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Essays in Financial Stability under Financial Frictions

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Abstract

This thesis is a collection of essays where I explore and extend the study of the role of financial frictions for the determination of asset prices, financial stability, and economic resilience. The frictions included in the analysis are individual and aggregate uncertainty, agent heterogeneity, money, liquidity and default. The first essay is an empirical study that motivates my research objectives. This work starts with the exploration of the role of liquidity on asset prices, specifically on sovereign bonds of emerging countries. I present a comprehensive model where I developed a novel methodology for finding the role of liquidity in the determination of asset prices during the financial crisis. In the second essay, illuminated by the empirical findings, I apply and expand the general equilibrium theory of money, default and financial stability. The contributions at the theoretical level are the extension of two-period model with discrete state space to the infinite horizon dynamic stochastic setting, and the inclusion of liquidity restrictions. In the third essay, I further extend this framework, allowing for production technology and endogenous market liquidity. Given the theoretical setting, I have analyzed the responses of financial stability and economic performance variables to real and financial shocks. Finally, in the fourth essay I produce an empirical application of this work. I apply a novel semi-parametric financial stability metric, and evaluate its relevance for the determination of asset prices, in the presence of liquidity restrictions. As a result, this thesis suggest plausible explanations for financial and economic issues that conventional models have not dealt with adequately.

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Chapter 1

Introduction

The work I present in this thesis explores and extends the research on financial frictions in the determination of asset prices, financial stability, and economic resilience. The frictions included in the analysis are individual and aggregate uncertainty, agent heterogeneity, money, liquidity and default. I combine and connect empirical and theoretical work.

I use the empirical work to guide my research objectives. This work starts with an exploration on the role of liquidity on asset prices, specifically on the sovereign bonds of emerging countries. I present a comprehensive model for which I have developed a novel methodology for identifying the role of liquidity in the determination of asset prices during the recent financial crisis. With these empirical findings, I apply and expand the general equilibrium theory of money, default and financial stability. At the theoretical level, the most relevant contribution is the extension of a discrete state two-period model to an infinite horizon and dynamic stochastic setting; together with the inclusion of production and liquidity. Given the proposed theory, I have developed empirical simulations, which allow an analysis of the impact of real and financial shocks on financial stability and macroeconomic performance. These insights from the revised theory are used to discuss the questions raised in the empirical work. Finally, I develop a novel semi-parametric financial stability metric, and evaluate its relevance on the determination of asset prices, in the presence of default and liquidity restrictions.

1.1 Emerging market debt and liquidity

The first paper of the thesis concentrates the analysis around the financial crisis. I have chosen a particularly interesting sample of emerging countries and the research work focuses on the determinants of emerging market bond spreads. As Reinhart and Rogoff (2010) suggest, decisions about debt are closely linked to future economic performance. The role of bankruptcy costs and debt levels are intrinsically related to bond spreads and also contribute to determining macroeconomic performance. One can examine the role of Modigliani and Miller (1958) theorem. That is, the capital irrelevance principle, when a sovereign is imagined to be a large firm.[1] While their assumptions (absence of taxes, bankruptcy costs, agency problems, asymmetric information and/or the presence of an inefficient market) are violated in this case, the most important concerns are transaction costs and bankruptcy. For sovereigns, capital structure has a key role in the determination of real economic outcomes, and so their fundamental value.

Since the 2007-2008 financial crisis, the determinants of emerging market debt spreads have attracted considerable attention. There is a growing literature on this topic. Eichengreen and Moody (1998) conducted an exercise to test the importance of fundamentals for a sample of developing economies' bonds. They find that fundamentals have an important influence. However, there is a portion of the pricing that has not been possible to explain. More recently, Hilscher and Norbush (2010) provided an interesting overview which reiterated the importance of economic fundamentals and global financial factors. Duffie and Pedersen (2003) conducted at test which showed that, apart from economic fundamentals and global financial factors, there was a liquidity premium which helped explain yield spreads. However, this exercise was only performed for Russian bonds. Recent research has significantly advanced by providing an explanation of emerging market debt pricing fluctuations, often concentrated in time periods close to the financial crises, as in Hilscher and Norbush (2010). However, none of these studies has given an explanation on the role of international funding or market liquidity in this

[1] If we aggregate the private and public balance sheet of a country, there is debt and equity. Equity belongs entirely to the private sector. However, in this thesis I focus primarily on the debt component, that belongs to the public and private sector.

pricing process, especially in turbulent financial times.

Reinhart and Rogoff (2009) discuss the causes and consequences of financial crises in several economies in a comprehensive data sample from 19th century (and back to the 16th century, in some cases). They suggest that the causes of such crises are over-leverage and relaxed credit and monetary policies. They assign the short memory of policy makers and market agents as one of the main causes of crises. This thesis complements their research about the recent crisis, by introducing liquidity. I consider market fundamentals, global financial factors and international liquidity to have an important impact in sovereign debt pricing determination. This of course is affected by financial stability of the countries under discussion. I include this issue in the final chapter of the thesis.

Emerging economies are particularly vulnerable to the debt position of developed countries. If there is an idiosyncratic shock in any of their important creditors, this will impact on their debt pricing and hence, macroeconomic performance, through this channel. Arora and Cerisola (2001) find an important relationship between US monetary policies and emerging market sovereign debt spreads, and hence to their country risk assessment. However, my interpretation is slightly different. I investigate an intermediate channel between US monetary policy and the price of emerging market sovereign debt, which they do not consider - the liquidity premium. The authors assume that higher spreads are translated directly into a higher default risk. Here, as I demonstrate, the risk is transmitted through liquidity, and thus there is scope for economic policy. When receiving and identifying a liquidity shock, economies should guarantee sufficient liquidity provision, principally by using monetary policy, among other instruments. Adrian and Shin (2009) find that there are important links between liquidity provision, financial stability and monetary policy and that monetary policy and financial stability should be coordinated. I agree with their approach and show how these dimensions have different effects on asset pricing, liquidity, financial stability, and monetary policy by concentrating the analysis on emerging economies.

1.2 Financial frictions

Using the findings from the first chapter, I then explore the theoretical underpinnings behind the empirical stylized facts demonstrated below, and which require an examination of the liquidity effects on asset prices, financial stability and economic resilience. My interest is to find out what are the key determinants of these elements and their causal relationships, in a context where I can assess the impact of financial and economic shocks.

The literature on financial frictions was well developed before the crisis of 2007-2008. Bernanke (1998) identifies the pertinent literature as Gertler and Hubbard (1988), Calomiris (1993), Gertler and Gilchrist (1993), Oliner and Rudebusch (1994), Bernanke and Gertler (1989), and Hubbard (1995). In addition, for this thesis, the economic research literature on monetary policy under financial frictions for the later period is also relevant, such as Bernanke et al. (1998), Kiyotaki and Moore (2001), Curdia and Woodford (2009, 2010). These authors have been successful in implementing their models as a coherent toolkit. Many central banks' assessment and implementation of monetary and financial stability policies has been inspired by their models. They generate amplification effects of monetary policy and its reactions. This is done by including financial frictions. The frictions included in their models comprise, nominal rigidities and agency problems. In this way they can explain credit and economic cycles, including, to a lower extent, the recent financial crisis.

Kiyotaki and Moore (2001) utilize entrepreneurial moral hazard as the shock amplification mechanism through the business cycle. That is the closest paradigm in terms of the modeling technique the authors use. They explain the transmission of financial shocks to the real economy by the existence of asymmetric information and the liquidity constraints it generates. The asymmetric information setting they choose is moral hazard present at the entrepreneurial level. This friction implies a lack of pledgeability of the future capital returns and so a reduction in entrepreneur's borrowing constraints. Consequently, by their definition, it generates a liquidity problem for traded assets. They analyze the effect of shocks to investment, production, asset trades and prices which are amplification effects generated by this moral hazard driven liquidity constraint. This paper contains some of the elements applied in this thesis such as money, liquidity and asset prices, but their model assumes that default is not found in equilibrium. Thus, financial stability plays a minor role in the determination of asset prices and real economic consequences. This model is based on a representative agent type of setting. Thus, trade and consumption cannot be evaluated. Furthermore, as Goodhart and Tsomocos (2010) suggest, the role of agent heterogeneity is crucial in assessing financial stability issues, since in order to model default in a general equilibrium setting, it is difficult to avoid diverging from the representative agent framework.

Bernanke et al. (1998) incorporate money and credit in a model that is designed to explain business fluctuations. Especially, they find a financial accelerator mechanism that explains business cycle dynamics. The main focus of their model is the role of monetary policy with frictions. The authors add several features that increase its empirical relevance such as price stickiness and costly state verification. The model representation in this framework also explores the presence of (parameter) firm heterogeneity, capturing asymmetrical access to financial markets. The friction from sticky prices was introduced earlier in dynamic models by Calvo (1983) and Taylor (1980). On the other hand, the costly state verification friction, developed by Townsend (1979) offers a way to think about problems facing lenders. They need to pay monitoring costs; to avoid the moral hazard in the credit relationship. This cost explains the risk premium of debt. These models have highly restrictive assumptions for it is easy to find a market where we can relax one or both assumptions, (ie. sticky prices, and supervision costs). The exclusion of default in equilibrium is a key drawback when analyzing monetary policy and/or financial stability with this model type (see Goodhart and Tsomocos, (2011)). Furthermore, the role of default should be considered as essentially interconnected to liquidity.

Recently, Curdia and Woodford (2009, 2010), have developed a New-Keynesian type of model that includes staggered pricing, change in forbearance of agents and imperfect credit markets. They use the model to evaluate how central banks should apply the Taylor rules during a crisis. As with others noted above, the model does not include default as an equilibrium phenomenon and surprisingly, money does not play any role in financial transactions. Covas and Fujita (2010) and Meh and Moran (2010) use this model to examine the effects of frictions on capital flows and their fluctuations. Albeit their contribution, they do include some questionably economic features, such as incorporating money in the utility function.

At this point it is pertinent to return to Fisher (1922, 1926, and 1933), and his view that the existence of exogenously determined business cycles constitutes an unrealistic and restrictive hypothesis. He argues that the business cycle values do not hold in reality and furthermore this simplification of the complicated equilibrium dynamics does not allow for an analysis of causes and consequences of fluctuations. Thus, a model that is based on the external sources of fluctuations lacks explanatory power, particularly, I should add, in crisis periods. Additionally, representative agent asset pricing models (Lucas, 1980, 1990) - the base of the current RBC modeling approach in macroeconomics - are not intended to analyze financial fragility in isolation. In this respect, Suarez and Sussman (1997) provide foundations for a theory that endogeneizes the existence of cycles through a reversion mechanism even in a complete contracts setting. Although this approach is not being considered by the contemporaneous macroeconomic literature.

1.3 Financial fragility and general equilibrium

In the general financial literature, Brunnermeier and Pedersen (2009), Vayanos (2004) and Acharya (2005, 2009), have included financial frictions in their formulations or arguments to explain the causes and consequences of the recent financial crisis. These theoretical-based works that applied empirical and policy formulations to the financial crises study had been less ambitious, but more precise in describing the particular issues surrounding the credit crunch in 2008. Their emphasis on the importance to model liquidity was useful to this thesis, although, following Goodhart et al. (2006), there is the need to embed this approach into a more general class of models, which analyze financial stability under financial frictions. There are, of course, other types of frictions that are derived naturally from economic interactions: liquidity, money, default, aggregate and individual uncertainty and agent heterogeneity (in preferences and budgets).

All of the previously mentioned frictions arise from the interconnection between default and liquidity. As Goodhart and Tsomocos (2010) suggest, liquidity and default should not exist in isolation. However, and to repeat, most of the current macroeconomic models with financial frictions assume that default is not present in equilibrium, mainly because of technical difficulties (Goodhart and Tsomocos, 2010). This assumption implies that agents are willing to repay their obligations as long as they have resources available. There is no scope for strategic default. And, if default is not present, there is no relevant role for financial intermediation, liquidity and money.

The previous paragraph indicates why we often find models for monetary policy that do not contain the issues discussed in this thesis. Goodhart (2007) emphasizes an often forgotten role for money. He argues that a modeling technique that does not consider money lacks the ability to extract valuable information from monetary aggregates. If a monetary authority uses this type of model, then it would lack a crucial piece of information. Specifically, they would be missing the identification of supply-side monetary shocks, and such shocks have a key role for risk aversion, default and income constraints.

There has been an extensive literature on monetary and financial general equilibrium during the past decades. Strategic Market Games is the main theory that has been developed and applied in a comprehensive set of financial and monetary general equilibrium models.

The inclusion of money as a source of funds and means of payment is the obvious step by which to include frictions into general equilibrium, and so allows for the inclusion of liquidity and default in these models. In this line, Shubik and Wilson (1977), Shubik (1999), Dreze and Polemarchakis (2000), Dubey and Geanakoplos (2003), Tsomocos

(2003), Dubey and Geanakoplos (2005) and Goodhart et al. (2006), have developed a general framework in which financial rigidities can be assessed rigorously within a general equilibrium setting in the presence of incomplete markets (GEI). These works develop a modeling technique where monetary policy and financial fragility can be investigated.

1.4 On default and liquidity

In most of the above mentioned papers, default is included as a friction, is present both in equilibrium and as a strategic decision. If there is no punishment or penalty when an agent stops paying his debts, it is in the agent's best interest to default as much as possible. That might imply there is no-trade equilibrium. On the other hand, if the punishment is too harsh, it could imply that agents risk too much when asking for credit or trading other assets, and so imply there is no trade in equilibrium. As Shubik and Wilson (1977), Dubey et al. (2005) propose, a transversality condition is needed in order to assure the existence of a trade equilibrium. A default punishment is needed in order to avoid Ponzi schemes, where agents can build up enormous amounts of debt.

An interesting case occurs when the punishment for default is intermediate (i.e., neither too weak nor too strong). This transversality condition can be modeled as a collateral requirement that gets expropriated in case of default; or a penalty when the obligations are not collateralized. Collateralized credit, as in the GEI model is to be found in Geanakoplos (1997) and Geanakoplos and Zame (2002). The motivation to collateralize could be adverse selection or moral hazard, as in Bester (1985) or Boot et al. (1991), who use a partial equilibrium model. If the asset trades are not collateralized, a default penalty is needed. This penalty could be pecuniary, as in Acharya and Bisin (2010) or could be non-pecuniary, as in Shubik and Wilson (1977) or Dubey et al. (2005) with similar results. The welfare properties, existence and determinacy of equilibrium are not trivial in a setting that includes default. Dubey and Geanakoplos (1992) and Dreze and Polemarchakis (2000), discuss these properties in a monetary setting. Tsomocos (2003) and Goodhart et al. (2006) apply and enhance this type of model to assess financial fragility.

This literature has the advantage of incorporating micro-foundations without the need of asymmetric information to explain the amplification effects of frictions on the financial equilibrium and its efficiency properties. These elements are included in the some papers (see Gottardi and Bisin (1999), and Rustichini and Siconolfi (2008)) offering the possibility of further amplifications and changes in equilibrium.

This literature, which analyses the causes and consequences of financial disturbances, has contributed policy recommendations, assigning an important role to the monetary and regulatory authorities and their policy instruments such as the monetary base and financial regulation. (See Goodhart et al. (2012), for a recent contribution).

The role of liquidity has grown in importance during the last decades, motivated by the recent financial crisis. However, there is no consensus about the definition of liquidity. Following Pastor et al. (2003), liquidity should be considered a state price; hence it is an outcome of equilibrium.

The liquidity concept is applied in several contexts for different purposes. In a seminal paper, Brunnermeier and Pedersen (2009), suggest taxonomy, distinguishing between *market* and *funding* liquidity. Funding liquidity refers to the ability to raise funds, and it is an agent property, while market liquidity is the ease by which an asset can be traded, that is a market property. There are several theoretical and empirical works in both areas. In the case of funding liquidity studies, it is the consequence of asymmetric information in partial equilibrium models, as in Hölmstrom and Tirole (1998, 2001). These authors define liquidity in a partial equilibrium setting as the firms' ability to raise resources, which is constrained as a result of imperfect enforceability of agent's productivity, because of moral hazard. Brunnermeier and Pedersen (2009) use similar foundations to build a general equilibrium analysis which examines both types of liquidity and their 'mutually reinforcing' pattern, but in the absence of default.

For funding liquidity, Diamond and Dybvig (1983) define the banks funding dimension of liquidity, investigate their role in transforming maturity of funds and the possibility of bank runs. Liquidity is the responsibility of the banks, but it comes with an associated risk-runs. There have been several attempts to apply these ideas, for example Diamond and Dybvig (1986), Bhattacharya and Gale (1987), Diamond and Rajan (2001JPE), Diamond and Rajan (2001AER), Diamond and Rajan (2005) and Diamond and Rajan (2006).

There is another type of theoretical contribution to modeling funding liquidity, that is the cash-in advance framework as in that of Tsomocos (2003), and others. In these model funding liquidity restrictions are based on Clower (1967) and Svensson (1985). The intuition behind these constraints is the need to use a means of payment in financial transactions. Following the argument in Goodhart et al. (2011), in a world without default, the use of IOU notes would be irrelevant. Espinoza et al. (2009) is a further example of liquidity funding analysis, and which explains the shape of the yield curve as a function of the funding liquidity provision (fiat money). In a later paper, Espinoza and Tsomocos (2010) investigate the role of liquidity by adding a parameter to adjust the tension of the cash-in-advance constraint. This is interpreted as liquidity, following the work of Grandmont and Younes (1972). They generalize the cash-in-advance framework and find, among others, a rationalization for holding money in a trading model.

For market liquidity, there is also a theory which uses a search approach for measuring market liquidity. In this type of model, it is assumed that is not easy to find a counterpart to trade. Therefore, search is an associated trading cost that acts as a friction. Lagos and Rocheteau (2009), suggest that this trading delay friction is responsible for variations in market liquidity proxies (bid-ask spreads, trading volume and trading delays. It consists of a complete information setting, so they do not need to model asymmetric information or other informational frictions to explain liquidity events in asset markets. The model is in similar spirit to that of Diamond and Dybvig (1986) which is based on a change in the maturity preferences of agents. However, with search friction models there is emergence of a new agent - the dealer - that charges for finding a trading partner. This allows them to explain market liquidity dynamics, instead of funding liquidity. Nevertheless, their model is not prepared to give normative recommendations on how to meet liquidity costs. Lagos (2011) also has a theoretical application that examines optimal monetary policy under market liquidity conditions. Finally, Lagos et al. (2011) apply their previous (2009) model, to explain asset pricing and policy implications in over-the-counter markets. While this is an interesting area of research, there are some arguable assumptions that are central in their models, such as the need to have stochastic preferences that change over time, and the presence of an exogenous (non-microfounded) search probability that affects the cost of matching.

Aikman (2009) and van den End and Tabae (2011) empirically examine the funding liquidity dimension of banks' or firms' balance sheets in a context of banking or financial fragility. The former, uses bank balance sheet and macro data to estimate a vector auto-regressive model that incorporates funding liquidity risk into a risk assessment model, while the latter uses firm level balance-sheet data and bank outflows to construct systemic risk indicators that explain the pro-cyclical liquidity responses. For market liquidity, Acharya and Pedersen (2005) construct a capital asset price model - type of economy where asset prices contain a liquidity premium. Using US stock market data, they empirically corroborate the theoretical insights of their model, explaining why agents hold liquidity. Lee (2010) studied the same type of model empirically, but on a global level. They find a relation between liquidity risk and international portfolio diversification. Pastor and Stambaugh (2003) also investigate the role of market liquidity by constructing a metric based on US stock market data, which showed that market liquidity accounted for an important portion of asset prices.

The lack of explanation for the medium term fluctuations of the variables of interest under a series of shocks might be seen as one of the weaknesses of the approach in the line of Tsomocos (2003) and Goodhart et al. (2006). Nevertheless, Goodhart et al. (2006) time series constitutes an attempt to include a time series analysis of financial stability, the authors work in an environment of discrete 'states of nature' distributions. Although is not a trivial task, it is possible to extend this analysis to a dynamically stochastic general equilibrium framework. Leao (2006), and de Walque (2008) extended Tsomocos (2003) and Goodhart et al. (2006) framework into the dynamic stochastic general equilibrium setting. However, they do not take into account simultaneously liquidity, agent heterogeneity, money and default risk. I contribute to this line of research by including a dynamic version of liquidity constraints and give an interpretation for market liquidity in the search frictions framework.

1.5 Metrics for Financial Stability

Financial stability is becoming a popular topic, especially after the recent global financial crisis, which continues to affect the global economy. However, there is still no consensus about how it should be defined. This failure is in contrast to an equally important indicator for central banks and policy makers - price stability and where there exists a universal indicator, inflation, which allows central banks to manage and assess compliance to its goals and long and short term policies; these are often mandated by laws and regulations. For example, Chile's central bank law (Ley Organica Constitucional) states that the central bank should "*contribute to the smooth functioning of the economy and the welfare of society, ensuring currency stability and the normal functioning of the internal and external payments."* and, *"promote a regulatory framework and infrastructure that contribute to the financial stability of the Chilean economy.*"

The need for definition and operationalisation requires both theory and empirical studies. The development of theories that allow the generation of measures of financial stability is central to the understanding of the elements that should be included in any definition and their relationship to one another. They should be consistent and allow for the central bank decision making. Aspachs et al. (2006), Dubey et al. (2003, 2005), Espinoza et al. (2011), Goodhart et al. (2006), Tsomocos (2003) and Goodhart and Segoviano et al. (2009), among others, have made efforts towards defining the theory and practice of financial stability. However, there are still outstanding issues to be resolved, especially for emerging countries, as most studies have focused on developed economies.

In empirical and statistical research about the measurement of financial fragility we find the early works based on contingent claims. Merton (1974) provides a statistical model where equity is taken as a call option on a firm's assets. This assumption allows calculating the distance to default and the implied default probability of the firm, which also depends on the difference between the firm's balance sheets' assets and liabilities. This approach has been applied to the banking sector in a sovereign context by Gray et al. (2010). These metrics are also complemented by measures of liquidity, already mentioned in the previous section. However, the lack of co-movement explanations and the inevitability of distributional assumptions make this type of models less robust and serviceable. In case of systemic risk assessment (co-movement) research, we find Brunnermeier (2010) and Acharya et al. (2010). These works have developed systematic models of co-movements; the former develops a co-varying Value-at-Risk measure, while the latter follows a similar idea to calculate a joint expected shortfall indicator. These metrics are important contributions but they lack theoretical foundations.

Other empirical research uses network analysis, as Kritzman et al. (2010), which calculates the absorption ratio or Chan-Lau et al. (2009). A disadvantage of this methodology, apart from the large computing time and data requirements, is that it assesses only systemic risk components, leaving aside idiosyncratic factors.

The works by Segoviano (2006) and Goodhart and Segoviano (2009) are very valuable for assessing the joint density of counter-party risks. These models are based on a solid theoretical foundation in Aspachs et al. (2007), Goodhart et al. (2006) or in Tsomocos (2003). However, they have used these measures in isolation, as financial stability and default has been the main focus of their work; they leave aside asset pricing concerns and do not consider market and liquidity risk.

In this thesis I propose to apply a semi-parametric technique (the *JLoss*, that will be defined in chapter four) based in Martin et al. (2001). This is a technique that obtains closed form solution for distributional moments of joint probability densities. Hence, it is very light in terms of computer power needs. It is similar to Segoviano (2006) or Goodhart and Segoviano (2009), but with a much simpler algorithm. In addition, I explore the relations among financial stability, liquidity and asset prices and which allows assessing risks in an integrated way. However, I have not produced a single measure for market and credit risks, as the required aggregation is highly complex (see Hartman (2010)).

Modeling financial stability under financial frictions in a dynamic stochastic framework, combined with empirical applications based on these insights, gives a more accurate and precise idea of the effects of shocks on financial and macroeconomic variables. Moreover it provides the financial and monetary authorities with a toolkit to assess financial liquidity policies and regulation, its optimal timing, and long and short run consequences. Further, this research can be used to contribute to a better understanding of regulation as discussed in Goodhart et al. (2012).

1.6 Thesis Chapters

This thesis investigates financial stability under financial frictions. The frictions I concentrate on are: money, liquidity and default. I provide a framework by which to examine the relationship between financial stability, asset prices, liquidity and economic resilience.

This thesis consists of four chapters (apart from the Introduction). The second chapter discusses the motivation for the research by studying the role of liquidity asset pricing of emerging market sovereign debt. The third chapter is a theoretical and applied model that uses the empirical findings of the second chapter. I develop a benchmark model to analyse the effects of liquidity on asset prices, financial stability and economic resilience. The fourth chapter expands this analysis by the inclusion of production and endogenous liquidity. This extension allows for a greater understanding of crisis-type equilibriums and simplifies the welfare analysis in the presence of market and funding liquidity restrictions. Finally, the fifth chapter applies a novel metric of financial fragility, based on the insights of the previous chapters. This metric is used to explain the relation among financial stability, asset prices and macroeconomic performance for emerging countries.

Chapter 2

Emerging market debt, liquidity and default

This chapter explains emerging economies sovereign bonds' spread compression and decompression. We explore the determinants of emerging markets debt spread around July 2007, where we situate the origin of the US sub-prime crisis. Employing a variety of econometric models for emerging markets sovereign credit ratings, this research finds evidence supporting that sovereign credit ratings are mostly driven by economic fundamentals, and characterize their variations. Based on this result, we perform a set of statistical tests on emerging market sovereign debt spreads. In contrast to the current research on the determinants of bonds' spreads at the firm level - using aggregate data - we find regularities and a plausible explanation for sovereign emerging market debt fluctuations. This investigation suggests that the spread compression produced prior to the sub-prime crisis is produced mainly by improvement in economic fundamentals, *proxied* by credit ratings and global financial factors. Whereas, after July 2007, the emerging market debt spread decompression is explained by the lack of international liquidity of developed economies, especially the US.[1]

[1]This chapter is entirely based on Martinez, Juan Francisco, *On the determinants of EM bond compression and decompression*; Working Paper, Saïd Business School University of Oxford, this version: 2010.

2.1 Introduction

Global financial markets have been growing rapidly over the last decade. Bond ratings had been high since the end of the big banking crises,[2] in emerging markets (from now on EM). Simultaneously, bonds' spreads decreased to their historic minimum levels between the end of 2002 until mid-2007. Furthermore, the spreads and the associated yields were not significantly different between economies. We refer to this phenomenon as "spread compression", and it lasted until June 2007. Whereas the "spread decompression" started after that date.

Our hypothesis is that EM spread compression and decompression are associated to international aggregate liquidity dynamics.[3] First, before July 2007 liquidity was abundant; hence, international investors had the resources to buy EM assets. Nevertheless, after July 2007 investors began to face liquidity constraints given the tightening in US monetary policy and as a consequence of a sustained high interest rate (5.25%, for more than a year, from mid 2006). This could explain why they pulled funds from the EM economies and re-balanced their portfolios, as we will show in this document. EM economies rely heavily on US financing, thus the price of their debt decreased importantly (i.e. spreads increased). But, what happened to EM fundamentals? And/or EM credit quality?

There is evidence indicating that credit rating movements account for changes in credit quality, which in turn is explained by variations in market fundamentals. This indicates that the ratings are associated to real factors. On the other hand, spreads and yields are linked to rating movements but also to global financial factors.[4] In the case of EM, during the period of economic prosperity (from 2001 to July 2007), most of the country credit ratings improved. We provide evidence suggesting that this was a consequence of enhancement in fundamentals. Accordingly, the spreads decreased

[2]Russia in 1998, emerging Asia in 1996-1998 and Argentina in 2000-2001 are the most emblematic cases. See Reinhart and Rogoff (2009) for further details.

[3]We will define proxies of liquidity more precisely in the following sections.

[4]Such as the VIX, that accounts for the volatility in the stock markets and the U.S. high yield, among others. For a more detailed explanation of these factors, consult Powell and Martinez (2008).

among the group of emerging countries, generating the compression phenomenon.

Conversely, from the end of June 2007, volatility in international financial markets increased. This was associated with the increasing amount of US mortgage sub-prime debt defaults and spill-overs to the structured products market, which provide financing to the banking industry. Therefore, the possibility of a credit crunch emerged, because the markets were not able to assess the true value of risk and lose confidence in the risk valuation system. This decompressed and underpriced EM spreads, independently of the intrinsic credit quality of EM economies.

In this paper, we will show that sovereign credit spreads[5] are mostly driven by fundamentals prior to July 2007 and are influenced by liquidity constraints after that date. Although the issue of avoiding excess liquidity scenarios is certainly important (i.e. the starting point of a crisis, according to Reinhart and Rogoff (2009)), in this work we concentrate on what would need to be done *once* excess liquidity is turned into scarcity of financial resources. Here the main point is how EMs should address unexpected negative US[6] liquidity shocks. The value of this argument is in showing that it is possible to avoid adverse consequences even after shocks are realized, but this depends crucially on timing.[7]

The paper is organized as follows. The second section describes the data which graphically illustrates the spread compression and decompression. The third section includes the empirical test performed to find ratings and spreads determinants and causalities. The fourth section closes the analysis by providing additional information. Finally, the fifth section concludes with a discussion of various financial policy issues.

[5] EMBI spreads when they are available.

[6] Or those of other important lenders.

[7] The liquidity shock derived from the US sub-prime event could have been identified promptly in July 2007, but most EM economies only started to apply liquidity policies at least a year later.

2.2 EM spread compression and decompression, stylized facts and literature overview

2.2.1 On spread movements

There are thirty emerging market countries included in the EMBI.[8] These countries have experienced a wide range of variations in their spreads and makes up our database sample of, which is described in the appendix section, indicating the sources for all the variables included in the analysis.

Figure (2.1) shows the spread variations since 1998. Some interesting features are the large spread variations of all EM countries during the Russian crisis and the appearance of some outlier spread movements, such as Russia (obviously affected by its own crisis), Argentina, after the default in 2001 as well as Ecuador and Ivory Coast, as a result of highly unstable internal financial and political conditions.

[Insert figure (2.1) here]

After dropping the most volatile country spreads, we can observe a group of economies with similar behavior. Considering that the spreads account for the country payment conditions due to both risk and demand for sovereign assets, this harmonized behavior is associated with these countries aggregate performance and financial conditions. The sample selection of EM countries will be supported by an econometric test performed in the empirical section.

[Insert figure (2.2) here]

Figure (2.2) shows the individual and aggregate spread movements of selected EM countries. It suggests that there are a number of systemic factors that influence the financial situation of EMs. These systemic factors can be related to fundamental or

[8]EMBI: Emerging Markets Bond Index, prepared by JP Morgan. This index is a weighted average of sovereign bonds spreads for emerging markets, relative to the US treasury rate

liquidity variables, depending on the global financial situation.

From July 2007, there is uncertainty when making financial decisions. This is different from the situation prior to that date, which was characterized by a continuous improvement in global economic and financial conditions, resulting in low and indistinguishable spreads among EM countries. To have a clearer idea of what happened before and during the sub-prime crisis, we focus the analysis on selected countries, based on spreads between January of 2006 and April 2008, as shown in Figure (2.3).

[Insert figure (2.3) here]

Figure (2.3) shows spread movements of a sample of EM countries. We argue that the relatively more systemically driven (i.e. co-varying similarly) countries have a close relationship, as with the low spread countries. Prior to the crisis, there were no large spread differences among countries in this group. Therefore, investment decisions based exclusively on spreads were difficult to make. After the sub-prime crisis in the US market (one of the most important investors in EM), the internal US financial turbulence resulted in a credit squeeze, which constrained liquidity and propagated to (i.e. introduced excessive noise in) the global financial market, and subsequently to the EM. As one of the most important consequences, spreads grew quickly. As a result EM countries experienced difficulties in acquiring external finance, because of its higher cost. Nevertheless, this lack of investment and increase in risk is not uniform among countries after 2008. There are some countries, for example Chile and Malaysia, whose risk has not yet increased significantly.

2.2.2 On fundamentals

Asset (external debt in our case) fundamentals in the context on sovereign economies are measured by financial, political and economic management variables that influence creditworthiness. Where the later is used in this paper as a summary of fundamentals.

Table (2.2) illustrates the improvement of emerging market macroeconomic variables before the crisis started. This progress was driven by systemic and idiosyncratic factors. Systemic factors include the improvement of world financial conditions, technological progress, increasing demand for commodities and a global tendency to increase production and efficiency; idiosyncratic factors are represented by better institutional development, sound macroeconomic fiscal and monetary policy, and strengthening of government institutions. Those factors improved the sovereign credit conditions among most EM countries.

[Insert table (2.2) here]

We can observe in Table (2.2) that, except for GDP growth, all the variables have shown a considerable improvement in all the EM country regions (Asia, Europe and Latin-America). It is understandable that growth has not increased or even slightly decreased in certain EM countries, between 2000 and 2005, as in this period most countries have stabilized growth after 2000. Nevertheless, the selected countries continued to improve in all the other dimensions by 2005.

Preliminary data and IMF country reports state that most of the countries are still improving in political and institutional development to the present, but there is still scope for improvement in growth and inflation control after the US sub-prime crisis. Most of EM countries were severely affected by the reduction of external demand, price pressures, elevated commodity prices and pernicious US currency instability.

Another plausible way to illustrate the continuous improvement in EM market performance and creditworthiness is to observe the cumulative upgrading that this group of countries received from the most important rating agencies regarding their external foreign currency debt. As we show in Figure (2.4)[9] the continuous rating improvement

[9]The cumulative upgrade series starts arbitrarily at zero in Jan 2000 and then a +1 is given to each one notch upgrade, +2 to each two notch upgrade, a -1 for each one notch downgrade and a -2 to each 2 notch downgrade, etc. All upgrades and downgrades are summed for each period and the graph plots the sum over time of that aggregate. The graph runs from January 2000 to April 2008. This plot is an updated version of Powell and Martinez (2008) figure 1, and its appearance obeys to illustrative purposes.

is followed by a considerable decrease in the EM spread. Initially, one can conclude that this reduction is driven by the improvement of the EM fundamentals. Also it is pertinent to note that the rating agencies reduced their ratings discrepancies.[10]

After June 2007, the EM rating upgrades increased, at least for one more year. We can infer that, in the aggregate, credit quality was not deteriorating. In light of these observations, the key remaining questions are: What drives the spread compression (and decompression)? Is it a fundamental improvement (weakening)? Or it is due to world financial (in) stability? Or is it a developed countries liquidity setback?

[Insert figure (2.4) here]

We address these questions in the following sections through an econometric analysis supporting these previous qualitative assessments. However, before we start the quantitative analysis, we would like to highlight the relevance of liquidity.

2.2.3 Liquidity

Liquidity can be defined in various ways. Investors and policy-makers are prone to define it purely in terms of presence of secondary markets. Econometricians prefer to relate it to bid-ask spreads, such that the more liquid an asset, the lower the bid-ask spread. Finally, economists prefer a more generic definition related to the inter-temporal budget constraint of the agents in the market. Following this definition, there are two main branches that have been explored. On the one hand, we have the interpretation of liquidity shocks as the outcome of new project ideas with a limited inter-temporal financing, as in Diamond (2001). On the other hand, we have the general equilibrium approach that treats funding liquidity as a preference for cash. As part of this latter approach, Espinoza et al. (2009), model the preference for funding liquidity in a cash-in advance framework.

These approaches all agree that liquidity refers to a price. It is a market equilibrium outcome itself and endogenous to underlying economic decisions. Thus, it is not trivial

[10] See Powell and Martinez (2008) for a more comprehensive treatment of differences in opinions.

to use a proxy of liquidity in a regression analysis. One of the objectives of this paper is to observe the influence of liquidity proxies on EM bond spreads. One underlying economic trigger is US financial conditions for the international economy, liquidity is mainly driven by financing costs, derived from the US monetary policy and international investors' behavior.

The estimations used in this paper are consistent with a currently accepted definition of liquidity. According to the IMF (2008) and the existing literature, for example that of Brunnermeier et al. (2009), liquidity is a fairly precise concept, and can be classified into *market* and *funding* liquidity. In this work we try to find suitable proxies for liquidity, which are then used in the statistical analysis.

A lack of market liquidity occurs when asset positions that are usually traded in reasonable size with little price impact, can only be transacted at a substantial premium or discount, if at all. This concept is specific to each asset. On the other hand, lack of funding liquidity arises when solvent counter-parties have difficulty borrowing immediate means of payment to meet liabilities falling due. This concept is specific to each institution. The first concept is a market occurrence, whereas the latter applies to individual institutions, although it is possible that both interact contemporaneously.

On the one hand, the liquidity shock produced in July 2007 was transmitted to the Asset Backed Commercial Paper (ABCP) market, where there are market liquidity pressures for Structured Investment Vehicles (SIV) such as CLO's (Commercial Loan Obligations). This ABCP link is measured by the spread between three-month ABCP rates and U.S. Treasury Bill yields. This measure captures the movement of the pressure by the banks to fund their sponsored SIVs, particularly their ABCP, but which is also controlled by market conditions. As a result, ABCP spreads capture variations in spread market liquidity. We will use this as proxy for market liquidity.

On the other hand, as financial conditions around 2007-2008 were highly unstable, the funding liquidity pressure is best captured by the spread between the three-month U.S. inter-bank LIBOR rate and the OIS (overnight index swap) rate. This is a measure of the increased costs of unsecured funds over the movement of one of the most liquid rates - the OIS. The OIS rate represents the instantaneous cost of changing in maturity and acts as a control for timing preferences. If this variable moves upwards, it implies that the banks are less willing to lend unsecured funds. In other words, the credit supply is reduced because of an unwillingness to trade. Another interpretation is that the lower the cost of trading inter-bank funds (the Libor-spread goes down), the easier it is to trade in the banking financial system, which results in more liquidity. Hence, Libor-OIS constitutes a proxy for funding liquidity.

Figures (2.5) and (2.6) show the liquidity proxy variables described above. The behavior of these spreads during the unstable financial period is worth noting. While remaining calm until the end of June 2007, they have exploded since then and have not stabilized in the year following.

[Insert figure (2.5) here]

The statistical - and economic - significance of all the liquidity proxies included in the analysis grew noticeably after July 2007. Recall that these variables measure lack of liquidity, so their movement indicates that liquidity was being considerably reduced. Further, these movements were greater than during the Russian crisis in 1998 and shows that world liquidity was more seriously constrained than during the previous EM crises. Moreover, while the Russian crisis affected severely the real economy, until the end of 2008 the sub-prime crisis had a greater impact on the nominal side of the economy.

In early 2008 there were brief episodes promising stability, but there has been no consistency towards greater stability. It is also noteworthy that the Libor-OIS and the ABCP spreads react similarly to market conditions, even though the Libor-OIS spread contains much less noise than the other liquidity proxies.

Market investors, because of these particularly volatile financial conditions, have reduced their maturities to shorter periods. Thus, they have shifted their positions to highly liquid asset classes. These movements in US sovereign bond maturity preferences are captured by the five year 'On/Off the Run' US Treasury spreads. 'On the Run spreads' represent for most recently issued Treasury securities; 'Off the Run spreads' are maturities issued at previous auctions with nearly identical maturity terms. Figure (2.6) shows the movement of the On/Off the Run spreads in the recent past. Consistent with other liquidity variables, this indicator also demonstrates a large increase after June 2007 but with greater volatility.[11]

[Insert figure (2.6) here]

To answer the key questions raised in section (2.2), we will use the previously discussed liquidity variables for the econometric tests on EM spreads. The following section uses panel data regressions to show that country credit ratings are driven principally by fundamentals. Then, a country-spread grouping is constructed. This is based on a co-integration test using principal component analysis that isolates the systemic and idiosyncratic country risks. Additionally, based on the result of the rating regressions on fundamentals and with the country spread sample selection obtained by the co-integration test, a series of panel data regressions and statistical tests are performed to analyze the effect of liquidity variables on spreads, controlling for fundamentals (sovereign credit ratings).

2.3 Empirical analysis

The quantitative analysis introduces a set of panel data regressions explaining the movements of credit ratings and spreads. This section relies heavily on Powell and Martinez (2008), but, in addition, extends to dynamic analysis and causality issues. For the ratings analysis we consider Cantor and Packer (1996) as a standard starting point and then examine, as in Afonso et al (2007) and Powell and Martinez (2008), alternative models. Models of ratings tend to include variables reflecting economic growth, debt

[11] This measure is often considered to be imprecise when analyzing market liquidity (see BIS (1999)), and it is noisy; therefore it will not be used in the following stages of this analysis.

and the external sector (including reserves), variables that attempt to capture political or institutional characteristics and dummy variables for debt payment history. We will show that models with a small set of variables can successfully show cross sectional ratings variations as well as their movement over time. We will replicate recent results examining the inclusion of specific variables (global financial conditions, government effectiveness and others) as well as the causality between ratings and fundamentals. This procedure has the objective of testing the validity of credit ratings for the subsequent analysis of spreads. The idea is to use variables with higher frequency than yearly sovereign national accounts data, which raise a number of issues for discussion.

