the bank lending channel is less numerous than the one on the interest rate channel ; Chatelain et al. [2003] and De Santis and Surico [2013] show that bank characteristics play a role in the effect of monetary policy on bank lending.

Many articles have studied the effect of conventional monetary policy in the Eurozone during the worldwide financial crisis. Andries and Lecarpentier-Moyal [2012], Blot and Labondance [2013], Belke et al. [2012], Aristei and Gallo [2012], Gigineishvili [2011], Panagopoulos et al. [2010], Karagiannis et al. [2010], and von Borstel et al. [2015] focus on the interest rate channel. However, during the financial crisis, implementing monetary policy became much more complex as the transmission mechanism has been severely impaired by disruptions in the financial markets ; as a consequence, the ECB resorted to unconventional measures to provide additional stimulus to the economy. A large literature assesses the effectiveness of such measures [1]. Cordemans and de Sola Perea [2011], Abbassi and Linzert [2011], Lenza et al. [2010], Altavilla et al. [2014], Ghysels et al. [2014] and Szczerbowicz [2015] focus on the effect of unconventional tools on interest rates. Gambacorta and Marques-Ibanez [2011], Giannone et al. [2012], Darracq-Paries and De Santis [2013], Boeckx et al. [2014] and Andrade et al. [2015] analyse more specifically the bank lending channel. Bonaccorsi di Patti and Sette [2012] study the transmission of monetary shocks affecting Italian banks' balance sheets to the volume and cost of credit to non-financial corporations.

The literature is much segmented indeed : analyses focus either on conventional or unconventional measures, either on interest rates or volumes, and either on the money market, sovereign bonds or loans to NFC. Two types of estimation strategies have been mostly used : event-studies looking at the response to policy announcements, so their implicit focus is on the signalling and confidence channel specifically and the high-frequency response to these announcements, or VAR analyses with the amounts of liquidities provided or securities bought by the monetary authority, so the implicit focus is on the other channels and the lower-frequency response to those policies.

This paper contributes to the literature using VARs in three ways. First, we assess at the same time the pass-through to interest rates and volumes so as to capture both dimensions of each market. Second, we investigate at the same time the effects of both conventional and unconventional monetary policies, the latter being decomposed at a fine level. Third, the analysis is performed, over the financial crisis sample, for the four largest economies of the Eurozone : Germany, France, Italy and Spain, and at a disaggregated level encompassing sovereign bonds

1. For the US, see Bernanke et al. [2004]'s indirect evidence or more recently, Fleming et al. [2010], Hrung and Seligman [2011], Krishnamurthy and Vissing-Jorgensen [2011], Thornton [2011], Stroebel and Taylor [2009], Aristei and Gallo [2012] among others ; for the UK, Joyce et al. [2011], Joyce [2012] and Butt et al. [2014].

at 6-month, 5-year and 10-year horizons, loans to non-financial corporations, and housing loans to households.

We proceed in two steps. We first identify series of ECB policy shocks on the main refinancing operation interest rate for conventional policy and the amounts spent for each unconventional policy as stated in the ECB's Weekly Financial Statements, at the euro area aggregated level. We do so by removing the systematic component of each series and therefore stripping out their unpredictable component. Using amounts spent rather than announcements suggests that these policies could have been anticipated by market participants. However, we show that this is not the case and that our series of shocks are not predictable. We focus on amounts spent as we are interested in the real effects of unconventional policies, not the high-frequency effects of announcements. To identify unconventional monetary shocks exogenous to anticipation effects, we control for the effects of policy announcements. In doing so, we focus on the transmission channels other than the signalling and confidence channels, and we therefore provide a lower bound estimate of the effects of these policies. Second, we include these four estimated series of interest rate and unconventional policy shocks in country-specific structural VARs with five additional endogenous variables, namely industrial production, inflation, a proxy variable to control for credit demand (or bond issuance), interest rates and volumes for each of the five markets considered, as well as oil prices, a composite indicator of systemic stress (CISS) and the Euro Stoxx 50 index as exogenous variables.

The main result is that only the pass-through from the ECB rate to interest rates has been effective, consistently with the existing literature, while the transmission mechanism of the ECB rate to volumes has been weak. Unconventional policies have had uneven effects. It gives support to the decomposition of unconventional policies between excess liquidity, Longer-Term Refinancing Operations (LTRO) and Securities Held for Monetary Policy Purposes (SHMPP). Excess liquidity has an effect on interest rates in Germany and Spain, and on volumes in France and Spain. In comparison, the impacts of LTRO measures are weaker and concentrated exclusively on interest rates. In contrast, SHMPP measures which were targeted towards peripheral countries have been effective at modifying interest rates in these countries and, to a lower extent, volumes. One argument to explain the differentiated pass-through of ECB monetary policies lies on the complementarity of these policies. As stated by Mario Draghi, the objective of unconventional policies may have been to restore the transmission mechanism of the conventional policy. So as to shed light on this issue, we look at the effect of conventional policy shocks on unconventional policy tools and vice-versa. A shock to the conventional tool of monetary policy has no effect on any of the unconventional policies. Regarding the effect of shocks to unconventional tools on the ECB interest rates, there are only a few occurrences where excess liquidity and SHMPP policies complement the latter.

Another argument is that the successful pass-through from the ECB rate to interest rates, which materialized as a decrease in interest rates during the sample period, had a negative effect on the supply side of loans, and offset its positive effects on lending volumes. The interest rate channel may be a substitute to the bank lending channel on the supply side when net interest margins deteriorate, and ever more so for larger banks which retain market power. Landier et al. [2013] show that a 100 basis point decrease in the Fed funds rate leads a US bank at the 75th percentile of the income gap distribution to decrease lending by about 1.6 percentage point annually relative to a bank at the 25th percentile.

In a context where commercial banks attempt to increase their capital ratios while governments try to reduce their debts, a policy implication of this result would be for central banks to target more directly non-financial corporations or households when implementing unconventional monetary policy or to constrain more effectively bank lending to ensure an operative pass-through towards the real economy.

The rest of the chapter is organized as follows. Section 4.2 presents the theoretical framework, section 4.3 data, section 4.4 the identification of policy shocks and section 4.5 the empirical strategy and results. Section 4.6 concludes.

4.2 Framework

This paper is at the crossroads of two evolutions in monetary policy : the first, theoretical, relates to the introduction of financial frictions ; the second relates to central bank practices and their unconventional measures. These evolutions raise the issue of the transmission channels of monetary policy. Under the classical view of the transmission channel, interest rates impact economic activity by affecting relative prices in the economy (relative prices of capital, of future consumption in terms of current consumption and of domestic goods in terms of foreign goods) ; this constitutes the interest rate channel and encompasses most mechanisms that are not associated with financial frictions.

To the extent that consumer and investment spending, and in the first place, durable / capital goods expenditure depend on long rather than short rates, the expectations theory of the term structure holds, so that short rate movements are transmitted to long rates. Nevertheless, many features of the configuration of interest rates during the financial crisis are puzzling from the perspective of the expectations hypothesis (Gurkaynak and Wright [2012]). Furthermore, term premia have affected the extent to which changes in short rates are translated into further changes along the yield curve by responding systematically to offset movements in short rates, which is expected to weaken the effect of policy changes. Interest rate channels, due to market segmentation, may well differ in size from one market to another. As regards the conventional instrument of monetary policy, we thus expect a larger transmission mechanism on short-horizon markets than at a longer horizon.

The introduction of imperfect information in monetary policy theory has stressed a distinct role for financial assets and liabilities. The usual bank lending channel explains the effects of monetary policy with movements in the supply of bank credit. The essential feature is that the central bank can affect credit supply by financial intermediaries by altering base money, which affects the banks' balance sheet. The monetary policy transmission through this channel may be incomplete thanks to limited liability, credit rationing, or the imperfect substitutability between retail deposits and wholesale deposits or debt on the liability side of banks' balance sheets. Bernanke and Blinder [1988] assume fixed costs of direct financial market participation and banks' incomplete/imperfect information in the market for equity and corporate debt. They show that such structures amplify the effects of monetary policy shocks. However, this amplification will depend on the size of the lending contraction for a given shock : the more interest-inelastic is the demand for money, the lower will be this contraction. Consequently, the bank lending channel not only emerges on the equilibrium price of the market – the interest rate set on this market – but also on the volumes, provided one control for the demand for bank credit (we do so using Bank Lending Survey, BLS).

The introduction of imperfect information and more precisely non-nested information sets between the central bank and private agents raises a conceptual issue. If the monetary shock conveys signals about the central bank's information about the state of the economy or signals about the central bank's sentiment, then the shock may not only affect credit supply through standard transmission channels, but also credit demand. Two cases may emerge. First, if the interest rate cut infuses some optimism, it may increase credit demand ; consequently, the shock would produce an increase in credit volumes but its impact on market rates would be indeterminate. Second, if the interest rate cut does not succeed in infusing some optimism and reveals how worried the central bank is about the situation, credit demand may decrease ; consequently, the shock would generate a decrease in market rates but its impact on volumes would be indeterminate. However, four reasons can be put forth to reinforce the standard transmission channels in our empirical modelling strategy. First, our empirical model includes macroeconomic variables that should capture the dynamics of credit demand in general. We also control more specifically for proxies of credit demand, using BLS or government bond issuance. The impact of shocks is thus corrected for credit demand variations. Second, the argument of an impact of monetary shocks on credit demand rests on the central bank revealing some new information. The impact is likely to go through the confidence and signalling channels. However, we do not focus on these channels, which rely on central bank announcements and require an event-study approach ; instead, we estimate monetary shocks stemming from central bank actions. Third, Hubert and Maule [2016] show that the signal about the macroeconomic outlook, even though present, is dominated by the policy signal so that the overall effect of monetary shocks is the standard one. Finally, Bernanke and Blinder [1992] also acknowledge the possibility for a response of the demand for credit but rule it out in light of the similar response of bank portfolios and firms' borrowing to monetary shocks across means of finance. These four arguments point towards a predominant response of credit supply to monetary shocks so that we expect a reduction of credit volumes and an increase in credit rates after a contractionary monetary shock.

In contrast with conventional policies, the implementation of unconventional monetary policies hinges on new channels (see Joyce et al. [2011], for a survey) : portfolio balance, and default channels. These policies can also help improve the bank lending channel and a complementarity may emerge between conventional and unconventional policies.

After a change in the volume or structure of central bank balance sheet, transmission channels of unconventional policies will be operating provided financial frictions are included. Without financial frictions, the composition of central bank assets is irrelevant in the same sense as in the Modigliani-Miller theorem on the structure of corporate liabilities (Wallace [1981]). Curdia and Woodford [2011] and Gertler and Karadi [2011] propose extensions of DSGE models to quantitative easing measures taken by a central bank under disruptive financial markets or intermediaries. They show that credit policy can improve welfare provided financial disruption is sufficiently high (Curdia and Woodford [2011]) or provided an agency problem is introduced between financial intermediaries and depositors (Gertler and Karadi [2011]).

Unconventional measures take different forms ; consequently, they have different impacts on markets. The purchase of large amounts of debt instruments like QE is expected to impact directly on the sovereign debt market, or on a segment of it, e.g. the market related to the maturity involved in policy measures [2]. We expect that QE policy will produce a reduction in the interest rate and/or an increase in the volume of the sovereign debt market or on the segment targeted by the central banker. We also expect some spillovers on other markets or other segments of the same market via portfolio changes. Fixed-rate full-allotment operations which gave rise to excess liquidity are targeted towards the money market. Their impact is expected to be small and potentially negative on other markets : excess liquidity is mainly driven by the refinancing needs of banks, either because of low deposits inflows or because of unsecured short run liabilities (ECB Monthly Bulletin, January 2014). Long-term refinancing operations (LTRO) initially fuel excess liquidity. We do not expect a large impact on financial markets, on the volumes and, consequently, on interest rates. The announcement of Targeted LTRO by the ECB in June 2014, which aims explicitly at improving bank lending, gives weight to our expectation of a low impact of LTRO, although some impact of 2011 and 2012 LTRO on sovereign bonds markets could emerge.

Although the multiplicity of unconventional measures requires a differentiated study of their respective effects, we will also investigate their aggregate effects. Table 4.1 [3] summarizes the

2. OMT measures (not operational yet) involve the purchase of public bonds up to 3-year maturity.
3. A positive conventional monetary policy shock corresponds to an increase in the policy rate, while a positive unconventional monetary policy shock corresponds to an expansion of the central bank balance sheet.

theoretical predictions of conventional and (undifferentiated) unconventional policies on credit volumes and interest rates, assuming standard transmission channels.