This analysis and discussion is the basis for an examination of spread movements for those countries included in EMBI global index, which constitute a group of systemically important emerging economies. The cost and/or price of financing for this group of countries is vital for both the public and private sector as well as the stability of the international financial system as a whole. Do ratings, liquidity and financial variables matter for spreads? The tests to answer this question will include real and financial variables and then draw conclusions about the importance of liquidity across time for determining the spread movements. It is the main focus of this paper. The liquidity significance across states of nature (defined by liquidity conditions before and after July 2007; these correspond to good and bad state of natures for EM, respectively) will be addressed by a set of liquidity proxies, used and proposed by the IMF[12] and found in the existing literature. As we previously mentioned, our hypothesis is that spread compression was initially driven (from the end of Russian crisis) by market fundamentals, and that the decompression, since the sub-prime crisis, was influenced by a liquidity shortage in financial markets; this constitutes a complete overview of sovereign credit risk in emerging markets during the last decade in emerging markets.

[12] See “Global Financial Stability Report", IMF (2008).

2.3.1 Rating regressions and fundamentals

The topic of ratings rationalization is a widely studied one, in particular for sovereign debt. The seminal paper is that of Cantor and Packer (1996), which was the first to analyze country variables to explain ratings in a cross-section framework. This timing constraint is a restrictive assumption, but can be relaxed. There are other papers that have tackled the time variations of ratings. Afonso et al. (2007) is one of the most successful summaries, where the authors develop a methodology to explain time variation in ratings using panel data regressions and include fixed and random effects in the model specifications. They show that random effects can be important when incorporating long term effects (for example, variable averages). Nevertheless, for the purposes of this paper, the fixed effects specification is preferred, as we want to explain the variation in spreads by using ratings variations over time. Therefore, the best way to capture this movement is by using fixed effects, recognizing that there are idiosyncratic factors that belong to each country, and allowing them vary over time.

There is discussion in the current literature about how to correctly specify a rating regression. One issue is related to the dependent variable. In this paper, the ratings are measured by the agencies with a non-linear[13] scale represented by 21 letters in the case of Moody's and Standard and Poor's. Perhaps there is some scope for trying this variable as a discrete outcome.[14] However, the construction of a linear scale from 1 to 21(AAA or Aaa) using OLS techniques turns out to be a much better approach by which to interpret the results. Although the ratings' non-linearity could be a problem, it should be recognized that, the rating variable is stable and does not vary much over time, even though its cross-section performance is quite good. It should be recalled that the rationale for using ratings is to summarize the information related to creditworthiness. The alternative would be to apply macro variables directly in the following spread regressions, but they have lower time variability, and the frequency of the regressions would have to limited to a couple of time data points.

[13]Especially around investment grade, or rating BBB- for S&P and Baa3 for Moody's.

[14]We performed also a set of Poisson Panel regressions to account for the non-linearities. The results are significantly similar to those for the OLS regressions, and although more precise do not resolve issues of interpretation. These regressions are not included in this paper.

2.3.1.1 Theoretical determinants of sovereign credit ratings

The dependant variable for the regressions about fundamentals is the sovereign credit rating for long term foreign currency debt assigned by the Standard and Poor's and Moody's credit rating agencies. We have converted these to a numerical scale from 1(default) to 21(AAA,Aaa) and OLS regressions are then applied considering the econometric issues described above.

The variables included in this set of regressions are the most relevant for creditworthiness; economic growth, debt level, external sector balance, political and institutional stability, debt payment history, world financial situation and group-specific geographic dummies. It turns out that those core variables can plausibly explain the cross sectional and time variations of ratings. The discussion of these variables is consistent with S&P and Moody's sovereign rating definitions (2008 and 2004, respectively).

1. *GDP per capita*. This variable is intended to capture the level of income across the EM. The greater the level of income, the better possibilities to repay obligations.
2. *Real GDP Growth*. It captures the current growth. Although, it certainly suffers from the gravity effect (i.e. it is difficult to maintain high growth), and is subject to volatility.
3. *Unemployment*. This variable responds to three main economic issues; first, labor flexibility, fiscal impact and finally political pressures on governments. As can be inferred, the effect of this variable on ratings is not necessarily unidirectional.
4. *Inflation*. Monetary flexibility is what this variable wants to capture. In circumstances when there are inflationary episodes, monetary flexibility gets damaged and it obliges the authorities to tighten money supply.
5. *Gross Central Government Debt to GDP*. This variable reflects the relative ability of the government to meet its payments. However definitions, for example 'gross',

are not uniform across EM economies.

6. *Fiscal Balance to GDP*. This variable is used as a proxy for the capacity to repay and efficiency of the public sector. It indicates the capacity of a government to raise the required amount of taxes, relatively to its size. Thus, measuring fiscal deficits or surplus rates relative to the size of each economy.

7. *Government Effectiveness*. This variable is open to more discussion as a measure of political risks. It is based on a careful global survey of the World Bank. However there are endogeneity issues, since government effectiveness could also be the product of a good credit rating management. We agree with Powell and Martinez (2008) in that it is difficult to distinguish among the different set of opinions that generate the ratings and government effectiveness surveys. Although it could be statistically significant, the results should be interpreted carefully.

8. *Foreign Debt to Exports*. This is a measure of how much the economies need to obtain external resources to repay external creditors.

9. *Current Account balance to GDP*. This variable is supposed to measure the ability of the economy to generate resources by trading goods and services produced internally. However, there are larger countries with higher deficits that are able to run those deficits, precisely because they are more resilient. Thus, this variable cannot be interpreted as directly affecting credit quality or ratings.

10. *Government Reserves to GDP*. This variable, which also measures ability to generate and save resources. However, it suffers from the same drawbacks than the current account to GDP variable. In this case, this variable is a stock rather than a flow.

11. *Tax Revenues to Total Debt*. Again, this variable represents payment capacity and effectiveness in raising resources internally relative to the size of obligations.

12. *Original Sin 3*. This variable is obtained by replicating Hausmann and Panizza (2003), and it is calculated as the domestic currency debt divided by total debt,

using the BIS securities' database.[15]

13. *Volatility of Real Exchange Rate*. It measures monetary flexibility and the resilience to external shocks in the currencies market and the relative local response.

14. *Public Debt denominated in Foreign Currency to Total*. It measures the sensitivity of debt to currency risks.

15. *US Treasury yield*. This is a control for external global financial conditions (global debt market).

16. *US High yield*. This is a control for external global financial conditions (global debt market).

17. *VIX index*. This is a control for external global financial conditions (global equity market).

[15] Original Sin 3, $OSIN3_i$ measures the issuance of debt in foreign currency as $Max\left\{1-\frac{\text{Securities in currency i}}{\text{Securities issued by country i}},0\right\}$, for more details please revise Eichengreen et al. (2005).

2.3.1.2 Credit ratings regression specification

$$
\begin{aligned}
Credit\ rating^{i,j}_{t\ or\ (t-1)} = & \alpha + \beta_1 * \log(GDP\ per\ capita^i_t) \\
& + \beta_2 * (Real\ GDP\ growth^i_t) + \beta_3 * (Real\ GDP\ growth^i_t) \\
& + \beta_4 * (Unemployment\ rate^i_t) + \beta_5 * (Inflation^i_t) \\
& + \beta_6 * (Gross\ Debt\ to\ GDP^i_t) + \beta_7 * (Fiscal\ balance\ to\ GDP^i_t) \\
& + \beta_8 * (Government\ effectiveness^i_t) + \beta_9 * (Foreign\ debt\ to\ exports^i_t) \\
& + \beta_{10} * (Current\ account\ balance\ to\ GDP^i_t) \\
& + \beta_{11} * (Government\ reserves\ to\ GDP^i_t) \\
& + \beta_{12} * (Revenues\ to\ total\ debt^i_t) + \beta_{13} * (Original\ sin\ 3^i_t) \\
& + \beta_{14} * (Volatility\ of\ RER^i_t) \\
& + \beta_{15} * (Foreign\ currency\ to\ total\ debt^i_t) \\
& + \beta_{16} * (\mathbb{1}(if\ in\ default\ at\ t)^i_t) \\
& + \beta_{17} * (\mathbb{1}(if\ in\ default\ since\ 1970)^i) \\
& + \beta_{18} * (\mathbb{1}(if\ entered\ to\ EU\ at\ t)^i_t) \\
& + \beta_{19} * (\mathbb{1}(if\ entered\ to\ EU\ at\ t\ step)^i_t) \\
& + \beta_{20} * (\mathbb{1}(if\ LAC^{16}\ country)^i) + \beta_{21} * (US\ Treasury\ 10y\ yield_t) \\
& + \beta_{22} * (US\ High\ 10y\ yield_t) + \beta_{23} * (VIX_t) \\
& + u_i + averages(on\ i\ countries\ for\ k\ variables)_t + \varepsilon^i_t
\end{aligned}
$$

The specification above sets out the shape of the general specification of rating regressions on fundamentals and financial control variables. Here $j \in \{S\&P, Moody's\}$ that is, the same set of regressions for both agencies are performed in this case, whereas $i = 1, ..., n$, represents the countries, which vary depending on the specification and data availability.[17] Averages are included for the random effects specification regressions, and u_i stands for those with fixed effects. The residual is ε^i_t and the β_k,where $k \in 1, 2, ..., 23$, is the total number of variables considered, thus, the number of coefficients depend on the particular specification.

[17]We also run the same specifications for the lagged rating variables, to take into consideration the predictability of ratings on fundamentals; this issue will be analyzed later in this section.

2.3.1.3 Results: rating regressions

Table (2.3) shows a set of annual frequency regressions of ratings on fundamentals with controls for Moody's and Standard and Poor's, respectively. We restrict the sample of regressions to those countries with sufficient information (especially debt, which under some definitions can be restrictive) and with enough rating variability in the time series dimension. IDB (2006), Cowan and Jaimovich (2006), Powell and Martinez (2008) and Panizza (2008) examine the issues of currency debt composition, debt ownership jurisdiction, government or private debt ownership which they regard as crucial, (for more details see the quoted papers).

[Insert table (2.3) here]

The first column of this set of regressions contains Afonso (2007)'s preferred model which is a specification with random effects, but controlling for long-term trends by the inclusion of average variables (not shown in this table). The models in columns (I) and (VII) have good explanatory power and the variables included explain ratings in a sensible way. In almost all the dimensions analyzed by rating agencies, the variables are in the correct direction, for example, macroeconomic performance, financial strength, payment history and political stability. Nonetheless it raises unsettled economic concerns. For instance, there is the issue of reverse causality when using the current account variable; a wrong sign is embedded in the latter. An example can be found with the relatively more developed economies, where the higher the rating, they are “allowed" to have a greater deficit. There are other issues noted below as modifications made in the specifications.

Column (II) has included fixed instead of random effects, in order to capture the time and cross sectional variations in a simpler model.[18] This specification also drops one of the regional dummies and that described as historic default. By looking at the R-squared, the within-variation explanation is enhanced, and it provides a more parsimonious model with which to describe the ratings.

[18] As proposed by Hausmann (2004).

In the following columns some irrelevant variables are dropped and some concepts added to construct a simpler model, to explain rating movements across countries. So the government effectiveness[19] variable is removed, as it is widely correlated with the credit rating; and leads to problems of endogeneity.

We also include the *Original Sin 3* variable, from Hausmann and Panizza (2003). This coefficient has the right sign, since it implies that a higher dependence on foreign currency denominated debt implies a lower repayment. Although it is not statistically significant, mainly due to the sample selection, it is an important variable for measuring debt currency risk. Indeed, it is documented (e.g. Eichengreen et al. (2005), IDB (2007), and others) that EM have suffered from the original sin effect. That is, from issuing debt in a foreign currency.

Debt quality and composition appears to be an important factor in determining ratings and is also a good approximation for country specific fiscal policy performance. It is one of the most important variables in determining the probability of default. Additionally, following Calvo et al.(2004), it increases the possibility of a *sudden stop*.

The preferred specifications are in columns (V) and (XI) which include financial external conditions as control variables, as well as stock market volatility through the VIX index. These variables are important for rating explanations, unlike the Treasury long rate, the effect of which is weak.

As noted above, we also performed a group of regressions with the same specifications of the first set, columns (XIII to XXIV), except that the dependent variable is the lagged credit rating. The objective here is to analyze the predictability of ratings. From the magnitude of the R-squared, one can conclude that these regressions have a slightly lower explanatory power. The reason is the way that governments' national accounts data are released. We know that the data are available at least with a lag of one semester. Therefore, the contemporaneous rating variable still captures the predictability of funda-

[19] A political stability variable developed by Kaufmann et al. (2006).

mentals. However, a remaining question is still unanswered: are these regressions free of a reverse causality problem?

2.3.2 Causality between rating and fundamentals

In this section we perform a series of tests in order to determine the predictability of credit ratings on changes to fundamentals and also to assess the ratings causality in terms of their relationship to fundamentals. For this purpose we performed a panel VAR (following Love, 2006) using a subset of the variables found in the above regressions. There are, of course, several endogeneity issues that cannot be avoided with this approach. Yet it provides an appropriate way to examine causality issues within the framework of panel data.

[Insert table (2.4) here]

Table (2.4) shows a panel VAR set of regressions that include ratings, GDP per capita and global financial factors. The columns represent different combinations of regressions applied to a specified dependant variable. In the rows appear the explanatory variables for each combination. These variables include 1 and 2 lags. We observe that for the majority of the cases, especially in the case of 2 lags, the t-statistics are more significant in regressions of credit ratings as dependant variables. Whereas t-stats are smaller for the reverse direction of causality. As one can observe in Table (2.4), there is at least weak evidence which shows that credit ratings are driven mainly by fundamentals in the proposed direction of causality. Both theoretically and practically, the effect of fundamentals in determining the likelihood of a country fulfilling or otherwise its obligations is important for the analysis of country creditworthiness. As the explanatory variables for credit ratings, we consider the same dimensions as the rating agencies. Therefore, at least in theory the causality should follow the assumed direction.

If one considers the persistence of ratings and fundamental variables, in the panel VAR specification, the preferred model might have a two years lag rather than one.

Thus, the preferred specifications should be those in the evened numbered columns. If for example, we take column (II), it can be observed that GDP per capita has a highly significant effect on S&P rating (t-stat is 2.54 and size is 6.114), but the reverse causality does not hold in this case, since GDP has a low statistical significance in determining ratings (t-stat is 0.69). If, as a robustness check, we take the lagged credit rating as an independent variable, the results still hold and in some cases are stronger[20]. Nevertheless, the evidence is weaker for the Moody's data but maintains the same direction of causality as those of the S&P rating agency.[21]

[Insert table (2.5) here]

As additional evidence which supports the causal effect of fundamentals on ratings, one can examine the variance decomposition matrix in Table (2.5), obtained from the Panel VAR analysis. The results indicate that GDP per capita explains at least 28% of credit ratings variability and this percentage increases to 41.6% when increasing the number of simulations. If one considers the lagged rating (S&P in this case) in the analysis, the results are even stronger. More than 65% of credit ratings variance is attributed to fundamentals, and just 4.3% is attributed to the reverse case (i.e. variance of fundamentals due to credit ratings).

Thus from this evidence, we are able to suggest that fundamentals cause credit ratings, whose contain and summarize its information. Therefore, we will include the rating variables as the control variables for the fundamentals on spread movements during the time window considered. However, before proceeding, it is necessary to identify which countries follow systemic factors rather than idiosyncratic financial determinants. The following section explains the screening procedure, using a co-integration test performed by a principal component analysis.

[20] We also controlled for the opposite. That is, we considered also the credit rating as a leading indicator, trying to capture a possible through-the-cycle sovereign debt evaluation. The results suggest that this relation is weak. Hence those are not presented in this paper.

[21] Those results diverge presumably because Moody's has a slightly different rating definition. On top of the probability of default they also consider the recoverability of debt after a default episode, which is not used in this simplified and parsimonious analysis.

2.3.3 Co-integration test and sample selection

Panel co-integration tests are a rather complex procedure especially with financial data; and their derivation and consequences have often been a matter of discussion. For a comprehensive analysis of panel co-integration tests and its asymptotic properties see Baltagi (2008).

Rather than running a standard co-integration test, this paper explores an alternative and *ad-hoc* statistical procedure. This procedure supports the grouping among emerging markets spreads that we apply in this paper. The method combines principal component analysis and standard OLS regressions.

First, a principal component analysis of the countries available in the Emerging Markets Bond Index (EMBI) is constructed. Remarkably, more than 70% of the spreads variance is explained by the first component while the two first components explain more than 86% and if a third is included then 91% is explained. This is the first sign EM spreads are strongly related to a systemic component and less to idiosyncratic factors. Figure (2.7) presents the scores for the first 3 principal components. In this case, the first component serves as a proxy for world financial liquidity (or illiquidity).

[Insert figure (2.7) here]

Undoubtedly, the first factor grows sharply after the sub-prime crisis increasing in volatility over time, and illustrated by the previous graphs on liquidity. The other two factors are more closely related to country idiosyncratic components, perhaps related to the internal capacity of each emerging market economy to meet its credit obligations.

Once the first 3 principal components have been calculated, we run a set of regressions using the individual country spread as the dependent variable. The set of independent variables include in this case, one, two, three or the combination of the first three principal components. The R-squared stands for the combination of all of these regressions, where due to the property of orthogonality of the principal components, the coefficient and standard errors of the OLS regressions remain invariant to the specification. Countries' values that do not follow the central tendency are in bold. In the case of the more systemically driven countries, the first column R-square values are higher than those of the second and third column. Countries with a lower systemic dynamic have greater R-squares in their second and third column (perhaps related to more idiosyncratic factors). Table (2.6) shows the results of the co-integration test regressions.

[Insert table (2.6) here]

We want to perform a clean analysis of the variables affecting EM debt spreads. Thus, outliers are eliminated to focus the analysis in the countries driven (comparatively more) by systemic factors. With the co-integration test results, these countries that are - more - related to the idiosyncratic components are discarded. In addition, and to show that there are uncharacteristic patterns among the idiosyncratic group of countries, the principal component factor loadings are plotted. Figure (2.8) shows the first three factor loading components against each other. It is clear that the group of idiosyncratic countries after 2006 is composed of the Ivory Coast (CIV)[22], Ecuador (ECU), Lebanon (LEB) and Nigeria (NGA). However, countries like Peru (PER), Philippines (PHL), Uruguay (URY) and Venezuela (VEN) are also weakly included in this exception.

[Insert figure (2.8) here]

From Kauffman et al. (2006) we can observe that most of these countries - Ivory Coast, Ecuador, Lebanon and Nigeria - are affected by political and financial difficulties. Their governments are politically unstable and their financial systems are weak. In sum, they are driven more by their internal difficulties than other factors.

With the remaining countries, it will be possible to perform an econometric analysis of what is driving spread movements. We will try to elucidate the determinants of

[22]The country codes are those of the World Bank.

spread compression and decompression. The following section discusses the statistical and econometric tests that will explain the variations of spreads through time and among countries and the proposed tests which are rather innovative in this matter.

2.3.4 Test on spreads, ratings, global financial and liquidity variables

Since the sub-prime crisis spreads have been increasing and have become more volatile. Prior to June 2007 spreads declined. To elucidate this spread compression and decompression, we run a set of panel regressions of spreads on the selection of countries driven by systemic factors; recall that the purpose of this study is to explain the central tendency and not outlier patterns.[23]

2.3.4.1 Theoretical determinants of sovereign spreads

Unlike the current literature on spreads' determinants (see for example Collin-Dufresne, et. al. 2001), we find a relationship between economic fundamentals, global financial factors, liquidity and spreads. We acknowledge that these factors are not necessarily attributable to private company debt spreads, but they do suggest a plausible direction for further research. We describe the chosen sovereign spread determinants as follows.

1. *Credit rating*. As we have shown in the previous section, this variable accounts for fundamental variations of the countries analyzed and therefore represents creditworthiness. We also performed a test considering the lagged credit rating in order to address the fact that ratings have predictive power on fundamentals.

2. *VIX Index*. This variable describes stock market volatility and for US investors constitutes an alternative source of funding. This variable is used to show international stock market risk.

3. *US Treasury 10 years yield*. This variable describes US financial costs, on which loans for EM countries are based.

[23]The countries excluded are the Ivory Coast, Ecuador, Nigeria, Peru, Philippines, Uruguay and Venezuela. This sample uses data between January 2006 and April 2008.

4. *US High 10 years yield.* This variable describes US financial costs, as above, but for riskier investments.

5. *On/Off the run spreads.* On the run spreads stands for most recently issued Treasury securities; off the run stands for securities issued at previous auctions with nearly identical maturity terms. It shows, how easily recent securities are traded, relative to those issued previously, describing market liquidity. However, this variable contains a considerable amount of noise.

6. *Libor-OIS spread.* As discussed earlier, this variable is a proxy for funding liquidity.

7. *ABCP spread.* As above, in this case, this variable accounts for US market liquidity.[24]

2.3.4.2 EMBI spreads regression specification

$$\begin{aligned}\log(EMBI\ spread_t^i) =& \alpha + \beta_1 * \log(Credit\ rating_t^{i,j}) \\ & + \beta_2 * \log(US\ Treasury\ 10y\ yield_t) + \beta_3 * \log(US\ High\ 10y\ yield_t) \\ & + \beta_4 * \log(VIX_t) + \beta_5 * \log(Libor - OIS\ spread_t) \\ & + \beta_6 * \log(ABCP\ spread_t) \\ & + \beta_7 * \log(On/Off\ the\ run\ spread_t) + u_i + \varepsilon_t^i\end{aligned}$$

The above shows the general specifications of spread regressions on ratings, liquidity and financial control variables. As before $j \in \{S\&P, Moody's\}$ and as previously the same set of regressions for the two agencies is performed in this section and where $i = 1,...,n$, represents the countries, which vary by specification and data availability. The term u_i stands for fixed effects. The residual is ε_t^i and β_k, where $k \in 1,2,...,7$, is the total number of variables considered. Thus, the number coefficients depend on the particular specification.

[24] It is important to emphasize that the set of US variables represent the global financial conditions, given the weight of the US economy in financial markets, especially for EM countries.

2.3.4.3 Results: spreads regressions

Table (2.7) contains a set of regressions od EMBI spread as a dependent variable on Moody's and S&P monthly credit ratings, plus some other controls. The first column contains the regression specification for S&P, using the whole sample; the two following columns contain the regression performed in two time windows. The first window is from January of 2006 to June 2007, and the second from July 2007 to April 2008. First, notice that the credit rating loose significance in the second period for the S&P rating. For all other cases it is not statistically significant. However, given to the reasons explained above, it is the best possible control variable for fundamentals. The sign is correct since the better the credit rating, the narrower the spread. Secondly, the global financial variables have a volatile pattern before and after the sub-prime crisis started, but act as a natural control for financial external conditions and also have the “correct" signs. Finally, the liquidity (perhaps more clearly illiquidity) variables vary positively in the period of spread decompression and move in the same direction (from negative to positive).

[Insert table (2.7) here]

The Libor-OIS spread has a positive sign and it is statistically significant for the period after and before the crisis. However its level of significance and size increase considerably following the sub-prime event. Conversely the asset backed commercial papers (ABCP) spread has a negative sign, but it changes in the right direction following the crisis. The On/off-the-run spread is rather insignificant. This is not surprising, given the reasons stated above.

In order to overcome the problem of the liquidity variables conflicting with each other and trying to isolate their effect, the On/off the run spread is dropped. This contributes to parsimoniousness and makes clearer the effect of the liquidity variables on the spreads when splitting the data. As a result, it can be seen that there is no lack of explanatory power and that the main conclusions of the previous analysis still hold. Table (2.7) shows the results of this variation.

The periods chosen for analysis might be considered arbitrary, although it was based on press reports. The criteria are explained using a rolling panel data regression methodology in the next section.

2.3.5 Parameter stability, structural change and explained spread variance

Parameter stability is an interesting feature to analyze. A graphical approach is used to get broader explanations of the emerging markets spread determinants and to confirm a change of path after the crisis began. With a window of six months, a set of rolling regression is prepared, for which, coefficients are plotted on the graphs below, where the value of the coefficient is assigned to the middle point of the rolling window. Figures (2.10) (a), (2.11) (b), (2.12) (c) show remarkable changes suffered by the fundamental, financial and liquidity variables during the crisis period. Figure (2.9) shows the betas for all the variables included in the regression.

[Insert figure (2.9) here]

First, from Figures (2.9) and (2.10) (a), it is clear that the credit rating[25] loses the “right sign" through time because its coefficient started to increase just after the crisis. Following the earlier analysis, fundamentals do not seem to be the reason why spreads increased after the crisis, but they are important in the previous period. Secondly, global financial variables seem to matter in the determination of spreads before and after the sub-prime event. Further they suffered a dramatic distortion following the crisis, influenced by an unpredictable financial environment. Except for the US high yield, the other variables’ coefficients experienced a change in direction. This means that those variables varied in economic importance after the episode, although the VIX effect was the largest.

[Insert figure (2.10) (a) here]

[25] We used Standard and Poor’s sovereign credit rating rather than Moody’s in this case; the results with the Moody’s data are similar.

On the other hand, after the sub-prime event, it can be observed that the coefficients associated with the liquidity variables started to increase, turning from negative to positive. It clearly means that those variables started to matter more for spread movements, where the greater the value of these coefficients means the greater the spread value. This is to be expected from the earlier analysis, as the higher the value of the coefficients the greater the likelihood of illiquidity.

[Insert figure (2.11) (b) here]

The previous analysis considers only the values of the coefficients rather than their level of statistical significance. So it is necessary to use a graphical approach which takes into account changes in significance during the crisis period. Thus, we plotted the 95% confidence level interval for the coefficients in the previous graph; this shows two standard deviations of the coefficients' mean.

The main purpose of these plots is to see whether there were noticeable changes in the significance of the variables. This would lead to have some interesting conclusions about the reasons that have driven the spreads to change before and after the sub-prime. Figures (2.10) (a), (2.11) (b) and (2.12) (c) capture those significance movements through time and they were constructed using the same specification as in Figure (2.10).

[Insert figure (2.12) (c) here]

First, from Figure (2.10) (a) it appears that sovereign credit ratings are losing significance as the crisis advanced. Our claim is that creditworthiness has not changed dramatically during the period of the crisis. Then, throughout the crisis, it appears that spreads are determined more by a liquidity shortage. The standard errors of Standard and Poor's credit rating have been increasing substantially after the crisis; this is strong evidence of a separation between fundamental and liquidity effects on spreads.

Secondly, from figure (2.11) (b) on the liquidity variables side, spreads are increasingly explained by liquidity shortages throughout the sub-prime event. It can be observed that the standard errors of the ABCP spread coefficient decreased since end of June 2007. On the other hand, Libor-OIS coefficient increased in absolute value. This supports the view that the investors' funding liquidity constraint started to bind after the sub-prime event. Whereas market liquidity was used as substitute financing (pushing EM spreads in a negative direction). The net effect was an increase in EM spreads with US liquidity providing a greater explanation for EM spreads after July 2007. Thus it would appear that US investments in emerging markets have been decreasing over time, not due to fear of sovereign default but due to their own liquidity demands, given the credit squeeze.

Thirdly, from figure (2.12) (c) we can conclude that the US Treasury (10 year) rate coefficient has been significantly stable through time, as its standard errors are bounded. However, as the coefficient's value is small, the accuracy of its significance increased after the crisis. Something similar happened to the US High Yield bond, but on a larger scale, as it too began to have greater significance after the sub-prime episode. On the other hand, the VIX coefficient has been volatile and also has large standard errors reflecting the considerable uncertainty in the stock markets and how it affects spreads. However, in this case, the VIX is less economically important when compared to the other financial variables, as it reflects more an increase in current market volatility rather than direct changes in spreads.

2.3.6 A structural break test on spreads

The previous evidence in support of a liquidity effect on sovereign spreads, after the sub-prime crisis can be strengthened by performing a Chow (structural change) test, performed in the preferred regressions. The test uses interactions with a dummy variable which take the value of 1 after the crisis and 0 for the previous period. Table (2.8) shows the result on a wide variety of combinations on the variables with the break at the end of June 2007.

2.3.6.1 Chow test regression specification

$$
\begin{aligned}
\log(EMBI\ spread_t^i) =& \alpha + \beta_1 * \log(Credit\ rating_t^{i,j}) \\
& + \beta_2 * \log(US\ Treasury\ 10y\ yield_t) + \beta_3 * \log(US\ High\ 10y\ yield_t) \\
& + \beta_4 * \log(VIX_t) + \beta_5 * \log(Libor - OIS\ spread_t) \\
& + \beta_6 * \log(ABCP\ spread_t) \\
& + \beta_7 * \log(Credit\ rating_t^{i,j}) * \mathbb{1}(t > July2007) \\
& + \beta_8 * \log(US\ Treasury\ 10y\ yield_t) * \mathbb{1}(t > July2007) \\
& + \beta_9 * \log(US\ High\ 10y\ yield_t * \mathbb{1}(t > July2007)) \\
& + \beta_{10} * \log(VIX_t) * \mathbb{1}(t > July2007) \\
& + \beta_{11} * \log(Libor - OIS\ spread_t) * \mathbb{1}(t > July2007) \\
& + \beta_{12} * \log(ABCP\ spread_t) * \mathbb{1}(t > July2007) \\
& + u_i + \varepsilon_t^i
\end{aligned}
$$

The expression above presents the general specification of a structural test of spreads on ratings, liquidity and financial control variables. As before $j \in \{S\&P, Moody's\}$ and as before the same set of regressions are performed for the two agencies in this section. The term $i = 1, ..., n$ it represents the countries, that vary depending on the specification and data availability. The term u_i stands for fixed effects. The residual is ε_t^i and the β_k,where $k \in 1, 2, ..., 12$, is the total number of variables considered, thus, the number coefficients depend on the particular specification.

2.3.6.2 Results: spreads structural break test

Table (2.8) contains the structural break combinations that allow splitting the different determinants and changes before and after the crisis. First, we run the complete specification, considering all the dummy combinations and explanatory variables. The explanatory variables follow the same behavior as in the previous section on spread regressions. The asset-backed commercial paper (ABCP spread) with dummy interaction is statistically significant when considering Standard and Poor's credit rating as a control, while the effect with Moody's data is weaker. The rest of the coefficients, associated to dummy variables interacted with financial variables, are weakly significant in the case o the US Treasury yield, but insignificant for the others.

[Insert table (2.8) here]

In order to avoid multi co-linearity issues in the test regressions, we selected the specific variables from the general to a more parsimonious model. The explanatory power of all of those regressions is more than acceptable, considering the R-Squared (within variation) between 50% and 69%.

First, for credit ratings, it is clear that this variable has not suffered from a structural break under any of the constructed specifications; this fact reconfirms the thesis that ratings (equivalent to fundamentals) are not driving the spread movements in the same proportion after the crisis as before.

Secondly, for global financial variables the evidence is somewhat mixed. In some specifications, the coefficient that interacts with the dummy variable is statistically significant. However, the effect is not totally robust.

Thirdly, when increasing parsimony in the regressions, the liquidity variables start to show unusual behavior. They are affected by a structural change. The effect is eloquent when analyzing the Asset Backed Commercial Papers spread, but it weaker in the case of the Libor-OIS spread. Nevertheless in the preferred specification (columns XV and XVI), both liquidity proxies interactions are statistically significant.

Market or funding liquidity?

The preferred specifications (in columns (XV) and (XVI) of table (2.8)), show the relatively larger economic importance of funding over market liquidity as an explanation of the spread decompression phenomenon. The rationale of this trade-off can be described as follows. First, when the international economy (US) faces liquidity constraints, there are two possible reactions. If liquidity constraints are associated with a lack of information within the US market, then, it is reasonable to assume that US investors send relatively more resources abroad, in particular to EM economies. On the other hand, when funding liquidity suffers a setback, the natural reaction of US investors should be to withdraw funds from the EM and finance their safer local investments (the hoarding hypothesis).

The coefficients on ABCP spreads are negative. This indicates that, on average, when market liquidity decreases in the US, international investors tend to increase their participation in EM. Figure (2.13) shows that once funding liquidity decreased (measured by Libor-OIS, around July of 2007), market liquidity started being more used (Market capitalization) without affecting the prices in the short run (Stock prices). On the other hand, when Libor-OIS spreads increases (i.e. when funding liquidity suffers a setback), US investors withdraw resources from EM economies. The net effect between the two variables is positive. In other words, after July 2007 spreads increased with EM economies. As might be expected, the coefficients of Libor-OIS spread were slightly higher than those for ABCP spreads in this simplified linear regression setting.

Considering the evidence from the data around July 2007, it can be inferred that EM spreads increased because of funding liquidity constraints in US. However, to show the link between funding liquidity, US demand for EM debt and spreads, it is important to examine the US holdings of EM debt and which is discussed in the following section.

2.3.7 Spread variance decomposition

Building on the previous evidence, and to conclude with a quantification of spreads' compression and decompression, we perform a variance decomposition of spreads using panel data estimation with fixed effects, consistent with the earlier analysis. The data starts in January 2006 and ends in April 2008. We divided the sample into periods before and after the sub-prime crisis began, This is consistent with the data window we used in the tests performed previously. Table (2.9) shows, in percentages, the total variance of emerging market spreads explained by the global financial variables, credit ratings (Moody's and Standard and Poor's), liquidity variables and fixed effects.

[Insert table (2.9) here]

The evidence for the credit ratings and fixed effects on variance decomposition is mixed; for Standard and Poor's, the results indicate that their ratings better explain spreads in the period before the crisis; the Moody's credit ratings seem to better explain the spreads' variance, while for the S&P ratings, the percentage of explained variance by the fixed effects increased dramatically after the sub-prime event started.

However, global financial variables have a strong relationship by periods, when following the crisis in particular, they doubled their own percentage of variance explanation.

Finally, liquidity variables start explaining the variance of spreads after the crisis started and so supports the thesis put forward in this paper. Liquidity constraints started to become more restrictive after the sub-prime crisis; they were not as economically and/or statistically relevant for emerging market spreads movements during the compression period.

To further reinforce the fact that international investors pulled their resources from EM, we provide data about US treasury asset holdings for the selected EM economies in the next section.

2.4 Additional data, closing the analysis

Liquidity should be considered as a price or, more precisely, a priced state variable, following Pastor et. al. (2003). Thus, it cannot imply direct causality, as it does not account for the relationship between spreads and the availability of funds directly. Liquidity is a symptom rather than the cause of asset price movements. However, it is an important feature, and is taken into account by investors when assessing a market's investment environment and the macro economy.

It follows that an explanation for causality on the determinants of EM spreads, requires further explanation about: i) the market and ii) funding liquidity, apart from the fundamental and global financial movements. The first obeys asymmetries of information in the asset market, whereas the second refers to the availability of resources to invest. It is certainly difficult to measure the asymmetries of information; we give an explanation of funding liquidity and the link to the demand for EM debt.

From Figure (2.6) it can be observed that when US investors experienced tight monetary policy, they faced funding liquidity problems, especially from July 2007 onwards. Taking into account the link between liquidity and the demand for EM debt, it is to be expected that US and international investor holdings of EM market decreased. However, it is difficult to measure international investors' holdings of EM debt separately (see IMF, 2006). Thus, assuming public and private investors have a similar behaviour, data of the assets holdings belonging to the US Treasury are used as a proxy for international EM debt holdings for the selected sample of EM countries.

Figure (2.14) shows the dramatic drop in US holdings on equity and long (LT) and short term (ST) debt of EM countries during 2008, with a recovery in 2009 for LT and equity holdings. Clearly this data reflects liquidity restrictions experienced by US investors from the second half 2007. Thus it is probable that when US monetary policy tightened, US investors faced liquidity pressures, and subsequently pulled out funds from EM markets to cover their positions in US. This situation is independent of EM risks and fundamentals, at least for the sample of countries considered.

2.5 Concluding remarks

This paper analyzes the recent events in the global financial market and their effects on the emerging markets cost of debt. The spread compression and decompression are defined and described. Both phenomena occurred before and after the sub-prime crisis. In order to test the validity of this definition, a methodology is developed and applied to identify the determinants of EM spreads through time.

First, as a robustness check, it is shown that the rating movements for emerging markets are driven by their economic fundamentals. The sovereign credit ratings given by the two most important credit agencies are shown to be closely related to the fundamental political and macroeconomic variables of the countries and so are used as proxies for fundamentals in the empirical analysis that follows. Nevertheless, those ratings are not exempt of some econometric issues, such as low variation, non-linearity and possible reverse causality. However despite these disadvantages sovereign credit ratings are a satisfactory measure for national creditworthiness and these issues do not invalidate the conclusions.

Secondly, we executed a rather innovative test to identify those countries which have common trends, since the main purpose of this study is to capture the central movements rather than those of outliers. These outliers present modeling difficulties for panel data regressions because of their particularly complicated internal conditions. It turns out that the group with common characteristics is composed of more than 20 countries, and the outliers are not a significant proportion of the total. It can be argued that the remaining emerging markets are similar, and can be modeled together. In terms of the econometric analysis, an interesting feature is that its first principal component explains more than 70% of the sovereign spreads variance, and its interpretation, by simple inspection is evidently related to liquidity issues.

Thirdly, we performed four different econometric tests regarding the importance of the fundamentals (ratings), global financial variables and liquidity proxies on spreads movements previous to and subsequent to the sub-prime crisis. We started with a set of spreads regressions differentiating the time frame *before* and *after* the sub-prime event. After that, we performed a parameter stability analysis. Subsequently, we ran a structural break test for spreads around July 2007. Finally, we performed a variance decomposition of spreads, based on the same determinants considered in the regressions. All the evidence points in the same direction: economic fundamentals matter during the period prior to the sub-prime crisis while spread decompression is clearly related to the liquidity shortage produced during the period of increasing financial market volatility.

Fourthly, in terms of policy implications, the probability of default has not increased by the same magnitude as the growth spread since the sub-prime event. Moreover, creditworthiness appears to be rather stable over this period. However, there was a serious liquidity shortage, and international sovereign investors decreased their investment in EM. Therefore, it is necessary to increase liquidity in EM economies, to substitute for the lack of external financing and decline in their asset prices. EM Central Banks should attempt to reduce the credit squeeze effect on the cost of debts to prevent it from becoming unsustainable in the future. One possibility is to follow a “liquidity pool" strategy to increase liquidity through a change of maturity of the available resources, lowering the risk on current investment. Another alternative is to focus liquidity injections on more productive start-ups that are most sensitive to those financing conditions. However, any of these approaches have inherent costs that have to be faced.

Fifthly, the spread movements follow liquidity shortages. However, this situation is not sustainable in the long run, as liquidity constraints could contribute to a serious world economic downturn, affecting and damaging market fundamentals and harming the emerging economies in particular. This situation was somewhat reversed in 2009, but with many negative consequences, as the cost of financial and economic stabilization was definitely much lower around July 2007. Therefore the national and international monetary authorities need to address the liquidity setbacks in a quick and timely way. As noted, liquidity injections have started in EM after a year from the beginning of the liquidity shortages faced by international investors.

Sixthly, this analysis provides a framework by which to examine the recent financial crisis and the consequences for EM sovereign debt. We analyze the spreads determinants throughout the worst financial period in 2007 and find that external liquidity seems to matter for the pricing of EM debt, and is not related to creditworthiness. To put this study in context, following Reinhart et. al. (2009), there are two types of debt risks; *liquidity* and *insolvency*. The present study suggests that EM market debt suffered more from external funding liquidity than insolvency because of a deterioration in economic fundamentals.

Finally, financial instability, found in international financial markets, affected EM debt and damaged their real economies. Thus, we present two main policy proposals. One, when designing metrics for financial stability, the important role of international liquidity should be taken into account. Thus governments should be prepared to take appropriate action when is needed. Two, it is imperative to develop calibrations of correctly specified theoretical models that allow policy makers to disentangle the possible adverse consequences produced by an international liquidity reduction, especially in EM. They should develop stress test tools in a context of general equilibrium. The latter, as different from the present paper's partial equilibrium approach, is a richer analytic tool, since it considers and accounts for feedback effects produced after nominal and real economy shocks, characterized by a set of complex and non-linear relationships, to obtain an accurate model of the broader economy.

2.6 Appendix

2.6.1 Data sources

Table 2.1: Data description

Concept	Variable	Source	Frequency
Country risk and pricing data	EMBI spread (basis points)	Bloomberg	Daily
	Sovereign credit ratings foreign currency denominated debt	Bloomberg, for Standard and Poor's and Moody's agencies	Issuance
	Original Sin 3 (5), Foreign denominated debt to total	Hausmann and Panizza (2003), own calculations	Yearly
Country macro data	GDP per capita (USD, nominal)	WEO, International Monetary Fund	Yearly
	Real GDP Growth (%)	WEO, International Monetary Fund, own calculations	Yearly
	Unemployment rate (%)	WEO, International Monetary Fund	Yearly
	Inflation (%)	WEO, International Monetary Fund	Yearly
	Government Effectiveness (-2.5,2.5)	Kaufmann (2006), World Bank, update 2008	Yearly
	GDP per capita (USD, nominal)	WEO, International Monetary Fund	Yearly
	Gross Central Government Debt to GDP (%)	Jaimovich and Panizza, 2010	Yearly
	Fiscal Balance to GDP (%)	WEO, International Monetary Fund, own calculations	Yearly
	Foreign Debt to Exports (%)	Global Developement Finance, World Bank	Yearly
	Current Account balance to GDP (%)	WEO, International Monetary Fund, own calculations	Yearly
	Government Reserves to GDP (%)	WEO, International Monetary Fund, own calculations	Yearly
	Tax Revenues to Total Debt (Private + Public) (%)	Revenues (WEO, IMF), Total debt (Jaimovich and Panizza (2010)	Yearly
	Volatility of Real Exchange Rate (%)	WEO, International Monetary Fund, own calculations	Yearly
	Public Debt denominated in Foreign Currency to Total (%)	Jeanne and Guscina (2006), own calculations	Yearly
Global Financial Factors	VIX index (%)	Bloomberg	Daily
	US High yield (10 Yrs, %)	Bloomberg	Daily
	US Treasury Yield (10 Years, %)	Bloomberg	Daily
Liquidity proxies	Libor-OIS spread (%)	Bloomberg, own calculations based on IMF(2008)	Daily
	ABCP spread (%)	Bloomberg, own calculations based on IMF(2008)	Daily
	On-off the run spread (logs)	Bloomberg, own calculations based on IMF(2008)	Daily
International holdings of EM debt	US Treasury debt holdings in EM debt and equity	US Treasury	Yearly

2.6.2 Tables

Table 2.2: Fundamental macro-variables

Values during the spread compression period, selected emerging economies.

	2000						2005					
Emerging Asia												
	N. Obs.	Mean	Median	Std. Dev	Min	Max	N. Obs.	Mean	Median	Std. Dev	Min	Max
Rating S&P (Scale 1-21, AAA=21)	7	9.86	11.00	3.13	6.00	13.00	7	10.29	9.00	3.55	6.00	15.00
Rating Moody's (Scale 1-21, Aaa=21)	6	9.67	9.50	3.98	5.00	15.00	7	10.00	8.00	4.08	6.00	16.00
GDP per capita (USD, nominal)	7	1,962	994	1,747	539	4,909	7	2,479	1,304	2,155	719	5,898
Real GDP Growth	7	5.46%	5.11%	2.55%	1.12%	8.86%	7	5.60%	5.00%	2.88%	1.08%	10.40%
Unemployment (Rate)	6	6.54%	6.48%	3.23%	3.00%	11.18%	6	8.02%	9.10%	3.63%	3.15%	11.35%
Inflation	7	2.25%	2.85%	1.74%	-0.36%	3.97%	7	5.76%	7.65%	4.33%	-0.72%	10.46%
Gross Central Government Debt to GDP	7	75.79%	73.19%	44.02%	22.80%	152.57%	7	73.64%	67.69%	46.55%	22.30%	169.25%
Fiscal Balance to GDP	7	-6.58%	-4.23%	7.79%	-23.99%	-1.22%	7	-3.66%	-3.04%	3.44%	-8.41%	0.34%
Government Effectiveness (-2.5=lower,2.5=higher)	7	0.03	0.12	0.43	-0.53	0.71	7	-0.12	-0.30	0.53	-0.53	1.01
Foreign Debt to Exports	6	1.37%	1.27%	0.94%	0.37%	2.90%	6	0.85%	0.98%	0.45%	0.31%	1.40%
Current Account balance to GDP	7	-0.86%	-0.29%	8.26%	-17.22%	9.05%	7	1.73%	2.01%	8.60%	-13.57%	14.57%
Government Reserves to GDP	7	18.95%	17.30%	11.73%	2.17%	37.83%	7	29.32%	23.09%	19.25%	9.25%	57.28%
Tax Revenues to Total Debt (Private + Public)	7	35.63%	35.40%	21.64%	12.71%	66.96%	7	38.42%	29.09%	26.67%	13.07%	91.18%
Volatility of Real Exchange Rate	5	4.50%	4.44%	2.75%	0.79%	7.35%	5	1.60%	0.84%	1.21%	0.67%	3.45%
Public Debt denominated in Foreign Currency to Total	4	22.28%	16.59%	14.97%	11.49%	44.43%	4	25.26%	22.05%	16.13%	9.42%	47.52%
EMBI spread (basis points)	5	814	338	1065	160	2690	7	179	198	108	58	302
Emerging Europe												
Rating S&P (Scale 1-21, AAA=21)	6	10.67	10.50	3.78	6.00	15.00	8	11.88	13.00	2.47	9.00	15.00
Rating Moody's (Scale 1-21, Aaa=21)	7	9.57	8.00	4.04	5.00	15.00	7	12.43	13.00	3.36	8.00	17.00
GDP per capita (USD, nominal)	7	2,771	2,036	1,640	642	4,690	7	5,657	5,326	3,221	1,843	10,944
Real GDP Growth	8	5.94%	5.30%	1.92%	3.95%	10.00%	7	5.07%	4.13%	2.00%	2.70%	8.40%
Unemployment	7	12.10%	11.48%	4.70%	6.40%	18.13%	7	10.82%	10.18%	4.01%	7.18%	17.75%
Inflation	7	19.51%	10.32%	17.80%	2.33%	55.04%	7	6.86%	6.04%	4.77%	2.01%	13.42%
Gross Central Government Debt to GDP	7	51.83%	54.86%	16.08%	29.23%	77.10%	6	39.79%	42.83%	18.48%	14.10%	60.73%
Fiscal Balance to GDP	7	-1.82%	-2.70%	3.88%	-8.11%	3.33%	7	-1.00%	-2.27%	5.09%	-7.80%	8.15%
Government Effectiveness (-2.5=lower,2.5=higher)	8	0.02	-0.01	0.74	-0.80	1.07	8	0.14	0.25	0.48	-0.45	0.79
Foreign Debt to Exports	7	1.26%	1.29%	0.46%	0.62%	2.03%	7	0.98%	0.87%	0.30%	0.73%	1.59%
Current Account balance to GDP	7	-0.70%	-4.22%	9.23%	-8.36%	18.04%	7	-1.72%	-1.57%	7.35%	-11.98%	11.05%
Government Reserves to GDP	7	13.75%	9.56%	7.99%	4.39%	25.42%	7	18.72%	16.79%	6.60%	10.52%	29.73%
Tax Revenues to Total Debt (Private + Public)	7	78.98%	73.71%	30.40%	48.51%	133.02%	6	132.04%	96.92%	88.29%	49.54%	278.65%
Volatility of Real Exchange Rate	6	4.30%	4.31%	1.18%	2.50%	5.99%	6	2.68%	3.12%	1.22%	0.56%	3.84%
Public Debt denominated in Foreign Currency to Total	4	26.44%	17.45%	24.91%	8.26%	62.61%	4	28.47%	22.56%	23.84%	8.09%	60.65%
EMBI spread (basis points)	6	846	788	665	136	1953	7	119	90	61	62	223
Emerging LAC												
Rating S&P (Scale 1-21, AAA=21)	11	10.09	10.00	2.26	7.00	15.00	12	9.33	9.50	3.08	5.00	16.00
Rating Moody's (Scale 1-21, Aaa=21)	10	9.50	9.50	2.92	4.00	14.00	12	9.08	9.00	3.18	5.00	14.00
GDP per capita (USD, nominal)	12	3,931	3,852	2,008	1,260	7,726	12	4,505	4,746	1,717	2,479	7,447
Real GDP Growth	12	3.19%	2.92%	2.63%	-1.44%	7.92%	12	6.23%	6.28%	2.51%	2.84%	10.32%
Unemployment	12	11.12%	13.32%	4.32%	2.20%	17.39%	12	10.43%	9.96%	3.41%	3.60%	18.39%
Inflation	12	13.41%	5.91%	26.43%	-0.94%	96.10%	12	5.40%	4.44%	3.97%	1.62%	15.95%
Gross Central Government Debt to GDP	11	40.26%	36.90%	17.43%	13.70%	71.80%	11	46.75%	45.18%	21.04%	8.17%	78.20%
Fiscal Balance to GDP	12	-1.66%	-2.51%	2.52%	-3.80%	4.45%	12	-0.64%	-1.10%	2.69%	-3.39%	4.72%
Government Effectiveness (-2.5=lower,2.5=higher)	12	-0.04	-0.12	0.62	-1.04	1.31	12	-0.14	-0.18	0.61	-1.01	1.26
Foreign Debt to Exports	12	1.76%	1.66%	1.12%	0.41%	3.80%	12	1.22%	1.10%	0.62%	0.57%	2.54%
Current Account balance to GDP	12	-1.20%	-2.81%	4.61%	-5.93%	10.12%	12	1.00%	0.40%	5.72%	-4.91%	17.72%
Government Reserves to GDP	12	9.97%	9.75%	5.00%	3.13%	20.00%	12	11.55%	11.12%	4.77%	4.72%	18.38%
Tax Revenues to Total Debt (Private + Public)	11	76.05%	75.91%	39.20%	38.36%	172.76%	11	90.40%	65.00%	96.74%	33.08%	372.87%
Volatility of Real Exchange Rate	12	3.45%	1.75%	5.26%	0.41%	19.61%	12	3.07%	3.12%	2.18%	0.00%	6.30%
Public Debt denominated in Foreign Currency to Total	6	33.53%	36.82%	17.72%	5.67%	56.80%	6	35.46%	35.40%	12.24%	19.89%	55.98%
EMBI spread (basis points)	9	716	748	345	220	1415	12	305	278	155	80	661

Table 2.3: Rating regressions on fundamentals

Robust t-statistic in parenthesis. (*,**,***) significant at (10%,5%,1%), respectively.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
GDP per capita (logs)	3.057	6.261	7.359	6.593	8.479	10.328	4.447	9.324	7.101	7.095	8.389	11.641
	(5.16)***	(6.97)***	(3.79)***	(5.03)***	(5.71)***	(4.66)***	(5.49)***	(8.82)***	(3.81)***	(4.60)***	(4.97)***	(5.58)***
Real GDP Growth (%)	-1.517	-2.851	1.435	-1.694	-1.274	0.717	-1.950	-3.478	2.193	-1.709	-1.278	1.143
	(0.95)	(1.76)*	(0.60)	(0.58)	(0.49)	(0.31)	(1.03)	(1.88)*	(0.88)	(0.50)	(0.40)	(0.40)
Unemployment (Rate %)	-0.224	2.162	-0.037	-2.418	0.395	4.038	0.122	3.778	-1.382	-4.947	-3.014	-2.060
	(0.08)	(0.77)	(0.01)	(0.55)	(0.09)	(0.76)	(0.04)	(1.14)	(0.22)	(1.01)	(0.64)	(0.42)
Inflation (%)	-1.683	-1.936	-0.127	-0.916	-1.283	-1.702	0.743	-0.319	-0.087	0.659	0.394	0.074
	(3.08)***	(3.13)***	(3.77)***	(1.65)	(2.78)***	(2.01)*	(1.25)	(0.50)	(3.40)***	(0.78)	(0.52)	(0.08)
Gross Central Government Debt to GDP (%)	-4.733	-3.858					-2.770	-1.101				
	(10.40)***	(7.66)***					(5.10)***	(1.92)*				
Fiscal Balance to GDP (%)	4.298	3.555	4.838	4.431	3.215	3.178	0.920	1.126	-2.500	-1.665	-1.460	1.167
	(1.98)**	(1.65)	(1.55)	(1.33)	(0.94)	(0.77)	(0.34)	(0.44)	(0.80)	(0.42)	(0.39)	(0.21)
Government Effectiveness (-2.5=lower,2.5=higher)	1.191	1.123					0.949	0.788				
	(3.87)***	(3.69)***					(2.41)**	(2.12)**				
Foreign Debt to Exports (%)	-27.920	-39.172	-62.734	-31.367	-43.024	41.584	-40.705	-69.413	-80.101	-41.230	-54.157	28.277
	(1.90)*	(2.38)**	(1.74)*	(0.72)	(1.02)	(0.73)	(2.56)**	(3.88)***	(1.98)*	(0.97)	(1.27)	(0.44)
Current Account balance to GDP (%)	-5.190	-4.284					-9.878	-8.643				
	(3.59)***	(2.85)***					(5.67)***	(5.01)***				
Government Reserves to GDP (%)	1.046	0.574	-2.079	-4.273	-2.678	-5.475	1.991	3.836	1.456	-2.388	-1.094	-4.517
	(0.85)	(0.44)	(0.72)	(1.56)	(0.99)	(1.52)	(1.27)	(2.40)**	(0.54)	(0.80)	(0.37)	(1.41)
Tax Revenues to Total Debt (Private + Public) (%)			0.546	0.542	0.514	0.833			0.462	0.421	0.400	0.639
			(2.46)**	(2.11)**	(2.11)**	(3.97)***			(1.98)*	(1.53)	(1.51)	(3.39)***
Original Sin 3 (%)				-0.622	-0.512					-0.536	-0.383	
				(1.04)	(0.82)					(0.76)	(0.53)	
Volatility of Real Exchange Rate (%)				-4.233	-2.368	-2.103				-6.095	-4.754	-1.531
				(1.61)	(1.02)	(1.38)				(2.82)***	(2.30)**	(0.65)
Public Debt denominated in Foreign Currency to Total (%)						-5.383						-6.362
						(2.31)**						(2.93)**
$\mathbb{1}$ (if in default at t)	-0.794						-1.505					
	(1.56)						(1.99)**					
$\mathbb{1}$ (if defaulted since 1970)	-3.288	-3.273	-5.592	-5.924	-5.619	-5.957	-0.735	-0.589	-1.716	-2.596	-2.317	-2.565
	(6.91)***	(6.96)***	(13.30)***	(9.24)***	(10.15)***	(6.46)***	(1.27)	(1.08)	(4.03)***	(4.55)***	(4.24)***	(3.24)***
$\mathbb{1}$ (if entered to EU at t)	0.611	0.266	0.974	0.467	0.378	-0.607	2.128	1.704	2.418	2.005	1.990	0.901
	(1.46)	(0.62)	(2.33)**	(1.69)	(1.19)	(1.15)	(4.12)***	(3.37)***	(6.97)***	(6.79)***	(5.81)***	(1.95)*
$\mathbb{1}$ (if entered to EU at t, step)	0.879	0.457	0.923	0.117	0.056	-1.266	1.559	1.539	2.323	0.990	1.094	0.106
	(2.34)**	(1.18)	(1.80)*	(0.26)	(0.11)	(1.95)*	(3.33)***	(3.34)***	(4.48)***	(2.40)**	(2.19)**	(0.18)
$\mathbb{1}$ (if LAC country)	-0.741						-1.384					
	(1.86)*						(2.56)**					
US Treasury yield (10 Yrs, %)					2.094						1.535	
					(3.20)***						(2.28)**	
US High yield (10 Yrs, %)					-0.685						-0.688	
					(1.72)*						(1.33)	
VIX index (%)					0.030						0.038	
					(1.24)						(1.72)*	
Constant	11.171	6.603	7.648	5.801	0.990	0.162	10.713	3.764	8.177	5.117	1.790	-0.492
	(12.51)***	(5.96)***	(4.73)***	(3.07)***	(0.40)	(0.07)	(9.39)***	(3.61)***	(4.80)***	(2.36)**	(0.68)	(0.22)
Effects	Random	Fixed	Fixed	Fixed	Fixed	Fixed	Random	Fixed	Fixed	Fixed	Fixed	Fixed
Lagged Rating	No	No	No	No	No	No	No	No	No	No	No	No
Agency	S&P	S&P	S&P	S&P	S&P	S&P	Moody's	Moody's	Moody's	Moody's	Moody's	Moody's
Time effects	No	Yes	Yes	No	No	No	No	Yes	Yes	No	No	No
Observations	357	357	422	341	341	152	353	353	430	341	341	148
Number	43	43	43	39	39	14	42	42	42	38	38	14
Rsq-Overall	0.87	0.33	0.18	0.24	0.23	0.06	0.79	0.27	0.19	0.24	0.23	0.04
Rsq-Within	0.72	0.74	0.58	0.56	0.59	0.74	0.51	0.59	0.46	0.47	0.48	0.66
Rsq-Between	0.91	0.40	0.31	0.34	0.33	0.03	0.85	0.34	0.32	0.30	0.30	0.03

	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI	XXII	XXIII	XXIV
GDP per capita (logs)	3.374	6.556	9.285	8.213	9.139	11.584	4.552	8.532	7.356	8.024	8.661	12.692
	(4.46)***	(5.60)***	(3.57)***	(4.80)***	(4.72)***	(4.27)***	(5.58)***	(7.78)***	(4.69)***	(5.82)***	(5.69)***	(8.09)***
Real GDP Growth (%)	-15.192	-15.662	-14.071	-16.637	-16.505	-15.251	-13.397	-14.841	-10.578	-13.364	-13.438	-11.441
	(7.81)***	(7.66)***	(4.05)***	(3.62)***	(3.57)***	(2.79)**	(7.24)***	(7.98)***	(3.61)***	(3.51)***	(3.50)***	(2.53)**
Unemployment (Rate %)	4.064	9.503	6.488	3.086	5.049	7.223	-0.574	5.226	0.698	-3.621	-2.007	-1.227
	(1.26)	(2.62)***	(0.84)	(0.42)	(0.71)	(0.71)	(0.18)	(1.54)	(0.12)	(0.90)	(0.51)	(0.28)
Inflation (%)	-1.163	-1.463	-2.853	-0.459	-0.642	-1.015	1.275	0.371	-0.096	1.108	0.991	0.954
	(1.73)*	(1.87)*	(3.07)***	(0.71)	(1.21)	(1.65)	(2.22)**	(0.58)	(3.73)***	(1.30)	(1.28)	(1.15)
Gross Central Government Debt to GDP (%)	-6.265	-5.710					-3.332	-2.161				
	(11.40)***	(9.08)***					(6.31)***	(3.79)***				
Fiscal Balance to GDP (%)	3.652	2.268	3.840	3.378	3.069	6.431	2.975	1.717	-2.644	-2.569	-2.288	1.802
	(1.36)	(0.83)	(0.94)	(0.56)	(0.53)	(0.73)	(1.10)	(0.64)	(0.63)	(0.46)	(0.42)	(0.22)
Government Effectiveness (-2.5=lower,2.5=higher)	0.938	1.123					0.425	0.464				
	(2.45)**	(2.89)***					(1.08)	(1.21)				
Foreign Debt to Exports (%)	6.946	17.695	-46.708	4.498	-0.961	97.590	-15.411	-12.392	-40.886	-8.804	-12.380	58.978
	(0.38)	(0.85)	(1.54)	(0.11)	(0.02)	(1.32)	(0.97)	(0.67)	(1.35)	(0.29)	(0.39)	(1.15)
Current Account balance to GDP (%)	-7.578	-5.406					-11.248	-9.024				
	(4.28)***	(2.87)***					(6.59)***	(5.18)***				
Government Reserves to GDP (%)	-0.547	-1.911	-5.454	-8.168	-7.499	-11.336	-0.959	-0.025	-1.667	-5.739	-5.123	-8.977
	(0.35)	(1.13)	(1.99)*	(2.33)**	(2.25)**	(2.29)**	(0.61)	(0.02)	(0.72)	(1.87)*	(1.73)*	(3.08)***
Tax Revenues to Total Debt (Private + Public) (%)			0.533	0.668	0.650	0.854			0.644	0.657	0.646	0.802
			(2.47)**	(2.42)**	(2.45)**	(2.94)**			(2.98)***	(2.31)**	(2.35)**	(3.78)***
Original Sin 3 (%)				-0.855	-0.783					-0.188	-0.078	
				(1.36)	(1.23)					(0.28)	(0.12)	
Volatility of Real Exchange Rate (%)				-6.062	-4.991	-3.473				-4.907	-4.457	-2.389
				(1.12)	(0.89)	(0.48)				(1.50)	(1.31)	(0.43)
Public Debt denominated in Foreign Currency to Total (%)						-4.785						-4.047
						(1.49)						(1.41)
$\mathbb{1}$ (if in default at t)	-1.008						-1.622					
	(1.69)*						(2.15)**					
$\mathbb{1}$ (if defaulted since 1970)	0.312	0.499	-1.668	-3.473	-3.345	-3.687	0.109	0.236	-0.906	-2.297	-2.190	-2.180
	(0.54)	(0.86)	(1.74)*	(7.72)***	(7.06)***	(5.87)***	(0.20)	(0.44)	(1.34)	(4.94)***	(4.27)***	(3.56)***
$\mathbb{1}$ (if entered to EU at t)	1.066	0.575	1.102	0.733	0.612	-0.359	2.887	2.611	3.084	2.612	2.471	1.499
	(2.13)**	(1.09)	(2.28)**	(2.05)**	(1.52)	(0.59)	(5.84)***	(5.23)***	(8.20)***	(7.74)***	(6.81)***	(3.54)***
$\mathbb{1}$ (if entered to EU at t, step)	1.178	0.628	0.911	0.052	-0.002	-0.917	2.464	2.129	2.685	1.671	1.656	0.761
	(2.60)***	(1.31)	(1.79)*	(0.11)	(0.00)	(1.22)	(5.46)***	(4.64)***	(7.05)***	(4.88)***	(3.74)***	(1.69)
$\mathbb{1}$ (if LAC country)	-0.352						-1.238					
	(0.77)						(2.30)**					
US Treasury yield (10 Yrs, %)					1.148						0.820	
					(1.77)*						(1.58)	
US High yield (10 Yrs, %)					-0.815						-1.061	
					(1.47)						(2.59)**	
VIX index (%)					0.024						0.034	
					(1.16)						(1.87)*	
Constant	11.301	7.375	7.126	4.148	2.445	-1.265	10.468	4.766	7.710	3.663	3.159	-2.078
	(11.10)***	(5.89)***	(2.60)**	(1.95)*	(0.93)	(0.44)	(9.21)***	(4.32)***	(5.32)***	(2.05)**	(1.29)	(1.13)
Effects	Random	Fixed	Fixed	Fixed	Fixed	Fixed	Random	Fixed	Fixed	Fixed	Fixed	Fixed
Lagged Rating	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Agency	S&P	S&P	S&P	S&P	S&P	S&P	Moody's	Moody's	Moody's	Moody's	Moody's	Moody's
Time effects	No	Yes	Yes	No	No	No	No	Yes	Yes	No	No	No
Observations	338	338	383	324	324	150	336	336	397	322	322	145
Number	41	41	41	38	38	14	42	42	42	38	38	14
Rsq-Overall	0.83	0.22	0.11	0.13	0.13	0.01	0.78	0.21	0.12	0.17	0.16	0.01
Rsq-Within	0.61	0.64	0.46	0.44	0.45	0.56	0.57	0.62	0.46	0.50	0.51	0.63
Rsq-Between	0.90	0.30	0.24	0.24	0.24	0.00	0.83	0.29	0.27	0.24	0.24	0.01

Table 2.4: Panel VAR regressions

Current and lagged sovereign credit rating, fundamental variables and global financial factors. Columns are the dependent variables in each combination, t-statistic in parenthesis.

	Rating (Scale 1-21, AAA,Aaa=21)				GDP per capita (logs)				US Treasury yield (10 Yrs, logs)				VIX (%)				US High yield (10 Yrs, logs)			
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**XIII**	**XIV**	**XV**	**XVI**	**XVII**	**XVIII**	**XIX**	**XX**
Rating (t-1)	0.816	0.760	(1.37)	0.89	0.011	0.003	0.048	-0.01	0.062	0.020	0.401	0.07	-1.386	-0.664	-14.950	-3.24	-0.047	-0.013	-0.528	-0.09
	(6.11)	(6.39)	0.659	(4.63)	(1.91)	(0.69)	(0.55)	(-1)	(2.29)	(1.91)	(0.58)	(1.5)	(-2.04)	(-1.67)	(-0.62)	(-1.67)	(-2.24)	(-1.23)	(-0.62)	(-1.56)
GDP per capita (logs) (t-1)	0.537	6.114	(0.46)	4.16	1.014	1.236	1.056	0.88	0.082	0.052	0.711	0.94	-1.687	-25.937	-26.204	-52.75	-0.059	-0.823	-0.933	-1.85
	(1.11)	(2.54)	(0.122)	(1.55)	(41.33)	(13.27)	(6.31)	(5.09)	(0.645)	(0.15)	(0.53)	(1.24)	(-0.52)	(-2.06)	(-0.56)	(-1.75)	(-0.59)	(-2.27)	(-0.57)	(-1.98)
US Treasury yield (10 Yrs, logs) (t-1)	0.022	0.109	(-0.06)	-0.28	0.069	0.078	0.156	-0.01	0.630	0.345	1.602	0.53	4.518	4.173	-32.937	-2.23	0.289	0.435	-1.001	0.22
	(0.07)	(0.38)	-0.047	(-0.56)	(3.67)	(5.7)	(0.67)	(-0.18)	(6.45)	(7.06)	(0.86)	(3.75)	(1.82)	(2.19)	(-0.51)	(-0.4)	(3.56)	(7.36)	(-0.44)	(1.28)
VIX (%) (t-1)	-0.033	-0.028	(-1.15)	-0.03	-0.002	-0.003	-0.004	0.00	-0.014	-0.011	-0.031	-0.01	0.982	0.997	1.697	1.06	0.012	0.003	0.038	0.01
	(-2.59)	(-2.09)	2.093	(-3.1)	(-4.41)	(-6.29)	(-0.88)	(-3)	(-5.1)	(-6.71)	(-0.82)	(-4.16)	(14.71)	(18.21)	(1.29)	(10.7)	(6.01)	(1.82)	(0.83)	(1.85)
US High yield (10 Yrs, logs) (t-1)	0.842	0.569	(0.6)	1.51	0.066	-0.071	0.229	-0.12	0.743	0.213	2.324	0.33	-13.506	-8.781	-76.630	-12.01	0.033	0.324	-2.222	0.17
	(1.17)	(1.15)		(2.97)	(1.99)	(-4.34)	(0.56)	(-3.56)	(4.13)	(3.62)	(0.71)	(2.32)	(-2.99)	(-4.07)	(-0.67)	(-2.17)	(0.24)	(5.16)	(-0.56)	(0.96)
Rating (S&P) (t-2)		0.008		-0.03		-0.005		-0.01		0.006		0.02		-0.340		-0.51		-0.012		-0.02
		(0.13)		(-0.83)		(-2.24)		(-3.97)		(1.01)		(1.86)		(-1.42)		(-1.27)		(-1.72)		(-1.45)
GDP per capita (logs) (t-2)		-5.217		-3.77		-0.193		0.07		-0.005		-0.78		23.012		45.42		0.799		1.63
		(-2.69)		(-1.64)		(-2.51)		(0.49)		(-0.02)		(-1.24)		(2.32)		(1.8)		(2.8)		(2.08)
US Treasury yield (10 Yrs, logs) (t-2)		-0.241		-0.80		0.031		0.00		0.617		0.65		2.166		-2.97		0.168		0.03
		(-1.11)		(-3.26)		(3.06)		(-0.32)		(14.08)		(8.73)		(1.64)		(-1.17)		(4.67)		(0.39)
VIX (%) (t-2)		0.007		-0.01		0.005		0.00		0.009		0.01		-0.199		-0.34		0.016		0.01
		(0.64)		(-0.95)		(10)		(4.54)		(6.39)		(3.44)		(-4.12)		(-2.74)		(12.03)		(3.18)
US High yield (10 Yrs, logs) (t-2)		0.127		0.32		-0.005		-0.03		-0.266		-0.27		-1.306		-1.39		-0.560		-0.59
		(0.42)		(1.58)		(-0.41)		(-2)		(-6.15)		(-4.28)		(-0.94)		(-0.64)		(-13.83)		(-8.82)
Agency	S&P		Moody's		S&P		Moody's		S&P		Moody's		S&P		Moody's		S&P		Moody's	
Observations	998	903	1018	923	998	903	1018	923	998	903	1018	923	998	903	1018	923	998	903	1018	923
	Rating (Scale 1-21, AAA,Aaa=21) (t-1)																			
Rating (t-2)	0.848	0.756	1.276	0.80	0.004	-0.004	-0.018	-0.02	0.062	0.013	0.546	0.08	-1.261	-0.501	-15.141	-3.51	-0.044	-0.017	-0.507	-0.12
	(6.32)	(7.03)	(1.23)	(-4.04)	(0.81)	(-1.29)	(-0.54)	(-2.15)	(2.39)	(1.44)	(0.57)	(1.4)	(-1.91)	(-1.35)	(-0.58)	(-1.56)	(-2.16)	(-1.61)	(-0.58)	(-1.6)
GDP per capita (logs) (t-1)	0.900	11.795	1.501	7.57	1.029	1.278	0.935	0.89	0.115	0.641	1.220	2.25	-2.591	-42.260	-33.438	-105.44	-0.085	-1.074	-1.145	-3.46
	(1.53)	(3.62)	(0.61)	(1.35)	(39.91)	(10.86)	(11.63)	(2.57)	(0.78)	(1.58)	(0.53)	(1.27)	(-0.69)	(-2.59)	(-0.53)	(-1.53)	(-0.73)	(-2.35)	(-0.55)	(-1.58)
US Treasury yield (10 Yrs, logs) (t-1)	0.480	0.006	1.142	-0.32	0.077	0.085	-0.013	0.01	0.670	0.380	2.030	0.54	4.662	4.568	-34.697	-1.41	0.304	0.459	-0.977	0.22
	(1.12)	(0.02)	(0.4)	(-0.64)	(4.06)	(5.81)	(-0.14)	(0.22)	(6.25)	(7.84)	(0.76)	(3.33)	(1.71)	(2.24)	(-0.48)	(-0.22)	(3.4)	(7.69)	(-0.4)	(1.1)
VIX (%) (t-1)	-0.027	0.002	-0.044	0.02	-0.003	-0.003	0.000	0.00	-0.017	-0.010	-0.050	-0.01	1.018	1.005	2.024	1.05	0.014	0.005	0.048	0.01
	(-1.78)	(0.16)	(-0.58)	(1.96)	(-4.36)	(-5.58)	(-0.14)	(-2.7)	(-4.57)	(-5.5)	(-0.69)	(-3.41)	(10.57)	(16.18)	(1.03)	(9.12)	(4.71)	(2.71)	(0.74)	(1.71)
US High yield (10 Yrs, logs) (t-1)	0.784	-0.016	2.666	-0.34	0.073	-0.070	-0.092	-0.13	0.836	0.225	3.439	0.37	-15.026	-9.085	-91.515	-14.47	-0.026	0.310	-2.629	0.05
	(0.98)	(-0.04)	(0.46)	(-0.5)	(2.01)	(-3.82)	(-0.49)	(-3.09)	(3.85)	(3.43)	(0.64)	(1.7)	(-2.7)	(-3.68)	(-0.62)	(-1.74)	(-0.15)	(4.31)	(-0.54)	(0.18)
Rating (S&P) (t-3)		0.026		-0.04		0.001		0.01		0.017		0.01		-0.530		-0.50		-0.009		-0.01
		(0.44)		(-0.92)		(0.66)		(2.54)		(2.84)		(0.98)		(-2.38)		(-0.85)		(-1.27)		(-0.34)
GDP per capita (logs) (t-2)		-10.566		-6.92		-0.225		0.06		-0.537		-1.97		37.649		94.42		1.020		3.12
		(-3.71)		(-1.39)		(-2.21)		(0.21)		(-1.6)		(-1.26)		(2.77)		(1.56)		(2.68)		(1.62)
US Treasury yield (10 Yrs, logs) (t-2)		-0.094		-0.60		0.032		0.02		0.554		0.60		1.740		-0.95		0.135		0.13
		(-0.36)		(-3.02)		(2.91)		(1.31)		(12.53)		(8.5)		(1.28)		(-0.41)		(3.62)		(1.78)
VIX (%) (t-2)		-0.014		-0.05		0.005		0.00		0.009		0.01		-0.206		-0.23		0.017		0.02
		(-2.04)		(-5.94)		(10.17)		(7.63)		(6.3)		(3.21)		(-4.2)		(-2.59)		(12.94)		(5.5)
US High yield (10 Yrs, logs) (t-2)		0.367		1.13		-0.010		-0.04		-0.271		-0.13		-1.539		-6.08		-0.630		-0.74
		(1.16)		(2.84)		(-0.72)		(-1.51)		(-5.74)		(-1.08)		(-0.97)		(-1.34)		(-13.86)		(-5.26)
Agency	S&P		Moody's		S&P		Moody's		S&P		Moody's		S&P		Moody's		S&P		Moody's	
Observations	918	825	949	855	918	825	949	855	918	825	949	855	918	825	949	855	918	825	949	855

Table 2.5: Panel VAR variance decomposition

Percent of variation in the row variable explained by column variable, for different simulation shock periods. Performed for current and lagged Standard and Poor's rating preferred regressions.

	Simulation periods	Rating S&P	GDP per capita	US Treasury yield	VIX Index	US High yield
	10	55.5%	**28.3%**	13.6%	2.5%	0.2%
Rating S&P (Scale 1-21, AAA=21)	20	27.3%	**40.4%**	28.9%	3.3%	0.1%
	30	23.9%	**41.6%**	30.9%	3.4%	0.1%
	10	**14.8%**	57.8%	23.7%	3.2%	0.4%
GDP per capita (logs)	20	**21.5%**	44.5%	30.5%	3.4%	0.2%
	30	**23.3%**	42.1%	31.1%	3.4%	0.1%
	10	28.7%	23.1%	43.3%	4.8%	0.2%
US Treasury yield (10 Yrs, logs)	20	26.4%	37.1%	32.8%	3.6%	0.1%
	30	24.1%	41.0%	31.3%	3.5%	0.1%
	10	5.4%	4.9%	16.2%	46.1%	27.5%
US High yield (10 Yrs, logs)	20	12.9%	6.0%	18.1%	39.6%	23.4%
	30	18.8%	17.5%	23.2%	26.0%	14.6%
	10	20.7%	25.7%	12.1%	39.7%	1.9%
VIX Index (%)	20	22.0%	40.1%	27.6%	9.8%	0.5%
	30	23.3%	41.7%	30.8%	4.0%	0.2%
		Rating S&P (t-1)				
	10	17.0%	**60.7%**	19.9%	2.0%	0.4%
Rating S&P (Scale 1-21, AAA=21) (t-1)	20	4.8%	**65.1%**	27.8%	1.9%	0.4%
	30	4.3%	**65.3%**	28.1%	1.9%	0.4%
	10	**1.5%**	72.7%	23.4%	1.9%	0.5%
GDP per capita (logs)	20	**3.9%**	66.0%	27.9%	1.9%	0.4%
	30	**4.3%**	65.3%	28.1%	1.9%	0.4%
	10	7.9%	54.5%	34.8%	2.6%	0.3%
US Treasury yield (10 Yrs, logs)	20	4.8%	64.4%	28.5%	1.9%	0.4%
	30	4.4%	65.2%	28.2%	1.9%	0.4%
	10	2.0%	15.0%	9.6%	49.5%	23.9%
US High yield (10 Yrs, logs)	20	2.1%	40.4%	17.4%	27.1%	12.9%
	30	4.0%	64.0%	27.4%	3.4%	1.2%
	10	5.0%	54.4%	17.7%	21.8%	1.1%
VIX Index (%)	20	4.2%	64.9%	27.6%	2.8%	0.4%
	30	4.3%	65.3%	28.1%	1.9%	0.4%

Table 2.6: Principal component analysis and co-integration

The R-squared columns represent the statistic for the spread on the principal components defined.
Because of orthogonality the estimated coefficients and t-stats remain the same. 607 observations.