TABLE 4.1 – Expected effects of positive monetary policy shocks

	Conventional policy	Unconventional policies
Interest rates	+	-
Volumes	-	+

4.3 Data

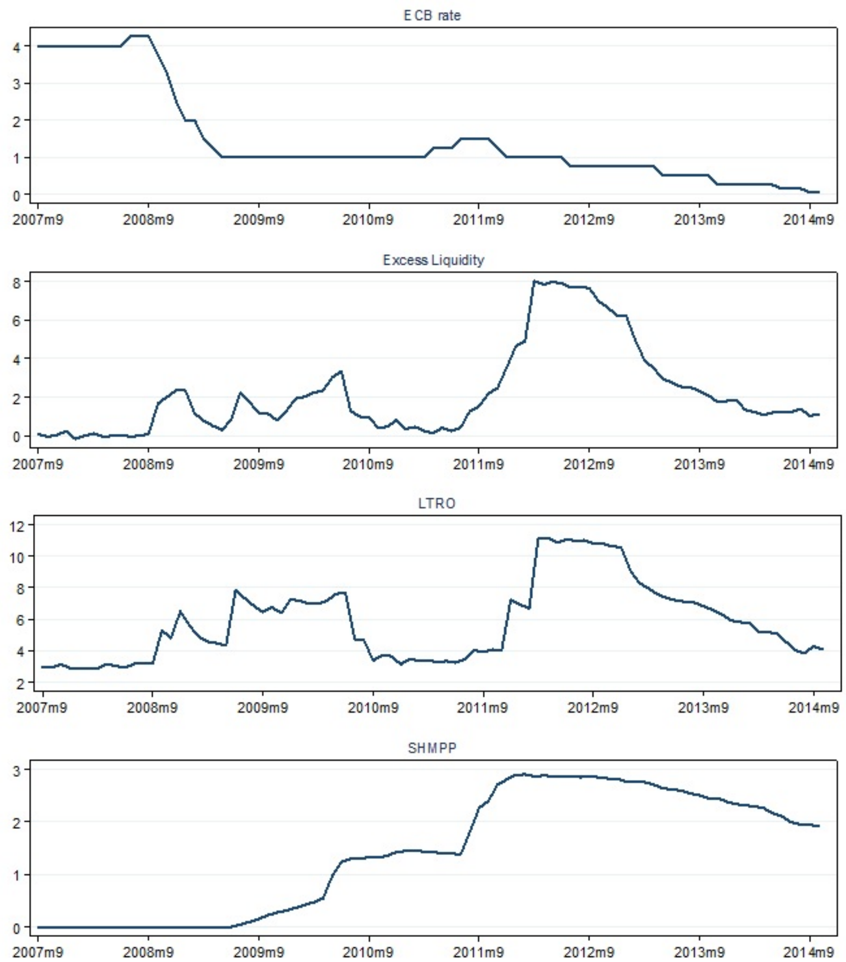
This paper focuses on the effects of monetary policies since the global financial crisis in four countries : France, Germany, Italy and Spain. Our dataset goes from June 2007 to October 2014 with a monthly frequency so it comprises 89 observations. The transmission mechanism is assessed for conventional and unconventional tools and on five markets : sovereign debt at three maturities, loans to non-financial corporations (NFC), and housing loans to households. Data descriptions and descriptive statistics are provided in the Appendix (Tables E.1 to E.3).

Conventional monetary policy is measured with the ECB rate for main refinancing operations, whose data over the period is available from the ECB database. We ground our decomposition of unconventional monetary policies in the accounting decomposition reported by the ECB itself ; the ECB decomposition rests on different purposes allocated to each policy tool. We therefore use the ECB's weekly financial statements (WFS) [4] to obtain a fine decomposition of all unconventional policy measures between liquidity provision tools, longer-term refinancing tools and asset purchase tools. We have already discussed in section 4.2 about the differentiated objectives of unconventional measures ; for this reason, we aim at estimating precisely their differentiated effects on interest rates and volumes. Focusing on one type of measure only would not give full credit to the set of measures that the ECB has implemented during the crisis. The simplest unconventional tool is excess liquidity (current accounts – reserve requirements + deposit facility – marginal lending facility, or in WFS terms : item 2.1 – res. req. + item 2.2 – item 5.5). The second set of unconventional tools is Longer-term Refinancing Operations (in WFS terms : item 5.2). The most unconventional instrument is the amount of Securities Held for Monetary Policy Purposes (SHMPP), which includes the Securities Market Program, the 1st, 2nd and 3rd Covered Bond Purchase Programs, and the most recent Asset-Backed Securities Purchase Program (in WFS terms : item 7.1) [5]. This latter category of tools appears heterogeneous in terms of types of assets purchased but it shares the common objective of decreasing risk premium and rebalancing

4. https ://www.ecb.europa.eu/press/pr/wfs/2015/html/index.en.html
5. Because the "Whatever it takes" of Mario Draghi on July 26, 2012 and the OMT program do not appear anywhere in the ECB's WFS, we are not able to assess their macroeconomic impact. This could only be done through event-studies measuring the confidence and signalling channels of their announcements, which goes beyond the scope of this paper.

bank portfolio to support financing conditions. These data series are taken from the ECB Statistical Data Warehouse, and are expressed in percentage of Euro area (changing composition) GDP. Figure 4.1 plots the four variables. It highlights the differences in the timing and size of policy measures which require an individual treatment.

FIGURE 4.1 – ECB policy instrument time series



Note : The ECB rate is expressed in % while the three unconventional tools are expressed in percentage of EA GDP.

For each country (France, Germany, Italy and Spain), the endogenous variables needed for estimating the monetary transmission mechanism include the specific interest rates and their corresponding volumes.

The monetary transmission mechanism is first assessed in the sovereign debt market. Data availability for auctions' results has limited the number of countries to only four. Data for new issuances were collected from national debt agencies (Agence France Trésor, Banco de España, Banca d'Italia, Deutsche Finanzagentur). These agencies publish their auctions of public debt on a daily basis with different occurrences, approximately 20 auctions per day for the Spanish debt agency, three daily auctions five times a month for the Agence France Trésor, three auctions per month for the Deutsche Finanzagentur and ten auctions per month for the Italian agency. Consequently, the notion of government bond supply which we consider here is the result of a high-frequency debt portfolio management ; it is disconnected from the low-frequency approval of national budget policies at parliaments. After compiling all auctions at a monthly frequency, we have chosen allotments and corresponding yields for bonds with 6-month, 5-year and 10-year maturity. Indeed, these maturities seem to be the most representative of monthly auction amounts [6]. For each country, bonds from 165-day to 210-day maturity are chosen as a proxy for 6-month maturity bonds, bonds from 54-month to 72-month maturity for 5-year maturity bonds and bonds from 114-month to 132-month maturity for 10-year maturity bonds ; thus, we escape the problem of disregarding close-to-reference maturity issuances (5 months and 27 days instead of 6 months for example). The allotments are expressed in percentage of Euro area GDP.

For the market of loans to NFC, we take the new business volumes and their corresponding annual interest rates, with new business volumes expressed as a percentage of Euro area GDP. These data were available over the period on national central bank's databases (Banque de France, Banca d'Italia, Bundesbank) or Datastream for Spain [7].

The lending market to households is usually decomposed into housing loans and cash loans. In each country, cash loans represent a relatively small portion of all loans to households and they are traded at a legal interest rate ceiling which has substantially less variance than interest rates on housing loans [8]. For both reasons, we decided to focus on housing loans whose interest rates vary with policy rates. For each country, we take the 'new business' volume of housing loans and their corresponding annual interest rates. New business volumes are expressed as a percentage of Euro area GDP. These data were available over the period on national central bank's databases (Banque de France, Banca d'Italia) or Datastream for Spain and Germany.

Consistently with the discussion of section 4.2, empirical outcomes will be partial, unless we correct the supply of bonds and credit for exogenous determinants and for demand-driven factors. New public debt gross issuance does not only respond to a new policy environment (policy rate, GDP change, etc.) but it also stems from former commitments, like debt redemption. Thus, we use debt redemption as a proxy of the lowest bound of refinancing needs of government, to net out new issuances of gross debt. Consequently, the estimated monetary channels on sovereign markets are based on a proxy of new issuances of net debt. As regards credit to NFC and hou-

6. Together, they represent 25% of the French newly issued sovereign debt (9% for 6-month maturity bonds, 8% for 5-year maturity bonds and 8% for 10-year bonds), 32% of the Spanish one (2% for 6-month, 14% for 5-year, 16% for 10-year), 49% of the Italian one (26% for 6-month, 12% for 5-year and 11% for 10-year), 58% of Germany's (21% for 6-month, 17% for 5-year and 20% for 10-year).

7. The transmission channel we will capture here won't be a pure banking channel, since firms can also issue bonds and be funded directly on the secondary market.

8. In each country, cash loans represent 30% of all loans to households on average over the sample. The variance of interest rates on housing loans is nine times higher than the variance of interest rates on cash loans in Germany, three times higher in Italy, 30% higher in France and 18% higher in Spain.

seholds, we use BLS as a proxy of credit demand, so that we control for that side of the market and the estimated responses of credit volumes to monetary shocks is driven by credit supply.

A set of macroeconomic variables is used for the two stages of the analysis, first the identification of common monetary policy shocks and, second, the estimation of country-specific and market-specific monetary channels of transmission. This dataset comprises Euro area aggregate data and national data. At the aggregate level, oil prices, the unemployment rate, the CISS, the Euro Stoxx 50, the 10-year euro area average sovereign bond interest rate, private credit growth and the euro/dollar exchange rate are taken from the ECB Statistical Data Warehouse. Oil prices, CISS and Euro Stoxx 50 indices are the same variable for all countries and correspond to Brent crude oil price in euro, expressed in month over month percentage change, to the Composite Indicator for Systemic Stress, capturing financial instability, and to the stock price index for the major 50 European firms. At the national level, for each country, the consumer price index is available on ECB Statistical Data Warehouse, and the volume of industrial production, used as a proxy for domestic output, is available on Eurostat. Both are expressed in year over year percentage change. We add the stock price index for their major firms : CAC40 for France, DAX for Germany, FTSE MIB for Italy and IBEX35 for Spain. All these are available on ECB Statistical Data Warehouse or Euronext website. Table E.1 in the Appendix provides some descriptive statistics for all variables.

4.4 Identifying ECB policy shocks

Before estimating country-specific and market-specific structural VARs, we identify for each instrument at the Euro area aggregated level ECB policy shocks orthogonal to a wide array of macroeconomic variables. We aim at removing the systematic component underlying the evolution of the four policy instruments so as to retain their unpredictable part. The rationale for this identification is twofold. First, it aims at avoiding endogeneity and, second, it is consistent with the ECB deciding and executing its policies at the aggregate Euro area level.

Our identification of shocks focuses on the actual implementation of monetary policies, although one may argue that the shock happens at the time of the announcement and that most of its effect is therefore realised on the announcement of the policy. However, focusing on announcements with event-studies[9] only measures the signalling and confidence channels on very short time windows. These effects might be offset over the following days. In addition, it does not tell what the actual effects of the policy are, and it only informs about the credibility of the monetary authority. Ultimately, if the effect comes directly on the announcement, this goes against our hypothesis and our identification should capture the lower bound of the effect of monetary policies. The fact that our shocks may be anticipated because of the announcements creates another issue. To cope with it, we first control for the systematic responses of monetary

9. Alternatives include Instrumental Variables but there is no obvious relevant instrument to our knowledge, or usual VAR sign-restrictions but they need strong theoretical priors, while our stance here is to let the data speak.

policies to announcements and second we assess that our series of shocks are not predictable.

Assuming first that the dynamics of $Y_t = \{ECB\ rate,\ EL,\ LTRO,\ SHMPP\}$ is driven by policymakers' systematic responses to data in their information set Ω_T, in the spirit of Romer and Romer [2004], where $f(.)$ is a function capturing their systematic reaction, and second that the term ε_t^Y reflects unexpected shocks to the four variables, the model extracting the exogenous shocks can be represented by equation (4.1). This equation introduces another assumption : by removing the policymakers' information set at date t, we capture the response of policymakers to contemporaneous macroeconomic developments, not to lagged ones only. This means that monetary shocks in turn cannot affect macro variables contemporaneously, which might be considered as an extreme assumption for high-frequency variables. However, since the purpose of this section is to generate exogenous shocks to deal with endogeneity issues, it is more important to extract the maximum of the possible systematic responses of policy instruments to contemporaneous and lagged macroeconomic developments rather than to keep some room for endogeneity in our later estimation of the effects of monetary policy.

$$Y_t = f(\Omega_t) + \varepsilon_t^Y \tag{4.1}$$

Equation (4.1) can be viewed as the reaction function of central bankers, so that in its simplest Taylor-rule form, the information set would only comprise inflation and output, proxied by industrial production. We augment the set of variables that policymakers are likely to focus on with oil prices, the unemployment rate, the CISS, the Euro Stoxx 50, the 10-year euro area average sovereign bond interest rate, private credit growth, and the euro/dollar exchange rate. For each of the four policy instruments, we also augment the information set with the remaining three policy instruments, making each of the four shocks orthogonal to the other policy instruments. The estimated equation for the ECB rate is given in equation (4.2) whereas the equations for EL, LTRO and SHMPP are of a similar form except that they are augmented with dummies for unconventional policy announcements :

$$i_t = \alpha + \beta_i i_{t-1} + \sum_{k=0}^{3} \beta_{X,k} X_{t-k} + \sum_{p=0}^{1} \beta_{Z,p} M_{t-p} + \sum_{j=0}^{1} \beta_{M,j} P_{t-j} + \varepsilon_t^i \tag{4.2}$$

where X_t includes inflation and output, M_t the additional macro variables listed above, and P_t the three remaining policy instruments. In contrast with conventional policy actions which are not announced in advance, unconventional policies are first announced and then implemented in the following months. We introduce dummies to control for the effects of unconventional policy announcements and so identify unconventional monetary shocks exogenous to anticipation effects. The estimation sample period starts in March 2006 to obtain residuals on the sample period studied : June 2007 - October 2014.

Table F.1 in the Appendix reports the output of the estimation of Equation (4.2) for the four policy instruments. The contribution of the systematic response to the variables in vectors X, M and P explains 99.7, 98.9, 98.2 and 99.8% of the variance of the ECB rate, excess liquidity, LTROs and SHMPP respectively. The unexplained components, the ε_t^Y residuals (plotted in Figure 4.2), are considered as the aggregate policy shocks implemented by the ECB. We introduce them in the country-specific structural VARs, which in turn enable us to derive ECB policy shocks that are also exogenous to country-specific and market-specific macroeconomic developments.

Properties of our series of shocks makes the identification approach relevant : residuals are not auto correlated (Table F.2 in the Appendix displays outcomes of the Cumby-Huizinga test), they are unpredictable from macro data over the last 3 or 6 months (Table F.3 in the Appendix shows p-values of a F-test), they have a zero mean ; although the shocks are not purely independent by construction, residuals are not statistically correlated together, except excess liquidity and LTRO shocks which share similar objectives (Table F.4 in the Appendix provides descriptive statistics and correlations of the estimated shock series). We could also compare these series to those obtained when policy announcements are included (high-frequency analysis and event-studies) : this is for instance done by Altavilla and Gianonne [2014], or more recently by Hubert [2017].

4.5 The Effects of Conventional and Unconventional Monetary Policies

4.5.1 A Structural VAR Model

A structural VAR model is used to decompose the aggregate ECB policy shocks into country-specific and market-specific mutually orthogonal components with a structural economic interpretation. We augment a standard VAR for monetary policy analysis including industrial production (IP), inflation (CPI), and (shocks to) the conventional policy instrument with the three other aggregate ECB policy shocks, a proxy for bond issuance/credit demand as discussed in section 4.3 (mc_d), new loans' interest rates (mc_r) and volumes (mc_v) for each market (m) and country [10] (c).

We also include as exogenous contemporaneous variables in the estimation oil prices, the CISS and domestic stock market indices in the vector F_t. For each market, let

$$Z_t = [IP_t, CPI_t, mc\_d_t, mc\_v_t, mc\_r_t, \varepsilon_t^{SHMPP}, \varepsilon_t^{LTRO}, \varepsilon_t^{EL}, \varepsilon_t^{ECBrate}]'$$

10. The estimated four shocks from equation (1) used in equation (3) are generated regressors that might cause biased standard errors (Saxonhouse, 1976Saxonhouse [1976]). This issue is common to all empirical studies that estimate exogenous shocks in a first step as in Romer and Romer (2004)Romer and Romer [2004], but is more acute when the generated regressors are not normally distributed, which is not the case of the estimated residuals from equation (4.1) – see Figure F.1 in the Appendix.

represent the (9 x 1) vector that contains the endogenous variables at date t :

$$AZ_t = a + B\sum_{k=0}^{3} Z_{t-k} + CF_t + DE_t \tag{4.3}$$

where $b_{i,j}$ in the B matrix are $(kx1)$ vectors, F is the vector comprising the three exogenous contemporaneous variables, C their associated parameters, and :

$$A = I_9 \tag{4.4}$$

and

$$B = (b_{i,j}) \tag{4.5}$$

for $[i, j] \in [1, 9]^2$.

The reduced-form errors

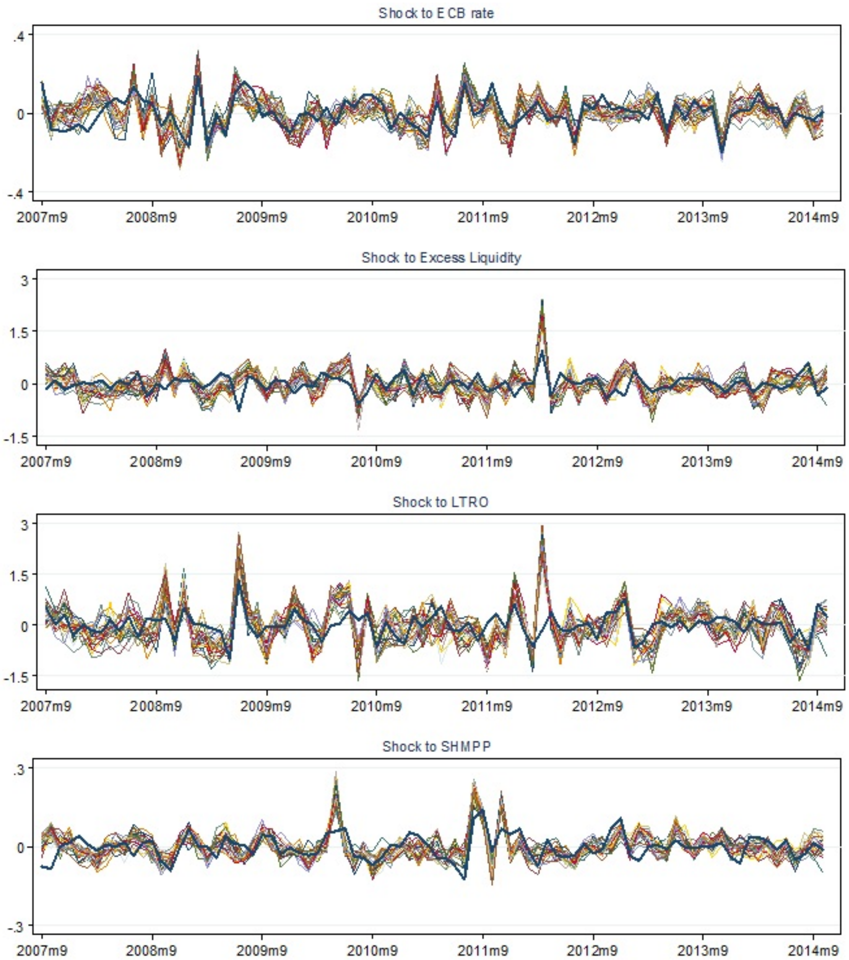
$$E_t = [e_t^{IP}, e_t^{CPI}, e_t^{mc\_d}, e_t^{mc\_v}, e_t^{mc\_r}, e_t^{SHMPP}, e_t^{LTRO}, e_t^{EL}, e_t^{ECBrate}]'$$

combine the structural innovation to a given variable with the contemporaneous responses to the other variables. The recursive identification assumption postulates that the structural errors are independent, and that reduced-form errors are related to structural errors through a lower triangular D matrix. This means that the covariance between the reduced-form errors is attributed to the structural error of the variable ordered previously in Z_t, and that the structural error is uncorrelated to the reduced-form errors of the preceding variables. This recursive identification therefore depends on the ordering of the variables in the Z_t vector.

In our benchmark VAR, we assume that shifts in industrial production and inflation produce a contemporaneous change in policy variables and in market prices and volumes. The latter two also react contemporaneously to policy variables, while by construction policy variables react to innovations to market prices and volumes only with a lag. This is consistent with the institutional framework and decision-making constraints which, at a monthly frequency, introduce delays in the monetary reaction to changes on financial and loans markets. Concerning the relative position of the policy variables, we assume that the unconventional interventions react with a lag to the ECB interest rate consistently with the prevalence of the conventional instrument over unconventional ones.

The structural VAR analysis is performed with $k = 3$ lags, and with a small sample estimator because the number of observations is small. The variance-covariance matrix is estimated with a small-sample degrees-of-freedom adjustment : the divisor used is $1/(T - m)$ instead of the maximum likelihood divisor $1/T$, where T is the sample size and m the average number of parameters in each of the equations. All the eigenvalues lie inside the unit circle, so the VAR model satisfies the stability condition to interpret impulse–response functions.

FIGURE 4.2 – Euro Area aggregate policy shocks and country- and market-specific shocks



Note : Thick lines plot the Euro Area aggregate policy shocks estimated in section 4.4 while thin lines plot the country- and market-specific shocks estimated with equation (4.4) but including ECB and unconventional variables in the vector of endogenous variables $\bar{Z}_t$ in section 4.5.1. Since the analysis is performed for four countries and five markets, there are 20 series of country- and market-specific shocks plotted

Figure 4.2 confronts ECB aggregate policy shocks, as discussed in section 4.4, with an alternative identification approach of country- and market-specific ECB policy shocks. The latter stem from the estimation of the model described in equation (3) where

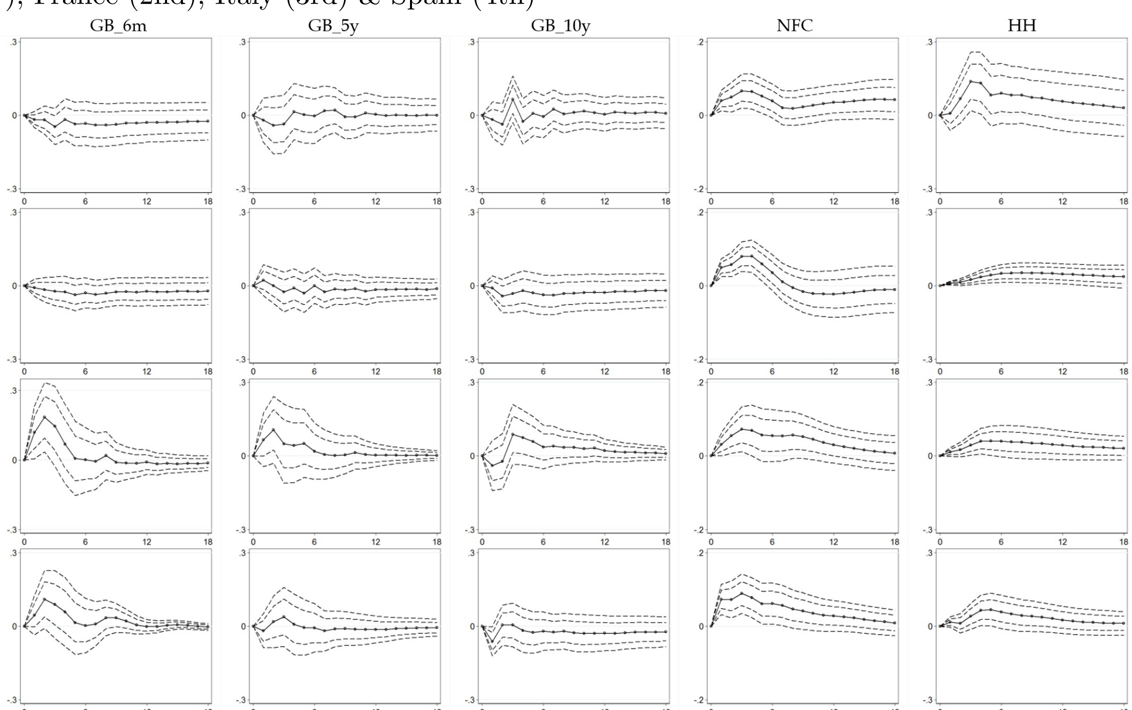
$$\bar{Z}_t = [IP_t, CPI_t, mc\_d_t, mc\_v_t, mc\_r_t, SHMPP_t, LTRO_t, EL_t, ECBrate_t]'$$

substitutes for vector Z_t. The differences among the country- and market-specific ECB policy shocks are substantial ; they show that this alternative identification approach is not suitable to an investigation into the country- and market-specific channels of transmission of a common monetary policy shock. Moreover, the differences between, on the one hand aggregate and, on the other hand, country- and market-specific policy shocks show that the former identification approach gives unique outcomes; it gives support to the choice of identifying aggregate policy shocks as in section 4.4.

4.5.2 Impulse Response Functions

Figure 4.3 plots the impulse responses of interest rates to a one-S.D. innovation (a 0.08 percentage point increase) in the ECB interest rate, for Germany, France, Italy and Spain (rows) and for sovereign bonds at 6-month, 5-year and 10-year horizons, loans to NFC, and housing loans to households (columns). The pass-through from the ECB interest rate to market rates is significant and positive as expected for all countries on the markets for loans to NFC and loans to households, though it is a bit less significant on the latter than on the former type of market. This result is in line with the literature (see for instance Cordemans and de Sola Perea [2011], Belke et al. [2012] or Andries and Lecarpentier-Moyal [2012]). The impacts on the NFC markets last 6 months in Germany, France and Italy and a bit longer in Spain. The length of impact is also close to 6 months on the market for housing loans, except in France where it last beyond 12 months. In contrast with the former markets, the pass-through on sovereign-debt markets is less significant and an opposition between Northern and Southern countries of the Euro area emerges : there is no pass-through in Germany and France, whereas it is positive and significant in Italy, at the three different maturities, and in Spain, temporarily at the 6-month maturity.

FIGURE 4.3 – Response of interest rates to a positive ECB interest rate shock in Germany (1st row), France (2nd), Italy (3rd) & Spain (4th)



Note : The impulse response corresponds to the percentage point change in interest rates, in response to a one-S.D. innovation in the ECB interest rate, together with one and two S.E. confidence band intervals.

Figure 4.4 plots the impulse responses of volumes to a one-S.D. innovation in the ECB interest rate. We would expect volumes to be negatively correlated to an increase in the ECB interest rate but we obtain mixed results. First, there is very scarce and temporary evidence of a pass-through. Debt at 10-year horizon in Germany, debt at 6-month horizon in Italy and NFC and housing loans in Spain show short-lived evidence. Second, the pass-through is very low, except for NFC loans in Spain where the elasticity is close to 2. Third, there are also unexpected positive impacts, in Italy and France.