Code	Country	1st score	t-stat	2nd score	t-stat	3rd score	t-stat	Constant	t-stat	R^2 1st score	R^2 2nd score	R^2 3rd score	R^2 1st and 2nd score	R^2 2nd and 3rd score	R^2 1st, 2nd 3rd score
ARG	Argentina	17.644	(79.88)***	4.156	(5.26)***	-24.231	(30.74)***	355.384	(245.57)***	0.75	0.01	0.10	0.76	0.85	0.86
BGR	Bulgaria	8.700	(77.54)***	-1.794	(13.07)***	0.678	(2.63)***	95.323	(255.49)***	0.94	0.01	0.00	0.95	0.94	0.95
BRA	Brazil	5.629	(110.66)***	11.802	(63.48)***	4.404	(18.57)***	213.539	(624.36)***	0.46	**0.47**	0.02	0.93	**0.48**	0.95
CIV	**Ivory Coast**	-34.069	(43.10)***	45.154	(24.98)***	210.988	(71.33)***	2,734.176	(736.96)***	**0.22**	0.09	**0.61**	**0.31**	0.83	0.92
CHL	Chile	6.452	(92.43)***	-6.516	(66.75)***	-0.134	(0.86)	101.460	(417.15)***	0.78	0.18	0.00	0.97	0.78	0.97
CHN	China	6.553	(117.58)***	-3.403	(27.41)***	-2.496	(13.57)***	77.913	(306.98)***	0.90	0.06	0.01	0.95	0.91	0.96
COL	Colombia	6.850	(65.02)***	7.112	(35.49)***	9.312	(33.19)***	186.661	(471.50)***	0.68	0.17	0.09	0.85	0.77	0.94
DOM	Dominican Republic	15.433	(55.59)***	10.344	(22.51)***	-1.008	(1.72)*	258.120	(275.06)***	0.83	0.09	0.00	0.91	0.83	0.91
ECU	**Ecuador**	-1.622	(4.67)***	-24.821	(21.13)***	49.228	(20.13)***	613.082	(253.60)***	**0.01**	**0.29**	**0.36**	**0.30**	**0.36**	**0.65**
EGY	Egypt	12.338	(103.92)***	-6.433	(17.01)***	2.016	(4.79)***	103.234	(135.68)***	0.85	0.05	0.00	0.91	0.85	0.91
SLV	El salvador	7.670	(72.48)***	6.027	(42.54)***	4.868	(24.25)***	188.610	(540.31)***	0.81	0.12	0.02	0.93	0.84	0.95
HUN	Hungary	4.777	(24.54)***	-1.899	(10.35)***	-2.120	(7.35)***	80.028	(168.14)***	0.75	0.03	0.01	0.78	0.76	0.79
IDN	Indonesia	11.068	(80.75)***	2.386	(7.83)***	-3.912	(11.92)***	220.226	(383.62)***	0.91	0.01	0.01	0.92	0.92	0.93
LBN	**Lebanon**	15.571	(72.31)***	-41.903	(50.92)***	17.689	(12.70)***	373.331	(230.30)***	**0.33**	**0.54**	0.03	0.87	**0.36**	0.90
MYS	Malaysia	4.484	(106.80)***	-1.498	(19.04)***	-2.633	(19.28)***	91.710	(500.47)***	0.91	0.02	0.02	0.93	0.93	0.96
MEX	Mexico	5.198	(59.97)***	1.798	(10.54)***	2.030	(11.24)***	139.010	(408.16)***	0.86	0.02	0.01	0.88	0.87	0.89
NGA	**Nigeria**	-4.498	(19.11)***	48.810	(65.11)***	-9.665	(7.31)***	131.900	(68.23)***	**0.03**	**0.80**	0.01	0.83	**0.04**	0.84
PAK	**Pakistan**	**28.781**	(65.32)***	-24.213	(39.46)***	-7.932	(7.71)***	286.700	(178.46)***	0.79	0.13	0.00	0.92	0.80	0.93
PAN	Panama	5.718	(83.98)***	6.287	(59.45)***	2.960	(18.60)***	176.474	(748.88)***	0.74	0.21	0.01	0.95	0.76	0.96
PER	**Peru**	5.433	(55.13)***	11.996	(40.63)***	-4.781	(10.69)***	167.488	(309.47)***	**0.41**	**0.46**	0.02	0.86	**0.43**	0.88
PHL	**Philippines**	6.370	(84.53)***	13.731	(61.09)***	-3.137	(11.12)***	213.384	(495.62)***	**0.45**	**0.48**	0.01	0.93	**0.46**	0.94
POL	Poland	3.857	(53.69)***	-1.444	(17.28)***	-0.787	(5.67)***	66.871	(297.69)***	0.88	0.03	0.00	0.91	0.89	0.91
RUS	Russia	6.625	(131.42)***	-3.235	(34.45)***	1.143	(7.67)***	126.685	(587.45)***	0.92	0.05	0.00	0.97	0.92	0.97
ZAF	South Africa	11.273	(83.75)***	-5.761	(32.74)***	2.277	(7.75)***	114.013	(279.58)***	0.91	0.05	0.00	0.96	0.91	0.97
TUN	Tunisia	8.736	(115.86)***	-3.687	(19.60)***	2.011	(8.27)***	108.072	(284.93)***	0.91	0.04	0.00	0.95	0.91	0.95
TUR	Turkey	7.180	(53.12)***	0.611	(1.71)*	10.048	(19.74)***	229.662	(362.53)***	0.73	0.00	0.10	0.73	0.84	0.84
UKR	Ukraine	13.282	(98.88)***	-1.623	(5.16)***	0.214	(0.84)	220.906	(380.49)***	0.94	0.00	0.00	0.95	0.94	0.95
URY	**Uruguay**	8.529	(120.99)***	10.168	(59.50)***	4.420	(22.86)***	229.578	(716.47)***	0.72	**0.24**	0.01	0.96	0.73	0.97
VEN	**Venezuela**	26.974	(117.91)***	-30.003	(34.81)***	-13.186	(17.41)***	321.420	(222.54)***	0.72	**0.21**	0.01	0.93	0.73	0.94

Table 2.7: Spread regressions on credit ratings, global financial factors and liquidity

Robust t-statistic in parenthesis. (*,**,***) significant at (10%,5%,1%), respectively. Regressions include fixed but no time effects, daily data.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Credit Rating (logs)	-1.377	-1.502	-0.003	-0.293	-0.252	-0.535	-1.377	-1.495	-0.003	-0.292	-0.237	-0.534
	(4.18)***	(4.64)***	(0.01)	(0.47)	(0.42)	(1.13)	(4.18)***	(4.66)***	(0.01)	(0.47)	(0.39)	(1.13)
US Treasury Yield (10 Years, logs)	-0.382	-0.280	-0.470	-0.308	-0.362	-0.536	-0.382	-0.305	-0.470	-0.308	-0.385	-0.535
	(4.41)***	(1.20)	(1.72)*	(2.79)**	(1.44)	(1.90)*	(4.41)***	(1.32)	(1.72)*	(2.79)**	(1.55)	(1.90)*
VIX Index (logs)	0.030	0.216	0.048	0.017	0.203	0.053	0.029	0.211	0.048	0.016	0.199	0.053
	(0.79)	(6.20)***	(1.11)	(0.50)	(6.00)***	(1.21)	(0.77)	(6.28)***	(1.11)	(0.47)	(6.12)***	(1.22)
US High Yield (10 Years, logs)	1.939	1.723	1.937	2.080	2.108	1.844	1.925	1.683	1.936	2.066	2.076	1.842
	(7.34)***	(3.05)***	(11.00)***	(7.58)***	(3.65)***	(11.24)***	(7.16)***	(2.92)***	(10.96)***	(7.42)***	(3.52)***	(11.20)***
Libor-OIS spread (logs)	0.040	0.050	0.064	0.035	0.049	0.062	0.041	0.054	0.064	0.035	0.052	0.062
	(3.85)***	(3.94)***	(7.26)***	(3.50)***	(3.72)***	(6.94)***	(3.86)***	(3.85)***	(7.25)***	(3.50)***	(3.60)***	(6.93)***
ABCP spread (logs)	-0.008	-0.036	-0.017	-0.020	-0.047	-0.017	-0.007	-0.033	-0.017	-0.019	-0.044	-0.017
	(0.48)	(1.69)	(3.55)***	(1.13)	(2.10)**	(3.45)***	(0.43)	(1.52)	(3.56)***	(1.08)	(2.00)*	(3.46)***
On-off the run spread (logs)	-0.006	-0.021	-0.001	-0.006	-0.018	-0.001						
	(2.14)**	(2.20)**	(0.72)	(2.13)**	(1.69)	(1.20)						
Constant	4.546	4.719	1.257	1.620	1.123	2.815	4.573	4.810	1.257	1.643	1.175	2.814
	(5.75)***	(2.80)**	(1.03)	(0.95)	(0.55)	(1.82)*	(5.76)***	(2.81)**	(1.03)	(0.96)	(0.57)	(1.82)*
Agency	S&P	S&P	S&P	Moody's	Moody's	Moody's	S&P	S&P	S&P	Moody's	Moody's	Moody's
Time window	01/2006-04/2008	01/2006-06/2007	07/2007-04/2008	01/2006-04/2008	01/2006-06/2007	07/2007-04/2008	01/2006-04/2008	01/2006-06/2007	07/2007-04/2008	01/2006-04/2008	01/2006-06/2007	07/2007-04/2008
Observations	13409	5750	2921	12826	5500	2794	13409	5750	2921	12826	5500	2794
Number of countries	23	23	23	22	22	22	23	23	23	22	22	22
Rsq-Overall	0.79	0.71	0.09	0.45	0.44	0.69	0.79	0.71	0.09	0.45	0.42	0.69
Rsq-Within	0.68	0.30	0.71	0.64	0.23	0.70	0.68	0.30	0.71	0.64	0.23	0.70
Rsq-Between	0.84	0.77	0.84	0.84	0.74	0.85	0.84	0.77	0.84	0.84	0.74	0.85

Table 2.8: Chow Test regressions

Robust t-statistic in parenthesis. (*,**,***) significant at (10%,5%,1%), respectively.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII
Rating (Logs)	-1.320	-0.254	-1.308	-0.260	-1.597	-0.558	-1.585	-0.559	-1.586	-0.522	-1.367	-0.336	-1.361	-0.336	-1.312	-0.243	-1.337	-0.272
	(4.17)***	(0.40)	(4.25)***	(0.42)	(4.63)***	(0.95)	(4.58)***	(0.96)	(4.65)***	(0.90)	(4.30)***	(0.60)	(4.36)***	(0.60)	(4.15)***	(0.39)	(4.05)***	(0.44)
US Treasury yield (10 Yrs, Logs)	-0.108	-0.070	-0.073	-0.012	-0.364	-0.314									-0.223	-0.176	-0.417	-0.320
	(0.98)	(0.59)	(0.65)	(0.10)	(3.98)***	(3.19)***									(2.37)**	(1.79)*	(3.64)***	(2.35)**
VIX Index (Logs)	0.087	0.077	0.104	0.083	0.257	0.270	0.287	0.300							0.063	0.049	0.068	0.056
	(2.96)***	(2.97)***	(3.09)***	(2.92)***	(6.43)***	(6.48)***	(6.38)***	(6.71)***							(1.92)*	(1.76)*	(2.14)**	(2.07)*
US High yield (10 Yrs, Logs)	1.701	1.895	1.730	1.870											1.772	1.929	1.790	1.917
	(5.51)***	(5.60)***	(6.60)***	(6.63)***											(6.61)***	(6.55)***	(7.39)***	(7.36)***
Libor-OIS spread (Logs)	0.054	0.034	0.068	0.052	0.121	0.114	0.167	0.153	0.203	0.190					0.032	0.014		
	(1.81)*	(0.97)	(2.96)***	(1.95)*	(7.67)***	(5.99)***	(8.50)***	(6.44)***	(9.75)***	(8.00)***					(1.29)	(0.48)		
ABCP spread (Logs)	0.025	0.011			0.084	0.076	0.071	0.066	0.133	0.129	0.338	0.322	0.336	0.322	0.035	0.029	0.048	0.034
	(1.11)	(0.46)			(4.01)***	(3.46)***	(3.21)***	(2.85)***	(5.22)***	(5.30)***	(11.07)***	(10.39)***	(11.62)***	(10.75)***	(2.22)**	(1.71)	(2.25)**	(1.39)
Rating*𝟙(t>July 2007)	-0.062	-0.051	-0.062	-0.051	-0.030	-0.035	-0.054	-0.056	0.056	0.034	0.020	0.003						
	(0.42)	(0.46)	(0.42)	(0.46)	(0.20)	(0.32)	(0.46)	(0.61)	(0.83)	(0.60)	(0.38)	(0.06)						
US High yield*𝟙(t>July 2007)	-0.341	-0.280	-0.359	-0.385	-0.117	-0.137												
	(1.88)*	(1.43)	(2.45)**	(2.53)**	(0.72)	(1.02)												
VIX Index*𝟙(t>July 2007)	-0.065	-0.046	-0.083	-0.040	0.134	0.131	0.069	0.053										
	(1.40)	(0.96)	(1.14)	(0.51)	(2.41)**	(2.78)**	(0.59)	(0.56)										
US High yield*𝟙(t>July 2007)	0.418	0.286	0.425	0.354														
	(1.37)	(0.97)	(1.98)*	(1.79)*														
Libor-OIS spread * 𝟙(t>July 2007)	0.017	0.034			-0.029	-0.024	-0.036	-0.023	-0.032	-0.024					0.069	0.088		
	(0.51)	(0.95)			(2.00)*	(1.54)	(1.05)	(0.66)	(0.94)	(0.65)					(2.28)**	(2.47)**		
ABCP spread * 𝟙(t>July 2007)	-0.042	-0.030	-0.016	-0.008	-0.061	-0.056	-0.050	-0.050	-0.066	-0.062	-0.072	-0.064	-0.062	-0.062	-0.068	-0.081	-0.011	-0.012
	(1.88)*	(1.27)	(1.06)	(0.50)	(3.85)***	(3.51)***	(2.26)**	(2.38)**	(1.09)	(1.12)	(2.30)**	(2.41)**	(9.65)***	(10.78)***	(2.96)***	(3.16)***	(2.31)**	(2.46)**
Constant	4.206	1.294	4.071	1.255	8.064	5.500	7.338	4.893	7.795	5.281	7.015	4.591	7.008	4.592	4.289	1.413	4.618	1.723
	(4.88)***	(0.72)	(5.02)***	(0.72)	(10.64)***	(3.70)***	(9.84)***	(3.50)***	(10.27)***	(3.84)***	(9.81)***	(3.45)***	(9.93)***	(3.45)***	(5.45)***	(0.82)	(5.78)***	(1.01)
Observations	13409	12826	13409	12826	13501	12914	13501	12914	13501	12914	13501	12914	13501	12914	13409	12826	13409	12826
Rating Agency	S&P	Moody's	S&P	Moody's	S&P	Moody's	S&P	Moody's	S&P	Moody's	S&P	Moody's	S&P	Moody's	S&P	Moody's	S&P	Moody's
Number of group(Countries)	23	22	23	22	23	22	23	22	23	22	23	22	23	22	23	22	23	22
Rsq-Overall	0.79	0.43	0.79	0.43	0.79	0.64	0.79	0.64	0.78	0.60	0.75	0.46	0.75	0.46	0.79	0.41	0.79	0.43
Rsq-Within	0.69	0.66	0.69	0.66	0.64	0.60	0.63	0.59	0.60	0.56	0.53	0.50	0.53	0.50	0.68	0.65	0.68	0.65
Rsq-Between	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84

Table 2.9: Variance decomposition of emerging markets spread

Based on daily data. The residuals explain approximately zero variance.

Time window	01/2006-04/2008	01/2006-06/2007	07/2007-04/2008	01/2006-04/2008	01/2006-06/2007	07/2007-04/2008
Agency		**Standard and Poor's**			**Moody's**	
Credit Rating(logs)	55.5%	67.1%	0.1%	13.9%	12.3%	27.8%
Global Financial Factors US Treasury Yield (10 Years, logs) VIX Index (logs) US High Yield (10 Years, logs)	17.5%	2.5%	6.7%	17.7%	2.9%	6.5%
Liquidity Libor-OIS spread (logs) ABCP spread (logs)	2.2%	0.0%	2.0%	1.2%	0.0%	1.9%
Fixed Effects	24.8%	30.5%	91.1%	67.3%	84.8%	63.8%

2.6.3 Figures

Figure 2.1: Compression and Decompression

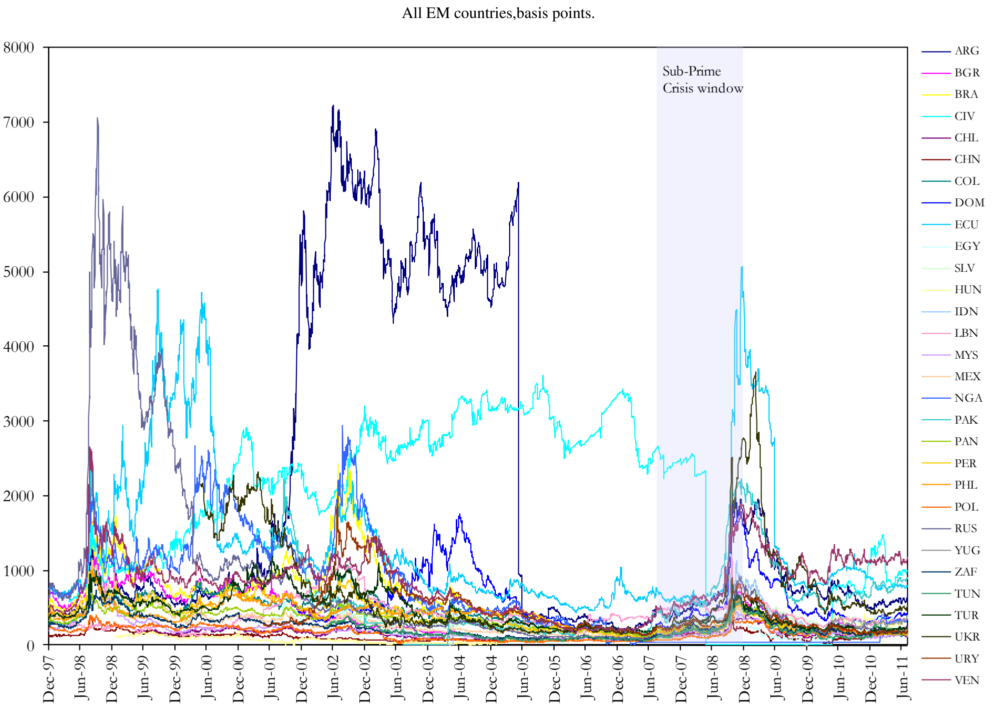


Figure 2.2: Spread Compression and Decompression

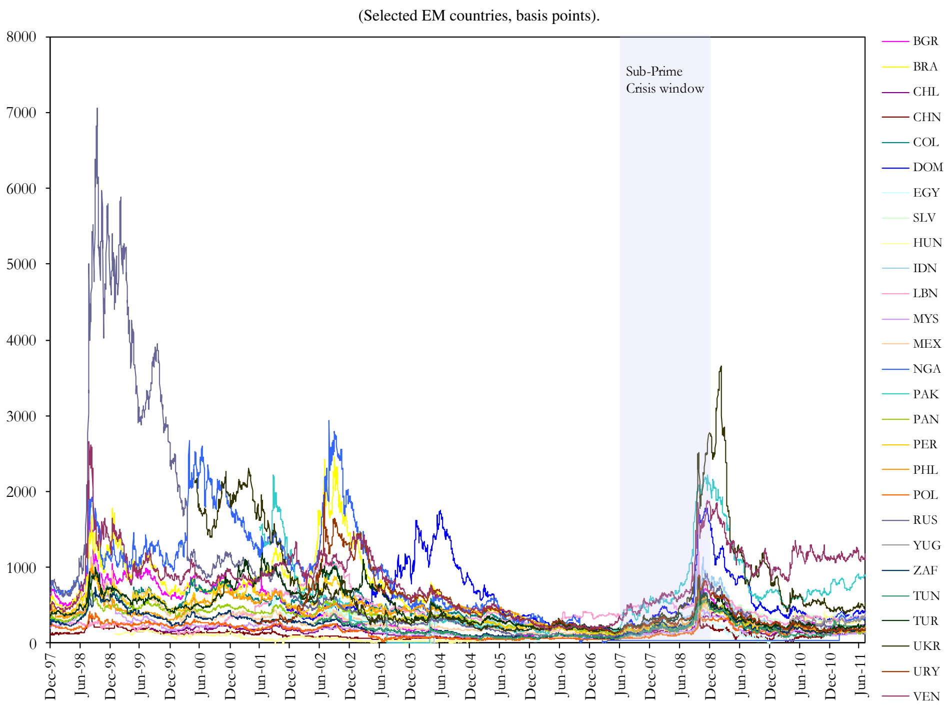


Figure 2.3: Spread Compression and Decompression

Selected EM countries, recent past, basis points.

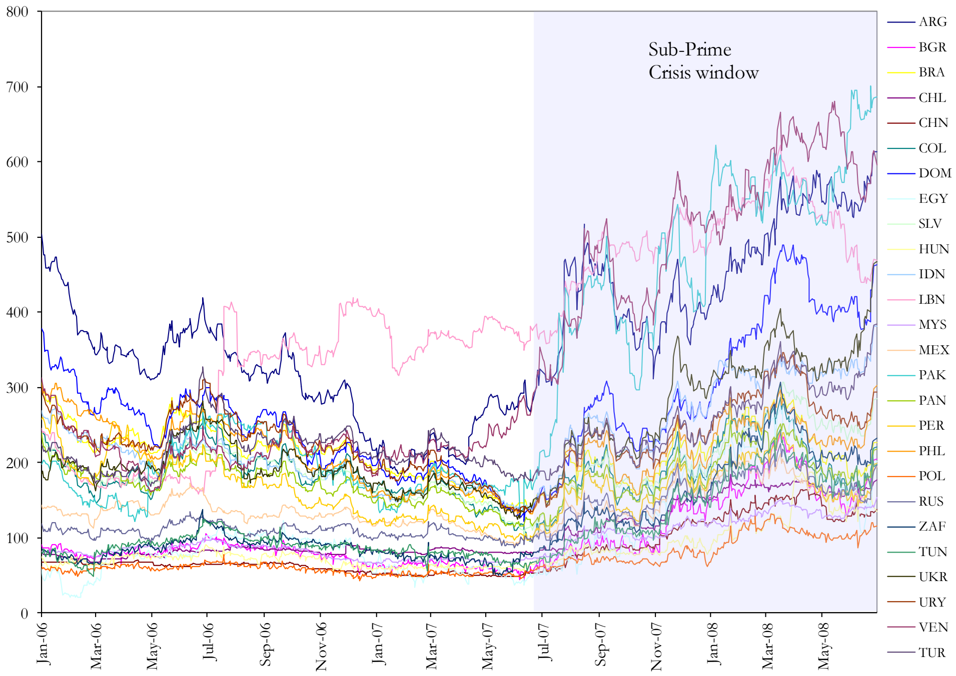


Figure 2.4: EM sovereign credit rating upgrades

Left axis are cumulative upgrades (number of rating changes among the EM group of countries). Right axis is EMBI spread in basis points.

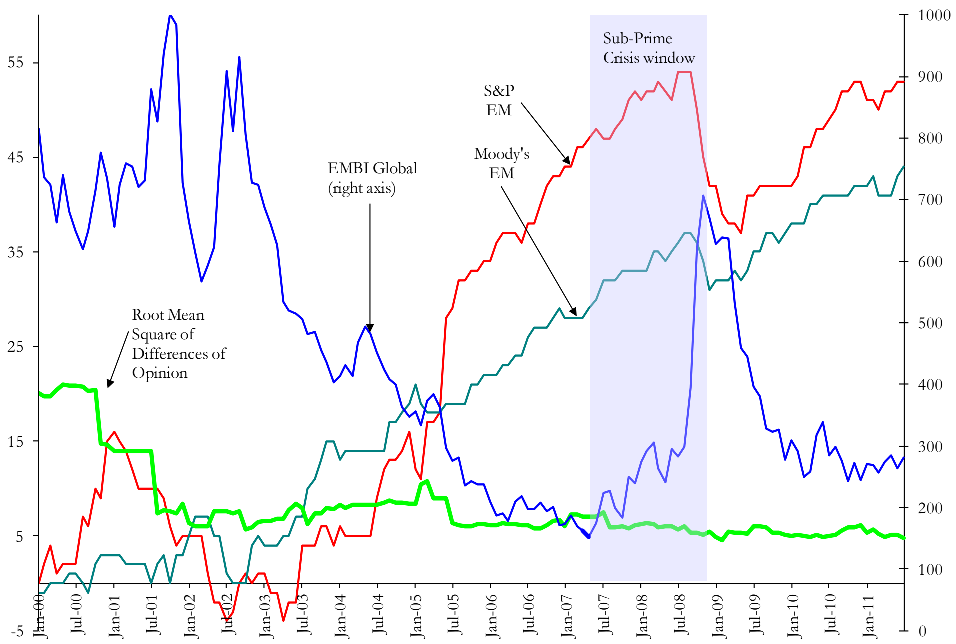


Figure 2.5: Liquidity Variables, LIBOR and ABCP spread (recent past, basis points)

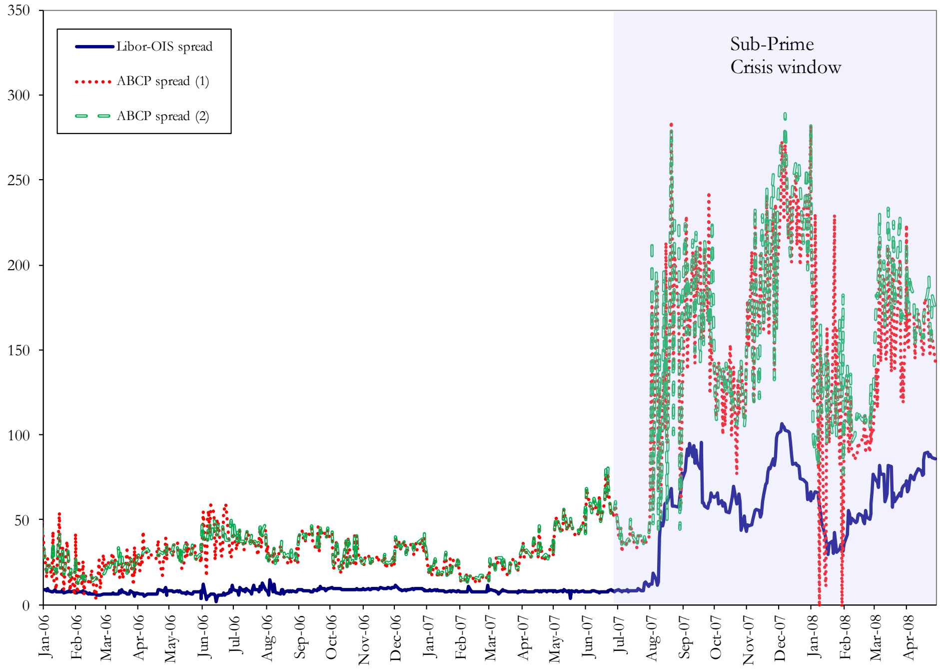


Figure 2.6: Liquidity Variables, On/Off the Run spreads (recent past, basis points)

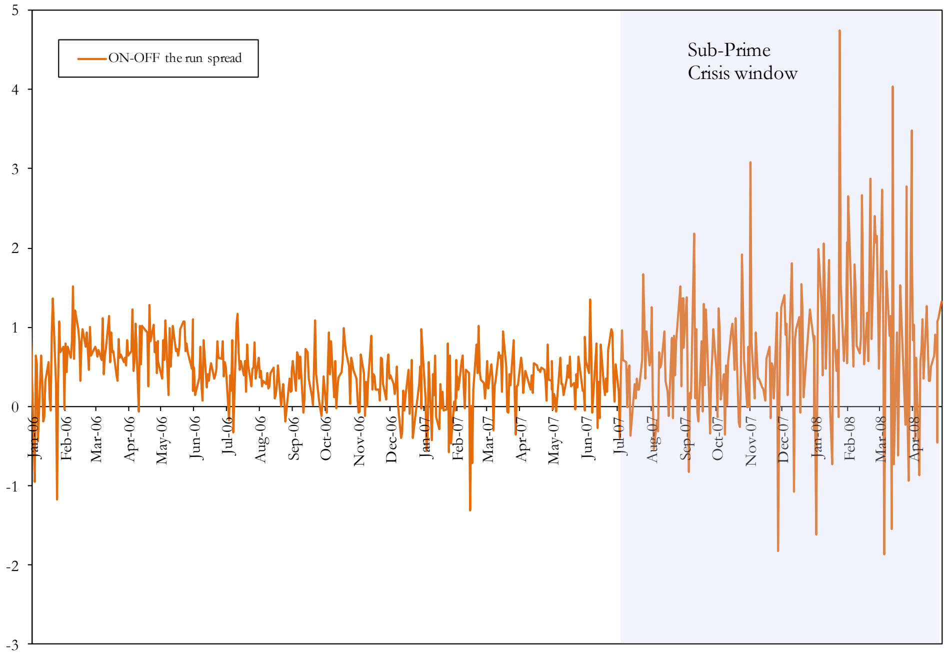


Figure 2.7: Spread principal component scores over time

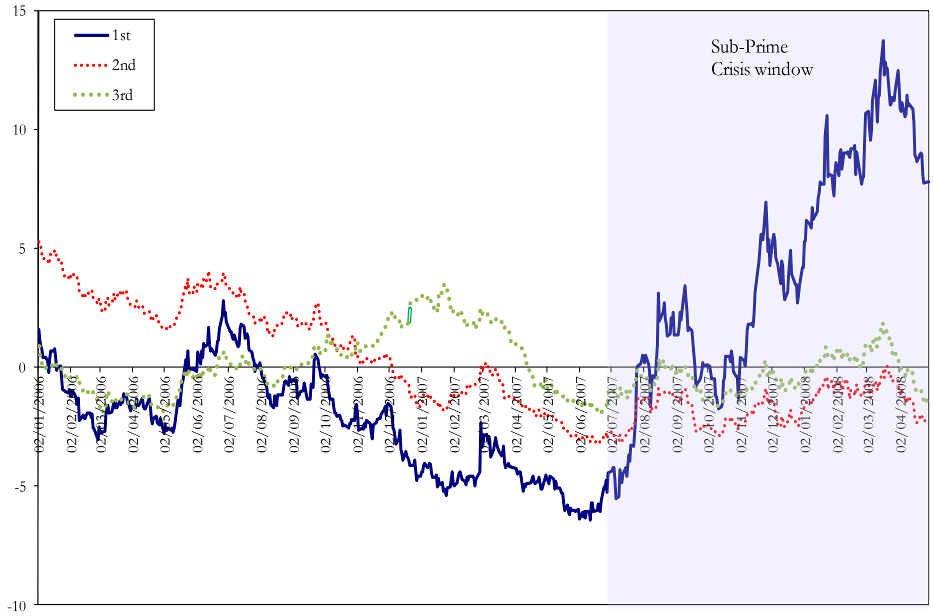


Figure 2.8: Factor loading components

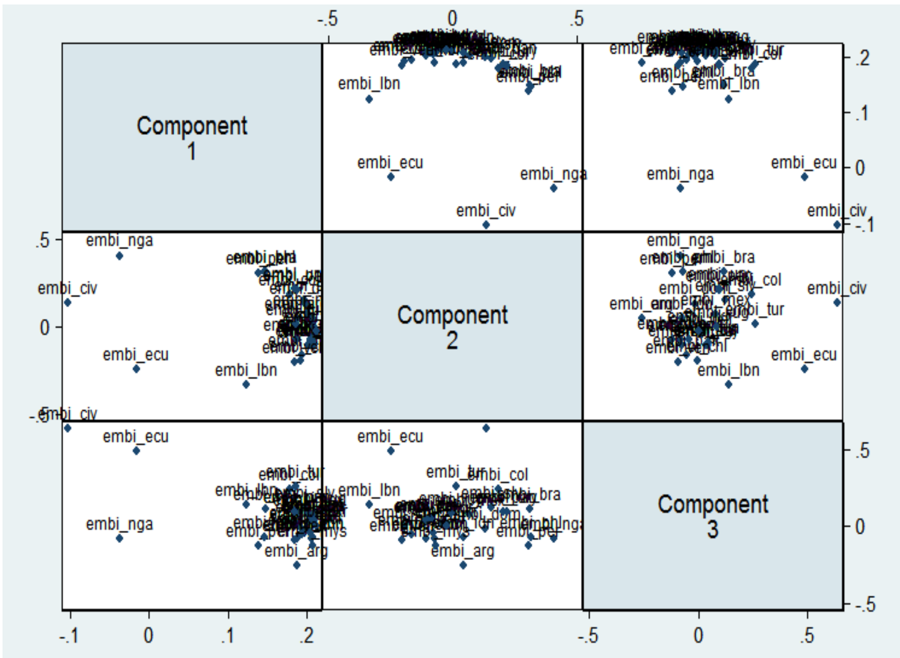


Figure 2.9: Regressions, beta coefficients stability during the crisis

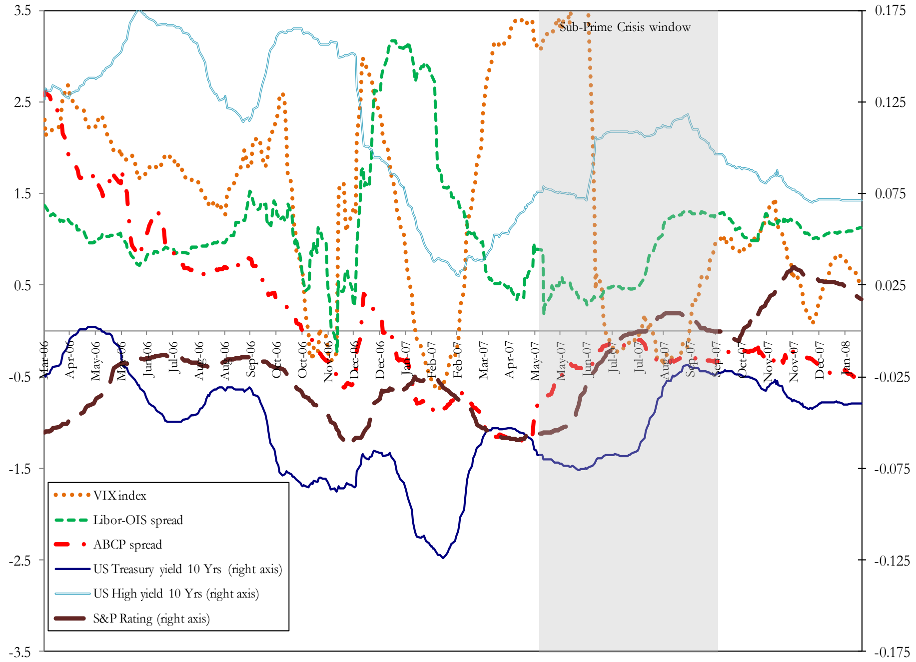


Figure 2.10: (a) Rolling regressions, S&P rating beta coefficient's standard errors during the crisis

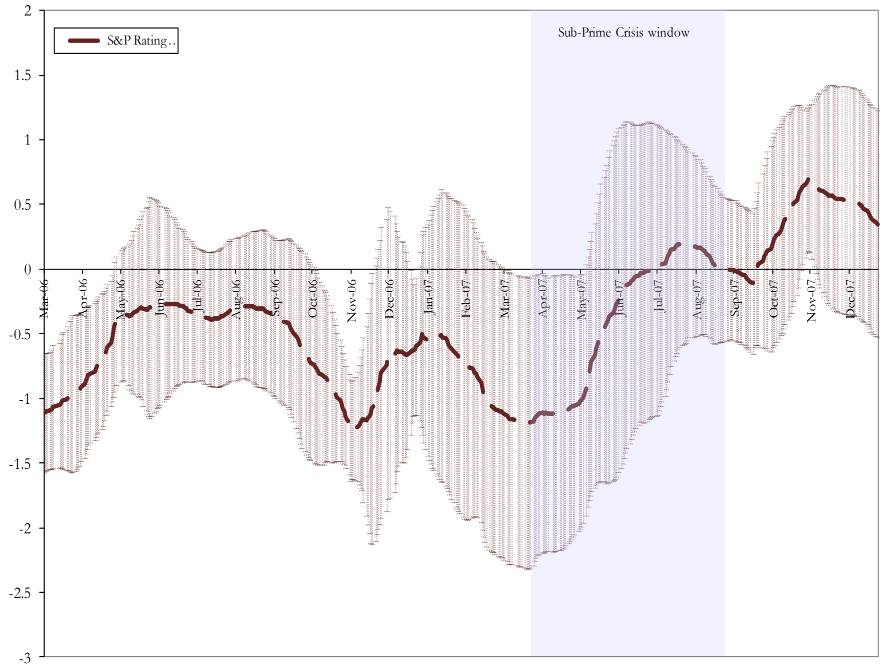


Figure 2.11: (b) Rolling regressions, liquidity beta coefficients' standard errors during the crisis

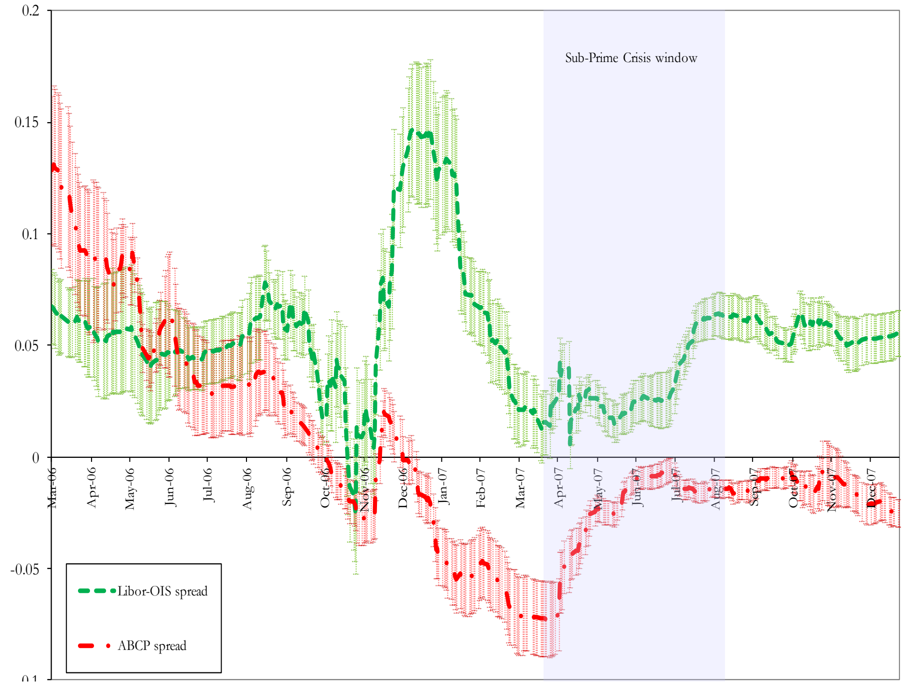


Figure 2.12: (c) Rolling regressions, global factors beta coefficients' standard errors during the crisis

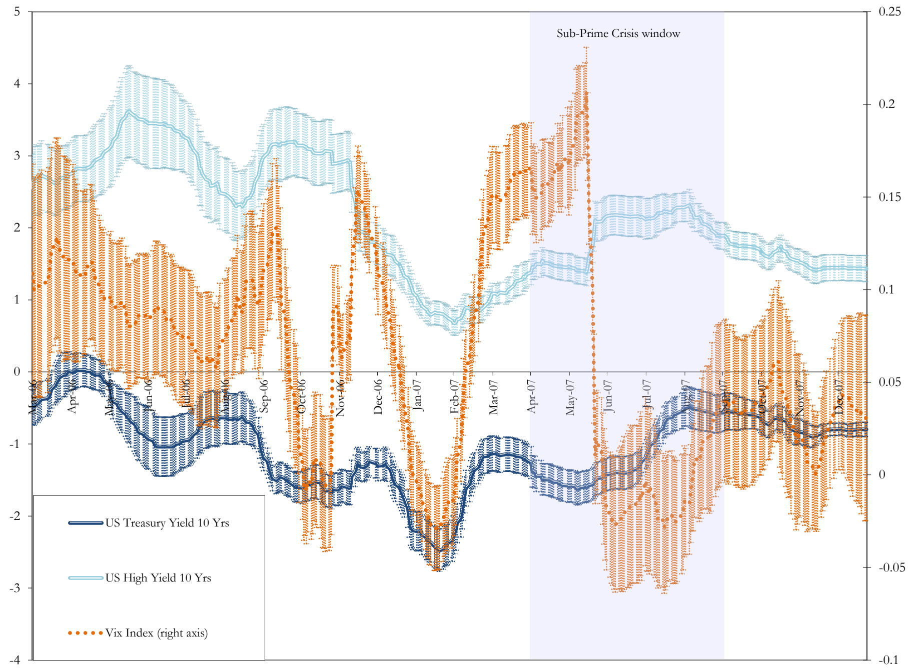


Figure 2.13: Emerging economies stock market vs Aggregated liquidity

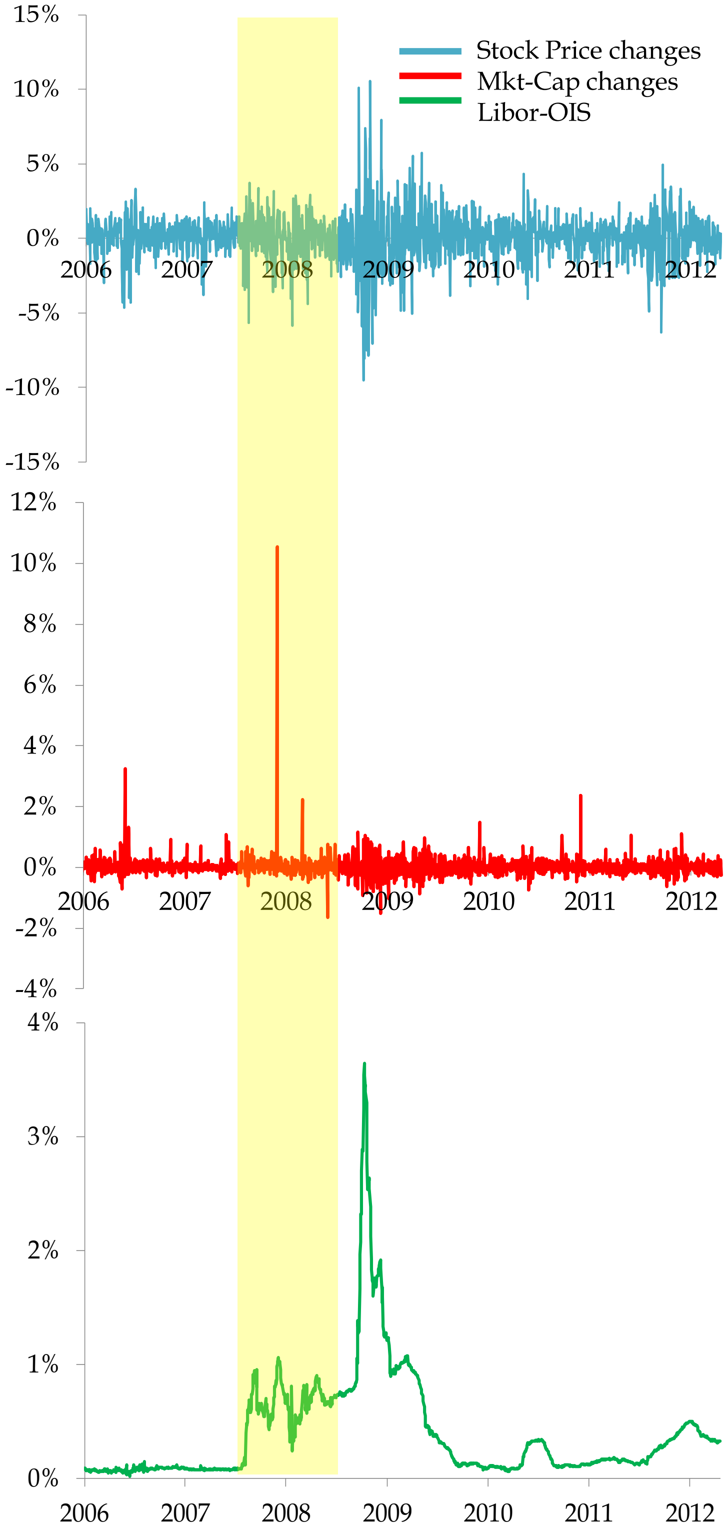
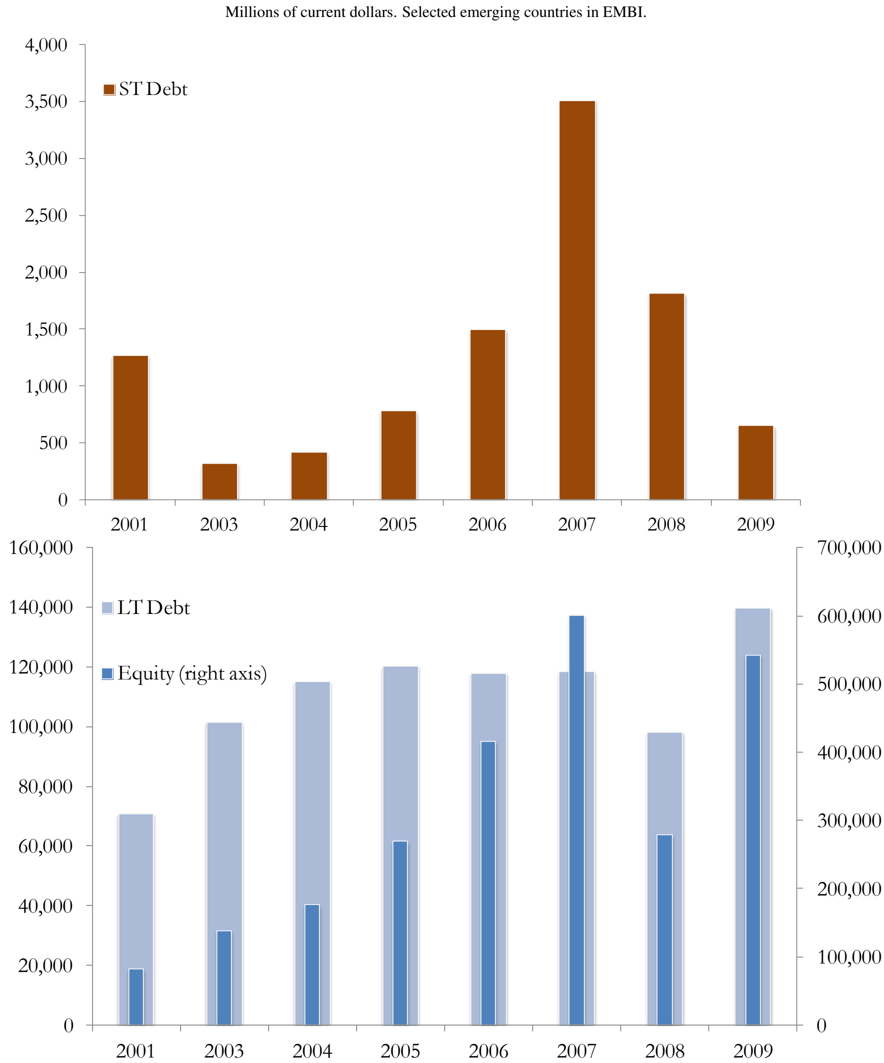


Figure 2.14: US treasury EM asset holdings



Chapter 3

Liquidity, Financial Stability and Economic Resilience

This chapter analyzes different channels of shock transmission in an economy affected by financial frictions. We distinguish between the liquidity and default effects on asset prices. Furthermore, we develop a framework in which we can assess financial stability policy under financial frictions. We introduce a simplified model of trade and financial intermediation that captures the effects of shocks on financial and real variables of the economy. Our results suggest that financial stability and economic resilience to adverse shocks should take into account default in the credit market as well as the liquidity of goods traded in the commodity market.[1]

3.1 Introduction

The classical macroeconomics archetype with its apparatus did not perform satisfactorily during the recent financial crisis. The micro-founded representative agent model embedded features of the Real Business Cycle (RBC) and New-Keynesian paradigms to guide policy makers and Central Banks to identify sources of economics fluctuations, to forecast and delineate the effects of policy interventions. However, the absence of liquidity, default and, more generally, financial frictions rendered it inadequate to address

[1] This chapter is based entirely on Martinez, Juan Francisco and Dimitrios P. Tsomocos, *Liquidity, Asset Prices, Financial Stability and Economic Resilience*; Working Paper, Saïd Business School University of Oxford, this version: 2011.(where I am the corresponding author)

issues of financial (in)stability and, therefore, simultaneously address monetary and regulatory policy in an integrated framework.

The financial frictions currently used in the majority of the literature investigate asymmetric information in the credit market that generates some inefficiencies in pricing and allocation. Other types of frictions that are added into these models are related to price stickiness.

Bernanke, Gertler and Gilchrist (1998), Curdia and Woodford (2008) and Kiyotaki and Moore (2001) include some of the leading examples in the literature of financial frictions in DSGE. Most of the Central Banks in the world are using their insights, because of practicalities in calibration and the useful and direct explanation of pricing and welfare they provide. Kiyotaki et al., include asymmetric information in the form of entrepreneur moral hazard and assume default as an out-of-the-equilibrium phenomenon, but it plays a reduced role in the budget constraint of the agents. They explain the transmission of financial shocks to the real economy by the existence of the asymmetric information and the liquidity constraints it generates. Bernanke et al. include money in the formulation and explain the financial accelerator consequences into the business cycle. In their framework, the main frictions are the price stickiness, and costly state verification, those are the main sources of business fluctuations. Other applications include the analysis of the effects of those frictions into the capital requirements fluctuations, as in Covas and Fujita (2010) or Meh and Moran (2010). Although they constitute valuable efforts to explain the dynamics of the credit market and are important tools to consider policy measures in the banking industry, they possess arbitrary features in the modeling (e.g. money in the utility function and change in the agent's roles through time).

These models do not include money, default and heterogeneity altogether; hence, they cannot properly consider aggregate frictions present in the credit market. That is exactly one of the reasons to them for including asymmetric information in the general equilibrium setting. In our case, as we model the aggregate frictions by including money, liquidity constraints and default in equilibrium, we capture the first order effects of those frictions. In our modeling context the aggregate financial frictions we observe in reality are enough to explain the dynamics of the nominal and real economy.

Shubik (1999), Dubey and Geanakoplos (2003), Tsomocos (2003), Dubey and Geanakoplos (2005) and Goodhart, Sunirand and Tsomocos (2006) have developed a general framework in which financial rigidities can be assessed rigorously within a general equilibrium setting. The main challenge is still how to extend those models in a dynamic setting, by preserving the main properties of a parsimonious model, without the inclusion of redundant or unrealistic features.

The initial endeavors, by Leao (2006), de Walque (2010) and Iacoviello (2007), that introduced those concepts into the DSGE framework, had not taken into account simultaneously liquidity, agent heterogeneity, money and default risk. Nevertheless, those model are valuable efforts in to the development of a plausible explanation of the phenomena we observe after the credit crisis.

We hasten to add that the mere possibility of default underscores the necessity of introducing liquidity in advance constraints. The interplay of liquidity and default justifies the presence of fiat money as the stipulated mean of exchange. Otherwise, the mere presence of a monetary sector without the possibility of endogenous default or any other friction in equilibrium may become a veil without affecting real trade and, eventually, final equilibrium allocation. Indeed, liquidity constraints, or their extreme version of cash-in-advance constraints, are the minimal institutional arrangement to capture a fundamental aspect of liquidity and how it interacts with default to affect the real economy.

The extension to the DSGE can be done following the Tsomocos (2003) and Goodhart, Sunirand and Tsomocos (2006) theoretical framework, that includes dynamics, aggregate uncertainty, agent heterogeneity, money, an active commercial banking sector, endogenous default and a formal definition for financial stability, contagion and systemic risk.

One of the crucial elements remaining to be introduced into the DSGE framework is the liquidity constraint faced by the agents, because the goods are not fully readily tradable. Acharya et al. (2005, 2009), Brunnermeier et al. (2009) and Vayanos (2004), have all studied liquidity within partial equilibrium models. In our model liquidity will be modeled following Espinoza and Tsomocos (2008). The extension to the dynamic framework is a direct and useful tool to assess the impact of the financial and real shocks since it provides two important advantages. The first is the ability to monitor the impact of a liquidity shock in the short, but also middle run. The second enhancement is that the dynamic setting allows to parameterize different liquidity environments (i.e. steady state values) and examine how shocks impact the economic variables in each case.

This paper aims to provide a basic framework to analyze financial stability policy under the presence of financial frictions, with a special focus on liquidity.

The paper is organized as follows. The first section contains the motivation of our paper. Section two defines the model we are going to solve. Section three includes the solution, features and calibration of the model. Finally, section four includes the main findings and conclusions from our study.

3.2 Motivation

In this section of the paper we give a brief description of the economical facts that motivate our research on this topic.

The motivation is mainly due to the previous empirical findings by Martinez (2010). In his paper, the author explains the variations in asset prices of emerging market countries. It analyzes the movement of the emerging market debt spreads through time. It considers the movement before and after the credit crisis, but it takes a look back in the beginning of this, around July of 2007, when financial markets started to suffer a high period of volatility. This phenomenon can be observed in figure (3.1).

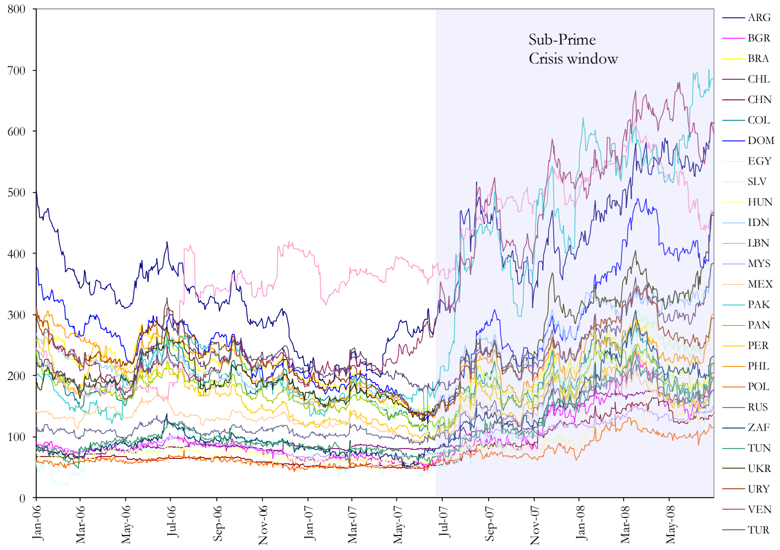


Figure 3.1: EMBI spreads compression and decompression

The question that this paper addresses is finding the determinants of the changes in prices (spreads) of emerging market debt fluctuations. It is due to fundamental movements, or it is due to the change in the aggregate liquidity in those markets. The paper finds that before the turbulence started, fundamentals explained a considerable portion of the pricing. However, after the turbulence started, credit markets dried up and liquidity started to bind for those markets. This phenomenon caused a detriment in emerging market debt, even when fundamentals were not worsening and default was not increasing at that time, as we can observe in figure (3.2). In the highlighted window the spreads are growing while the fundamentals are still improving. After that date, prices returned to follow fundamentals.

The conclusion of Martinez (2010) is that there is scope for financial intervention and liquidity injections. Those were needed during 2008 to avoid the transmission of the financial shock into the real economy, to improve welfare. Nevertheless that paper has some limitations, because the empirical approach does not allow to analyze the feedback

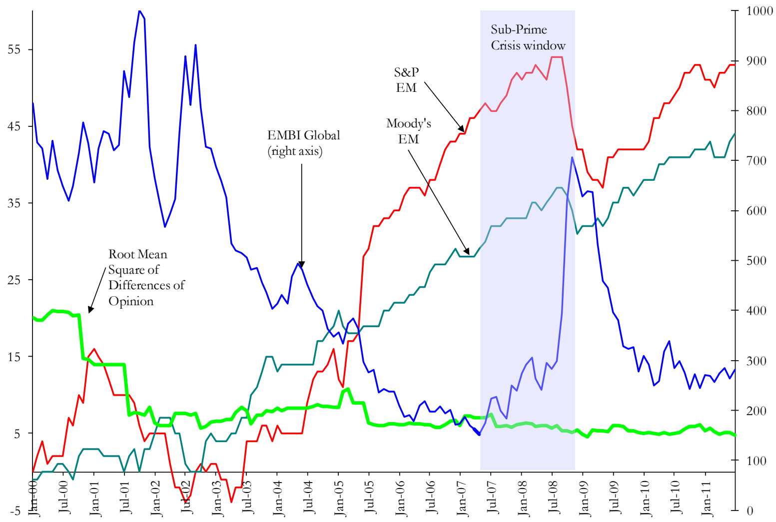


Figure 3.2: EMBI spreads versus credit quality

effects and short and medium run dynamics between default, liquidity and asset pricing. Furthermore, welfare effects cannot be measured or tested.

The present paper is an attempt to analyze the previously described phenomenon, and explain the dynamics of the stylized observation in Martinez (2010), by including these features into the DSGE framework.

3.3 The Benchmark Model

In this section we introduce a simple dynamic stochastic general equilibrium model (DSGE) with liquidity constraints and endogenous default, where we examine asset prices and real economy variables. The structure of the model and agents interaction are depicted in figure (3.3).

This benchmark model provides an environment where we have the financial frictions we want to analyze (i.e., money, default and liquidity). Also, it allows to see feedback effects among these variables and analyze those effects on asset prices, financial stability, and economic performance. In addition, we can compare the response of the model against shocks, given some liquidity environment.

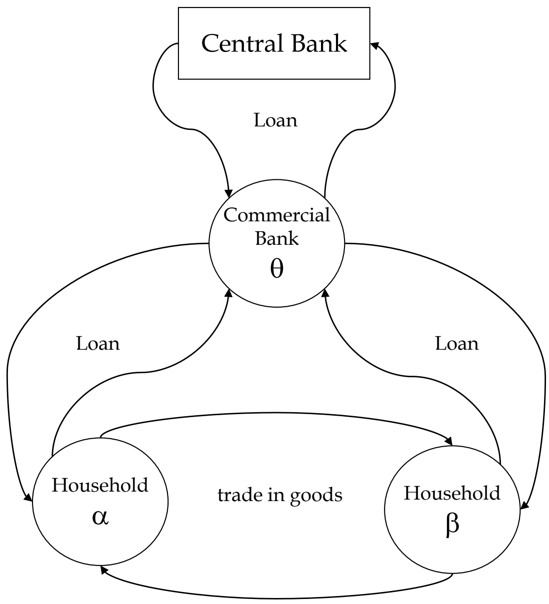


Figure 3.3: Nominal Flows of the Economy

3.3.1 Model setting

There are infinite *dates* indexed (T=0,1,2,...) and two short-lived (1-period) commodities available at each date. We have three types of *agents*: i) **Households** (α and β) that are endowed with and consume commodities; ii) a risk-averse competitive monopolistic **Commercial bank** θ that provides credit (the only financial asset available) and maximizes profits and iii) a **Central Bank** that acts as a *strategic dummy*[2]. Except for the Central Bank, agents are allowed to default partially on their obligations, subject to a non-pecuniary penalty proportional to the defaulted amount.

In our problem we assume that household α is endowed only with good 1 every period, and household β is endowed only with good 2. Both of them face cash in advance constraints, therefore, they have to borrow money from the Commercial bank. The latter

[2]That is, it provides funding liquidity in the interbank market each period by giving credit to the Commercial bank. However, it does not optimize any reaction function, the Central Bank is seen as creating a monetary shock for the rest of the agents.

also borrows money from the Central Bank at the REPO market, because it also faces cash in advance constraints as a consequence of the constraints faced by the households. Nevertheless, there exists a liquid portion of commodity endowments that can be used to repay debts and consume[3].

Household $h \in \{\alpha, \beta\}$ optimization problem

$$\max_{\tilde{\mu}_t^h, \tilde{b}_{j_h,t}^h, \upsilon_t^h, q_{i_h,t}^h} U^{\alpha} = E_0 \sum_{t=0}^{\infty} \beta^t \left\{ ln\left(e_{i_h,t}^h - q_{i_h,t}^h\right) + ln\left(\frac{\tilde{b}_{j_h,t}^h}{\tilde{p}_{j_h,t}}\right) - \frac{\tau_t^h}{\pi_t} Max[0, (1-\upsilon_t^h)\tilde{\mu}_{t-1}^h] \right\}$$

s.t.

$$\upsilon_t^h \tilde{\mu}_{t-1}^h \leq \tilde{p}_{i_h,t-1} q_{i_h,t-1}^h \cdot \left(1 - \lambda_{t-1}^h\right) \qquad \left(\eta_{1,t}^h\right) \tag{3.1}$$

Loan repayment $\leq$ Previous period illiquid sales of commodities.

$$\tilde{b}_{j_h,t}^h \leq \lambda_t^h \cdot \tilde{p}_{i_h,t} q_{i_h,t}^h + \frac{\tilde{\mu}_t^h}{1 + r_t^c} \qquad \left(\eta_{2,t}^h\right) \tag{3.2}$$

Money spent $\leq$ Liquid portion of sales of commodities + Loan taken from the commercial bank.

[3] At this point, it is worth to specify the nature of the cash-in-advance constraints. Although agents need to borrow money from the commercial bank, to finance the fraction of their consumption that cannot be readily financed by the current revenues of commodity sales, the money does not arrive immediately to the pocket of the seller. The seller needs to wait until the beginning of the next period. The economic interpretation is natural and realistic. The buyer extends a document (a check) backed by the amount of money in their current account. The check will be converted into cash at the beginning of the following period. Remember that the check only covers the portion of consumption that cannot be financed by the currently available revenues from commodities.

Where:

$h \in \{\alpha, \beta\}$	households.
(i_h, j_h)	index of goods for agent h. i_h is the good the agent is endowed with. If $h = \alpha$ then $(i_\alpha, j_\alpha) = (1,2)$, if $h = \beta$ then $(i_\beta, j_\beta) = (2,1)$.
U^h	overall utility of household h.
β^t	discount factor.
$q^h_{i_h,t}$	amount of good i_h sold by h.
$b^h_{j_h,t}$	amount of money spent on good j_h.
$c^h_{i_h,t}$	$= \left(e^h_{i_h,t} - q^h_{i_h,t}\right)$, consumption of good i_h.
$c^h_{j_h,t}$	$= \left(\frac{\tilde{b}^h_{j_h,t}}{\tilde{p}_{j_h,t}}\right)$, consumption of good j_h.
$u\left(c^h_{i_h,t}, c^h_{j_h,t}\right)$	$= ln\left(c^h_{i_h,t}\right) + ln\left(c^h_{j_h,t}\right)$, utility from consumption absent from penalties.
μ^h_t	loan amount taken from the commercial bank.
υ^h_t	loan repayment rate.
τ^h_t	default penalty for household h.
r^c_t	commercial bank loans rate.
λ^h_t	liquid portion of goods for household h.
$\eta^h_{k,t}$	lagrange multiplier for constraint $k \in \{1,2\}$ for household h.
$\sim$	on the top is for real amounts correction (division by P_t or P_{t-1}).

Commercial Bank θ optimization problem

$$\max_{\tilde{\Pi}_t^{\theta},\mu_t^{\theta},l_t^{\theta},\upsilon_t^{\theta}} U^{\theta} = E_0 \sum_{t=0}^{\infty} \hat{\beta}^t \left\{ ln\left(\tilde{\Pi}_t^{\theta}\right) - \frac{\tau_t^{\theta}}{\pi_t} Max[0,(1-\upsilon_t^{\theta})\tilde{\mu}_{t-1}^{\theta}] \right\}$$

s.t.

$$\tilde{\Pi}_t^{\theta} = \frac{R_t \tilde{l}_{t-1}^{\theta}\left(1+r_{t-1}^{c}\right)}{\pi_t} - \upsilon_t^{\theta}\frac{\tilde{\mu}_{t-1}^{\theta}}{\pi_t} \qquad \left(\eta_{1,t}^{\theta}\right) \tag{3.3}$$

Utility = Expected loan repayment - Repayment to Central Bank.

$$\tilde{l}_t^{\theta} \leq \frac{\tilde{\mu}_t^{\theta}}{1+r_t^{IB}} \qquad \left(\eta_{2,t}^{\theta}\right) \tag{3.4}$$

Credit extension ≤ Loan taken from Central Bank.

Where:

U^{θ}	overall utility of commercial bank θ.
$\hat{\beta}^t$	discount factor.
Π_t^{θ}	profits obtained by the commercial bank θ.
l_t^{θ}	loan amount given to the households.
μ_t^{θ}	loan amount taken from the Central Bank.
υ_t^{θ}	loan repayment rate.
τ_t^{θ}	default penalty for commercial bank θ.
r_t^{IB}	interbank loans rate, provided by Central Bank.
R_t	expected delivery rate from households loan.
$\eta_{i,t}^{\theta}$	lagrange multiplier for constraint $i \in \{1,2\}$ for bank θ.
$\sim$	on the top is for real amounts correction (division by P_t or P_{t-1}).

We could think of the commercial bank (θ) as a set of competitive banks of the same type. The balance of the commercial bank is as follows:

A	L
Loans to households	REPO borrowing Equity

Similarly, the balance sheet of the Central Bank,

A	L
REPO loans	Currency (Fiat money)

This reduced type economy implies that the primary function of the commercial bank is providing liquidity to the households and the Central Bank provides the liquidity to be transferred by the commercial banks. This is precisely the channel for shock transmission that we want to analyze.

3.3.2 Timing of the model and flows description

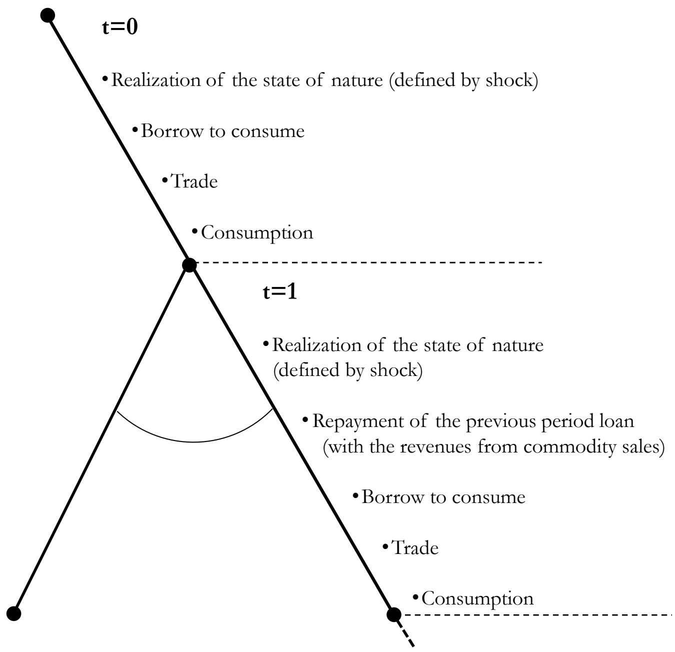


Figure 3.4: Timing of events

The timing of the different transactions in this simple model is described in Figure (3.4). This figure describes the order of households actions. Actions of the bank follow naturally. You can observe that consumers decide after the state of nature is realized how much they are going to borrow, trade and consequently consume. Prices are formed accordingly. From the first period they also decide how much they repay from previous period loans. In order to observe the flow of money through time, and also complement the information for banks' actions, please see table (3.1).

Table 3.1: Monetary flows

Money inflow		Money Outflow	
Commercial Bank	**Households**	**Commercial Bank**	**Households**
Loan taken from Central Bank	Loan taken from Commercial bank	Loan given to the households	Consumption
Repayment from households	Revenues from sales of commodities	Repayment to Central Bank	Repayment to Commercial bank

3.3.3 Financial frictions

The financial frictions contained in this analysis include default, liquidity constraints, agent heterogeneity, aggregate uncertainty and money.

3.3.3.1 Default

Assets - or credit extensions - are subject to default from the households to the commercial bank and from the latter to the Central Bank. Default is treated as in Shubik and Wilson (1977) and, more recently, in Dubey, Geanakoplos and Shubik (2005). The default is modeled by using non pecuniary penalties, proportional to the size of the unrepaid amount of the contractual obligations. These penalties are subtracted from the utility functions of the households and the commercial bank. This type of default is continuous and strategic. It is continuous since the agents repay partially and they are only punished following a continuous function[4]. On the other hand, default is strategic due to the fact that in equilibrium the agents equate the marginal utility from the additional consumption available from defaulting with its costs. The penalties can be interpreted as reputational sanctions the companies may suffer by deciding not to honour their obligations. Therefore, it consists of a deadweight cost from defaulting. We only concentrate on this kind of default. We acknowledge that there is also a discontinuous default case when agents cannot meet their obligations because the value of the collateral falls below the value of the mortgage/loan[5]. In this model, for the sake of simplicity, we have no collateral requirement on the loans that are contracted.

[4] See Geanakoplos and Zame (2002) for a case of discrete default: default in collateralized debt. In this case agents default fully when the collateral value is lower than the value of the debt. Consequently collateral is seized.

[5] For a recent application of this type of default in general equilibrium modeling see Lin et al. (2010).

The default penalties we include in the case of default of the agents in the economy, are subject to regulatory changes, which can be thought of as shocks.

$$\ln(\tau_t^\alpha) = \rho^\alpha \ln(\bar{\tau}^\alpha) + (1-\rho^\alpha)\ln(\tau_{t-1}^\alpha) + \varepsilon_{\alpha,t}^\tau \tag{3.5}$$

$$\ln(\tau_t^\beta) = \rho^\beta \ln(\bar{\tau}^\beta) + (1-\rho^\beta)\ln(\tau_{t-1}^\beta) + \varepsilon_{\beta,t}^\tau \tag{3.6}$$

$$\ln(\tau_t^\theta) = \rho^\theta \ln(\bar{\tau}^\theta) + (1-\rho^\theta)\ln(\tau_{t-1}^\theta) + \varepsilon_{\theta,t}^\tau \tag{3.7}$$

Where:

τ_t^α	default penalty for household α.
τ_t^β	default penalty for household β.
τ_t^θ	default penalty for commercial bank θ.

Tighter regulation works as an unexpected event accommodated over time. Examples of this type of regulation can be found in the registration of defaulting agents in a public list in times of financial fragility. If one of the financial agents appears on the list, is because there is a temporary (or even permanent) change in their financial characteristics (e.g. limits of debt, debt composition, asset maturity, etc.). Then, this type of shock is plausible if occurs randomly once in a while. Agents would still want to continue business with her, as long as time passes and there is recovery from the trespassed thresholds.

Finally, we convert the nominal amounts to real by deflating them by an inflation index.

3.3.3.2 Liquidity

Our model considers two sources of liquidity. The *funding* and *market* liquidities. The first concept will be represented by inside money, or money injected by the Central Bank, that will determine the interest rates and consequently the cost of credit. This will be described in the next section. On the other hand, market liquidity will be characterized by the liquidity of traded goods.

In this section we follow the work of Espinoza and Tsomocos (2010), which in turn is an extension of Grandmont and Younes (1972). We choose λ_t^{α} and λ_t^{β} as the parameters for the budget constraints relaxations. Our interpretation is that these parameters characterize the speed of liquidation for goods sold by households[6]. In steady state there exists a level that represents the relative liquidity of those goods in the economy. This level will be parameterized later in the calibration section. Furthermore, in the simulations section we will address how our system responds to a shock on the steady state level of liquidity for each good. We will analyze the cases when there is no market liquidity and when there is partial symmetric and asymmetric liquidity.

When the transactions of goods are not instantaneous, a fraction of the proceedings of goods sales will be expected to be available only at the end of the period. Therefore receipts associated to the revenues of commodity sales are partly available. This fraction of ready-to-use receipts from sales of commodities is referred to as liquidity. However, following the same argument, as we mentioned previously, a better interpretation for this exogenous parameter is considering it as *speed of liquidation*.

The argument to relate this goods' liquidity with assets liquidity is straightforward. When the good that is backing some asset is less liquid, the asset becomes less liquid as well, in the sense that the speed of trade is lower, and if there is any other asset using the previously described asset as underlying guarantee, this other asset becomes less liquid as well. The natural example is the mortgage market. In that case, the asset involved is the mortgage, whereas the good is the physical property (i.e. the collateral). When there is any shock to the liquidity of the property, then the mortgage is affected, as well as the asset backed securities involved. In bad states of nature liquidity binds and a negative shock is transmitted into both asset markets (primary and secondary).

[6]One alternative interpretation is a world where commodity sales are done through real assets trades that give the right of equivalent units of consumption. These assets hold the property of having some degree of liquidity: since agents are impatient, the more immediate consumption an asset can generate revenues, makes it more liquidity.

The economy is subject to liquidity shocks on the goods household α and β are endowed with. The following equation describes the dynamics of the shocks.

$$\ln(\lambda_t^h) = \rho^h \ln(\bar{\lambda}^h) + (1-\rho^h)\ln(\lambda_{t-1}^h) + \varepsilon_{h,t}^{\lambda} \quad \text{for } h \in \{\alpha, \beta\} \tag{3.8}$$

$\bar{\lambda}^h$ remains to be parameterized at the steady state of the economy. The *aggregate* liquidity on the market is defined by using the following expression.

$$\lambda_t = \frac{\lambda_t^{\alpha} p_{1,t} q_{1,t}^{\alpha} + \lambda_t^{\beta} p_{2,t} q_{2,t}^{\beta}}{p_{1,t} q_{1,t}^{\alpha} + p_{2,t} q_{2,t}^{\beta}} \tag{3.9}$$

From the previous expression we can see that the aggregate liquidity index is a weighted average of the individual liquidities for the available goods. There is full aggregate liquidity if and only if there is full individual liquidity for every good in the market.

Liquidity is a market price, and reflects market conditions. The expression (3.10) relates the demand and supply of money in this economy, and consequently reflect market liquidity of goods as a price. Note that $h \in \{\alpha, \beta\}$ and $l = 1,2$ are the two commodities in this economy.

$$\lambda_t = \frac{\sum_l b_{l,t} - M_t}{\sum_l \sum_h p_{l,t} \cdot q_{l,t}^h} \tag{3.10}$$

3.3.3.3 Inside Money

Inside money is considered as the interventions of the Central Bank in the interbank lending market. In our simple case it only represents the intra-temporal lending that the Central Bank makes to the banking sector. These liquidity injections must exit the system (with accrued interest and net of default) when borrowing commercial banks repay their obligations. We model inside money shocks as changes to the level of open market operations (OMOs).

$$M_t = \eta_t^{CB} \bar{M} \tag{3.11}$$

Where

$$\ln(\eta_t^{CB}) = \rho^{CB} \ln(\bar{\eta}^{CB}) + (1 - \rho^{CB}) \ln(\eta_{t-1}^{CB}) + \varepsilon_{CB,t} \tag{3.12}$$

and $\bar{\eta}^{CB} = 1$ is the monetary operations gross growth at the steady state of the economy.

3.3.4 Stochastic Endowment

Since the focus of our model is on financial stability, we allow for a parsimonious endowment of economy with trade. This way we simplify the calculations and concentrate just on the part of the model that allows us to take into account the price and endowment divergences. We assume a stochastic endowment for each agent. Therefore, the only way to smooth consumption across agents is through commodities trading between the households. The following equation describes the form of the stochastic endowment.

$$\ln(e_{h,t}^l) = \rho_e^h \ln(\bar{e}_h^l) + (1 - \rho_e^h) \ln(e_{h,t-1}^l) + \varepsilon_{h,t}^l \quad \text{for } h \in \{\alpha, \beta\} \text{ and } l \in \{1, 2\} \tag{3.13}$$

This endowment is a part of the fundamental value in this simplified economy. If there is a positive or negative shock on this state contingent endowment, there are consequences for the asset prices, which are described by the rate of the loan obtained from the commercial bank. Of course, due to the interaction with the financial sector, a positive shock in goods' market endowment does not necessarily have positive consequences for the agents, as the effect on prices also needs to be considered.

Fundamentals should explain the asset prices and economic variables dynamics. Nevertheless, we will show how those financial and real variables are also affected by the liquidity of goods.

3.3.5 Inflation

From economic theory we know that the gross rate of inflation obeys the following equation.

$$\pi_t = \bar{\pi} + \frac{P_t}{P_{t-1}} \tag{3.14}$$

After obtaining the right weights for the two commodities present in the consumption basket (see Appendix 2 for more detail), we are able to compute a Laspeyres type of inflation index.

$$\pi_t = (1 + \hat{\pi}_t) = \bar{\pi} + \frac{p_{1,t}\bar{q}_1^{\alpha} + p_{2,t}\bar{q}_2^{\beta}}{p_{1,t-1}\bar{q}_1^{\alpha} + p_{2,t-1}\bar{q}_2^{\beta}} \tag{3.15}$$

In our case π is the gross inflation index, whereas $\hat{\pi}$ is the net inflation growth and $\bar{\pi}$ is the steady state level of net inflation. This is calibrated to the target level of the Central Bank (see calibration section for more details). From the previous calculations, we have thus constructed the inflation index as a function of the variables in our model. In the section related to characterization of the equilibrium, we are going to see the quantity theory of money proposition, as a function of the price index we have defined, and the money spent in the system every period.

In the simulations section we are going to show the response of inflation to different financial shocks.

3.3.6 Market Clearing Conditions

The economy implied by our model contains three different markets: goods, consumer loans and REPO[7]. These markets determine prices by equating demand and supply.

[7] Commercial bank repurchase agreements with the Central Bank.

3.3.6.1 Goods Market

The (fiat) money spent in goods market is equal to the value of the supply of goods 1 and 2 at every period.

$$\tilde{b}^{\beta}_{1,t} = \tilde{p}_{1,t} q^{\alpha}_{1,t} \tag{3.16}$$

$$\tilde{b}^{\alpha}_{2,t} = \tilde{p}_{2,t} q^{\beta}_{2,t} \tag{3.17}$$

3.3.6.2 Consumer Loans Market

The household loans demand equals the supply of funds offered by the commercial bank at every period.

$$1 + r^{c}_{t} = \frac{\tilde{\mu}^{\alpha}_{t} + \tilde{\mu}^{\beta}_{t}}{\tilde{l}^{\theta}_{t}} \tag{3.18}$$

3.3.6.3 REPO Market

The commercial bank loan demand equals the supply of funds offered by the Central Bank at every period.

$$1 + r^{IB}_{t} = \frac{\tilde{\mu}^{\theta}_{t}}{M_t} \tag{3.19}$$

3.3.7 Rational Expectations

The following conditions indicate that commercial bank is accurate in its expectations of the repayments on the loans extended. Therefore the expected repayment rate for bank θ is given by the following expression.

$$R_t \begin{cases} \frac{\upsilon^{\alpha}_{t}\tilde{\mu}^{\alpha}_{t-1} + \upsilon^{\beta}_{t}\tilde{\mu}^{\beta}_{t-1}}{\tilde{\mu}^{\alpha}_{t-1} + \tilde{\mu}^{\beta}_{t-1}}, & \text{if } \tilde{\mu}^{\alpha}_{t-1} + \tilde{\mu}^{\beta}_{t-1} > 0; \\ \text{arbitrary}, & \text{if } \tilde{\mu}^{\alpha}_{t-1} + \tilde{\mu}^{\beta}_{t-1} = 0. \end{cases} \tag{3.20}$$

3.4 Equilibrium

In this section we define the equilibrium of the model. This definition depends upon the definition of: decision variables, macroeconomic variables, parameters and budget sets. In the case of endogenous variables and variables being shocked, those are mainly defined to keep track of the simulation procedure we perform afterwards.

3.4.1 Decision Variables

$$\Sigma^{\alpha} = \left\{ \tilde{\mu}_t^{\alpha}, \tilde{b}_{2,t}^{\alpha}, \upsilon_t^{\alpha}, q_{1,t}^{\alpha} \right\}_{t=0}^{\infty}$$

$$\Sigma^{\beta} = \left\{ \tilde{\mu}_t^{\beta}, \tilde{b}_{1,t}^{\beta}, \upsilon_t^{\beta}, q_{2,t}^{\beta} \right\}_{t=0}^{\infty}$$

$$\Sigma^{\theta} = \left\{ \tilde{\Pi}_t^{\theta}, \tilde{\mu}_t^{\theta}, \tilde{l}_t^{\theta}, \upsilon_t^{\theta}, \right\}_{t=0}^{\infty}$$

3.4.2 Macroeconomic variables

$$\kappa = \left\{ M_t, \pi_t, r_t^c, r_t^{IB}, R_t, \tau_t^{\alpha}, \tau_t^{\beta}, \tau_t^{\theta}, \lambda_t^{\alpha}, \lambda_t^{\beta} \right\}_{t=0}^{\infty}$$

3.4.3 Parameters

$$\delta = \left(\bar{\eta}^{CB}, \bar{\lambda}^{\alpha}, \bar{\lambda}^{\beta}, \bar{\lambda}^{\theta}, \bar{e}_1^{\alpha}, \bar{e}_2^{\beta}, \beta, \hat{\beta}, \rho^{CB}, \rho_e^{\alpha}, \rho_e^{\beta}, \bar{M} \right)$$

3.4.4 Budget sets

$$\begin{gathered} B^{\alpha}(\kappa) = \{ \Sigma^{\alpha} : (4.1\alpha) - (4.2\alpha) \text{ hold} \} \\ B^{\beta}(\kappa) = \left\{ \Sigma^{\beta} : (4.1\beta) - (4.2\beta) \text{ hold} \right\} \\ B^{\theta}(\kappa) = \left\{ \Sigma^{\theta} : (4.5) - (4.6) \text{ hold} \right\} \end{gathered}$$

3.4.5 Endogenous Variables

$$\chi = \left\{ \tilde{p}_{1,t}, \tilde{p}_{2,t}, \pi_t, r_t^c, r_t^{IB}, R_t, \tilde{\mu}_t^{\alpha}, \tilde{b}_{2,t}^{\alpha}, \upsilon_t^{\alpha}, q_{1,t}^{\alpha}, \eta_{1,t}^{\alpha}, \eta_{2,t}^{\alpha}, \tilde{\mu}_t^{\beta}, \tilde{b}_{1,t}^{\beta}, \upsilon_t^{\beta}, q_{2,t}^{\beta}, \eta_{1,t}^{\beta}, \eta_{2,t}^{\beta}, \tilde{\Pi}_t^{\theta}, \tilde{\mu}_t^{\theta}, \tilde{l}_t^{\theta}, \upsilon_t^{\theta}, \eta_{1,t}^{\theta}, \eta_{2,t}^{\theta} \right\}_{t=0}^{\infty}$$

3.4.6 Variables being shocked

$$\varphi = \left\{ M_t, e_{1,t}^{\alpha}, e_{2,t}^{\beta}, \tau_t^{\alpha}, \tau_t^{\beta}, \tau_t^{\theta}, \lambda_t^{\alpha}, \lambda_t^{\beta} \right\}_{t=0}^{\infty}$$

3.4.7 Definition of Equilibrium

Given the previous definitions we are able to define the **FSMLD** (financial stability with money, liquidity and default equilibrium), for the short as well as the long run. In our case in the long run the economy converges to its steady state.

3.4.7.1 Short run

In our model, $(\Sigma^{\alpha}, \Sigma^{\beta}, \Sigma^{\theta}, \kappa)$ is a short run **FSMLD** iff:

(i) All agents optimize given their budget sets:

(a) $\Sigma^h \in \text{Argmax}_{\Sigma^h \in B^h(\kappa)} U\left(C^h\right)$, for h $\in \{\alpha, \beta\}$ and $\forall t \in T$.

(b) $\Sigma^{\theta} \in \text{Argmax}_{\Sigma^{\theta} \in B^{\theta}(\kappa)} U\left(\Pi^{\theta}\right)$, $\forall t \in T$.

(ii) All markets (4.9)-(4.12) clear.

(iii) Expectations are rational, (i.e. (4.13) holds).