FIGURE 4.4 – Response of volumes to a positive ECB interest rate shock in Germany (1st row), France (2nd), Italy (3rd) & Spain (4th)

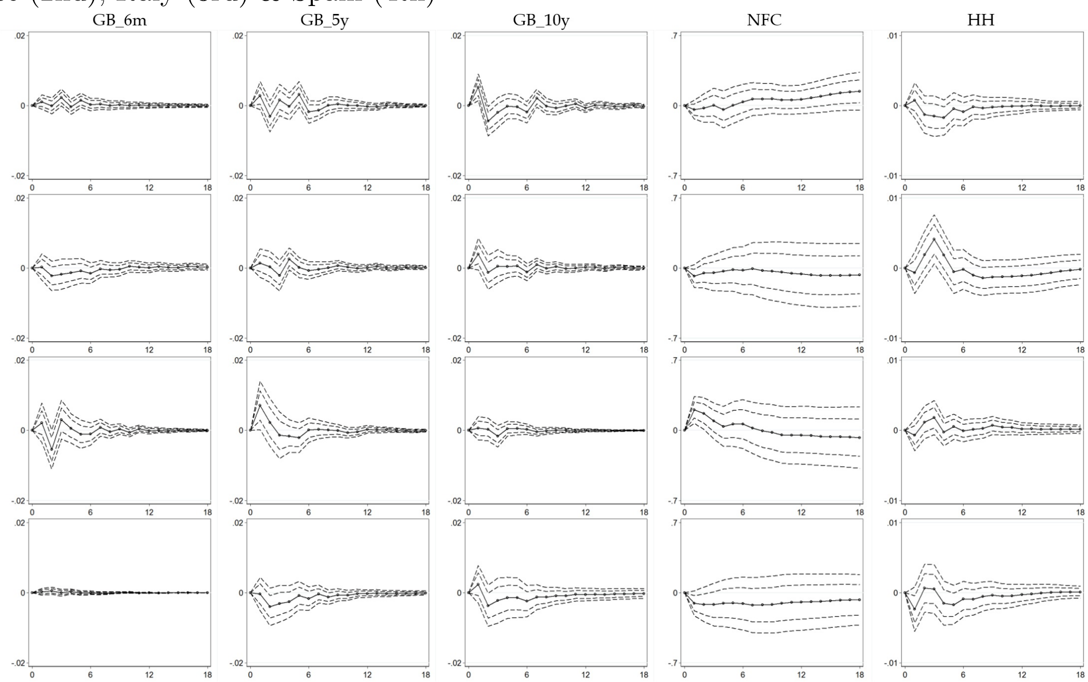


Figure 4.5 presents the impulse responses of interest rates to a one-S.D. innovation (a 0.16 percentage point increase in terms of Euro Area GDP) in excess liquidity. There is evidence of a pass-through from unconventional policies to interest rates over our sample in Germany on the market for housing loans and in Spain on the market for NFC loans. Both last more than 6 months. The fact that the interest-rate pass-through of excess liquidity is relatively short-lived and similar between a core and a peripheral country is consistent with results reported in von Borstel et al. [2015]. In our setting however, for Italy, there is no such pass-through. In France, one can interpret the (statistically weak) positive response of interest rates on sovereign bonds at 10-year horizon as a portfolio balance effect. Excess liquidity would induce demand for high-yield bonds. Figure 4.6 which plots the impulse responses of volumes to a one-S.D. innovation in excess liquidity shows that French public debt at 10-year horizon reacts positively and temporarily to the shock on EL. In Germany and Italy, there is no evidence of a pass-through from EL to volumes. In contrast, Spain shows evidence of a relatively strong pass-through for NFC loans, with a maximum elasticity above unity.

Figure 4.5 – Response of interest rates to a positive Excess Liquidity shock in Germany (1st row), France (2nd), Italy (3rd) & Spain (4th)

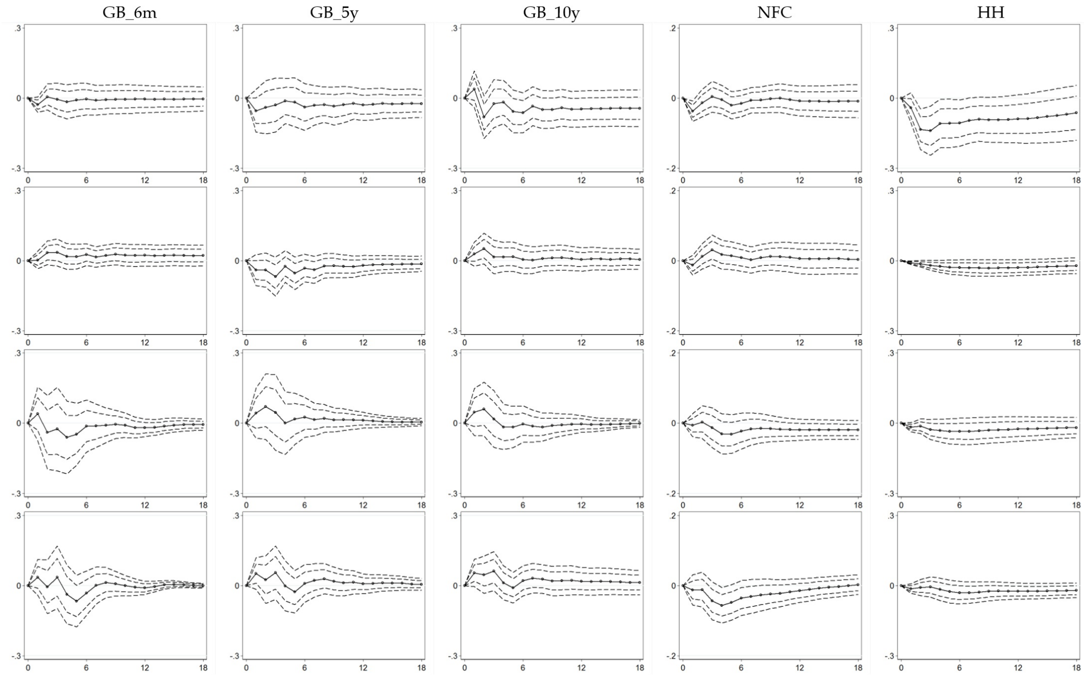
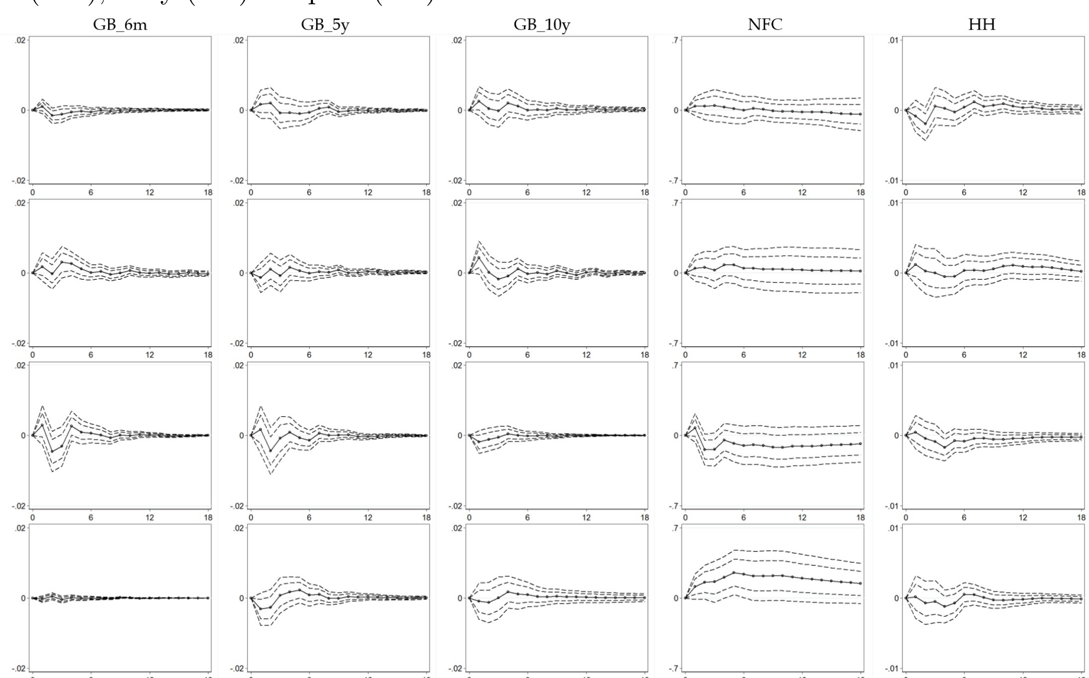


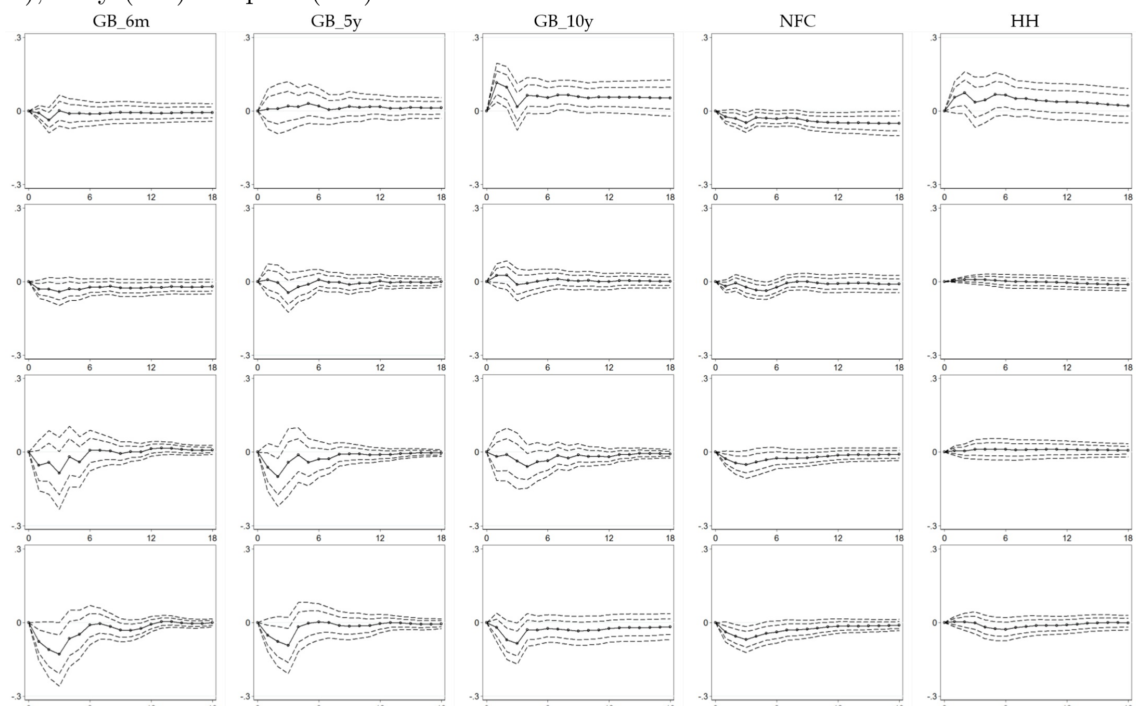
Figure 4.6 – Response of volumes to a positive Excess Liquidity shock in Germany (1st row), France (2nd), Italy (3rd) & Spain (4th)



Note : The impulse response corresponds to the percentage point change in interest rates, in response to a one-S.D. innovation in the ECB interest rate, together with one and two S.E. confidence band intervals.

Among the four countries studied, Spain emerges as the most beneficial one of LTRO measures, but only in terms of market rates. Figure 4.7 presents the impulse responses of interest rates to a one-S.D. innovation (a 0.32 percentage point increase in terms of Euro Area GDP) in LTROs. The impact on the market for NFC loans in Spain is significant, negative and lasting 6 months. The same impact is weaker in Germany, where evidence also points to temporary and significant rises in interest rates, on the 10-year bond market and on the market for housing loans. In France and Italy, there is no pass-through from LTRO to interest rates.

FIGURE 4.7 – Response of interest rates to a positive LTRO shock in Germany (1st row), France (2nd), Italy (3rd) & Spain (4th)



Note : The impulse response corresponds to the percentage point change in interest rates, in response to a one-S.D. innovation in the ECB interest rate, together with one and two S.E. confidence band intervals.

Figure 4.8 plots the impulse responses of volumes to a one-S.D. innovation in LTROs, and does not show any evidence of a pass-through. For France, this result contrasts with Andrade et al. [2015] who use data on individual firms and banks and conclude on a significant impact of LTRO on volumes ; the semi-elasticity of additional bank credit to firms vis-à-vis LTRO is 0.1 in their study. According to our results, LTRO measures have only had a limited impact in the Euro area.

Figure 4.9 presents the impulse responses of interest rates to a one-S.D. innovation (a 0.04 percentage point increase in terms of Euro Area GDP) in SHMPP. The shock shows a discrepancy in impact between, on the one hand, Germany and France, and on the other hand, Italy and Spain. This result is in line with Szczerbowicz [2015]. In the former countries, we find a statistically weak but positive impact of SHMPP on interest rates, for sovereign bonds at 6-month horizon and NFC loans in Germany, and for sovereign bonds at 5 and 10-year horizon in France.