3.4.7.2 Long run

In our model, in steady state, in addition to the conditions for a short run equilibrium, in order to obtain a long run **FSMLD**, we need that:

(i) All real and nominal variables do not grow, thus

$$x_t = x, \quad \forall\, t \, \in \, T \quad x_t \, \in X_t = \left\{\Sigma^{\alpha}, \Sigma^{\beta}, \Sigma^{\gamma}, \kappa\right\}$$

(ii) The economy is not subject to any shock, thus

$$e_t = 0, \quad \forall\, t \, \in \, T \quad e_t \in \left\{\varepsilon_{CB,t}, \varepsilon^{\alpha}_{1,t}, \varepsilon^{\beta}_{2,t}, \varepsilon^{\tau}_{\alpha,t}, \varepsilon^{\tau}_{\beta,t}, \varepsilon^{\tau}_{\theta,t}, \varepsilon^{\lambda}_{\alpha,t}, \varepsilon^{\lambda}_{\beta,t}\right\}$$

That is, there are no shocks on monetary base, endowment, default penalties or liquidity.

3.4.8 Characterization of Equilibrium

In this subsection we are going to use the results obtained from the FOCs (i.e. First Order Conditions) in order to get insights about important relationships that are maintained in our model: money non-neutrality, fisher effect, quantity theory of money, on the verge condition and interest rates under default and no default. Appendix 1 contains proof of these propositions.

3.4.8.1 Proposition 1: Money non-neutrality

This proposition implies that if there is a non-zero monetary operation by the Central Bank (i.e. $M_t \neq M_t' \Rightarrow r_t^c \neq r_t^{c\prime}$, from market clearing conditions), monetary policy is not neutral in the short-run. Therefore it affects the consumption and consequently real variables.

Suppose that for $\alpha, \beta \in H$, $b_t^h > 0$, for $l \in L$, $\lambda_t^h \in [0,1)$ and some state of nature defined by the set of shocks at t. We have that at a **FSMLD**,

$$r_t^c \leq r_t^{c\prime}, \text{ and } \lambda_t^{\alpha} \geq \lambda_t^{\alpha\prime} \Rightarrow q_{1,t}^{\alpha} \geq q_{1,t}^{\alpha\prime}$$

Note that by symmetry the proposition also holds for household β.

We have two extreme cases to analyze[8]:

i. If $\lambda_t^{\alpha} = 0$, we have that monetary policy is not neutral. This is the usual cash-in-advance setting, and the proof is analogous to the previous one.

$$\frac{\partial u\left(c_{1,t}^{\alpha}, c_{2,t}^{\alpha}\right)}{\partial c_{1,t}^{\alpha}} = \frac{1}{1+r_t^c} \frac{\partial u\left(c_{1,t}^{\alpha}, c_{2,t}^{\alpha}\right)}{\partial c_{2,t}^{\alpha}} \frac{\tilde{p}_{1,t}}{\tilde{p}_{2,t}} \tag{3.21}$$

ii. If $\lambda_t^{\alpha} = 1$, we have no liquidity restrictions. Therefore there are no incentives to borrow money and monetary policy is neutral. We can observe this directly from

[8] These are equivalent for agent β.

the following equation.

$$\frac{\partial u\left(c_{1,t}^{\alpha}, c_{2,t}^{\alpha}\right)}{\partial c_{1,t}^{\alpha}} = \frac{\partial u\left(c_{1,t}^{\alpha}, c_{2,t}^{\alpha}\right)}{\partial c_{2,t}^{\alpha}} \frac{\tilde{p}_{1,t}}{\tilde{p}_{2,t}} \tag{3.22}$$

3.4.8.2 Proposition 2: Fisher effect

Suppose that for $\alpha, \beta \in h$, $b_t^h > 0$, for $l \in L$, $\lambda_t^h \in [0,1)$ and some state of nature defined by the set of shocks at t. We have that at a **FSMLD**, for agent α, we have,

$$\left(\frac{1}{1-\lambda_t^{\alpha}} \left(\frac{\frac{\partial u\left(c_{1,t}^{\alpha}, c_{2,t}^{\alpha}\right)}{\partial c_{1,t}^{h}}}{\frac{\partial u\left(c_{1,t}^{\alpha}, c_{l,t}^{\alpha}\right)}{\partial c_{2,t}^{\alpha}}} \frac{\tilde{p}_{2,t}}{\tilde{p}_{1,t}} - \lambda_t^{\alpha} \right) \right)^{-1} = (1 + r_t^c) \tag{3.23}$$

whereas, for agent β, we have

$$\left(\frac{1}{1-\lambda_t^{\beta}} \left(\frac{\frac{\partial u\left(c_{1,t}^{\beta}, c_{2,t}^{\beta}\right)}{\partial c_{2,t}^{h}}}{\frac{\partial u\left(c_{1,t}^{\beta}, c_{l,t}^{\beta}\right)}{\partial c_{1,t}^{\beta}}} \frac{\tilde{p}_{1,t}}{\tilde{p}_{2,t}} - \lambda_t^{\beta} \right) \right)^{-1} = (1 + r_t^c) \tag{3.24}$$

Taking logarithms and interpreting loosely, this proposition indicates that nominal interest rates are approximately equal to real interest rates plus expected inflation and risk premium, which depends on liquidity and default. Fisher effect explains how nominal prices are linked directly to consumption.

3.4.8.3 Proposition 3: Quantity theory of money

Assume no money is carried over. In an interior **FSMLD** equilibrium, $\forall t \in T$

$$(1-\lambda_t^{\alpha})\, \tilde{p}_{1,t} q_{1,t}^{\alpha} + \left(1-\lambda_t^{\beta}\right) \tilde{p}_{2,t} q_{2,t}^{\beta} = M_t \tag{3.25}$$

Thus, the model possesses a non-trivial quantity theory of money, where prices and quantities are determined simultaneously.

Fisher's (1911) quantity theory of money proposition states,

$$P_t Q_t = M_t V_t \tag{3.26}$$

It implies that money supply has a direct, proportional relationship with the price level, where P_t stands for the price index, Q_t is an index of the real value of final expenditures, M_t is the total amount of money in circulation every period, and V_t is the average velocity of money in the market.

We already know P_t from equation (3.53). However, we still need to define the other variables in the expression. We need to define the real value of final expenditures Q_t. To achieve this, we write,

$$Q_t = \omega_1^q \frac{q_{1,t}^{\alpha}}{\bar{q}_1} + \omega_2^q \frac{q_{2,t}^{\beta}}{\bar{q}_2} \tag{3.27}$$

and the corresponding weight for traded quantities as,

$$\omega_1^q = \frac{p_{1,t}\bar{q}_1^{\alpha}\left(\bar{p}_1\bar{q}_1 + \bar{p}_2\bar{q}_2\right)}{p_{1,t}\bar{q}_1^{\alpha} + p_{2,t}\bar{q}_2^{\beta}} \tag{3.28}$$

$$\omega_2^q = \frac{p_{2,t}\bar{q}_2^{\beta}\left(\bar{p}_1\bar{q}_1 + \bar{p}_2\bar{q}_2\right)}{p_{1,t}\bar{q}_1^{\alpha} + p_{2,t}\bar{q}_2^{\beta}} \tag{3.29}$$

From the previous expression we can observe that the weights in this case add up to the total expenditures amount in steady state (the basis year). Therefore, we define Q_t as the average portion of expenditures in each year, by considering the average price and quantity changes in each period, i.e.

$$Q_t = \frac{\left(p_{1,t}q_{1,t}^{\alpha} + p_{2,t}q_{2,t}^{\beta}\right)\left(\bar{p}_1\bar{q}_1 + \bar{p}_2\bar{q}_2\right)}{p_{1,t}\bar{q}_1^{\alpha} + p_{2,t}\bar{q}_2^{\beta}} \tag{3.30}$$

From the quantity theory of money proposition, we know that the money in the system every period is defined as follows.

$$M_t = \left(1-\lambda_t^{\alpha}\right) p_{1,t}q_{1,t}^{\alpha} + \left(1-\lambda_t^{\beta}\right) p_{2,t}q_{2,t}^{\beta} \tag{3.31}$$

If we use the aggregate liquidity definition in equation (3.9), we then have,

$$M_t = (1-\lambda_t)\left(p_{1,t}q^{\alpha}_{1,t} + p_{2,t}q^{\beta}_{2,t}\right) \tag{3.32}$$

The only remaining term to define in expression (3.26) is V_t, the velocity of money. In our case it is equal to $1/(1-\lambda_t)$ so,

$$V_t = \frac{1}{(1-\lambda_t)} \tag{3.33}$$

That is, greater liquidity in goods increases the effective amount of money in the economy, and therefore, the proportion of the Central Bank's money is lowered. In this sense, to maintain the level of transactions. With the same amount of money, there is the need to increase the speed of transactions.

As we can observe, our model provides an explicit expression for a Fisher quantity theory of money relation. The importance of this proposition in our benchmark economy lies in the fact that despite our model being very parsimonious, it provides a non-trivial determination of prices and quantities.

Our model is in stark contrast with the classical RBC representative agent model, wherein traded quantities are fixed since there is no trade in equilibrium. Hence, any monetary policy change has nominal effects only as it merely changes prices. The upshot of our argument is that when one introduces liquidity *and* default, this class of models is non-dichotomous.

3.4.8.4 Proposition 4: On the verge condition

Suppose that for $\alpha, \beta \in H$, $b^h_t > 0$, for $l \in L$, $\lambda^h_t \in [0,1)$ and some state of nature defined by the set of shocks at t. We have that at a **FSMLD**, the on-the-verge condition for default penalties, for agents α, β and bank θ, respectively, is given by

$$\frac{1}{1+r_t^c}\frac{\partial u\left(c_{1,t}^{\alpha},c_{2,t}^{\alpha}\right)}{\partial c_{2,t}^{\alpha}}\frac{1}{\tilde{p}_{2,t}}=\beta\mathbb{E}_t\left(\frac{\tau_{t+1}^{\alpha}}{\pi_{t+1}}\right) \tag{3.34}$$

$$\frac{1}{1+r_t^c}\frac{\partial u\left(c_{1,t}^{\beta},c_{2,t}^{\beta}\right)}{\partial c_{1,t}^{\beta}}\frac{1}{\tilde{p}_{1,t}}=\beta\mathbb{E}_t\left(\frac{\tau_{t+1}^{\beta}}{\pi_{t+1}}\right) \tag{3.35}$$

$$\frac{\partial u\left(\Pi_t^{\theta}\right)}{\partial \Pi_t^{\theta}}=\tau_t^{\theta} \tag{3.36}$$

Whereas, in the steady state, the optimal default penalties for agents α, β and bank θ in **FSMLD** will be determined as follows,

$$\frac{1}{1+\bar{r}^c}\frac{\partial u\left(c_1^{\alpha},c_2^{\alpha}\right)}{\partial c_2^{\alpha}}\frac{1}{\bar{\tilde{p}}_2}=\beta\left(\frac{\bar{\tau}^{\alpha}}{\bar{\pi}}\right) \tag{3.37}$$

$$\frac{1}{1+\bar{r}^c}\frac{\partial u\left(c_1^{\beta},c_2^{\beta}\right)}{\partial c_1^{\beta}}\frac{1}{\bar{\tilde{p}}_1}=\beta\left(\frac{\bar{\tau}^{\beta}}{\bar{\pi}}\right) \tag{3.38}$$

$$\frac{\partial u\left(\bar{\Pi}^{\theta}\right)}{\partial \bar{\Pi}^{\theta}}=\tau^{\theta} \tag{3.39}$$

These conditions imply that the optimal amount of default is defined when the marginal utility of defaulting equals the marginal dis-utility.

There are three cases to analyze for agents α, β and bank θ (in this case $\hat{h}\in\hat{H}=\{\alpha,\beta,\theta\}$).

i. $u^{\hat{h}\prime}(\cdot)>\tau^{\hat{h}}$. This condition implies that the agent $\hat{h}\in\hat{H}$ will default completely. Consequently, the asset will not be traded.

ii. $u^{\hat{h}\prime}(\cdot)\ll\tau^{\hat{h}}\left(\text{ i.e. }\tau^{\hat{h}}\to\infty\right)$. This condition implies that buyers will anticipate full delivery, but sellers of the asset (i.e. borrowers) will realize that with some probability they will not be able to avoid a crushing penalty. Consequently, the asset will not be traded.

iii. $u^{\hat{h}\prime}(\cdot)=\tau^{\hat{h}}$. An intermediate level of default penalties can make everyone better-off. This condition implies that there is trading in assets.

3.4.8.5 Proposition 5: Interest rates under default and no default

This condition implies that in case there is default the interest rates are defined to be positive, because the commercial and central bank need to be compensated because of the losses from default.

Suppose that for $\alpha, \beta \in H$, $b_t^h > 0$, for $l \in L$, $\lambda_t^h \in [0,1)$ and some state of nature defined by the set of shocks at t. We have that at a **FSMLD**, the interest rates under default are $r_t^c, r_t^{IB} > 0$. Whereas under no default, the interest rates are $r_t^c = r_t^{IB} = 0$.

3.5 Solution of the model

In this section, we describe the different steps we follow in order to find the numerical solution of our model and also generate the impulse response functions of the shocks affecting the variables. The solution method includes the parametrization and calibration, the steady state solution and the simulations.

3.5.1 Calibration

In this solution step we calibrate our model for three different cases. The first is the pure cash in advance economy, when goods (real assets) are not liquid. The second case is the one with asymmetric liquidity. The third case is symmetric in liquidity with slightly higher overall liquidity than the asymmetric case.

In this exercise the calibration is made to match an annual commercial bank interest rate rate of 5% in the steady state. Additionally, we can observe from table 3.2, that we have set the steady state monetary operations to constant. We will shock this variable afterwards. It is worth remembering that the Central Bank in our case acts as a strategic dummy, and we want to see the effect of its actions in the presence of different liquidity environments and default.

Table 3.2: Parametrization

Parameter	**Basic model**	$\lambda^{\alpha} = 0.5, \lambda^{\beta} = 0.4$	$\lambda^{\alpha} = 0.5, \lambda^{\beta} = 0.5$
$\bar{\eta}^{CB}$	1	1	1
$\bar{\tau}^{\alpha}$	2.023	1.106	1.011
$\bar{\tau}^{\beta}$	2.023	1.121	1.011
$\bar{\tau}^{\theta}$	150	150	150
$\bar{e}_1^{\alpha}$	2	2	2
$\bar{e}_2^{\beta}$	2	2	2
β^{CB}	0.97	0.97	0.97
$\hat{\beta}^{CB}$	0.98	0.98	0.98
ρ^{CB}	0.5	0.5	0.5
ρ_e^{α}	0.5	0.5	0.5
ρ_e^{β}	0.5	0.5	0.5
ρ^{α}	0.5	0.5	0.5
ρ^{β}	0.5	0.5	0.5
ρ^{θ}	0.5	0.5	0.5
$\bar{M}$	1	1	1

Following the same logic and as a consequence from the previous parameter setting, in steady state, default penalties are set equal for both households, except in the asymmetric liquidity case. In the latter, the default penalty is higher for the agent endowed with the less liquid good, this is because he needs to borrow more money from the commercial bank and therefore, to align his incentives to repay, the punishment should increase accordingly.

Betas, or time impatience parameters for households and commercial bank are set according to the common trend in literature. In this case, as in reality, banks have a higher parameter than households.

Finally, we use persistence of shocks parameters to 0.5 to have every shock in the same scale. This will help us in the posterior simulation (i.e. impulse responses) step.

3.5.2 Steady state

Steady state can be calculated after the calibration solution step. It is a non-linear system of equations that we solve by using the standard Newton-Raphson algorithm. As our problem is relatively simple and our functions are continuous and smooth, this technique presents no problems. In table (3.3) we present the steady state solution.

Table 3.3: Steady state

Variable	**Basic model**	$\lambda^{\alpha}=0.5$, $\lambda^{\beta}=0.4$	$\lambda^{\alpha}=0.5$, $\lambda^{\beta}=0.5$
p_1	0.513	0.920	1.012
p_2	0.513	0.922	1.012
r^c	0.05	0.05	0.05
r^{IB}	0	0	0
R	0.952	0.953	0.952
μ^{α}	0.525	0.486	0.525
b_2^{α}	0.500	0.915	1.000
υ^{α}	0.952	0.928	0.952
q_1^{α}	0.976	0.981	0.988
η_1^{α}	-1.94	-1.074	-0.982
η_2^{α}	-2.000	-1.093	-1.000
μ^{β}	0.525	0.563	0.525
b_1^{β}	0.500	0.902	1.000
υ^{β}	0.952	0.974	0.952
q_2^{β}	0.976	0.992	0.988
η_1^{β}	-1.964	-1.088	-0.982
η_2^{β}	-2.000	-1.108	-1.000
Π^{θ}	0.007	0.007	0.007
μ^{θ}	1	1	1
ł^{θ}	1	1	1
υ^{θ}	0.993	0.993	0.993
η_1^{θ}	-150	-150	-150
η_2^{θ}	-143	-143	-143
M	1	1	1
e_1^{α}	2	2	2
e_2^{α}	2	2	2
τ^{α}	2.023	1.106	1.011
τ^{β}	2.023	1.121	1.011
τ^{θ}	150	150	150
η^{CB}	1	1	1
π	1.03	1.03	1.03

The steady state equilibrium is robust since it is calculated in an interior region of the equilibria. This follows an economically sensible array of parameters that avoid non-convexities or severe non-linearities. Recall that the utilities for all the agents are concave and budget sets are convex. Thus, for a given parameterization (that includes a selection of individual and aggregate endowments), an interior solution is guaranteed.

Central Bank interest rate is set to zero to isolate the effects on financial stability rather than concentrate on monetary policy. Commercial bank rate is calibrated to 5% per annum. Inflation is set to an average of 3% per year, which is the target for most Central Banks around the world.

Given our calibration, we have a symmetric allocation and pricing equilibrium in steady state, except in the asymmetric liquidity case. The purpose is to set the easiest benchmark case to be compared in the presence of shocks in the simulations section. Thus, we can observe direction and magnitude of the divergences from the steady state. In the case when there is asymmetric liquidity, prices are higher for the less liquid good, as we would expect. The relatively scarcer the good, the higher the price. Following the same argument, trade is higher in the less liquid good.

Average repayment rate is higher in steady state in the case of asymmetric liquidity case for the less liquid good since the agent is punished more in case there is default on this asset. Additionally, default penalties for banks are higher than for households, since the volume of credit they trade is higher and at a lower price and they need to be punished more in order to align their incentives.

As a result of our calculation and steady state **FSMLD**, the profits of banks are about 0.007 per annum. As we have set the amount of lending to 1 in steady state, this means that the annual real profits of the commercial bank are 0.7%.

3.5.3 Simulations

For the dynamic solution of our model, we follow a standard perturbation method procedure[9]. There are two possible solution methods for the dynamic programming problem we need to solve for the dynamics of our system. The first is a global method, consisting in solving recursively the Bellman system of equations. This method implies a grid search and consequently the need to specify the special properties of the value function and it is also computationally demanding. The second alternative is a local method or approximation. Our problem is parsimonious, it does not have severe non-linearities and has a limited number of variables, therefore we take the second alternative approach and solve by using a second order approximation.

In this section we describe the effect of shocks to M, fundamentals, default penalties and liquidity on commercial bank interest rate (asset prices), inflation, repayment rates, quantities traded, welfare and bank profitability. We compare the effects of shocks in three cases.

1. Basic case when there is only a pure cash in advance constraint because there is no liquidity in goods, $\bar{\lambda}^{\alpha} = \bar{\lambda}^{\beta} = 0$.

2. Asymmetric liquidity case $\bar{\lambda}^{\alpha} = 0.5,\ \bar{\lambda}^{\beta} = 0.4$.

3. Symmetric liquidity case, $\bar{\lambda}^{\alpha} = \bar{\lambda}^{\beta} = 0.5$.

The impulse-response graphs are measured as percentage deviations from the steady state of the selected group of variables. The time of convergence is measured in monthly terms.

3.5.3.1 Asset prices

The only financial asset available for both households is credit, which they can obtain from the commercial bank θ. This asset works exactly as a 1-period maturity bond and it is priced in the commercial loans market. For its pricing, we analyze the interest rate fluctuations, since it is the inverse of the price and it has meaningful and comparable

[9] For further reference see Sargent (1986), Marimon and Scott (1999) and Sims (2002).

results. Figure (3.6) summarizes the different shock effects on commercial bank interest rate. Naturally, by the credit and REPO market clearing conditions, as we decrease monetary base in the economy interest rates increase in the short run. As we expected from Martinez (2010), a negative shock on liquidity exerts a negative impact on asset prices, when keeping all of the other variables constant (including fundamentals). As a result, interest rates increase accordingly. This impact is lower for the less liquid good shock in the asymmetric liquidity case. Additionally, an increase on default penalties implies a reduction in the interest rates, because a higher default penalty implies a higher cost of default for the agents. Finally, an unexpected improvement in endowments in the short run implies an increase in the interest rate. This is because there are higher pressures to trade and credit receives a higher demand, therefore interest rates increase to compensate for the growth in default possibilities.

3.5.3.2 Inflation

Figure (3.7) summarizes the different shock effects on inflation. When the monetary base decreases, inflation responds negatively in the short run. In the medium run it increases and then returns to the steady state. This is because prices fall immediately to compensate the relative scarcity of fiat money in the economy. Conversely, in the medium run, inflation over adjusts because of the increase in credit costs, traduced in lower prices, especially in the case of liquid good environments. In the same line, a positive shock on endowment implies a negative immediate impact on inflation, but in the medium run it has a positive effect. This is because the reduced availability of goods implies an immediate price decline due to the substitution effect. After this price reduction, excess demand pressures produce an over-adjustment that reduces to the steady state level in the long run. The larger effect of a combined negative shock of endowment (i.e. affecting both households) on inflation is explained by a more severe reduction in demand (and supply) of goods in the short run. The same logic applies as to the goods' liquidity (λ^h) shock on inflation, but in this case it is about availability of resources. As we expected, a negative shock on liquidity implies a negative response of inflation because the lower - relative -

availability of resources as means of payment causes a reduction in demand. However, in the medium run it has a positive impact because of the over-adjustment. It is also important to mention that default penalties have a higher impact on inflation in the case when there is no liquidity in the market. In this sense, liquidity acts as a buffer in case of changes in credit regulation, because it provides a better alternative source of funds when credit conditions are tighter.

3.5.3.3 Repayment rates

Figures (3.8) and (3.9) summarize the different shock effects on the average household repayment rate and commercial bank repayment rate, respectively. We can see that a negative shock in money supply decreases repayment rates only in the medium run, because at that point agents are able to repay less contracted debt, since it is relatively more costly for them. As explained before, a positive shock on endowment implies a worsening in repayment rates in the medium run, because there are more pressures to trade and therefore more credit is contracted. This excess of credit involves a reduction in the repayment until the system adjusts to the steady state. It is relevant to mention that a negative shock in liquidity implies an important negative impact on repayment rates. This is due to less accessibility to resources to repay existing debts in the medium run. This fact is crucial for financial stability. When the economy is experiencing a bad state of nature, the systemic drivers of the credit market become worse. As a result, there is less agreement on the true value of assets (in particular real assets), causing their liquidity to decrease; thus, facilitating defaults.[10]

In case of the commercial bank, as this institution aggregates the risks, the impact of the shocks is different. There is still an impact of money supply on the repayment rate of the bank, but the effect is smaller. The opposite dynamics occur with the effect of shocks to endowment, and the impact is even more reduced. We can also observe that relative liquidity environment is a factor in determining the bank repayment rate when shocked by regulation or liquidity.

[10] We can observe similar issues in the mortgage and assets markets during the last financial crisis.

3.5.3.4 Trade

Figures (3.10) and (3.11) summarize the different shock effects on the quantities traded. Less fiat money implies less trade because there are less financing opportunities in the economy. We have different effects of endowment shocks on trade depending on the good that is receiving the perturbation. For a particular household, if the commodity bought receives the positive shock in endowment, it generates a negative change of quantities of the sales, the opposite of what happens with a shock on the quantity of good that the agent is endowed with. This is because of the relative imbalance in quantities. If the shock is simultaneous and positive, it generates more trade for both agents, proportional to the increase in quantities. If regulation is tighter for one of the agents, he will lower the amount he buys since he has a higher cost to finance the trade.

3.5.3.5 Welfare

Figures (3.12), (3.13) and (3.14) summarize the different shock effects on welfare. In order to approach welfare, we look at the effects of shocks on overall utilities of households and the commercial bank. A negative shock on fiat money is welfare inferior in the medium run for both, households and the commercial bank, because it increases the cost of credit and lowers trade and consumption, especially as we can examine in depressed economic scenarios. A positive individual shock on endowment generates an immediate improvement in welfare, but utility is reduced in the medium run for the households when the shock on endowment is simultaneous for both goods, since higher supply implies a considerable price reduction that generates less revenues and consequently, less consumption for both households. The impact of a positive shock in default penalties in the short run is negative for all of the market participants. However, as the agent is able to pay more afterwards, it is welfare improving in the medium run. In the commercial bank individual case, a higher default penalty for the agent endowed with the most liquid good generates an improvement in utility, because the household will be able to repay relatively more in the medium run. Additionally, utility is reduced in case of negative shock to liquidity, since it causes less resources to be available to finance trade.[11] The bank is better off when the shock affects the less liquid good, since it acts as a financial intermediary and is most needed when there is a negative shock in liquidity, especially for the illiquid good owner. As we can observe, liquidity environment plays an important role on commercial bank's utility, especially when receiving a liquidity or regulatory shock.

3.5.3.6 Bank Profitability

Figure (3.15) summarizes the shock effects on bank profitability. The only significant impact on profitability is the shock on the default penalty for the bank. All the other effects are naturally minimal, given that in our model we just have one asset to trade and there is no alternative investment. Bank profitability is affected mainly by the penalties. If we follow the Aspachs et. al. (2007) definition of financial stability, probability of default and bank profitability play an important role. This implies a trade-off for the regulatory agency, since it need to equilibrate an increase in the penalties, to control default, but also affects commercial bank profits. Profits are needed to be sufficiently robust to keep the bank from reneging on its contractual obligations, or to avoid a reduction in credit extension, with the consequent detriment in trade and consumption.

3.5.4 On resilience and financial stability

In this section we describe economic resilience in the presence of default and liquidity. In this context we define economic resilience as the ability of the economic variables to face and recover from adverse shocks. This recovery can be assessed as the impact and speed of shocks transmission and recovery to the steady state values. Put differently, resilience can be seen as the second derivative of the multiplier (i.e. acceleration of convergence) from a starting initial impact.

[11] Recall that our interpretation of the budget constraint relaxation provides more financial opportunities through market liquidity. That is, the immediately liquefiable portion of sales of goods that can be used to trade for other goods and directly consume.

In our case speed of adjustment is controlled by the persistence parameter ρ for every shock process (AR(1) in our case, for all the shocks). We could try to calibrate this parameter for each economic series. Instead, we start from a symmetric case where all the shocks have the same persistency, just to address the differences in adjustment across the variables being shocked and not within each one. The individual calibration of this persistence parameter is a useful procedure left for future investigation.

As we have seen in the previous section and according to Goodhart et al. (2006), financial stability can be roughly approximated by bank profitability and joint repayment rates. Through the comparison of the different impulse responses we can rank the responses to shocks, assess whether financial stability is affected more than price stability, and measure the effects on the real economy.

Following this analysis we can also compare responses to shocks across agents. Our results suggest that the commercial bank is more resilient to adverse shocks, since it aggregates the risks of the agents.

The principal findings of our simulations suggest that financial stability is relatively more affected than price stability. In the short run inflation responds to the negative shock in monetary base by decreasing its level. However in the medium run, inflation as well as repayment rates revert their patterns. As we can observe in Figure (3.5), in this framework, yet reduced through our initial parametrization, monetary policy needs to incorporate financial stability, because trying to improve price stability can generate financial distress and a detriment to trade and welfare.

Additionally, albeit reducing inflation in the short run, a sudden tightening in monetary policy causes a reduction in repayments and simultaneously inflation to grow in the medium run. The explanation for the apparently counterintuitive result is that when there is a shock in the monetary base, it affects the demand as well as the supply of traded goods. When the supply of goods is more sensitive to an augment in interest rates, as in our case, it is possible to obtain inflation. This equilibrium is certainly subject to improvement in efficiency. Thus, regulators should consider not only effects of monetary policy on demand, but also supply of goods, depending of the size of each sector.

In our analysis welfare lags trade, although it converges faster to the steady state. Therefore trade needs to be considered as an indicator of future economic performance. When interest rates are low a reduction in monetary base decreases trade in a higher magnitude than the benefits obtained from price control. Therefore, as in reality, there is a trade off between price targeting and welfare. Since we do not model production, all of the welfare effects are determined through trade.

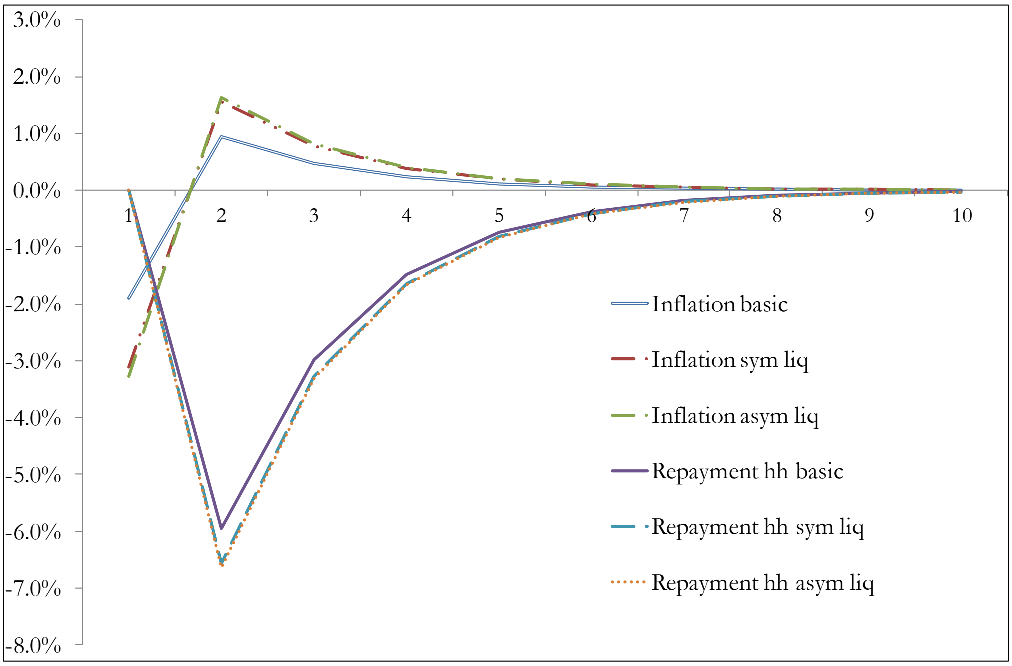


Figure 3.5: Simulation plot, $\Delta^{-}5\%$ M, selected variables

3.6 Concluding Remarks

We have developed a model that, by including agent heterogeneity, liquidity and default in a pure exchange DSGE model, is capable of addressing issues of financial stability.

Our results suggest that liquidity and default in equilibrium should be studied contemporaneously. Moreover, agent heterogeneity is essential to assess the welfare effects of exogenous shocks, since these depend on the part of the economy directly affected. In addition, the presence of financial frictions underlines the importance of studying the impact of shocks to the short to medium run behaviour of financial variables and welfare. Finally, unlike New-Keynesian models, due to endogenous determination of interest rates and default in the credit market, there is no need to resort to artificial fixing of prices to obtain equilibria that possess real as well as nominal determinacy.

Following the results of our study, we propose three further developments in this framework. The first improvement would be to micro-found liquidity of financial assets as a result of the endogenous interaction with the liquidity of goods. The second implication is the need to consider liquidity in the measurement of financial stability; as we ascertain in this work, liquidity constitutes a critical factor when addressing financial fragility. The third suggestion of this work, would be to include the possibility of price anomalies due to misalignment in expectations of the agents on the future asset prices. Our conjecture is that this additional financial friction would imply a further impact on financial stability and, as a result, a large impact to economic performance.

This model and its preliminary results should be viewed as an initial attempt to study financial stability and monetary policy. Undoubtedly, one needs to introduce production and the reaction function of policy makers, in particular the Central Bank. Our model can be used to make these extensions, but these will be addressed in future studies.

3.7 Appendix 1: Proof of the propositions

3.7.1 Proposition 1: Money non-neutrality

Proof.

From the FOC (4.41) and (4.42) for agent α, we have:

$$\frac{\partial u\left(c_{1,t}^{\alpha}, c_{2,t}^{\alpha}\right)}{\partial c_{1,t}^{\alpha}} - \frac{\partial u\left(c_{1,t}^{\alpha}, c_{2,t}^{\alpha}\right)}{\partial c_{2,t}^{\alpha}} \frac{\tilde{p}_{1,t}}{\tilde{p}_{2,t}} \lambda_t^{\alpha} = \tilde{p}_{1,t} \beta \mathbb{E}_t \left(\frac{\tau_{t+1}^{\alpha}}{\pi_{t+1}}\right)(1-\lambda_t^{\alpha}) \tag{3.40}$$

And combining with (4.39) and (4.40), we have that:

$$\frac{\partial u\left(c_{1,t}^{\alpha}, c_{2,t}^{\alpha}\right)}{\partial c_{1,t}^{\alpha}} - \frac{\partial u\left(c_{1,t}^{\alpha}, c_{2,t}^{\alpha}\right)}{\partial c_{2,t}^{\alpha}} \frac{\tilde{p}_{1,t}}{\tilde{p}_{2,t}} \lambda_t^{\alpha} = \frac{1}{1+r_t^c} \frac{\partial u\left(c_{1,t}^{\alpha}, c_{2,t}^{\alpha}\right)}{\partial c_{2,t}^{\alpha}} \frac{\tilde{p}_{1,t}}{\tilde{p}_{2,t}} (1-\lambda_t^{\alpha}) \tag{3.41}$$

And simplifying, we have,

$$\frac{\partial u\left(c_{1,t}^{\alpha}, c_{2,t}^{\alpha}\right)}{\partial c_{1,t}^{\alpha}} = \frac{\partial u\left(c_{1,t}^{\alpha}, c_{2,t}^{\alpha}\right)}{\partial c_{2,t}^{\alpha}} \frac{\tilde{p}_{1,t}}{\tilde{p}_{2,t}} \left(\frac{1+\lambda_t^{\alpha} r_t^c}{1+r_t^c}\right) \tag{3.42}$$

Similarly, for household β, we have:

$$\frac{\partial u\left(c_{1,t}^{\beta}, c_{2,t}^{\beta}\right)}{\partial c_{2,t}^{\beta}} = \frac{\partial u\left(c_{1,t}^{\beta}, c_{2,t}^{\beta}\right)}{\partial c_{1,t}^{\beta}} \frac{\tilde{p}_{2,t}}{\tilde{p}_{1,t}} \left(\frac{1+\lambda_t^{\beta} r_t^c}{1+r_t^c}\right) \tag{3.43}$$

Suppose at some period t, M_t decreases. from REPO market clearing condition (4.12) we have that it translates in a increase of r_t^{IB}, and if budget conditions are binding, r_c decreases accordingly. If we also have that λ_t^{α} is decreasing (or constant), from (3.42) to hold, $\frac{\tilde{p}_{1,t}}{\tilde{p}_{2,t}}$ must increase. Whereas, for (3.43) to hold, if λ_t^{α} is decreasing (or constant), $\frac{\tilde{p}_{2,t}}{\tilde{p}_{1,t}}$ must increase. This is a contradiction, therefore, monetary policy is not neutral in the short-run if $\lambda^{\alpha}, \lambda^{\beta} \in [0,1)$. The consequent inequality in quantities after a change in OMOs is guaranteed by our logarithmic utility functions. □

3.7.2 Proposition 2: Fisher effect

Proof.

It follows directly from the Money-non neutrality proposition proof, equations (3.42) and

(3.43) above.□

3.7.3 Proposition 3: Quantity theory of money

Proof.

In an interior equilibrium and with no money carried over, all the budget constraints are binding. We add budget constraints (4.2a) and (4.2b), and we have,

$$\tilde{b}^{\alpha}_{2,t} + \tilde{b}^{\beta}_{1,t} \leq \lambda^{\alpha}_t \cdot \tilde{p}_{1,t} q^{\alpha}_{1,t} + \lambda^{\beta}_t \cdot \tilde{p}_{2,t} q^{\beta}_{2,t} + \frac{\tilde{\mu}^{\alpha}_t}{1+r^c_t} + \frac{\tilde{\mu}^{\beta}_t}{1+r^c_t} \tag{3.44}$$

From the goods market clearing condition (4.9), and the previous relation we have,

$$\tilde{p}_{1,t} q^{\alpha}_{1,t} + \tilde{p}_{2,t} q^{\beta}_{2,t} \leq \lambda^{\alpha}_t \cdot \tilde{p}_{1,t} q^{\alpha}_{1,t} + \lambda^{\beta}_t \cdot \tilde{p}_{2,t} q^{\beta}_{2,t} + \frac{\tilde{\mu}^{\alpha}_t}{1+r^c_t} + \frac{\tilde{\mu}^{\beta}_t}{1+r^c_t} \tag{3.45}$$

Finally, by the Consumer Loans and REPO markets clearing conditions (4.11) and (4.12), respectively, we have:

$$\tilde{p}_{1,t} q^{\alpha}_{1,t} + \tilde{p}_{2,t} q^{\beta}_{2,t} = \lambda^{\alpha}_t \cdot \tilde{p}_{1,t} q^{\alpha}_{1,t} + \lambda^{\beta}_t \cdot \tilde{p}_{2,t} q^{\beta}_{2,t} + M_t \tag{3.46}$$

Where the equality comes from the assumption of no money being carried over, so the market clearing conditions are binding. Rearranging we have that relation (3.25) holds.□

3.7.4 Proposition 4: On the verge condition

Proof.

The proof follows immediately from agent α, β and bank θ FOCs.□

3.7.5 Proposition 5: Interest rates under default and no default

Proof.

From the agent α and β budget constraints (4.1a) and (4.1b) addition, and the assumption that no money is carried over (i.e. budget constraints are binding) we have:

$$\upsilon_t^\alpha \tilde{\mu}_{t-1}^\alpha + \upsilon_t^\beta \tilde{\mu}_{t-1}^\beta = \tilde{p}_{1,t-1} q_{1,t-1}^\alpha \cdot \left(1 - \lambda_{t-1}^\alpha\right) + \tilde{p}_{2,t-1} q_{2,t-1}^\beta \cdot \left(1 - \lambda_{t-1}^\beta\right) \tag{3.47}$$

From the quantity theory of money proposition, we have:

$$\upsilon_t^\alpha \tilde{\mu}_{t-1}^\alpha + \upsilon_t^\beta \tilde{\mu}_{t-1}^\beta = M_{t-1} \tag{3.48}$$

Additionally, from the market clearing conditions (4.11) and (4.12) and equation (refirdnf1), we have that the following relation must hold,

$$\upsilon_t^\alpha \tilde{\mu}_{t-1}^\alpha + \upsilon_t^\beta \tilde{\mu}_{t-1}^\beta = \frac{\tilde{\mu}_{t-1}^\alpha + \tilde{\mu}_{t-1}^\beta}{1 + r_{t-1}^c} \tag{3.49}$$

In the full delivery case[12], we have that $\upsilon_t^\alpha = \upsilon_t^\beta = 1$. Thus, for (3.49) to hold it must be the case that $r_{t-1}^c = 0$. Whereas for the case when $\upsilon_t^\alpha < 1$ or $\upsilon_t^\beta < 1$ or both, r_{t-1}^c must be strictly grater than zero. This applies $\forall t \in T$.

In case of the bank θ, from the combination of FOC, we can easily derive that:

$$\mathbb{E}_t\left(R_{t+1}\right) = \left(\frac{1 + r_t^{IB}}{1 + r_t^c}\right) \tag{3.50}$$

Therefore, in the full delivery case (in $t+1$), we need that $r_t^c = r_t^{IB} = 0$. While in the case of partial default ($\mathbb{E}_t\left(R_{t+1}\right) < 1$), we must have that $0 < r_t^c < r_t^{IB}$.□

[12]Recall that $\upsilon_t^\alpha, \upsilon_t^\beta \in [0,1]$.

3.8 Appendix 2: Inflation index derivation

In order to define inflation in terms of the model variables, we need to determine a price index for P_t, which should be a weighted average of products of the representative consumption basket in the economy. As we only have two goods, we can use these goods weights in order to build the basket. Therefore we have:

$$P_t = \omega_1^p p_{1,t} + \omega_2^p p_{2,t} \tag{3.51}$$

Where ω_1^p and ω_2^p are the weights of the goods in the consumption basket, and $p_{1,t}$ and $p_{2,t}$ are the prices of the goods 1 and 2, respectively.

In practice, the index is calculated by considering a fixed basket at the basis year. The common trend analyzed by Roberts (2000) in the historic context, is to use a Laspeyres (1864,1871,1883) type of index, which in our two goods case is defined as follows.

$$P_t = \frac{p_{1,t} q_{1,0}^{\alpha} + p_{2,t} q_{2,0}^{\beta}}{p_{1,0} q_{1,0}^{\alpha} + p_{2,0} q_{2,0}^{\beta}} \tag{3.52}$$

Where $q_{1,0}^{\alpha}$ and $q_{2,0}^{\beta}$ are the commodities quantities traded by the households at the basis year time period (i.e. t=0). In our case we are using year zero as our basis. As we start from the steady state, all the variables at time zero are the steady state variables. Therefore, we have the following equation for the price index.

$$P_t = \frac{p_{1,t} \bar{q}_1^{\alpha} + p_{2,t} \bar{q}_2^{\beta}}{\bar{p}_1 \bar{q}_1^{\alpha} + \bar{p}_2 \bar{q}_2^{\beta}} \tag{3.53}$$

Where $\bar{q}_1^{\alpha}$ and $\bar{q}_2^{\beta}$ correspond to the commodities quantities traded by the households at the steady state. As we see in the previous index, a convenient selection of weights allows us to investigate some interesting features of our model. The weights are determined to meet three requirements. First, we need the weights to add up to one. Second, we need the weights to allow us to construct the inflation as a function of the variables of our model. Third, we need to be able to derive the quantity theory of money proposition.

If we conveniently calculate our index in terms of changes with respect to the basis year, the equation (3.53) becomes.

$$P_t = \omega_1^p \frac{p_{1,t}}{\bar{p}_1} + \omega_2^p \frac{p_{2,t}}{\bar{p}_2} \tag{3.54}$$

Therefore, in order for the relationship in equation (3.53) to hold, we need to define the following weights.

$$\omega_1^p = \frac{\bar{p}_1 \bar{q}_1^{\alpha}}{\bar{p}_1 \bar{q}_1^{\alpha} + \bar{p}_2 \bar{q}_2^{\beta}} \tag{3.55}$$

$$\omega_2^p = \frac{\bar{p}_2 \bar{q}_2^{\beta}}{\bar{p}_1 \bar{q}_1^{\alpha} + \bar{p}_2 \bar{q}_2^{\beta}} \tag{3.56}$$

As we can observe, the weights add up to one. By replacing this definition of weights in the expression for inflation, we have.

$$\pi_t = (1 + \hat{\pi}_t) = \bar{\pi} + \frac{p_{1,t} \bar{q}_1^{\alpha} + p_{2,t} \bar{q}_2^{\beta}}{p_{1,t-1} \bar{q}_1^{\alpha} + p_{2,t-1} \bar{q}_2^{\beta}} \tag{3.57}$$

□

3.9 Appendix 3: First Order Conditions

3.9.1 FOCs for Household α

$$-\frac{\eta^{\alpha}_{2,t}}{1+r^{c}_{t}}-\beta\mathbb{E}_{t}\left(\frac{\tau^{\alpha}_{t+1}\left(1-\upsilon^{\alpha}_{t+1}\right)}{\pi_{t+1}}-\eta^{\alpha}_{1,t+1}\upsilon^{\alpha}_{t+1}\right)=0 \tag{3.58}$$

$$\frac{\tau^{\alpha}_{t}}{\pi_{t}}+\eta^{\alpha}_{1,t}=0 \tag{3.59}$$

$$\frac{1}{\tilde{b}^{\alpha}_{2,t}}+\eta^{\alpha}_{2,t}=0 \tag{3.60}$$

$$\frac{1}{e^{\alpha}_{1,t}-q^{\alpha}_{1,t}}+\eta^{\alpha}_{2,t}\lambda^{\alpha}_{t}\tilde{p}_{1,t}+\beta\mathbb{E}_{t}\left(\eta^{\alpha}_{1,t+1}\tilde{p}_{1,t}\left(1-\lambda^{\alpha}_{t}\right)\right)=0 \tag{3.61}$$

$$\upsilon^{\alpha}_{t}\tilde{\mu}^{\alpha}_{t-1}-\tilde{p}_{1,t-1}q^{\alpha}_{1,t-1}\left(1-\lambda^{\alpha}_{t-1}\right)=0 \tag{3.62}$$

$$\tilde{b}^{\alpha}_{2,t}-\frac{\tilde{\mu}^{\alpha}_{t}}{1+r^{c}_{t}}-\lambda^{\alpha}_{t}\tilde{p}_{1,t}q_{1,t}=0 \tag{3.63}$$

3.9.2 FOCs for Household β

$$-\frac{\eta^{\beta}_{2,t}}{1+r^{c}_{t}}-\beta\mathbb{E}_{t}\left(\frac{\tau^{\beta}_{t+1}\left(1-\upsilon^{\beta}_{t+1}\right)}{\pi_{t+1}}-\eta^{\beta}_{1,t+1}\upsilon^{\beta}_{t+1}\right)=0 \tag{3.64}$$

$$\frac{\tau^{\beta}_{t}}{\pi_{t}}+\eta^{\beta}_{1,t}=0 \tag{3.65}$$

$$\frac{1}{\tilde{b}^{\beta}_{1,t}}+\eta^{\beta}_{2,t}=0 \tag{3.66}$$

$$\frac{1}{e^{\beta}_{2,t}-q^{\beta}_{2,t}}+\eta^{\beta}_{2,t}\lambda^{\beta}_{t}\tilde{p}_{2,t}+\beta\mathbb{E}_{t}\left(\eta^{\beta}_{1,t+1}\tilde{p}_{2,t}\left(1-\lambda^{\beta}_{t}\right)\right)=0 \tag{3.67}$$

$$\upsilon^{\beta}_{t}\tilde{\mu}^{\beta}_{t-1}-\tilde{p}_{2,t-1}q^{\beta}_{2,t-1}\left(1-\lambda^{\beta}_{t-1}\right)=0 \tag{3.68}$$

$$\tilde{b}^{\beta}_{1,t}-\frac{\tilde{\mu}^{\beta}_{t}}{1+r^{c}_{t}}-\lambda^{\beta}_{t}\tilde{p}_{2,t}q_{2,t}=0 \tag{3.69}$$

3.9.3 FOCs for Bank θ

$$\frac{1}{\tilde{\Pi}_t^{\theta}} + \eta_{1,t}^{\theta} = 0 \tag{3.70}$$

$$-\frac{\eta_{2,t}^{\theta}}{1+r_t^{IB}} - \hat{\beta}\mathbb{E}_t\left(\frac{\tau_{t+1}^{\theta}\left(1-\upsilon_{t+1}^{\theta}\right)}{\pi_{t+1}} - \eta_{1,t+1}^{\theta}\frac{\upsilon_{t+1}^{\theta}}{\pi_{t+1}}\right) = 0 \tag{3.71}$$

$$\tau_t^{\theta} + \eta_{1,t}^{\theta} = 0 \tag{3.72}$$

$$-\hat{\beta}\mathbb{E}_t\left(\frac{\eta_{1,t+1}^{\theta}R_{t+1}^{\theta}\left(1+r_t^c\right)}{\pi_{t+1}}\right) + \eta_{2,t}^{\theta} = 0 \tag{3.73}$$

$$\tilde{\Pi}_t^{\theta} - \frac{R_t\tilde{l}_{t-1}^{\theta}\left(1+r_{t-1}^c\right)}{\pi_t} + \upsilon_t^{\theta}\frac{\tilde{\mu}_{t-1}^{\theta}}{\pi_t} = 0 \tag{3.74}$$

$$\tilde{l}_t^{\theta} - \frac{\tilde{\mu}_t^{\theta}}{1+r_t^{IB}} = 0 \tag{3.75}$$

3.9.4 Market Clearing conditions and rational expectations

$$\tilde{b}_{1,t}^{\beta} - \tilde{p}_{1,t}q_{1,t}^{\alpha} = 0 \tag{3.76}$$

$$\tilde{b}_{2,t}^{\alpha} - \tilde{p}_{2,t}q_{2,t}^{\beta} = 0 \tag{3.77}$$

$$1 + r_t^c - \frac{\tilde{\mu}_t^{\alpha} + \tilde{\mu}_t^{\beta}}{\tilde{l}_t^{\theta}} = 0 \tag{3.78}$$

$$1 + r_t^{IB} - \frac{\tilde{\mu}_t^{\theta}}{M_t} = 0 \tag{3.79}$$

$$R_t - \frac{\upsilon_t^{\alpha}\tilde{\mu}_t^{\alpha} + \upsilon_t^{\beta}\tilde{\mu}_t^{\beta}}{\tilde{\mu}_t^{\alpha} + \tilde{\mu}_t^{\beta}} = 0 \tag{3.80}$$

3.9.5 Equations of shocks

$$\pi_t = \frac{M_t}{M_{t-1}} \tag{3.81}$$

$$M_t = \eta_t^{CB}\bar{M} \tag{3.82}$$

$$\ln(\eta_t^{CB}) = \rho^{CB}\ln(\bar{\eta}^{CB}) + (1-\rho^{CB})\ln(\eta_{t-1}^{CB}) + \varepsilon_{CB,t} \tag{3.83}$$

$$\ln(e_{1,t}^{\alpha}) = \rho_e^{\alpha}\ln(\bar{e}_1^{\alpha}) + (1-\rho_e^{\alpha})\ln(e_{1,t-1}^{\alpha}) + \varepsilon_{1,t}^{\alpha} \tag{3.84}$$

$$\ln(e_{2,t}^{\beta}) = \rho_e^{\beta}\ln(\bar{e}_2^{\beta}) + (1-\rho_e^{\beta})\ln(e_{2,t-1}^{\beta}) + \varepsilon_{2,t}^{\beta} \tag{3.85}$$

$$\ln(\tau_t^{\alpha}) = \rho^{\alpha}\ln(\bar{\tau}^{\alpha}) + (1-\rho^{\alpha})\ln(\tau_{t-1}^{\alpha}) + \varepsilon_{\alpha,t}^{\tau} \tag{3.86}$$

$$\ln(\tau_t^{\beta}) = \rho^{\beta}\ln(\bar{\tau}^{\beta}) + (1-\rho^{\beta})\ln(\tau_{t-1}^{\beta}) + \varepsilon_{\beta,t}^{\tau} \tag{3.87}$$

$$\ln(\tau_t^{\theta}) = \rho^{\theta}\ln(\bar{\tau}^{\theta}) + (1-\rho^{\theta})\ln(\tau_{t-1}^{\theta}) + \varepsilon_{\theta,t}^{\tau} \tag{3.88}$$

$$\ln(\lambda_t^{\alpha}) = \rho^{\alpha}\ln(\bar{\lambda}^{\alpha}) + (1-\rho^{\alpha})\ln(\lambda_{t-1}^{\alpha}) + \varepsilon_{\alpha,t}^{\lambda} \tag{3.89}$$

$$\ln(\lambda_t^{\beta}) = \rho^{\beta}\ln(\bar{\lambda}^{\beta}) + (1-\rho^{\beta})\ln(\lambda_{t-1}^{\beta}) + \varepsilon_{\beta,t}^{\lambda} \tag{3.90}$$

3.10 Appendix 4: Impulse response experiments

3.10.1 Asset prices

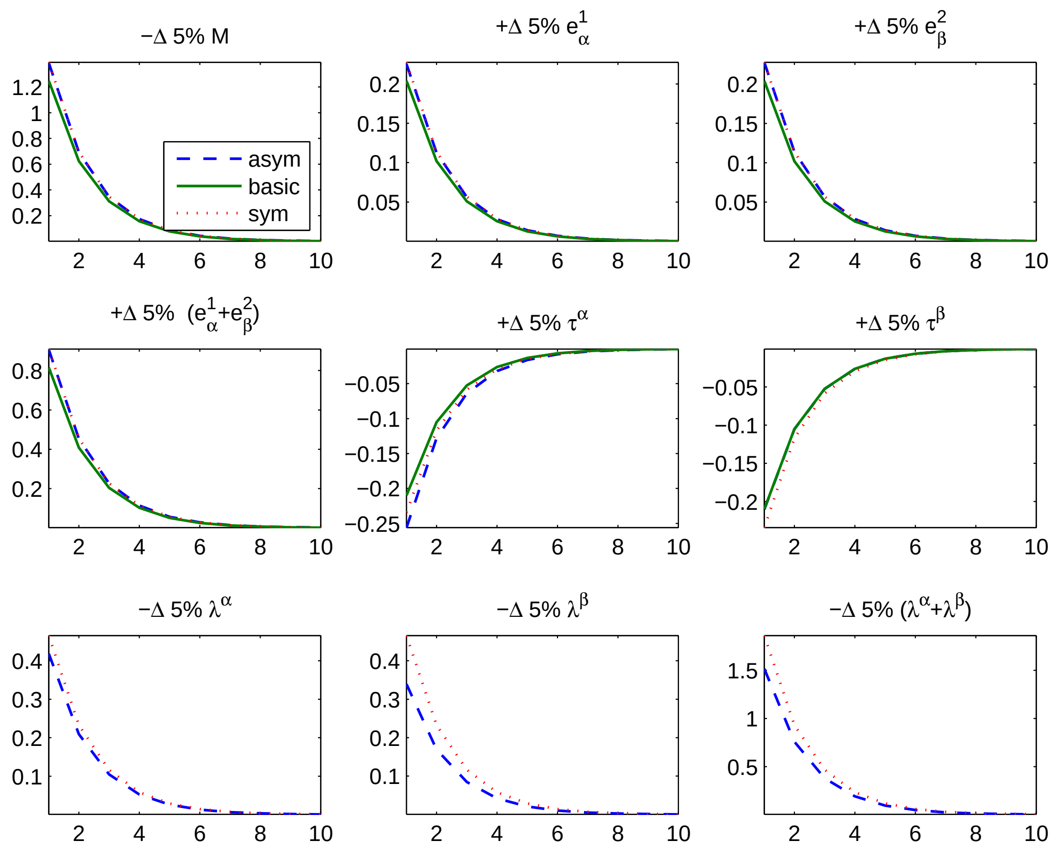


Figure 3.6: Impulse responses on commercial bank interest rate (r^c_t)

3.10.2 Inflation

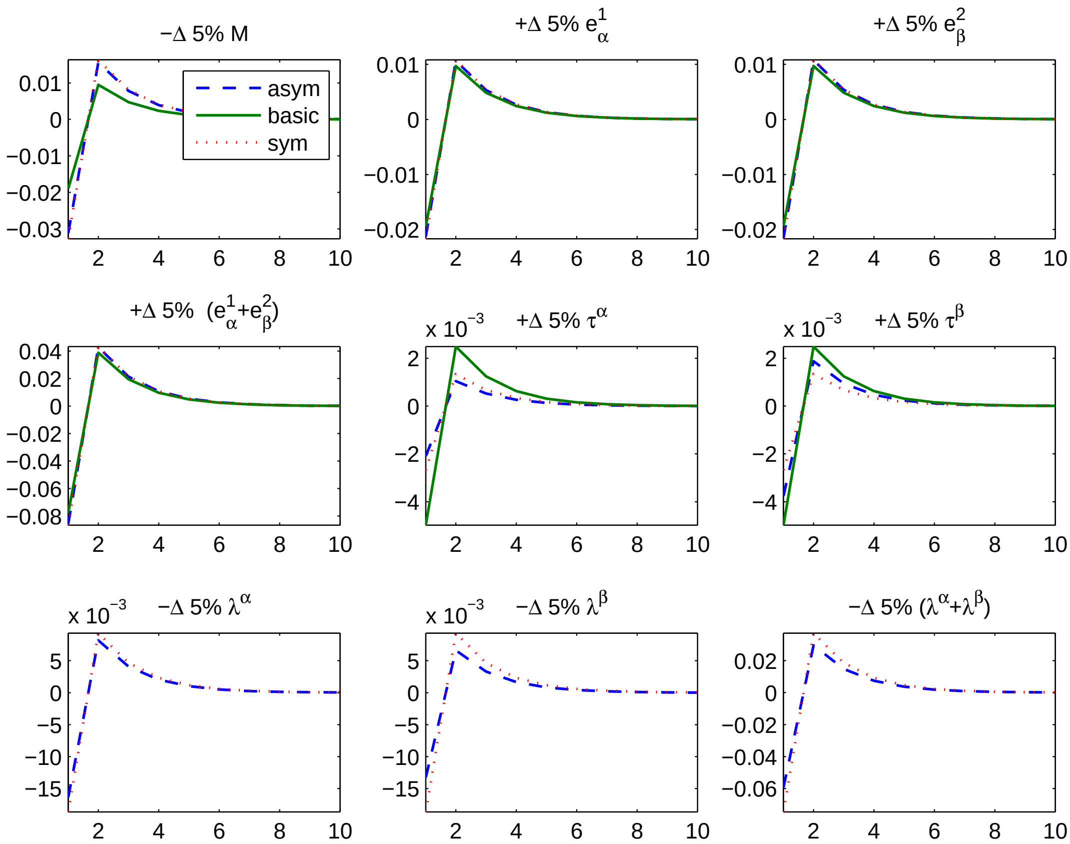


Figure 3.7: Impulse responses on inflation (π_t)

3.10.3 Repayment rates

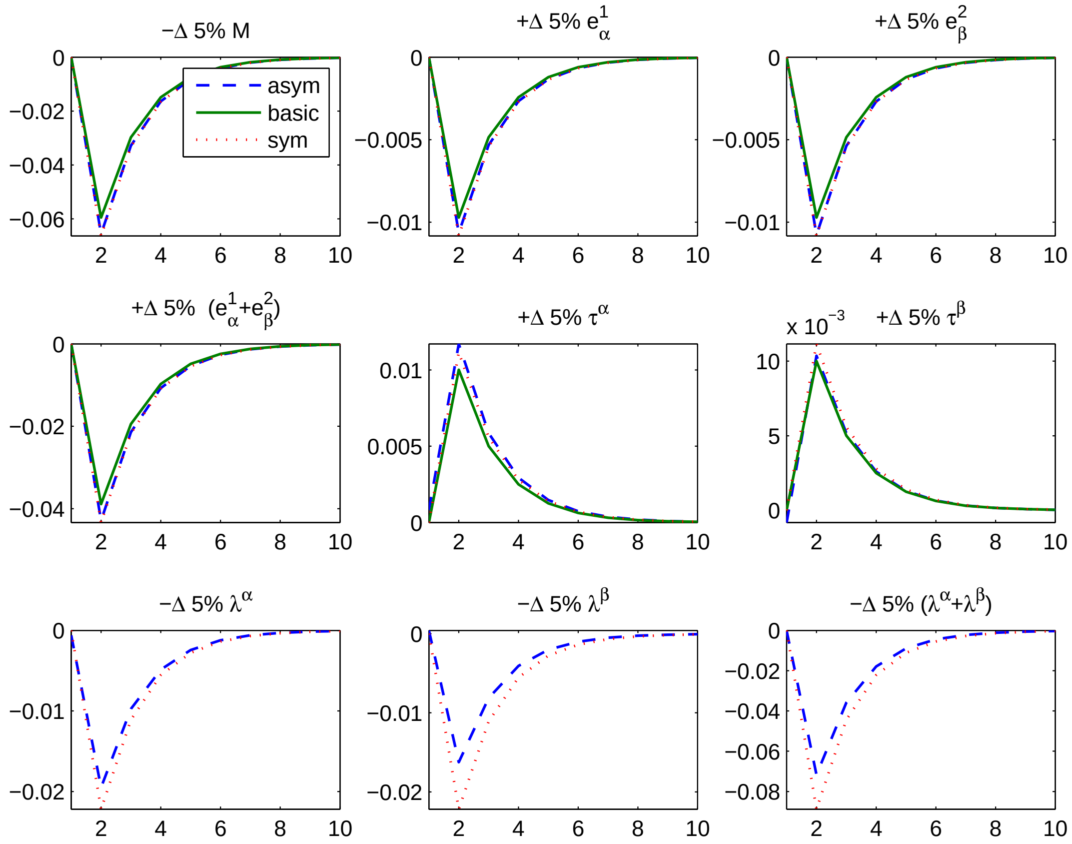


Figure 3.8: Impulse responses on average repayment rate (R_t)

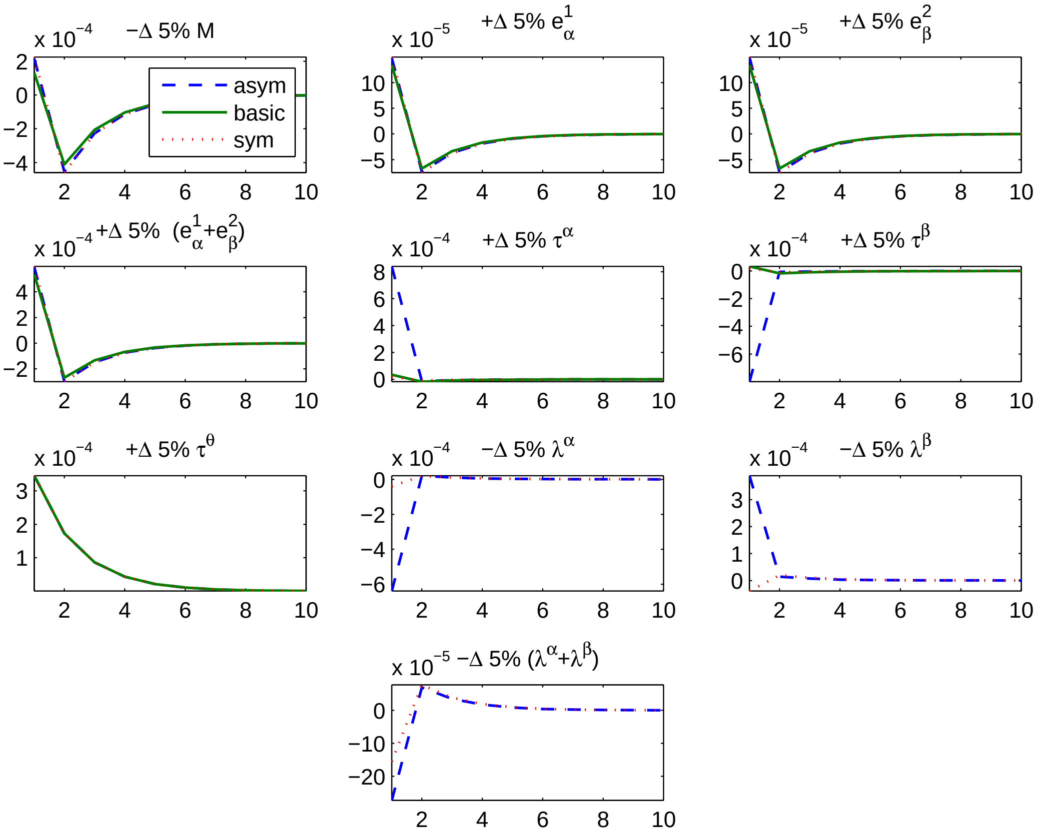


Figure 3.9: Impulse responses on commercial bank repayment rate (υ_t^θ)

3.10.4 Trade

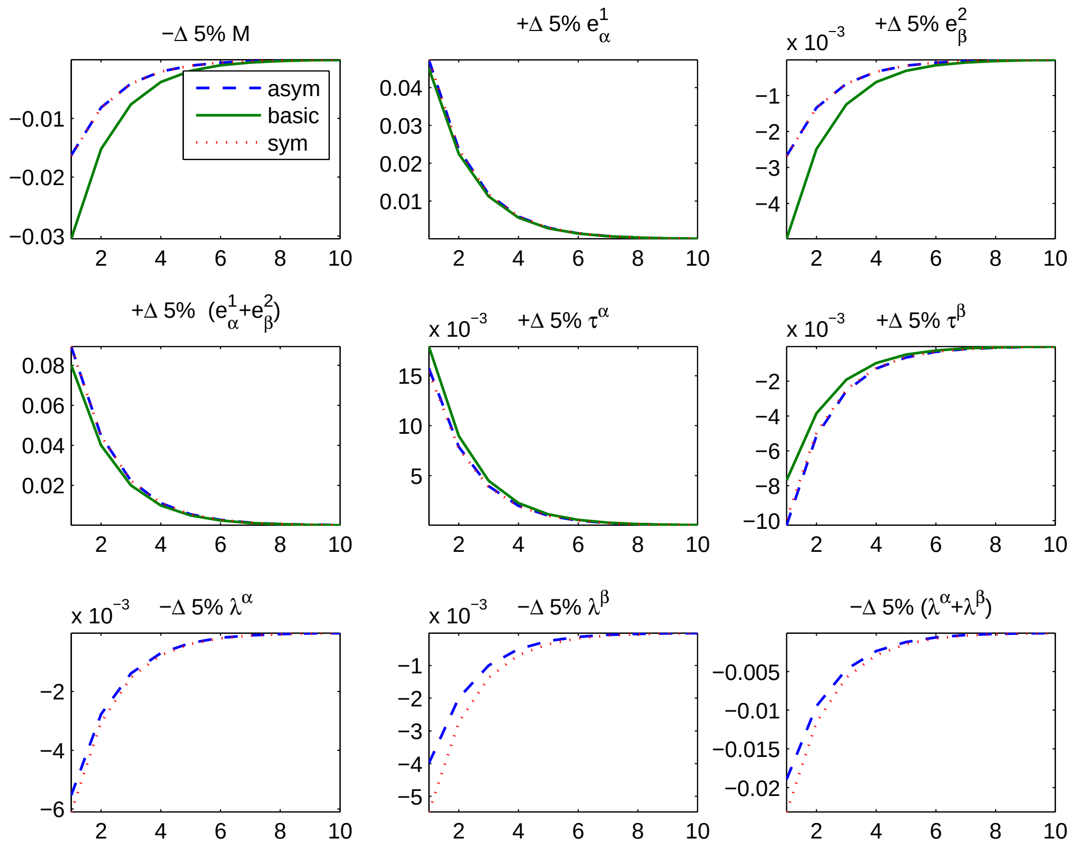


Figure 3.10: Impulse responses on quantity of good 1 traded by agent α ($q^{\alpha}_{1,t}$)

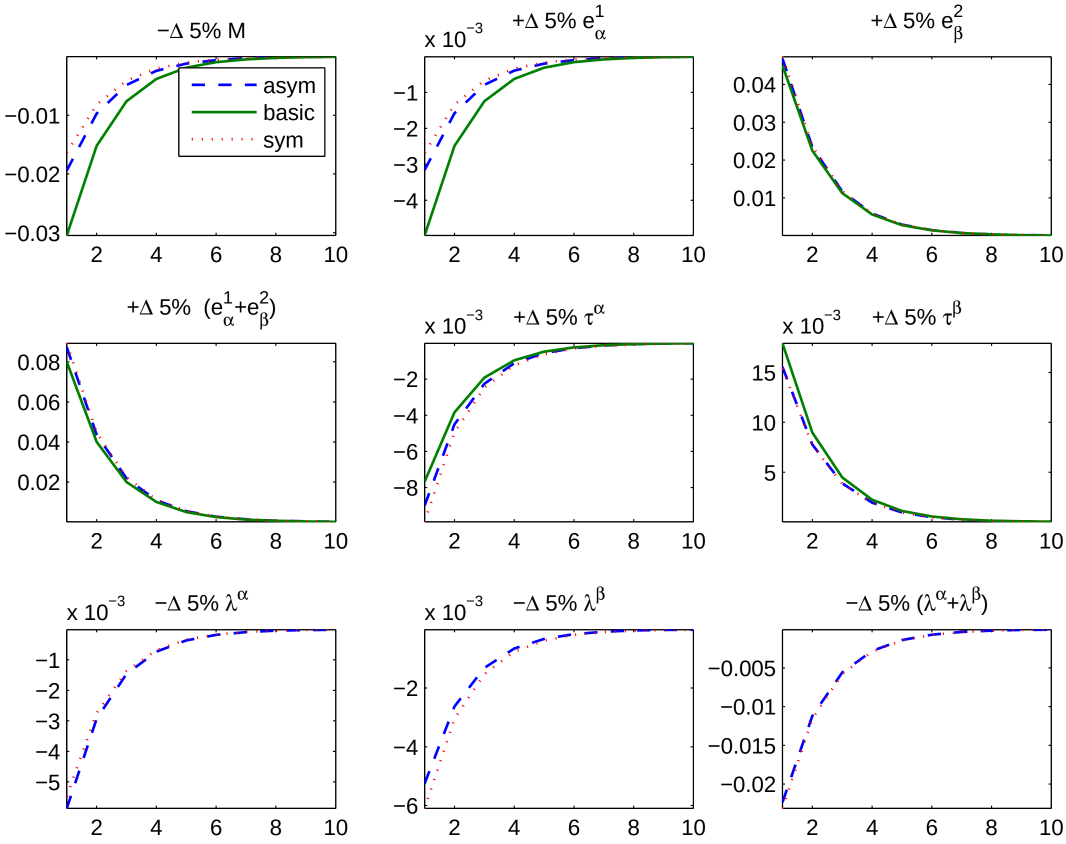


Figure 3.11: Impulse responses on quantity of good 2 traded by agent β ($q^{\beta}_{2,t}$)

3.10.5 Welfare

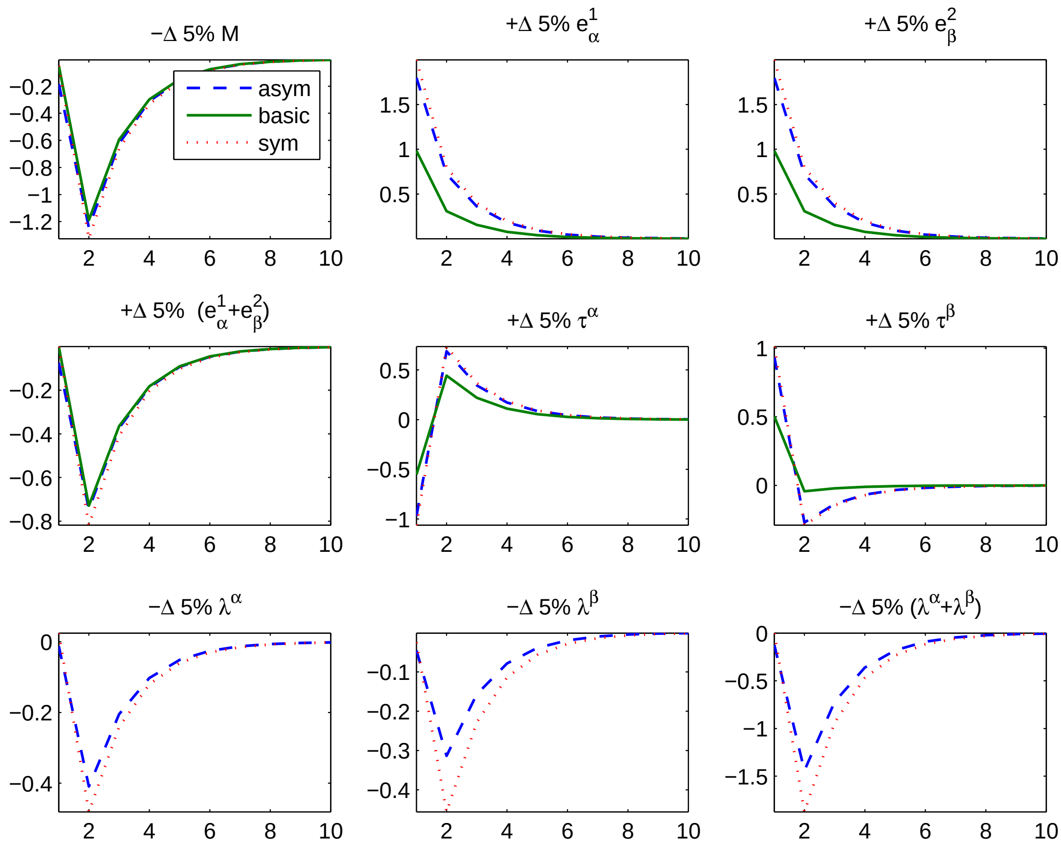


Figure 3.12: Impulse responses on utility of agent α (U_t^{α})

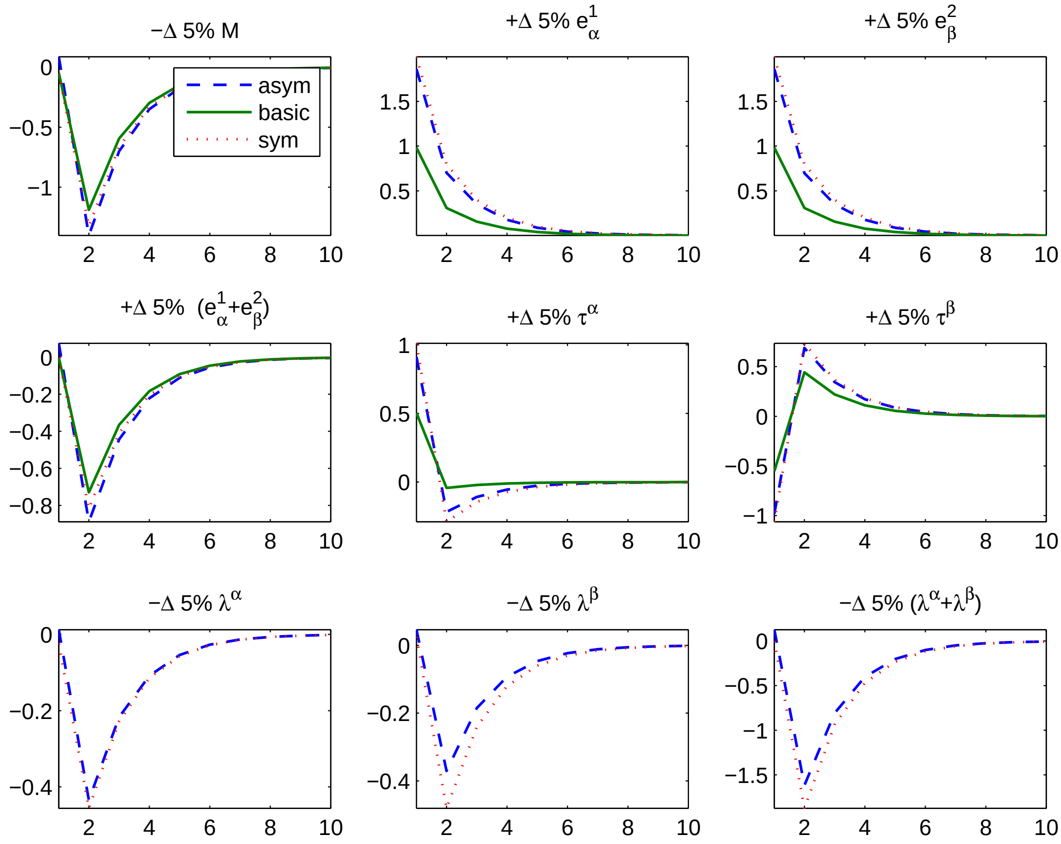


Figure 3.13: Impulse responses on utility of agent β (U_t^β)

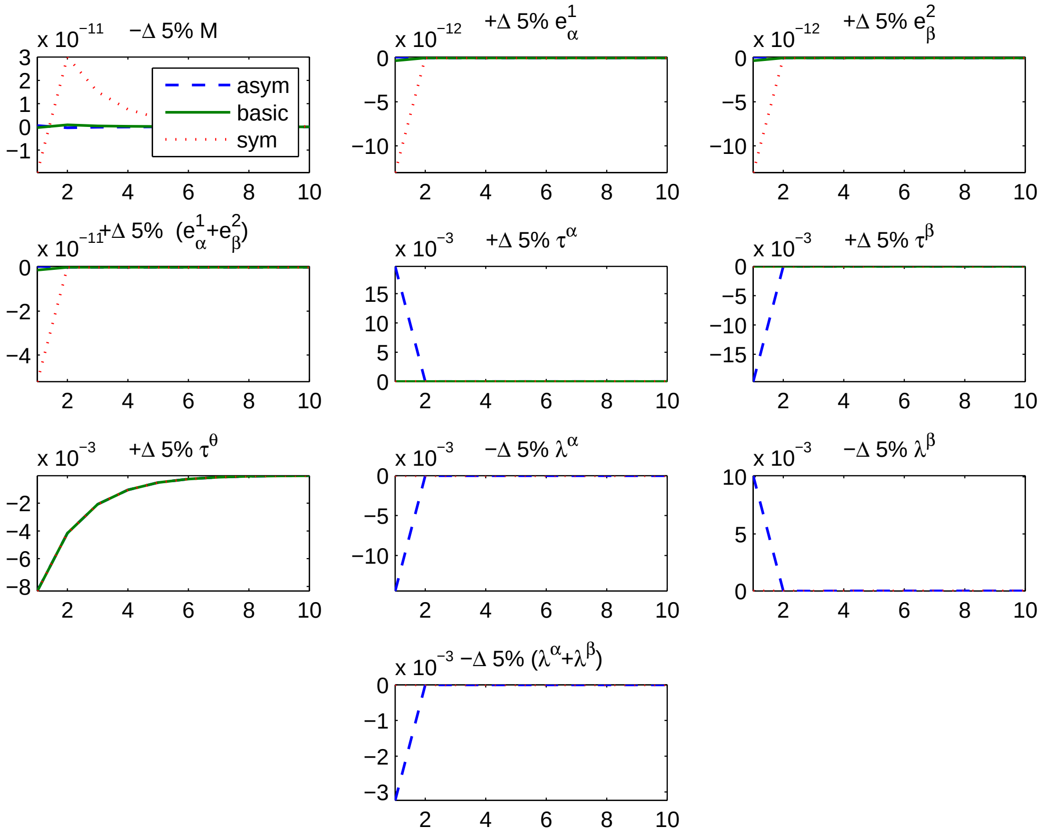


Figure 3.14: Impulse responses on utility of commercial bank θ (U_t^{θ})

3.10.6 Bank Profitability

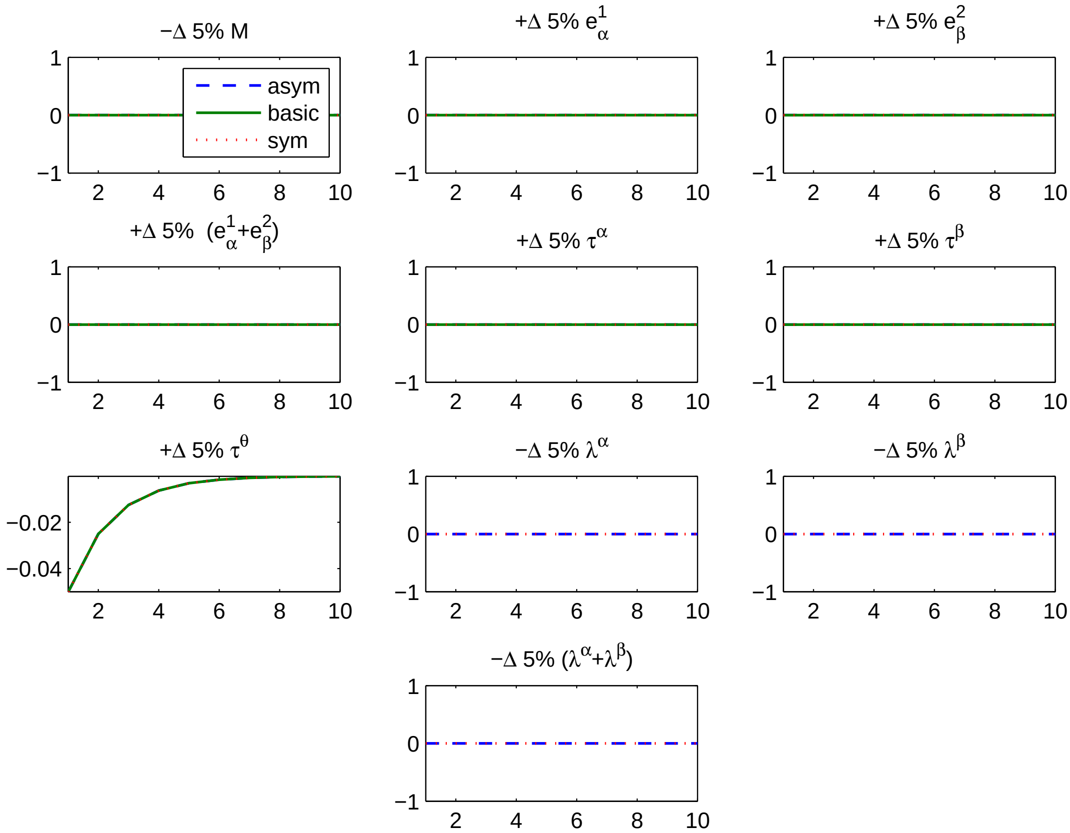


Figure 3.15: Impulse responses on bank profitability (Π_t^θ)

Chapter 4

Liquidity, Production and Default

The objective of this chapter is to present a model of financial intermediation with money, endogenous default and production that helps explain economic outcomes observed during financial crises. As a first step the paper sets out a base model by which to analyse the effects of a series of shocks on real and financial variables. In a second step, the model is expanded to allow for an endogenous relaxation of the budget constraints of the agents. This relaxation is obtained by the agents' decision of *market* liquidity, which arises by imposing a search friction. There follows an examination of the interaction between market and funding liquidity by which the effects of shocks on credit, financial stability and economic performance can be assessed. The results suggest that a negative monetary shock helps explaining a phase consisting of low production, increasing inflation and long term financial instability. In addition, the relaxation of the budget constraints smoothes the response of the majority of financial and real economic variables to various types of shocks.[1]

4.1 Introduction

It is becoming widely accepted among most macro-economists that financial frictions amplify the response of economic variables to shocks. The introduction of asymmetric information is one of the primary tools at hand to explain the exacerbated consequences

[1]This chapter is entirely based on Martinez, Juan Francisco, *Funding, market liquidity, financial stability and real effects in general equilibrium.* Working Paper, Saïd Business School University of Oxford, this version: 2012.

of nominal shocks in the aggregate economy. Indeed, aggregate and individual uncertainty, combined with the presence of information asymmetries, provides a plausible explanation of the recent crises (2007-2008 and 2010-). However, the approach of this paper is different.