Figure 4.8 – Response of volumes to a positive LTRO shock in Germany (1st row), France (2nd), Italy (3rd) & Spain (4th)

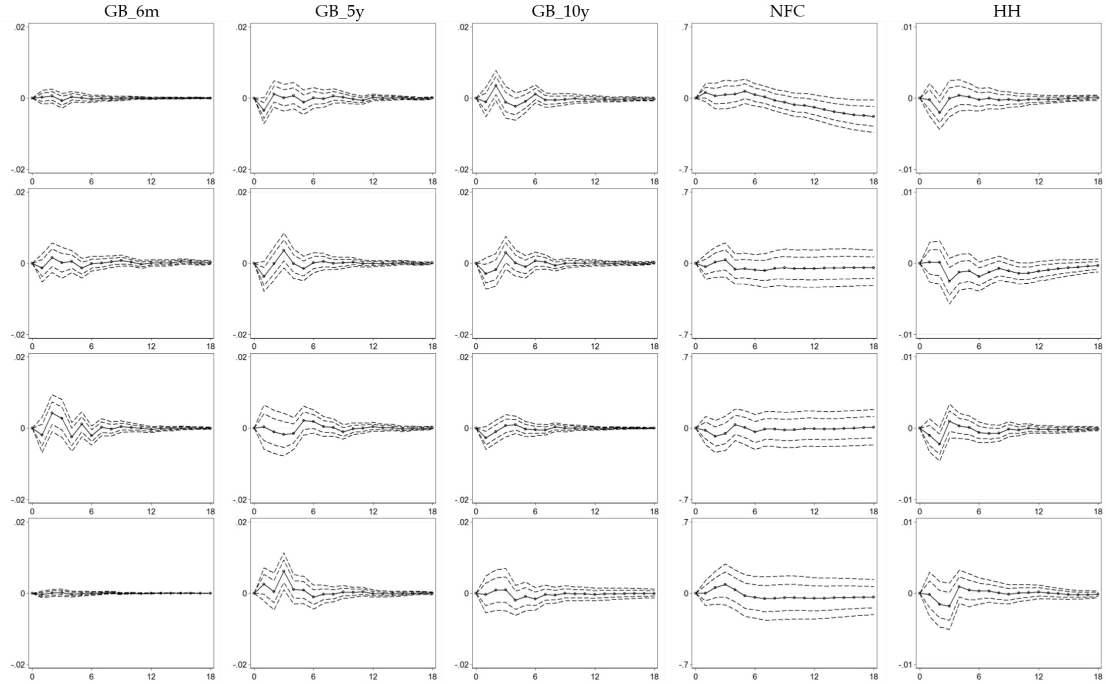
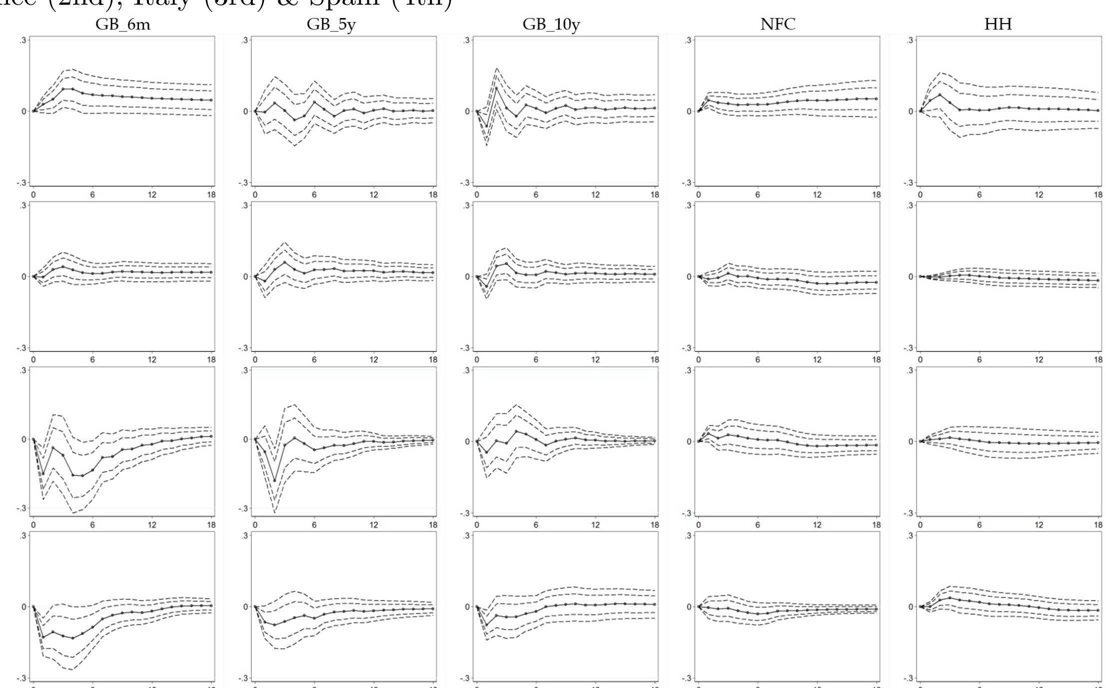


Figure 4.9 – Response of interest rates to a positive SHMPP shock in Germany (1st row), France (2nd), Italy (3rd) & Spain (4th)

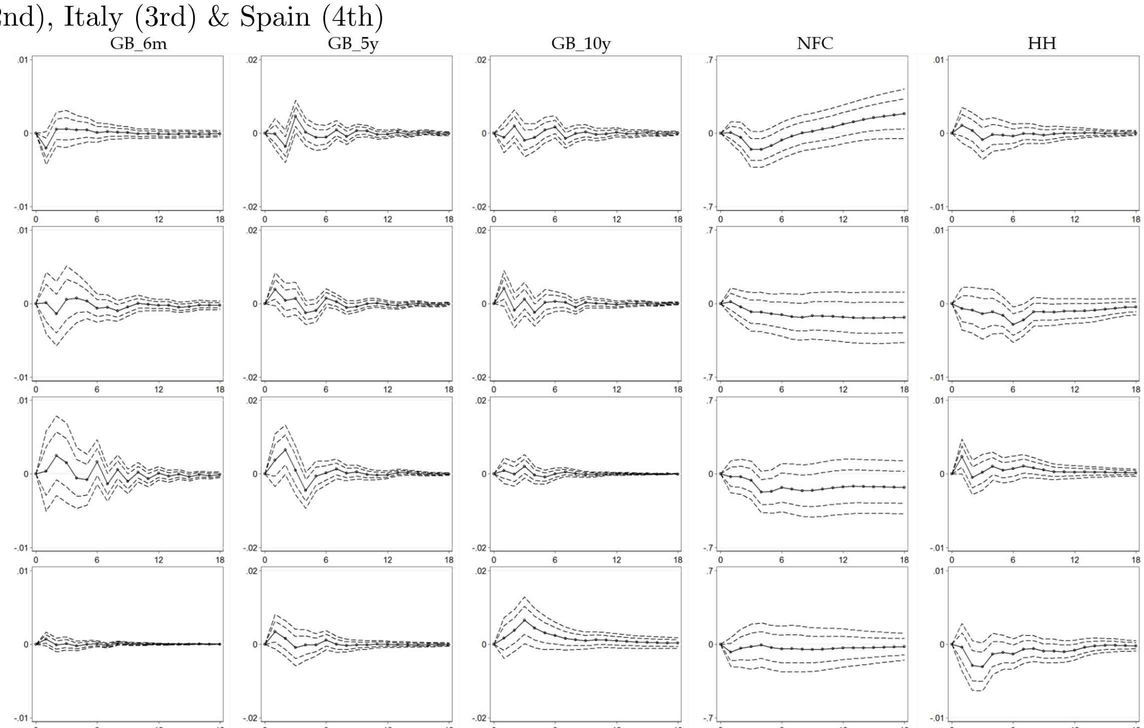


Note : The impulse response corresponds to the percentage point change in interest rates, in response to a one-S.D. innovation in the ECB interest rate, together with one and two S.E. confidence band intervals.

In the latter countries, IRFs show evidence of statistically significant negative impacts on sovereign bond markets, at 6-month and 5-year horizon in Italy and 6-month and 10-year horizon in Spain. This discrepancy in impact can be interpreted as reflecting the discrepancy in context : peripheral countries, like Spain or Italy, have been hit by the sovereign debt crisis, with growing spreads vis-à-vis the German Bund, whereas core countries, like Germany and France, have to some extent benefited from the crisis via their role of safe havens, evidenced by a negative trend in their bond yields. Evidence about the impact of the same policy on volumes is weaker than the impact on interest rates.

Figure 4.10 plots the impulse responses of volumes to a one-S.D. innovation in SHMPP. In Italy and Spain, there is some evidence of an increase in volumes on sovereign bond markets, but it is very short and weakly significant. In both countries, weak evidence also points to a different reaction of the housing loans markets : loans increase in Italy and decrease in Spain. In Germany, SHMPP has a short negative impact on volumes on public debt at 6-month horizon whereas in France, the sovereign bond market at 5-year horizon reacts positively in the short run.

FIGURE 4.10 – Response of volumes to a positive SHMPP shock in Germany (1st row), France (2nd), Italy (3rd) & Spain (4th)



Note : The impulse response corresponds to the percentage point change in interest rates, in response to a one-S.D. innovation in the ECB interest rate, together with one and two S.E. confidence band intervals.

In summary, IRFs show that the conventional interest rate channel has been at work in the four countries, but conventional monetary policy has only had a weak effect on volumes. IRFs for unconventional policies show that they have had quite different effects. It gives support to the break-up of unconventional policies between excess liquidity, LTRO and SHMPP. Excess liquidity has had a pass-through on interest rates in Germany and Spain, and on volumes in France and Spain. In comparison, the impacts of LTRO measures have been weaker and concentrated exclusively on interest rates. In contrast, SHMPP measures which were targeted towards peripheral countries have been effective at modifying interest rates in these countries and, to a lower extent, volumes.

In the following, we discuss about the relevance of our identification approach and of main results. First, we discuss about the introduction of sign restrictions and, second, about restrictions on the linkages between conventional and unconventional policies. Third, we show results stemming from a unique monetary policy stance, mixing the conventional and the three unconventional measures.

4.5.3 Isolating the direct effect of policy variables on rates and volumes

The structural VAR model already introduces short-run restrictions, with the Cholesky decomposition in the D matrix of equation (4.3), but it does not introduce sign restrictions. Sign restrictions in VAR estimations of monetary policy channels of transmission have been common in the literature since Faust [1998]. For instance, Uhlig [2005] argues that sign restrictions help reconsider the impact of monetary policy shocks on output. Although Faust [1998] imposes sign restrictions on impact, Uhlig [2005] extends sign restrictions to several periods after the monetary shock and concludes that monetary shocks in the US have no clear-cut impact on output.The relevance of sign restrictions can be assessed by the estimates of the direct effect of policy variables on market rates and volumes from equation (4.3). They consist in the country- and market-specific estimated coefficients $b46 - b49$ (impacts of policy variables on volumes) and $b56 - b59$ (impacts of policy variables on interest rates) in the B matrix. By construction, interest rates and volumes cannot respond on impact (i.e. contemporaneously) to shocks to the policy variables since they are ordered before in the Z vector.

Results are reported in Table 4.2. They show that the sum of coefficients is in most cases not significantly different from zero. Consequently, the introduction of sign restrictions in the structural VAR discussed in this paper would not fit the data. The evaluation of the reliability of sign restrictions thus supports the choice of not introducing such restrictions.

Table 4.2 – Estimates of the direct effect of policy variables on rates and volumes

Effect on interest rates											
ECB rate - b49			EL - b48			LTRO - b47			SHMPP - b46		
model	param	se	model	param	se	model	param	se	model	param	se
g_gb_6m	-0.72	0.41	g_gb_6m	-0.18	0.24	g_gb_6m	-0.14	0.16	g_gb_6m	1.49**	0.74
g_gb_5y	-0.76	1.09	g_gb_5y	-0.60	0.63	g_gb_5y	-0.19	0.43	g_gb_5y	0.05	1.95
g_gb_10y	-0.20	0.96	g_gb_10y	-0.48	0.54	g_gb_10y	0.42	0.39	g_gb_10y	-0.66	1.71
g_nfc	0.74	0.38	g_nfc	0.00	0.21	g_nfc	-0.21	0.14	g_nfc	2.05***	0.64
g_hh	0.89	0.82	g_hh	-1.41***	0.49	g_hh	-0.52	0.32	g_hh	0.65	1.43
f_gb_6m	-0.41	0.49	f_gb_6m	0.24	0.27	f_gb_6m	0.08	0.19	f_gb_6m	0.91	0.82
f_gb_5y	-0.49	0.83	f_gb_5y	-0.74	0.49	f_gb_5y	-0.74**	0.35	f_gb_5y	1.27	1.47
f_gb_10y	-0.39	0.62	f_gb_10y	0.10	0.39	f_gb_10y	0.13	0.27	f_gb_10y	0.54	1.17
f_nfc	1.13***	0.34	f_nfc	0.21	0.21	f_nfc	0.04	0.14	f_nfc	1.04	0.56
f_hh	0.16	0.09	f_hh	-0.07	0.05	f_hh	-0.04	0.04	f_hh	0.08	0.16
i_gb_6m	1.34	1.38	i_gb_6m	0.02	0.80	i_gb_6m	-0.52	0.52	i_gb_6m	-3.66	2.31
i_gb_5y	0.93	1.34	i_gb_5y	0.99	0.82	i_gb_5y	0.15	0.52	i_gb_5y	-1.79	2.41
i_gb_10y	1.01	1.25	i_gb_10y	0.73	0.730	i_gb_10y	0.25	0.50	i_gb_10y	0.17	2.18
i_nfc	0.43	0.46	i_nfc	0.01	0.25	i_nfc	-0.17	0.15	i_nfc	0.57	0.72
i_hh	0.33	0.24	i_hh	-0.15	0.14	i_hh	0.04	0.09	i_hh	0.25	0.46
s_gb_6m	1.96**	0.98	s_gb_6m	0.77	0.57	s_gb_6m	-0.45	0.38	s_gb_6m	-1.46	1.74
s_gb_5y	1.07	0.83	s_gb_5y	0.92	0.54	s_gb_5y	-0.08	0.35	s_gb_5y	-1.05	1.46
s_gb_10y	0.26	0.69	s_gb_10y	0.71	0.43	s_gb_10y	-0.12	0.29	s_gb_10y	-0.91	1.30
s_nfc	2.19***	0.63	s_nfc	0.12	0.30	s_nfc	-0.37	0.20	s_nfc	0.67	0.90
s_hh	0.33	0.28	s_hh	-0.02	0.16	s_hh	-0.01	0.10	s_hh	0.65	0.46
Effect on volumes											
ECB rate - b59			EL - b58			LTRO - b57			SHMPP - b56		
model	param	se	model	param	se	model	param	se	model	param	se
g_gb_6m	0.04	0.03	g_gb_6m	0.00	0.01	g_gb_6m	0.00	0.01	g_gb_6m	-0.03	0.05
g_gb_5y	0.06	0.05	g_gb_5y	0.04	0.03	g_gb_5y	0.00	0.02	g_gb_5y	0.06	0.09
g_gb_10y	0.00	0.05	g_gb_10y	0.04	0.03	g_gb_10y	0.03	0.02	g_gb_10y	-0.03	0.09
g_nfc	0.58	1.30	g_nfc	0.21	0.71	g_nfc	0.34	0.48	g_nfc	-2.10	2.16
g_hh	-0.03	0.03	g_hh	-0.02	0.02	g_hh	-0.02	0.01	g_hh	-0.02	0.05
f_gb_6m	-0.02	0.05	f_gb_6m	0.02	0.03	f_gb_6m	0.02	0.02	f_gb_6m	-0.03	0.09
f_gb_5y	-0.01	0.05	f_gb_5y	-0.02	0.03	f_gb_5y	-0.03	0.02	f_gb_5y	0.24**	0.09
f_gb_10y	0.03	0.06	f_gb_10y	0.06	0.03	f_gb_10y	0.02	0.02	f_gb_10y	0.23**	0.10
f_nfc	-1.33	1.66	f_nfc	0.16	0.99	f_nfc	0.67	0.66	f_nfc	0.21	2.70
f_hh	0.07**	0.04	f_hh	0.00	0.02	f_hh	-0.00	0.02	f_hh	-0.00	0.06
i_gb_6m	-0.05	0.07	i_gb_6m	-0.02	0.04	i_gb_6m	0.02	0.03	i_gb_6m	0.00	0.11
i_gb_5y	0.03	0.08	i_gb_5y	-0.01	0.05	i_gb_5y	-0.03	0.03	i_gb_5y	0.15	0.15
i_gb_10y	-0.01	0.04	i_gb_10y	-0.02	0.02	i_gb_10y	-0.02	0.02	i_gb_10y	0.06	0.07
i_nfc	3.35	1.96	i_nfc	-0.72	1.06	i_nfc	-1.01	0.67	i_nfc	0.13	3.08
i_hh	0.02	0.03	i_hh	-0.02	0.02	i_hh	-0.01	0.02	i_hh	0.08	0.06
s_gb_6m	0.01	0.01	s_gb_6m	-0.00	0.00	s_gb_6m	0.00	0.00	s_gb_6m	0.02	0.02
s_gb_5y	-0.09	0.07	s_gb_5y	-0.07	0.04	s_gb_5y	0.00	0.02	s_gb_5y	-0.03	0.10
s_gb_10y	-0.07	0.07	s_gb_10y	-0.02	30.04	s_gb_10y	0.00	0.03	s_gb_10y	0.12	0.11
s_nfc	-0.53	1.95	s_nfc	0.78	0.94	s_nfc	0.89	0.61	s_nfc	-0.16	2.78
s_hh	0.02	0.04	s_hh	-0.01	0.02	s_hh	-0.02	0.02	s_hh	-0.08	0.07

Notes : Estimated from equation (4.3). ** $p < 0.05$, *** $p < 0.01$.

4.5.4 Isolating the cross-effects of policy variables

The empirical literature has pointed out that unconventional monetary policy measures may impact directly on conventional policy (see, e.g. Krishnamurthy and Vissing-Jorgensen [2011]). The introduction of some restrictions in the direct relationships between different types of monetary policy must be discussed. The reliability of such restrictions can be assessed via the country- and market-specific estimated coefficients $b69 - b89$ (impacts of ECB rate on unconventional policy variables) and $b96 - b98$ (impacts of unconventional policy variables on ECB rate) in the B matrix of equation (4.3).

Table 4.3 – Estimates of the cross-effects of policy variables

Effect of unconventional policy variables on the ECB rate								
EL - b98			SHMPP - b97			LTRO - b96		
model	param	se	model	param	se	model	param	se
g_gb_6m	-0.15	0.11	g_gb_6m	-0.17**	0.08	g_gb_6m	0.42	0.36
g_gb_5y	-0.15	0.11	g_gb_5y	-0.18**	0.08	g_gb_5y	0.31	0.37
g_gb_10y	-0.22**	0.11	g_gb_10y	-0.14	0.08	g_gb_10y	0.03	0.35
g_nfc	-0.13	0.12	g_nfc	-0.11	0.08	g_nfc	0.20	0.37
g_hh	-0.16	0.13	g_hh	-0.13	0.08	g_hh	0.03	0.40
f_gb_6m	-0.06	0.11	f_gb_6m	-0.08	0.08	f_gb_6m	0.30	0.34
f_gb_5y	-0.21	0.11	f_gb_5y	-0.18**	0.08	f_gb_5y	-0.02	0.34
f_gb_10y	-0.21	0.12	f_gb_10y	-0.16	0.08	f_gb_10y	0.01	0.38
f_nfc	-0.00	0.12	f_nfc	-0.08	0.08	f_nfc	0.04	0.33
f_hh	-0.26**	0.12	f_hh	-0.23**	0.09	f_hh	0.35	0.37
i_gb_6m	-0.16	0.12	i_gb_6m	-0.10	0.08	i_gb_6m	0.15	0.35
i_gb_5y	-0.12	0.12	i_gb_5y	-0.107	0.08	i_gb_5y	0.13	0.37
i_gb_10y	-0.14	0.11	i_gb_10y	-0.12	0.08	i_gb_10y	0.22	0.35
i_nfc	-0.13	0.12	i_nfc	-70.08	0.08	i_nfc	-0.27	0.37
i_hh	-0.17	0.13	i_hh	-0.15	0.08	i_hh	-0.20	0.43
s_gb_6m	-0.17	0.12	s_gb_6m	-0.17*	0.08	s_gb_6m	0.11	0.39
s_gb_5y	-0.13	0.14	s_gb_5y	-0.13	0.09	s_gb_5y	-0.05	0.38
s_gb_10y	-0.15	0.13	s_gb_10y	-0.11	0.09	s_gb_10y	-0.10	0.40
s_nfc	-0.18	0.12	s_nfc	-0.21***	0.08	s_nfc	-0.00	0.35
s_hh	-0.15	0.12	s_hh	-0.14	0.08	s_hh	0.32	0.36

Effect of unconventional policy variables on the ECB rate								
EL - b89			SHMPP - b79			LTRO - b69		
g_gb_6m	-0.82	0.61	g_gb_6m	0.06	0.79	g_gb_6m	0.17	0.11
g_gb_5y	-0.81	0.62	g_gb_5y	0.58	0.75	g_gb_5y	0.14	0.11
g_gb_10y	-0.92	0.65	g_gb_10y	0.36	0.87	g_gb_10y	0.2	0.11
g_nfc	0.14	0.64	g_nfc	-1.21	0.86	g_nfc	0.13	0.11
g_hh	-0.88	0.67	g_hh	0.54	0.91	g_hh	0.17	0.12
f_gb_6m	-0.53	0.68	f_gb_6m	-0.12	0.89	f_gb_6m	0.15	0.11
f_gb_5y	-0.35	0.64	f_gb_5y	-0.13	0.82	f_gb_5y	0.13	0.10
f_gb_10y	-0.55	0.62	f_gb_10y	0.10	0.82	f_gb_10y	0.15	0.10
f_nfc	-0.21	0.71	f_nfc	-0.41	0.94	f_nfc	0.14	0.12
f_hh	0.05	0.69	f_hh	-0.14	0.89	f_hh	0.03	0.12
i_gb_6m	-0.47	0.64	i_gb_6m	-0.16	0.85	i_gb_6m	0.10	0.11
i_gb_5y	-0.69	0.61	i_gb_5y	0.63	0.84	i_gb_5y	0.08	0.11
i_gb_10y	-0.40	0.60	i_gb_10y	0.19	0.84	i_gb_10y	0.11	0.11
i_nfc	-0.19	0.70	i_nfc	-0.44	1.01	i_nfc	0.13	0.13
i_hh	-0.67	0.66	i_hh	0.36	0.89	i_hh	0.13	0.11
s_gb_6m	-0.26	0.67	s_gb_6m	-0.02	0.93	s_gb_6m	0.13	0.11
s_gb_5y	-0.36	0.63	s_gb_5y	0.06	0.88	s_gb_5y	0.10	0.11
s_gb_10y	-0.42	0.61	s_gb_10y	0.05	0.86	s_gb_10y	0.12	0.11
s_nfc	-0.85	0.75	s_nfc	0.17	1.08	s_nfc	0.25	0.14
s_hh	-0.40	0.67	s_hh	-0.34	0.96	s_hh	0.23	0.12

Notes : Estimated from equation (4.3). $** \ p < 0.05$, $*** \ p < 0.01$.

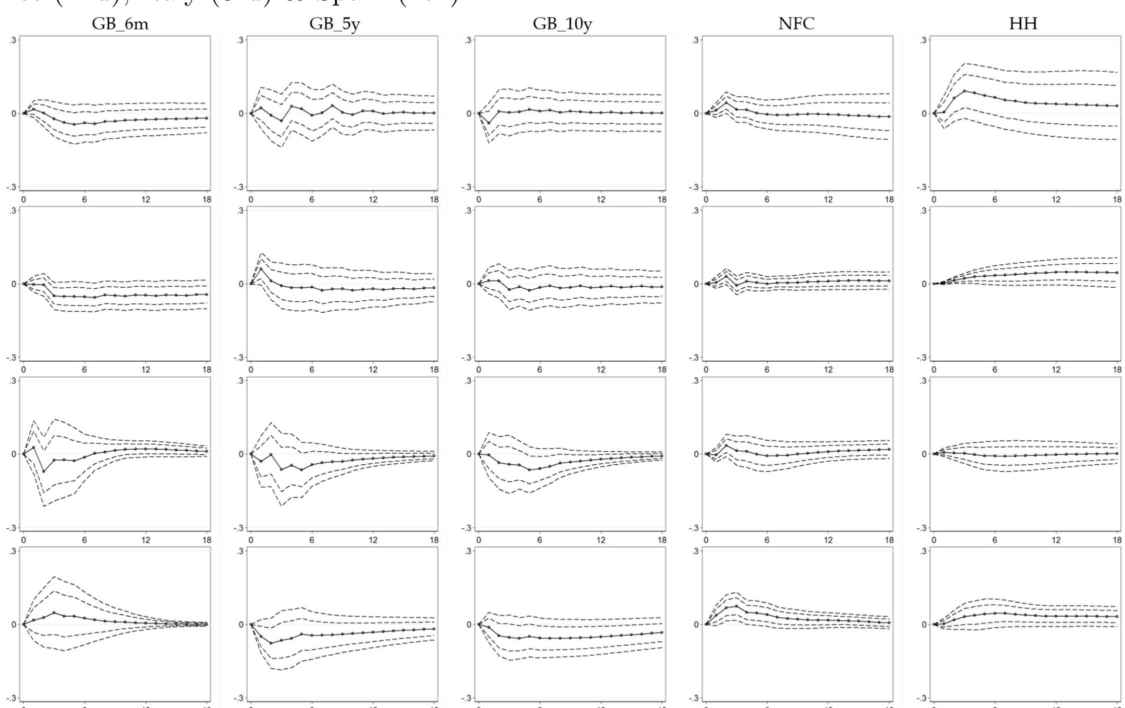
Results reported in Table 4.3 show a very clear picture. A shock to the conventional tool of monetary policy has no statistically significant impact on unconventional policies, whatever the latter is, whatever the market and whatever the country. Regarding the direct effect of shocks to unconventional tools on the ECB interest rates, there are only a few occurrences where the former complements the latter, two related to excess liquidity, five related to SMHPP but none related to LTRO.

4.5.5 Squaring the preceding results with a unique policy stance variable

Although our results point to different outcomes across the different monetary policy instruments, a simpler model in which all instruments are summarised into a single one is worth investigating. If this model gives similar results overall – an effective interest rate channel and an impact of ECB monetary policy on some specific market's volumes - it will weaken the approach of this paper to deal with a detailed description of ECB monetary policies.

The new environment of monetary policy, with the growing importance of unconventional measures because of the zero-lower bond on the conventional instrument, has urged research on the assessment of the overall monetary stance and led to the computations of "shadow rates" as single measure of conventional and unconventional policies. Wu and Xia [2015] have used their shadow rate to gauge the macroeconomic effects of US monetary policies during the crisis. We first identify shocks to their shadow rate for the Euro area using the same method as for the previous policy measures, so estimating equation (4.2) without the P vector. Second we measure the impact of ECB monetary policy on the twenty markets under study. Estimates stem from equation (4.3) in which the shadow rate substitutes for the four policy variables, so the model is a five-equation VAR.

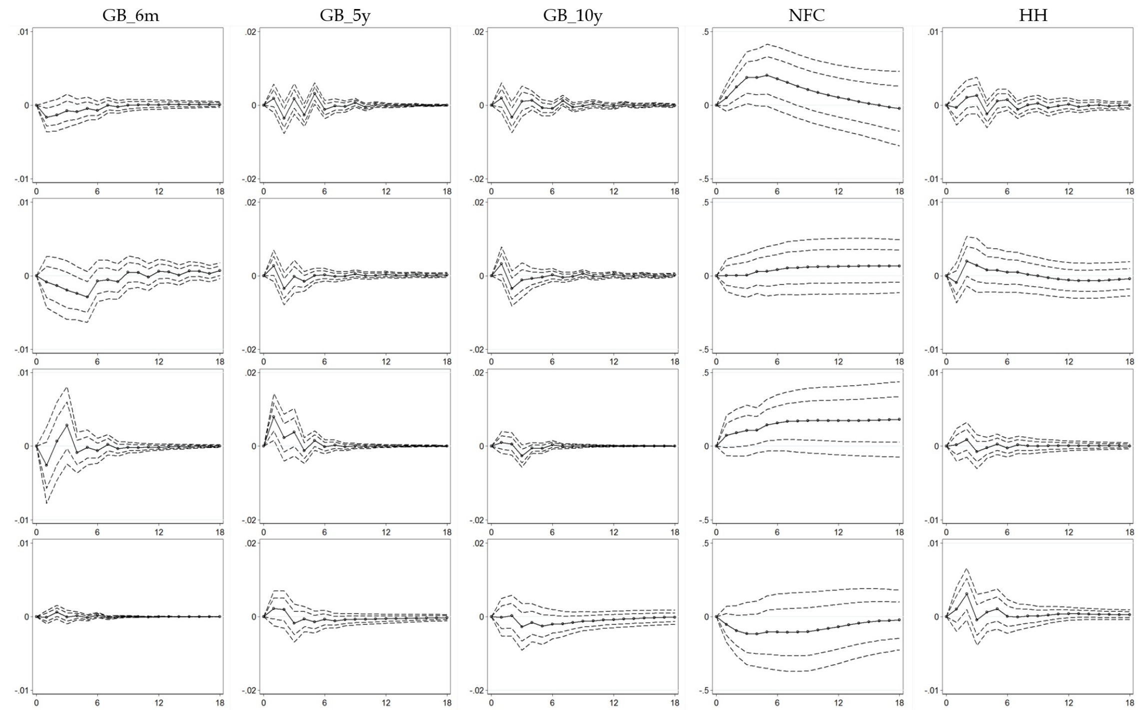
FIGURE 4.11 – Response of interest rates to a positive shadow rate shock in Germany (1st row), France (2nd), Italy (3rd) & Spain (4th)



Note : The impulse response corresponds to the percentage point change in interest rates, in response to a one-S.D. innovation in the ECB interest rate, together with one and two S.E. confidence band intervals.

Results reported in Figures 4.11 and 4.12 show that contrary to our former results, the interest rate channel vanishes. The only exception is the market for loans to NFC in Spain. As for the impact of ECB monetary policy on volumes, most impulse responses are not statistically significant. When they are, they give counter-intuitive outcomes : volumes increase (temporarily) in Germany (NFC loans) and Italy (5-year sovereign bonds and NFC loans).

FIGURE 4.12 – Response of volumes to a positive shadow rate shock in Germany (1st row), France (2nd), Italy (3rd) & Spain (4th)



Note : The impulse response corresponds to the percentage point change in interest rates, in response to a one-S.D. innovation in the ECB interest rate, together with one and two S.E. confidence band intervals.

We check that these outcomes are not sensitive to an identification approach without sign restrictions. Results reported in Table 4.4 show that the shadow rate has no direct impact (at the 1% level) either on interest rates or on volumes in all markets studied. Sign restrictions would not fit the data.

In summary, the use of an overall stance of ECB monetary policy does not give the same results as with detailed stances of monetary policies, which we interpret as supportive of our detailed approach.

Table 4.4 – Estimates of the effect of a shadow rate

on interest rates			on volumes		
model	param	se	model	param	se
g_gb_6m	-0.03	0.16	g_gb_6m	-0.01	0.01
g_gb_5y	-0.07	0.36	g_gb_5y	-0.01	0.02
g_gb_10y	0.06	0.35	g_gb_10y	-0.01	0.02
g_nfc	0.12	0.15	g_nfc	0.78	0.46
g_hh	0.47	0.31	g_hh	0.01	0.01
f_gb_6m	-0.13	0.17	f_gb_6m	-0.01	0.02
f_gb_5y	-10.02	0.30	f_gb_5y	-0.01	0.02
f_gb_10y	-0.05	0.23	f_gb_10y	-0.01	0.02
f_nfc	0.07	0.14	f_nfc	-0.36	0.66
f_hh	0.07**	0.03	f_hh	0.01	0.01
i_gb_6m	0.05	0.48	i_gb_6m	-0.00	0.02
i_gb_5y	-0.36	0.48	i_gb_5y	0.06**	0.03
i_gb_10y	-0.33	0.42	i_gb_10y	-0.01	0.01
i_nfc	0.10	0.14	i_nfc	0.92	0.68
i_hh	-0.01	0.09	i_hh	0.00	0.01
s_gb_6m	0.21	0.37	s_gb_6m	0.00	0.00
s_gb_5y	-0.27	0.30	s_gb_5y	0.00	0.00
s_gb_10y	-0.26	0.27	s_gb_10y	-0.01	0.02
s_nfc	0.53**	0.22	s_nfc	-0.60	0.63
s_hh	0.09	0.12	s_hh	0.01	0.02

Note : Estimated from equation (4.3) in which the four policy variables are replaced by a shadow rate. ** $p < 0.05$, *** $p < 0.01$.

4.6 Conclusion

This paper aims at establishing the effects of a fine decomposition of conventional and unconventional ECB monetary policies on both interest rates and volumes in the four largest economies of the Eurozone during the global financial crisis. We first identify series of ECB policy shocks on the main refinancing operation interest rate for conventional policy and on amounts spent for each unconventional policy as stated in the ECB's Weekly Financial Statements, at the euro area aggregated level, by removing the systematic component of each series. Second, we include these four estimated series of interest rate and unconventional policy shocks in maket- and country-specific structural VARs with five macro variables.

The pass-through from the ECB rate to interest rates has been effective, consistently with the existing literature, whereas the transmission mechanism of the ECB rate to volumes has been weak. Unconventional policies have had uneven effects. It gives support to the break-up of unconventional policies between excess liquidity, LTRO and SHMPP. Excess liquidity has an effect on interest rates in Germany and Spain, and on volumes in France and Spain. In comparison, the impacts of LTRO measures are weaker and concentrated exclusively on interest rates. In contrast, SHMPP measures which were targeted towards peripheral countries have been effective at modifying interest rates in these countries and, to a lower extent, volumes.

This paper focuses on the effects of ECB monetary policies on low-frequency interest rates and volumes. Further research may be directed towards a cross investigation of higher-frequency event-studies allowing to capture the confidence and signalling channels with lower-frequency analysis allowing to capture the channels of transmission to macro variables. It would permit to estimate in a single framework both the effects of monetary policy actions and announcements.

Annexe E

Data description and descriptive statics

Table E.1 – Descriptive Statistics

	Obs	Mean	Std. Dev.	Min	Max		Obs	Mean	Std. Dev.	Min	Max
g_gb_6m_r	89	1.03	1.45	-0.09	4.38	g_gb_6m_v	89	0.04	0.02	0	0.07
g_gb_5y_r	89	1.79	1.26	0.02	4.69	g_gb_5y_v	89	0.03	0.02	0	0.09
g_gb_10y_r	88	2.54	1.11	0.90	4.66	g_gb_10y_v	89	0.04	0.02	0	0.08
g_nfc_r	89	3.22	1.22	1.79	5.77	g_nfc_v	89	2.22	3.99	-3.4	11.6
g_hh_h_r	89	4.70	1.11	2.84	6.47	g_hh_h_v	88	0.13	0.01	0.10	0.18
f_gb_6m_r	89	1.12	1.49	-0.01	4.45	f_gb_6m_v	89	0.04	0.03	0	0.10
f_gb_5y_r	89	2.18	1.19	0.36	4.91	f_gb_5y_v	89	0.04	0.02	0	0.08
f_gb_10y_r	89	3.08	0.92	1.2076	4.85	f_gb_10y_v	89	0.04	0.02	0	0.09
f_nfc_r	89	3.13	1.12	2.04	5.8	f_nfc_v	89	4.26	5.52	-2.8	16
f_hh_h_r	89	3.90	0.67	2.75	5.32	f_hh_h_v	88	0.10	0.03	0.05	0.22
i_gb_6m_r	89	1.78	1.40	0.13	6.50	i_gb_6m_v	89	0.10	0.03	0	0.19
i_gb_5y_r	89	3.46	1.21	0.29	6.46	i_gb_5y_v	89	0.04	0.03	0	0.26
i_gb_10y_r	89	4.42	0.94	1.66	7.56	i_gb_10y_v	89	0.04	0.01	0	0.08
i_nfc_r	89	3.57	1.03	1.93	5.84	i_nfc_v	89	2.21	6.07	-6.3	14.3
i_hh_h_r	89	3.90	1.04	2.50	5.95	i_hh_h_v	88	0.04	0.02	0.01	0.09
s_gb_6m_r	89	1.79	1.35	0.08	4.45	s_gb_6m_v	89	0.01	0.00	0	0.03
s_gb_5y_r	89	3.61	1.075	0.96	6.17	s_gb_5y_v	89	0.05	0.03	0	0.15
s_gb_10y_r	89	4.51	0.95	2.08	6.73	s_gb_10y_v	89	0.06	0.04	0	0.15
s_nfc_r	89	3.78	0.98	2.46	5.91	s_nfc_v	89	-0.62	10.74	-14.3	27.6
s_hh_h_r	89	3.61	1.08	2.36	6.07	s_hh_h_v	88	0.05	0.03	0.01	0.15
f_cpi	89	1.63	1.05	-0.8	4	f_ip	89	-1.71	6.24	-20.80	7.25
s_cpi	89	1.98	1.63	-1.3	5.3	s_ip	89	-4.08	6.61	-21.71	4.85
i_cpi	89	2.00	1.23	-0.2	4.2	i_ip	89	-3.11	7.97	-25.70	10.40
g_cpi	89	1.7	0.95	-0.7	3.5	g_ip	89	0.90	8.56	-23.64	14.89
rate	95	1.64	1.37	0.05	4.25	op	95	9.14	28.55	-48.88	63.88
el	95	1.98	2.28	-0.15	8.01	unemp	95	9.87	1.64	7.2	12.03
ltro	95	5.41	2.66	1.38	11.17	ciss	95	0.29	0.20	0.03	0.77
shmpp	95	1.28	1.16	0	2.90	stoxx	95	0.03	20.28	-45.12	44.96
shadow	95	1.18	1.63	-0.60	4.33	bonds	95	3.690461	0.75	1.69	4.81
cpi	95	1.82	1.06	-0.6	4	credit	95	3.33	4.38	-2.20	12.11
ip	95	-0.47	6.96	-21.56	9.17	eurodol	95	1.42	9.06	-16.21	17.83

TABLE E.2 – Common variables

BCE	ECB interest rate on main refinancing operations	Annual Interest Rate	ECB Statistical Data Warehouse
CPI	Overall inflation in the euro area (changing composition)	Index	ECB Statistical Data Warehouse
IP	Industrial production for the euro area (18 fixed composition)	Year over year percentage change	ECB Statistical Data Warehouse
UNEMP	Euro area (changing composition) standardised unemployment rate	Annual Rate	ECB Statistical Data Warehouse
BONDS	Euro area (changing composition) 10-year government benchmark bond yield	Yield	ECB Statistical Data Warehouse
CREDIT	Stocks of loans and securities, all maturities, all amounts, euro area (changing compositon)	As a percentage of euro area GDP	ECB Statistical Data Warehouse
GDP	Gross domestic product at market prices, euro area (changing composition)	Annual level, monthly frequency	ECB Statistical Data Warehouse
SHADOW	Shadow rate for the euro area	Annual Rate	Wu and Xia (forthcoming)
EL	Excess liquidity, computed as current accounts – reserve requirements + deposit facility – marginal lending facility	As a percentage of euro area GDP	ECB Statistical Data Warehouse
SHMPP	Securities held for monetary purposes (Securities Market Program, 1st 2d and 3d Covered Bond Purchase Programs, Asset-Backed Securities Purchase Program)	As a percentage of euro area GDP	ECB Statistical Data Warehouse
LTRO	Longer-term refinancing operations	As a percentage of euro area GDP	ECB Statistical Data Warehouse
SIZE	Size of ECB's balance sheet (total assets / liabilities)	As a percentage of euro area GDP	ECB Statistical Data Warehouse
EL_i	Dummies for excess liquidity announcements	Dummy	Based on ECB Monthly Bulletins
LTRO_i	Dummies for longer-term refinancing operations announcements	Dummy	Based on ECB Monthly Bulletins
SHMPP_i	Dummies for securities held for monetary policy purposes announcements	Dummy	Based on ECB Monthly Bulletins
EURODOL	Euro-dollar exchange rate	Monthly rate	FRED Saint Louis
CISS	Composite Indicator of Systemic Stress	Index	ECB Statistical Data Warehouse
STOXX	Dow Jones Euro Stoxx 50 Price Index (Historical close, average of observations through period)	Equity/index	ECB Statistical Data Warehouse
OP	Oil price (for commodity, brent crude oil 1 month forward) - free on board per barrel, in euro	Year over year percentage change	ECB Statistical Data Warehouse

Table E.3 – Country specific variables

C_GB_6M_R	Weighted average yield of 6-month maturity bonds (from 165 to 210 days)	Annual Interest Rate	Deutsche Finanzagentur, Agence France Trésor, Banca D'Italia, Banco de España
C_GB_6M_V	Total allotment of 6-month maturity bonds (from 165 to 210 days) over the month	As a percentage of euro area GDP	Deutsche Finanzagentur, Agence France Trésor, Banca D'Italia, Banco de España
C_GB_5Y_R	Weighted average yield of 5-year maturity bonds (from 54 to 72 months)	Annual Interest Rate	Deutsche Finanzagentur, Agence France Trésor, Banca D'Italia, Banco de España
C_GB_5Y_V	Total allotment of 5-year maturity bonds (from 54 to 72 months) over the month	As a percentage of euro area GDP	Deutsche Finanzagentur, Agence France Trésor, Banca D'Italia, Banco de España
C_GB_10Y_R	Weighted average yield of 10-year maturity bonds (114 to 132 months)	Annual Interest Rate	Deutsche Finanzagentur, Agence France Trésor, Banca D'Italia, Banco de España
C_GB_10Y_V	Total allotment of 10-year maturity bonds (from 114 to 132 months) over the month	As a percentage of euro area GDP	Deutsche Finanzagentur, Agence France Trésor, Banca D'Italia, Banco de España
C_GB_DMD	Flows of redemptions, securities in nominal value, all currencies combined	Month to month percentage change	ECB Statistical Data Warehouse
C_NFC_R	Lending rate to domestic non-financial corporations (new business, index of notional stocks), all maturities, all amounts	Annual Interest Rate	ECB Statistical Data Warehouse
C_NFC_V	Loans to domestic non-financial corporations (new business, index of notional stocks), all amounts, all maturities	Year over year percentage change	Bundesbank, Banque de France, Banca D'Italia, Datastream
C_NFC_DMD	Diffusion index of loan demand, enterprise, forward looking three months	Quarterly Index, monthly frequency	BLS Survey
C_HH_H_R	Lending rate to domestic households (new business), for housing loans (all maturities, all amounts)	Annual Interest Rate	ECB Statistical Data Warehouse
C_HH_H_V	Loans to domestic households (new business), housing loans (all maturities, all amounts)	As a percentage of euro area GDP	Datastream, Banque de France, Banca d'Italia
C_HH_DMD	Diffusion index of loan demand, loans for house purchase, forward looking three months	Quarterly Index, monthly frequency	BLS Survey
C_CPI	Consumer Price Index	Annual rate of change	ECB Statistical Data Warehouse
C_STOXX	DAX (GDAXI), CAC 40, FTSE MIB and IBEX 35 indices	Year over year percentage change	Euronext
C_IP	Volume index of industrial production	Year over year percentage change	Eurostat

C stands for the country : G for Germany, F for France, I for Italy and S for Spain

Annexe F

Shocks identification and tests

Figure F.1 – Distribution of shocks to the four policy instruments

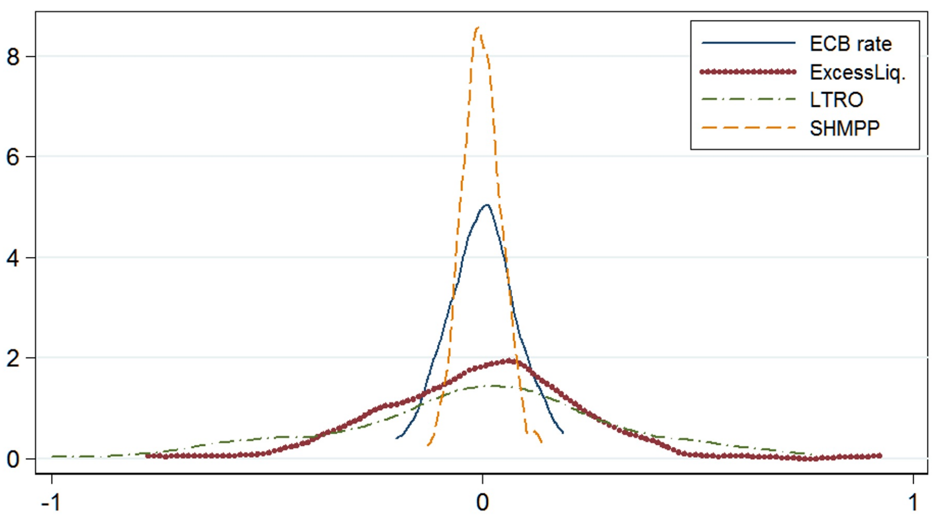


TABLE F.1 – Identification of shocks

	(1)	(2)	(3)	(4)
	ECB rate	EL	LTRO	SHMPP
CPI	0.12*	-0.03	0.38	0.07
	[0.07]	[0.27]	[0.37]	[0.05]
L.CPI	-0.03	0.33	-0.53	-0.07
	[0.08]	[0.26]	[0.39]	[0.05]
L2.CPI	-80.08	-0.14	0.18	0.02
	[0.06]	[0.22]	[0.31]	[0.04]
L3.CPI	0.04	0.03	-0.16	-0.05
	[0.05]	[0.18]	[0.27]	[0.04]
Ind.Pro.	0.01	-0.01	-0.01	0.01
	[0.01]	[0.04]	[0.05]	[0.01]
L.Ind.Pro.	-0.01	0.05	-0.01	0.01
	[0.01]	[0.04]	[0.06]	[0.01]
L2.Ind.Pro.	-0.02**	-0.01	-0.06	-0.00
	[0.01]	[0.04]	[0.05]	[0.01]
L3.Ind.Pro.	0.01	-0.08**	0.08	-0.01
	[0.01]	[0.03]	[0.05]	[0.01]
Oil prices	-0.00	0.00	-0.01	-0.00
	[0.00]	[0.01]	[0.01]	[0.00]
L.Oil prices	0.00	0.00	0.01	0
	[0.00]	[0.01]	[0.01]	[0.00]
Unemp.	-0.72***	1.16	-0.55	0.04
	[0.26]	[1.07]	[1.60]	[0.19]
L.Unemp.	0.49*	-2.78***	2.40	0.13
	[0.28]	[0.94]	[1.47]	[0.20]
CISS	0.01	0.18	0.44	0.21
	[0.25]	[0.88]	[1.35]	[0.15]
L.CISS	-0.56**	-2.11**	2.21*	0.44**
	[0.26]	[0.90]	[1.28]	[0.17]
STOXX	0.00	0.00	0.01	-0.00
	[0.00]	[0.01]	[0.01]	[0.00]
L.STOXX	-0.00	-0.01	0.01	0.00
	[0.00]	[0.01]	[0.01]	[0.00]
10y gov. rates	0.02	-0.28	0.24	0.07*
	[0.06]	[0.20]	[0.31]	[0.04]
L.10y gov. rates	-0.00	-0.13	0.28	0.02
	[0.07]	[0.22]	[0.33]	[0.04]
Credit	0.06**	-0.24**	0.35**	0.01
	[0.02]	[0.09]	[0.14]	[0.02]
L.Credit	-0.04	-0.00	-0.02	-0.03
	[0.03]	[0.11]	[0.15]	[0.02]
Euro/Dollar	-0.00	-0.04***	0.01	0.00
	[0.00]	[0.01]	[0.02]	[0.00]
L.Euro/Dollar	0.01**	0.01	0.02	0
	[0.00]	[0.02]	[0.02]	[0.00]
ECB rate		0.03	-0.46	0.06
		[0.47]	[0.70]	[0.08]
L.ECB rate	0.72***	-0.12	0.81	0.10
	[0.06]	[0.41]	[0.62]	[0.08]
EL	0.01		1.18***	0.07**
	[0.04]		[0.13]	[0.03]
L.EL	0.03	0.29***	0.01	0.01
	[0.03]	[0.11]	[0.17]	[0.02]
LTRO	-0.03	0.48***		-0.04**
	[0.02]	[0.05]		[0.02]
L.LTRO	0.03	0.06	-0.07	-0.01
	[0.02]	[0.08]	[0.12]	[0.02]
SHMPP	0.24	0.67	-1.05	
	[0.18]	[0.65]	[1.05]	
L.SHMPP	-0.14	0.43	-0.97	0.77***
	[0.17]	[0.60]	[1.10]	[0.08]
Constant	2.49**	15.82***	-19.08***	-2.28***
	[1.03]	[3.08]	[5.63]	[0.69]
Announcement dummies	No	Yes	Yes	Yes
Nb of obs.	92	92	92	92
R^2	0.997	0.989	0.982	0.998

Note : Standard errors in brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. L is the lag operator.

Table F.2 – Cumby-Huizinga test for autocorrelation

ECB rate			EL		
lag	chi2	p-val	lag	chi2	p-val
1	0.09	0.92	1	3.75	0.05
2	0.72	0.39	2	0.66	0.41
3	0.13	0.71	3	0.39	0.53
LTRO			SHMPP		
lag	chi2	p-val	lag	chi2	p-val
1	2.70	0.10	1	7.68	0.01
2	1.29	0.25	2	2.35	0.12
3	2.64	0.10	3	2.49	0.11

Note : H0 : disturbance is MA process up to order q, HA : serial correlation present at specified lags $> q$.

Table F.3 – Predictability of policy shocks

	3 lags		6 lags	
Variable	F-stat	p-value	F-stat	p-value
ECB rate	0.44	0.99	0.51	0.98
EL	0.23	1	0.41	0.99
LTRO	0.27	0.99	0.44	0.99
SHMPP	0.56	0.95	0.69	0.89

Note : Vector of explanatory variables : CPI, IndPro, Oil, Unemp, CISS, STOXX, 10yBond rates, Credit, Euro/Dollar.

Table F.4 – Descriptive statistics and correlations

	Mean	Std. Dev.	Min	Max
eps_rate	-1.44E-10	7.94E-2	-0.20	0.18
eps_el	2.53E-10	0.24	-0.77	0.93
eps_ltro	-1.33E-9	0.35	-0.99	1.32
eps_shmpp	3.79E-11	4.65E-2	-0.12	0.13
	eps_rate	eps_el	eps_ltro	eps_shmpp
eps_rate	1			
eps_el	-1.52E-2	1		
eps_ltro	0.13	-0.69***	1	
eps_shmpp	-0.14	-0.19	0.2	1

Note : The eps variables correspond to the shocks estimated in section 4.4. *** means that the p-value < 0.01.

Chapitre 5

Conclusion

In this thesis I have tried to contribute to a better understanding of the mechanisms at work behind sovereign default.

My first contribution is to better understand when countries default. Although most of structural models of sovereign default judge the output gap as the main trigger of the default decision, I show that the correlation between output and debt distress is non-significant. Yet, defaults need two types of discontinuity to occur, which are necessary but not sufficient by their own. First, defaults need a first-order discontinuity in the country's growth pattern : a large majority of defaults occur in a downturn, defined as a peak-to-trough episode ; defaults exiting this downturn rule appear to be non-economic defaults, that cannot be explained empirically by any macroeconomic variables. This finding paves the way for new structural models, incorporating regime switches à la Hamilton rather than transitory or permanent shocks on productivity. Second, the defaulting country experiences a large discontinuous shock on its debt-to-GDP ratio, mainly brought by a currency crisis (through the denominator) or by a banking crisis (through the numerator). This result hastens to further study the link between debt, currency and banking crises. Last, the combination of these two discontinuities with initial [1] bad conditions, like a deteriorated debt ratio, debt distresses become highly plausible.

As another contribution, I have established the key role of habit persistence in the preference for a currency zone, and its impact on the default decision. Although the large majority of macroeconomic models neglect this parameter and calibrate it at 0, I show that high habit persistence reverses the preference for flexibility. Increasing the permanence of adverse shocks and reducing households' leeway in case of brutal adjustments, it increases the need for stability brought by a currency union. It is even more the case when a default decision is at stake : called the "Schaüble Theorem", I find that in a monetary union and if habit formation is sufficiently high, if you give a country the choice between (i) default and leave the zone and (ii) default and stay in the union, it will always choose (ii). This result is reversed in the case of low habit

1. At the beginning of the downturn, thus.

persistence.

Finally, I have made an empirical contribution by assessing the monetary transmission from ECB tools, including quantitative easing, to sovereign rates and auctions. Although most recent papers use net public debt data to assess the efficiency of ECB monetary policy during the Eurozone debt crisis, I build a database using accurate sovereign yields and auction volumes for three maturities in the four largest economies in the Eurozone. I also study four monetary policy tools, including the policy rate and three measures of quantitative easing (LTRO, excess liquidity and SMP programs). It allows me to assess the differentiated effects of the various QE programs, and to find for instance that Assest Purchase Program measures, which were targeted towards peripheral countries, have been effective at modifying sovereign yields in these countries and, to a lower extent, bond issuance.

Even though I hope these contributions help at arriving at a better understanding sovereign debt crises, many questions still need to be answered before economists can claim to fully understand the issues at hand. The first open question is why contingent debt instruments are not more widely used, and especially growth-indexed bonds. Indeed, one of the legacies of the global financial crisis has been a high ratio of public debt to GDP, that most advanced economies, and mostly European countries, fail at reducing. While current levels may be sustainable, another series of bad shocks (political shocks or financial shocks, brought by high risk in the increase in private debt and zero interest rates) could easily tip the balance and lead to unsustainable debt ratios and to default, even in apparently “strong” economies. As shown by Blanchard et al. [2016] growth-indexed bonds can play an important role in that context. By decreasing payments when growth is low, they can substantially reduce the “tail risks” associated with explosive debt paths starting from today’s high ratios.

One interesting research direction would be to better understand the Greek debt crisis, and its resolution inside the Eurozone. This cannot be done using actual default models, which allow only two or three state variables. Merging elements of the DSGE paradigm into endogenous default models is a real technical challenge. As already argued in Chapter 3, the construction of endogenous default models which incorporate features borrowed from DSGE models seems the natural way forward for the quantitative sovereign debt literature. The range of questions that could be addressed within such a class of models would be very large, and this would be particularly relevant to explain the Hellenic crisis. One of the main obstacles to the development of such models is computational, but it also calls on macroeconomic modelling innovations in the New-Keynesian framework, such as the combination of capital control, financial autarky induced by a default, fixed exchange rate and exogenous monetary policy, as it may summarize what Greece has experienced since 2009.

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