The current situation in emerging as well as the developed economies indicates that there is the possibility of a stagflation-like economic phase.[2] This paper hopes to provide a feasible explanation of current economic outcomes, (rising inflation and a decrease in production as of 2012), even when the authorities have correctly tried to implement model-based policies and which may turn out to be inadequate.

This analysis introduces financial frictions, extending the work of Martinez and Tsomocos (2011), as a way of analyzing the origins of the crisis, but leaves agency problems aside. Frictions arise from the type of budget constraints faced by agents, together with the strategic nature of their behavior when deciding to repay their obligations.

Financial crises are directly or indirectly reinforced by inappropriate economic policies. For example, Fisher (1933) in his debt deflation work argued that over-indebtedness combined with monetary contraction generated fire sales and greater default and thus an economic downturn. These phenomena are caused by policy decisions, or lack of them. As a corollary, the response to policy shocks under these financial frictions is not necessarily appropriate if the assumptions or modeling techniques lack explanation of these elements in equilibrium.

In this paper, as in Tsomocos (2003), and Goodhart et al (2006), we assume that central bank's principal instrument is the monetary base, which in turn acts as a strategic

[2]See *Fiscal and monetary policy in a liquidity trap*, by Martin Wolf, Financial Times (April 2011), available at http://blogs.ft.com/martin-wolf-exchange/2012/04/17/fiscal-and-monetary-policy-in-a-liquidity-trap/. He argues that the world economic situation is moving toward stagflation equilibrium. What is needed are expansionary economic measures, not monetary contraction. However, interest rates are close to zero in advanced economies, so that in order to ease liquidity, there is a need for an active fiscal policy. A similar argument is presented by Mackinnon (2011) and (2012). This author attributes the current stagflation phase to the close-to-zero interest rates and their detrimental effects on the supply of credit.

dummy.[3] The objective is to analyze the macro and financial variables reactions after an unexpected behavior of the monetary authority, among others. It has to be noted that the monetary authority could also be interpreted as a stochastic source of funding of an economy. The present framework enriches the analysis avoiding providing biased explanations relying on unobservables (asymmetric or hidden information). That is how our contribution includes in a logical order of priority, money, liquidity, default and uncertainty in a parsimonious framework, were we can also analyze the financial and real effects of various shocks.

This paper is based on Martinez and Tsomocos (2011). In that investigation, the authors set out a rich, yet simplified version of the economy, taking the central elements of the work of Shubik (1999), Dubey and Geanakoplos (2003), Tsomocos (2003), Dubey and Geanakoplos (2005) and Goodhart, Sunirand and Tsomocos (2006). However, in this work, in order to observe the effects on aggregate output, following Martinez and Tsomocos (2011), we include a production technology, replacing commodity endowments. In this extended version, the agents will decide how much to produce.

There is also another important contribution of the present paper, as it includes the interaction of market and funding liquidity[4] in general equilibrium. We modified the framework in Martinez and Tsomocos (2011) by introducing an endogenous relaxation of the budget constraints of the producers. With this modification, the model captures the reaction of market liquidity after a funding liquidity shock (and others).

Finally, note that the analysis in this paper will be on the demand side of market liquidity, whereas the supply will be considered as an exogenous cost.

The rest of the paper is organized as follows. The second section contains the motivation of this paper. Section three defines the model. Section four describes the model equilibrium. Section five presents the numerical results. Finally, section six includes the

[3]The monetary authority does not optimize, but rather reacts to shocks (i.e. it is assumed to have predetermined policy options).

[4]See Brunnermeier et. al. (2009) for a definition.

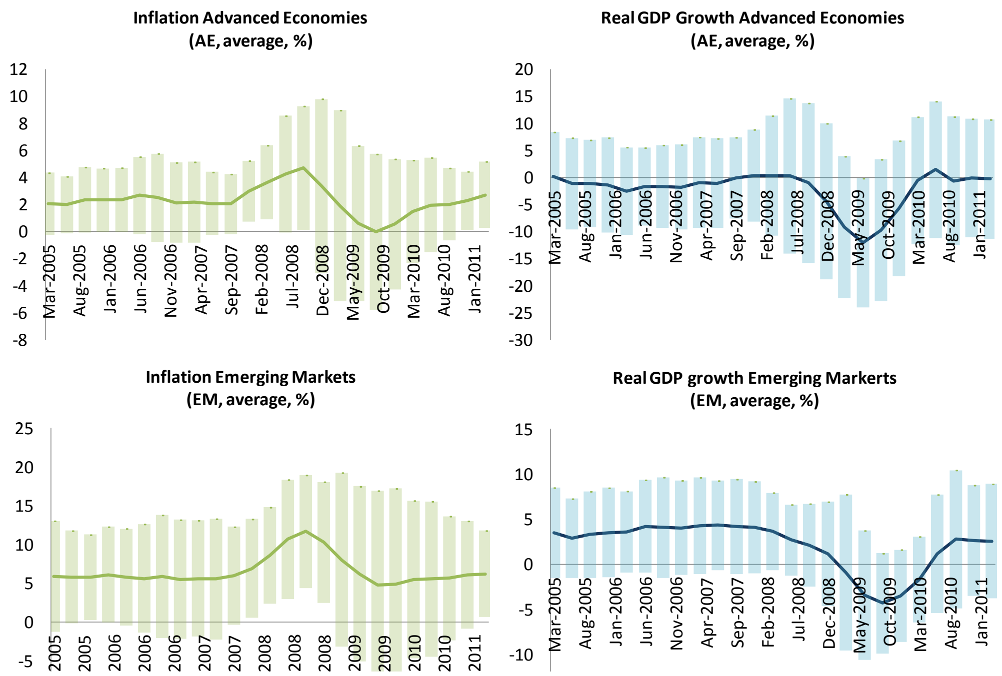
main findings and conclusions from this study.

4.2 Motivation

Since the second half of 2010 there has been a clear pattern of economic downturn, especially in advanced economies (AE). Greece, Portugal, Ireland, Spain and Italy are some examples of the situation. The paper does not discard difficulties of the emerging economies (EM) either. As compared to the previous crisis (2007-2008), the current downturn is much more widespread. As figure (1) shows, inflation has been growing and output decreasing since 2010; it has not recovered to levels prior to the sub-prime crisis. On the other hand, inflation has been growing to levels above those of 2006. These outcomes have the characteristics of potential stagflation.

Figure 4.1: Real GDP growth and Inflation

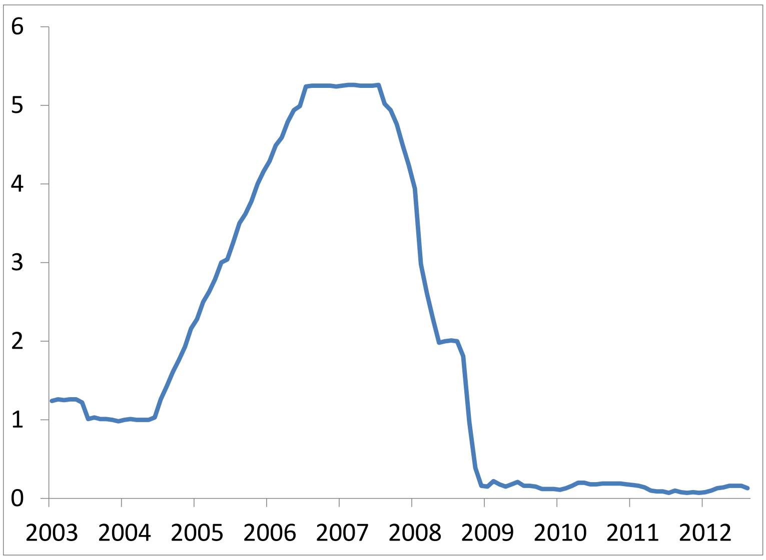
The average includes EM: Argentina, Bulgaria, Brazil, Chile, China, Egypt, Croatia, Indonesia, Lebanon, Mexico, Malaysia, Peru, Philippines, Poland, Russia, Turkey, Ukraine, Venezuela South Africa. AE: Australia, Belgium, Canada, Germany, France, Italy, Japan, Netherlands, Sweden, Singapore, US, Ireland, Portugal, Greece, Spain,Luxembourg, Iceland, Switzerland, Norway, Austria, Denmark, Finland. The bars show the 95% confidence interval.



Some economists would argue that the current economic situation is a recurrence of the previous crisis (2007-2008). Reinhart and Rogoff (2009) write about why such crises can easily reoccur. Their focus is on over-indebtedness, caused by the short term memory of financial agents and regulators. While agreeing with this view, we add that there has to be a triggering factor, which is the inability of economies, especially emerging market countries, to generate fresh or additional resources after a serious liquidity shortage.

There are other explanations. For example Cetorelli and Goldberg (2011) argue that the liquidity crisis was produced by an unexpectedly sustained monetary contraction policy in US, starting at in the second half of 2004 and reaching critically high levels - of the FED rate - during 2007; see figure (4.2), Martinez (2011) and Martinez and Tsomocos (2011) for more details.

Figure 4.2: US Effective Fed Rate (percentage)



The background to this crisis (2010 -), is the 2007-2008 financial crisis, so that in contrast to the former, the economic conditions are weaker, with it the ability of economies to raise funds is more difficult, especially in advanced economies. How can this phenomenon be explained by economic theory? Is there an explanation for the current equilibrium, characterized by a low recovery of key economic variables?

Fisher (1926) finds a positive relation between the use of the factors of production (employment) and inflation. His argument goes like this: there is an increase in the price level, produced by an external source that affects producer revenues. However, it does not affect production costs immediately, given adjustment frictions. It follows that after an inflation shock, the producer has extra revenue, to be spent on more factors of production. That is how unemployment is reduced. This argument is correct if Fisher's assumptions are accepted. But if this is so, then the current stagflation-like phase should not have occurred.

However, if Fisher's assumptions are relaxed, the results are reversed. The source of shocks is key to the analysis. What if we model a monetary (funding) shock instead of a price level one? Given the same general equilibrium setting, with traders allowed to consume and produce at the same time, the simultaneous responses of the demand and supply of commodities can be observed. Martinez and Tsomocos (2011) model can be interpreted as a case of a small open economy, subject to an external funding liquidity shock. Then the shock will affect both the demand and supply of goods. An interesting example - provided by the current work - is where the shock impacts more on production that is the supply of goods as opposed to demand. This relationship will tend to raise prices, rather than lowering them, in the short run.

There are a number of other key elements by which to assess the remaining part of this puzzle, principally on the production side. In this model a production technology is included to simultaneously analyze the effects of funding shocks (among others) on asset prices (credit), inflation, production and employment. The agents are able to trade and produce, using their own labour and capital endowments and so it is possible to construct a GDP variable by adding up investment and consumption.

This work considers restrictions similar to those faced by commodity producing economies in an international context. Thus, oil, copper and other important commodity producing countries would be interested in the outcomes of this type of exercise. However, there are important simplifications of exchange and interest rate parity effects. For details about the international economy, in a general equilibrium setting, in the presence of money and default, see Peiris et al. (2011).

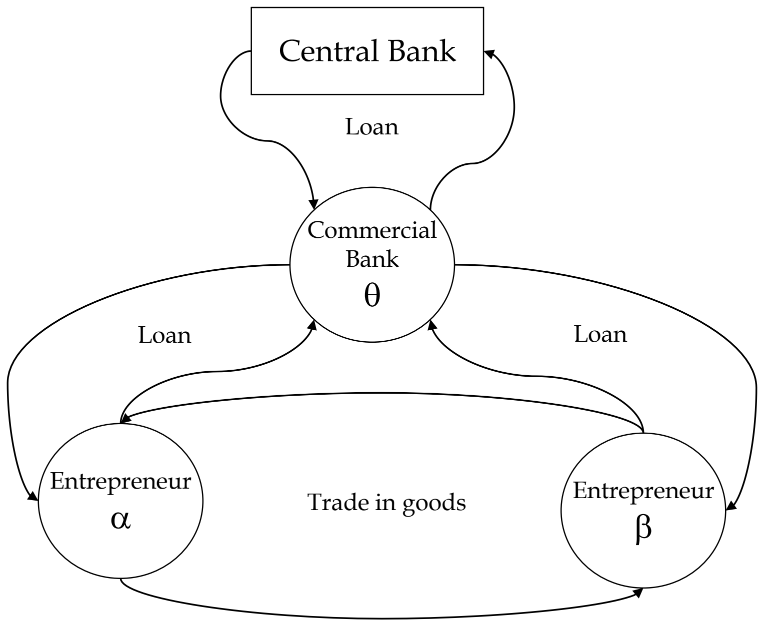
Finally, to reiterate, market and funding liquidity have both been key to the current economic crisis. As funding liquidity became scarce during 2007, stock markets became an alternative source of funding. However, price volatility increased and selling assets became more costly, because of higher premiums. These additional costs imply inefficiency in capital allocation as market and funding liquidity should not be analyzed separately. Consequently, in order to capture these interactions, the Martinez and Tsomocos (2011) assumptions about market liquidity are relaxed, although the external funding liquidity shock (M) will be maintained. Nevertheless, there is allowance for an endogenous relaxation of the budget constraints, by the use of market liquidity. This approach is also intended to contribute to economic theory, such as that in Brunnermeier et al. (2009), but using a general equilibrium framework with money, and default as central elements.

4.3 The Model

This section builds on Espinoza and Tsomocos (2010) and Martinez and Tsomocos (2011) by introducing a simple dynamic stochastic general equilibrium model (DSGE) with endogenous default and production, and which allows for an examination of asset prices and real economy variables, by focusing on the link between asset prices and production. The structure of the agents' interactions are depicted in figure (4.3).

There are infinite *dates* indexed (T=0,1,2,...) and two short-lived (1-period) commodities available at each date. We have three types of *agents*: i) **Entrepreneurs** (α and β) that produce and consume commodities ii) a risk-averse competitive monopolistic **Commercial bank** that provides credit (the only financial asset available) and maximizes profits and iii) a **Central Bank** that acts as a *strategic dummy*. That is, it provides funding liquidity in the interbank market in each period by giving credit to the commercial bank. However, the Central Bank does not optimize any function and can be seen as creating a monetary shock for the other agents. Apart from the Central Bank, agents are allowed to partially default on their obligations, subject to a non-pecuniary penalty proportional to

Figure 4.3: Nominal Flows of the Economy



the defaulted amount.

4.3.1 Entrepreneur $h \in \{\alpha, \beta\}$ optimization problem - Basic Model

Entrepreneurs are endowed with capital and labor at the initial period; they have to decide how much capital and labor to allocate in order to produce more of a commodity. The technology is agent specific; entrepreneurs know how to produce one type of good only. The entrepreneur that receives commodity 1 (e.g. potatoes) as endowment is only able to use labor to 'plant' commodity 1 and produce more of commodity 1; the same occurs with agent β and commodity 2 (e.g. tomatoes). Although entrepreneurs α and β can only produce one good, they are able to trade in order to maximize their utility. Thus, they need to decide how much to purchase and sell at every period.

Both entrepreneurs face cash-in-advance constraints, since the revenues of their sales of commodities are available one period later, but they need to consume within each period and for which they borrow money from the commercial bank. The latter finances itself from money borrowed from the Central Bank, because it also faces cash-in-advance constraints as a consequence of those of the entrepreneurs.

The agents maximize their utilities subject to budget constraints. Their preferences are modeled as separable log-utility functions that (positively) value consumption of both commodity goods and leisure, and negatively the default penalty, (proportional to the defaulted amount).

The budget constraints are organized in terms of their objectives. The first constraint concerns the repayment they make at the beginning of each period (except for the first period). They repay the loans contracted in the previous period with the money received from the sales of commodities (that is one period later than the loan). The second constraint describes the consumption and investment opportunities; the money spent by agents on consumption of the goods (those they do not produce) and investment (valued in terms of their own endowed good[5]) comes from credit they contract to the commercial bank and dividends that come from their ownerships.

To summarize, entrepreneurs α and β need to decide (at time T = 0): 1) How much do they need to borrow from the commercial bank? 2) How much money do they need to they spend in consumption of the good they do not produce? 3) How much to repay on their obligations? 4) How much to sell of their production (the remaining is for their own consumption)? 5) How much of their initial capital endowment to allocate during each period?, and 6) How much of their initial endowment of labor (basically time) to allocate at every period? The complete description of the entrepreneurs' optimization issues are presented below.

$$\max_{\tilde{\mu}_t^h,\tilde{b}_{z,t}^h,\upsilon_t^h,q_{x,t}^h,k_t^h,n_t^h} U^h = E_0 \sum_{t=0}^{\infty} \beta^t \left\{ ln\left(y_{x,t}^h - q_{x,t}^h\right) + ln\left(\frac{\tilde{b}_{z,t}^h}{\tilde{p}_{z,t}}\right) + \psi^h ln\left(N^h - n_t^h\right)\right.$$

[5] Another modeling alternative was examined, which involves subtracting the invested amount from the consumption of good 1 (in the utility function). This modeling choice has an intuitive interpretation: "the agent uses his/her own potatoes to produce more potatoes, so he/she needs to sacrifice its consumption." However, this option provides a highly non-linear set of first-order-conditions equations, which makes the equilibrium unstable.

$$-\frac{\tau_t^h}{\pi_t} Max[0,(1-\upsilon_t^h)\tilde{\mu}_{t-1}^h]\Big\}$$

s.t.

$$\upsilon_t^h \tilde{\mu}_{t-1}^h \leq \tilde{p}_{x,t-1} q_{x,t-1}^h + m^h \qquad \left(\eta_{1,t}^h\right) \tag{4.1}$$

Loan repayment ≤ Previous period sales of commodities + Monetary endowment.

$$\tilde{b}_{z,t}^{\alpha} + i_t^h \tilde{p}_{x,t} \leq \frac{\tilde{\mu}_t^h}{1+r_t^c} + s_\theta^h \frac{\tilde{\Pi}_{t-1}^{\theta}}{\pi_t} \qquad \left(\eta_{2,t}^h\right) \tag{4.2}$$

Money spent in final goods + Money spent in capital goods ≤ Loan taken from the commercial bank + Bank dividends from previous period.

$$i_t^h = k_t^h - (1-\delta)\, k_{t-1}^h \tag{4.3}$$

Law of motion of capital.

$$y_t^h = a_t^h \left(k_t^h\right)^{\phi_h} \cdot (n_t)^{(1-\phi_h)} \tag{4.4}$$

Production technology.

Where:

h	entrepreneur $h \in \{\alpha, \beta\}$.
x	good produced by agent h, $x=1$ for agent α, and $x=2$ for agent β.
z	good purchased by agent h, $z=2$ for agent α, and $z=1$ for agent β.
U^h	overall utility of entrepreneur h.
β^t	stochastic discount factor.
k_t^h	capital acquisition of entrepreneur h.
$p_{k,t}$	price of capital goods.
i_t^h	capital investment of entrepreneur h.
y_t^h	production of entrepreneur h.
a_t^h	total factor productivity of entrepreneur h.
ϕ_h	returns to scale parameter of entrepreneur h.
$q_{x,t}^h$	amount sold of good x.
$b_{z,t}^h$	amount of money spent in good z.
$c_{x,t}^h$	$=\left(y_t^h - q_{x,t}^h\right)$, consumption of good x.
$c_{z,t}^h$	$=\left(\frac{\tilde{b}_{z,t}^h}{\tilde{p}_{z,t}}\right)$, consumption of good z.
$u\left(c_{x,t}^h, c_{z,t}^h\right)$	$=ln\left(c_{x,t}^h\right)+ln\left(c_{z,t}^h\right)$, utility from consumption, absent from penalties.
$u\left(N^h - n_t^h\right)$	$=ln\left(N^h - n_t^h\right)$, utility from leisure, absent from penalties.
μ_t^h	loan amount taken from the commercial bank.
υ_t^h	loan repayment rate.
Π_t^{θ}	Commercial bank profits.
s_θ^h	portion of ownership of bank θ from entrepreneurs h.
τ_t^h	default penalty for entrepreneur h.
r_t^c	commercial bank loans rate.
$\eta_{i,t}^h$	lagrange multiplier for constraint $i \in \{1,2\}$ for entrepreneur h.
ψ^h	parameter of leisure preference.
n_t^h	hours of work.
N^h	labor endowment.
$\sim$	on the top is for real amounts correction (division by P_t or P_{t-1}).

4.3.2 Commercial Bank θ optimization problem

The commercial bank maximizes profits and it is risk averse. In this way the bank aggregates risks but it does more than just transmitting shocks. It can lend as much money as it gets from the authority receiving repayments of interest and initial capital, net of default. The bank must repay at least a portion of what it has borrowed. However, as with the entrepreneur, there is a penalty proportional to the non-repaid amount. The commercial bank optimization problem is presented as follows.

$$\max_{\tilde{\Pi}_t^\theta,\mu_t^\theta,l_t^\theta,\upsilon_t^\theta} U^\theta = E_0 \sum_{t=0}^{\infty} \hat{\beta}^t \left\{ ln\left(\tilde{\Pi}_t^\theta\right) - \frac{\tau_t^\theta}{\pi_t} Max[0,(1-\upsilon_t^\theta)\tilde{\mu}_{t-1}^\theta] \right\}$$

s.t.

$$\tilde{\Pi}_t^\theta = \frac{R_t \tilde{l}_{t-1}^\theta \left(1+r_{t-1}^c\right)}{\pi_t} - \upsilon_t^\theta \frac{\tilde{\mu}_{t-1}^\theta}{\pi_t} \qquad \left(\eta_{1,t}^\theta\right) \tag{4.5}$$

Utility = Expected loan repayment - Repayment to Central Bank.

$$\tilde{l}_t^\theta \leq \frac{\tilde{\mu}_t^\theta}{1+r_t^{IB}} \qquad \left(\eta_{2,t}^\theta\right) \tag{4.6}$$

Credit extension ≤ Loan taken from Central Bank.

Where:

U^θ	overall utility of commercial bank θ.
$\hat{\beta}^t$	stochastic discount factor.
Π_t^θ	profits obtained by the commercial bank θ.
l_t^θ	loan amount given to the entrepreneurs.
μ_t^θ	loan amount taken from the Central Bank.
υ_t^θ	loan repayment rate.
τ_t^θ	default penalty for commercial bank θ.
r_t^{IB}	interbank loans rate, provided by Central Bank.
R_t	expected delivery rate from entrepreneurs loan.
$\eta_{i,t}^\theta$	lagrange multiplier for constraint $i \in \{1,2\}$ for bank θ.
$\sim$	on the top is for real amounts correction (division by p_t or p_{t-1}).

4.3.3 Model Extension - endogenous relaxation of budget constraints for entrepreneur $h \in \{\alpha, \beta\}$

As noted, each entrepreneur (h) decides how much to produce and consume. However, the agents are cash-in-advance constrained and so need credit from the commercial bank. The nature of the cash-in-advance constraints is binary. That is, agents need to wait 1-period to receive the entire amount. Espinoza et al. (2009, 2010) and Martinez and Tsomocos (2011), follow Grandmont and Younes (1972) by relaxing cash-in-advance constraints. This is a crucial feature in general equilibrium models, when money is included.

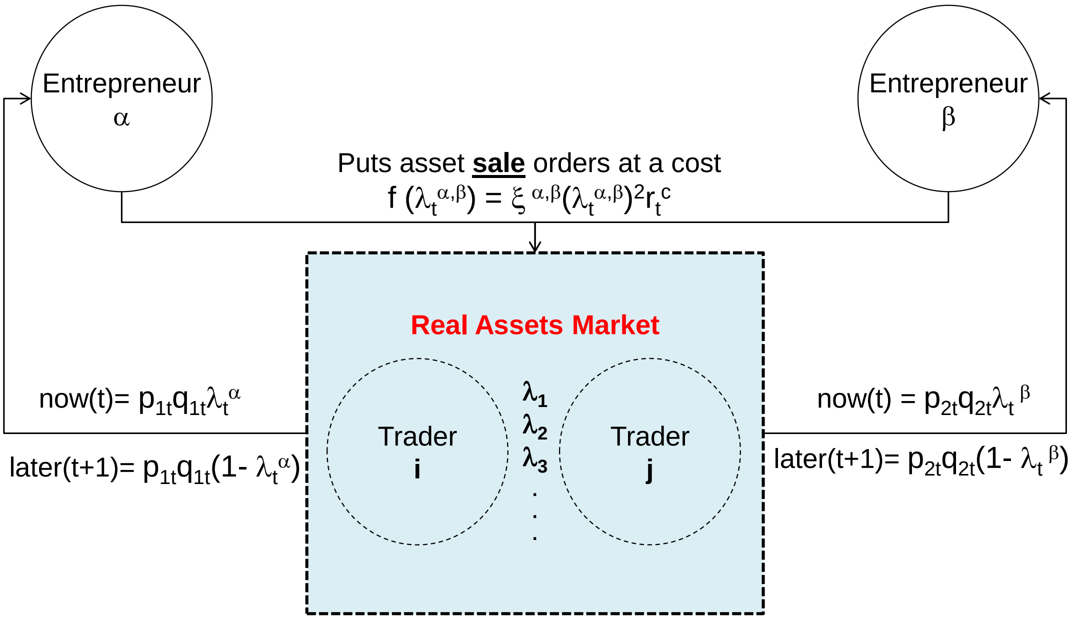
In simple terms, the relaxation in this model is toward an intermediate cash-in-advance constraint, consistent with the proposals made in these two papers. However, in contrast to the existing literature, the present paper proposes a slightly different technology; instead of imposing an exogenous coefficient that establishes the portion of the revenues that is immediately available, relaxation is modeled as an endogenous liquidity function of the markets in which the agents trade.

Let us suppose that instead of trading goods directly, every transaction between entrepreneurs is done by exchanging real assets in some virtual assets market. The real assets give the right to the entrepreneurs to consume immediately equivalent units of commodities. In our reduced form model, for simplicity and without loss of generality, the agents contact an - another virtual and not modeled - dealer that charges them for deciding where to sell his/her commodity. If the agents want to sell in a more liquid asset market (i.e. that allows them to get more resources immediately), they are charged proportionately to the amount they want to get immediately, but also for the fact that they avoid the credit market. Thus, the charge is proportional (linear) to interest rates and (quadratic) to liquidity.[6]

[6] Note that this is a deadweight cost for the agents ($LiqCost_t^h$); and although there is not a specific agent receiving its revenues, it is compensated with private monetary endowments: outside money. Thus, the system gets balanced in terms of monetary flows.

The liquid portion of resources obtained through this operation can be used to both consume and to invest and is interpreted as a *market* type of liquidity. The methodology for modeling market liquidity is depicted in figure (4.4).

Figure 4.4: Liquidity modelling approach



NOTE: the agents also **buy** assets (with cash and credit), that give them the right to consume equivalent units of commodities (the ones they do not produce).

Once this modeling technology has been implemented, the problem for agents α and β is changed slightly, by transforming equations (4.1) and (4.2), into (4.7) and (4.8). Furthermore, the entrepreneurs incorporate λ_t^h (i.e. the liquidity of the market in which they want to trade, or the portion of sales that would be immediately available to consume) as a decision variable into their optimization problems.

$$\upsilon_t^h \tilde{\mu}_{t-1}^h \leq \tilde{p}_{x,t-1} q_{x,t-1}^h \cdot \left(1-\lambda_{t-1}^h\right) + m^h \qquad \left(\eta_{1,t}^h\right) \qquad (4.7)$$

Loan repayment $\leq$ Previous period illiquid sales of commodities + Monetary endowment.

$$\tilde{b}^{\alpha}_{z,t} + i^h_t \tilde{p}_{x,t} \leq \frac{\tilde{\mu}^h_t}{1+r^c_t} + \lambda^h_t \cdot \tilde{p}_{x,t} q^h_{x,t} - \zeta^h {\lambda^h_t}^2 r^c_t + s^h_\theta \frac{\tilde{\Pi}^\theta_{t-1}}{\pi_t} \qquad \left(\eta^h_{2,t}\right) \tag{4.8}$$

Money spent in final goods + Valuation of investment ≤ Loan taken from the commercial bank + Liquid portion of commodity sales - cost of market liquidity + Bank dividends from previous period.

Where:

λ^h_t	liquid portion of goods for entrepreneur *h*.
ζ^h	cost of liquidity market parameter.

4.3.4 Timing of the model

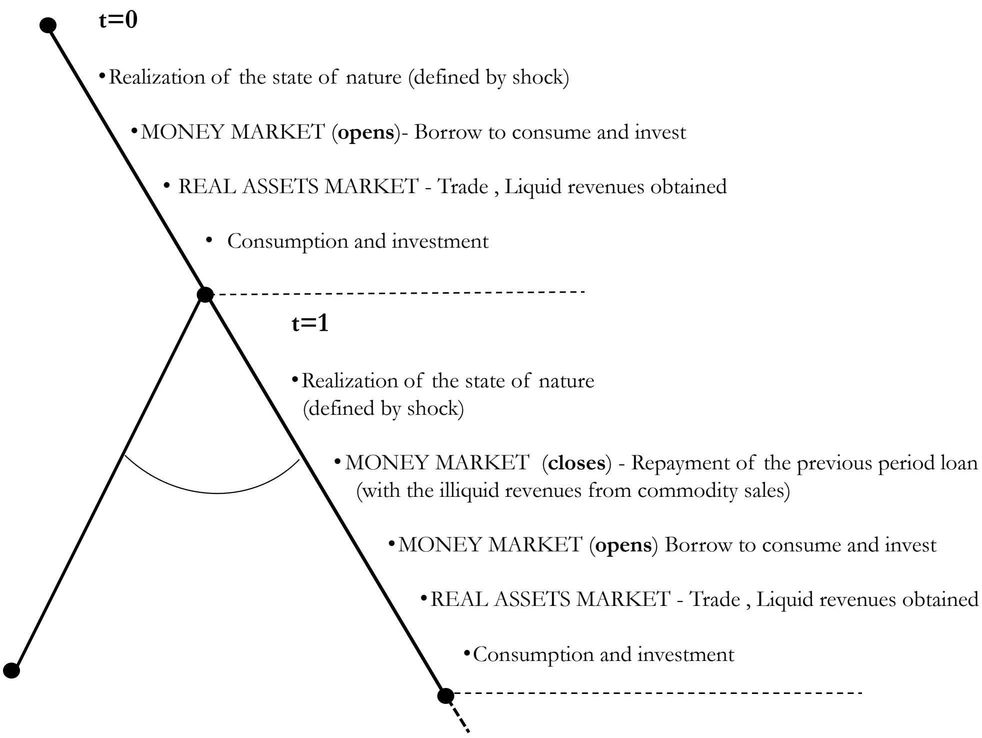
The timing of transactions in this model is described in figure (4.5). After the open market operation (OMO) is performed money flows go to the commercial bank that provides loans to entrepreneurs. Using those loans and the liquid portion of revenues, entrepreneurs can finance consumption and investment. After money is used to finance goods purchases, if there is default then sales revenues are returned to the commercial bank. The bank then returns loans obtained in the form of an OMO, net of default, and provides dividends to entrepreneurs.

The monetary flows between the entrepreneurs and the commercial bank are depicted in table (4.1).

Table 4.1: Monetary flows

Money inflow		Money Outflow	
Commercial Bank	**Entrepreneurs**	**Commercial Bank**	**Entrepreneurs**
Loan taken from Central Bank	Loan taken from Commercial bank	Loan given to the entrepreneurs	Consumption and Investment
Repayment from entrepreneurs	Revenues from sales of commodities	Repayment to Central Bank	Repayment to Commercial bank
	Profits	Dividends from the bank	Dividends distribution to entrepreneurs

Figure 4.5: Timing of events



4.3.5 Market Clearing Conditions

The economy implied by this model contains three different markets: goods, consumer loans and REPO[7]. These markets determine its prices by equating demand and supply.

4.3.5.1 Goods Market

The (fiat) money spent in goods market is equal to the value of the supply of goods 1 and 2 at every period.

$$\tilde{b}^{\beta}_{1,t} = \tilde{p}_{1,t} q^{\alpha}_{1,t} \tag{4.9}$$

$$\tilde{b}^{\alpha}_{2,t} = \tilde{p}_{2,t} q^{\beta}_{2,t} \tag{4.10}$$

[7]Commercial bank repurchase agreements with the Central Bank.

4.3.5.2 Consumer Loans Market

The entrepreneur loans demand equals the supply of funds offered by the commercial bank at every period.

$$1+r_t^c = \frac{\tilde{\mu}_t^{\alpha}+\tilde{\mu}_t^{\beta}}{\tilde{l}_t^{\theta}} \tag{4.11}$$

4.3.5.3 REPO Market

The demand for commercial bank loans equals the supply of funds offered by the Central Bank at every period.

$$1+r_t^{IB} = \frac{\tilde{\mu}_t^{\theta}}{M_t} \tag{4.12}$$

4.3.6 Rational Expectations

The following condition shows that the commercial banks are accurate in their expectations about repayments that it receives from loans. Therefore the expected repayment rate for bank θ is given by the following expression;

$$R_t^C \begin{cases} \frac{\upsilon_t^{\alpha}\tilde{\mu}_{t-1}^{\alpha}+\upsilon_t^{\beta}\tilde{\mu}_{t-1}^{\beta}}{\tilde{\mu}_{t-1}^{\alpha}+\tilde{\mu}_{t-1}^{\beta}}, & \text{if } \tilde{\mu}_{t-1}^{\alpha}+\tilde{\mu}_{t-1}^{\beta}>0; \\ \text{arbitrary}, & \text{if } \tilde{\mu}_{t-1}^{\alpha}+\tilde{\mu}_{t-1}^{\beta}=0. \end{cases} \tag{4.13}$$

4.3.7 Financial frictions

The financial frictions for this analysis are default, liquidity, money, aggregate uncertainty and agent heterogeneity.

4.3.7.1 Default

Default is considered here as a strategic decision. Therefore, default is present in equilibrium. As in Martinez and Tsomocos (2011), default is modeled with continuous default penalties (following Shubik (1977), and Dubey, Geanakoplos and Shubik (2005)), generating a punishment on that proportion of the unfulfilled obligation. The default penalties for the agents in the economy are subject to regulatory changes, which are equivalent to shocks.

$$\ln(\tau_t^H) = \rho^H \ln(\bar{\tau}^H) + (1-\rho^H)\ln(\tau_{t-1}^H) + \varepsilon_{H,t}^{\tau} \tag{4.14}$$

Where τ_t^H is the default penalty for agent $H \in \{\alpha, \beta, \theta\}$.

Tighter regulation is considered to be a shock event, which decreases over time. Examples of this type of regulation can be found in the public listing of defaulting agents in times of financial fragility. The effect of this type of regulation is captured by a loss of utility that decreases over time, to the point they are unlisted.[8]

4.3.7.2 Liquidity

Our liquidity modeling technique follows that of Espinoza et al (2009), Espinoza and Tsomocos (2010) and Martinez and Tsomocos (2011). Funding liquidity is defined as the exogenous aggregate monetary base (supply). Market liquidity is proxied by the liquidity of traded goods, as an approximation of the speed by which a real asset can be exchanged.

In this paper, liquidity (market and funding) takes place using cash-in-advance constraints, as introduced in Clower (1967) and Svensson (1985). The intuition for these constraints is the need to use a means of payment in financial transactions. Following Goodhart et al. (2011), in a world without default, the use of IOU notes would be irrelevant; therefore, liquidity, money and default must be intrinsically related. It should be pointed out that in a frictionless world we would be in an Arrow-Debreu type of economy, fulfilling both welfare theorems. Thus, an interesting case to be analyzed is that with a liquidity friction, where liquidity and default interaction can be observed and financial stability assessed.[9]

[8]Cases of this type of registry can be found in Chilean financial regulation and supervision system. The list is privately managed and it is named DICOM (Commercial Directory), managed by Equifax.

[9]Following Goodhart et al. (2006), financial stability can be measured by probabilities of the private sector default and banking profits. In this paper we concentrate on the former, proxied by repayment rates

The possibility of an agent's default on the contractual obligations calls attention to the requirement for cash-in-advance constraints. The interplay of liquidity and default justifies fiat money as a stipulated mean of exchange. Otherwise, the mere presence of a monetary sector without any possibility of endogenous default or any other friction in equilibrium would become a veil, leaving real trade unaffected and eventually final equilibrium allocations. Indeed, cash-in-advance constraints are the minimal institutional arrangement to capture a key aspect of liquidity and how it interacts with default to modify the real economy.

The role of liquidity for financial stability is crucial, with important implications for the real economy. Liquidity cannot be disentangled from default, since in the presence of the latter, monetary policy (funding liquidity) will influence total output, affecting credit conditions too. The rationale for this argument appears in Lin et al. (2010). The authors show that lack of liquidity, as a consequence of increased default, impacts on productivity. In this case the capital reallocation becomes the source of inefficiency.

The lack of collateral for backing money payments and the exogenously given supply of money are potentially the most relevant disadvantages. Nevertheless, the most important advantage, noted, for example, in Espinoza et al. (2009), is that cash-in-advance constraints permit financial and money markets to be incorporated contemporaneously, even in a 2-period type model.

Market liquidity is incorporated in Martinez and Tsomocos (2011) as an exogenous parameter that relaxes the cash-in-advance constraint. The parameter defines the portion of commodity goods that can be turned into cash and sold in every period. The usual cash-in-advance constraint assigns a value of zero to this parameter, so that no commodity can be used as a direct and immediate means of exchange. The rationale for this type of relaxation is to be found in Grandmont et al. (1972). The authors generalize the cash-in-advance approach and they argue that the velocity parameter could be modified by taking trading speed, or to use their term, “viscosity", into account. Their analysis, has a significant role for money with non-trivial implications for Fisher’s quantity theory of money proposition. However, the authors state that their modeling technique should be improved.

In contrast to Martinez and Tsomocos (2011) and other related literature, market liquidity is endogenously determined in the present work. The main assumption is that agents can decide in which market they want to trade their production. However, as Jones (2002), Butler et. al (2006) and Hölmstrom and Tirole (1993) suggest, trading in a liquid market bears a cost. In this paper, it is assumed that there is a quadratic cost for liquidity. Market liquidity is a credit alternative to finance production, while the cost of market liquidity is directly proportional to the commercial bank interest rate.

Initially, agents are inter-temporally financially constrained, and are subject to the usual cash-in-advance friction. If the quantity of commodity consumed is agreed by an instantaneous contract[10] (e.g., a real-time type of forward contract) that gives the owner the right of claiming and consuming units of commodity without delay, then commodity markets could be interpreted as a real asset market. This type of interpretation and modeling technique appears in various innovative papers, for example that of Lagos and Rocheteau (2009). If entrepreneurs trade real assets in different markets then they should bear a different cost. Thus market liquidity can be endogenized and consequently allow for the budget constraint relaxation.

As mentioned above, the present paper provides a micro-foundation and financial interpretation for the market liquidity parameter. First, the rough interpretation found in Martinez and Tsomocos (2011) (with the same idea also in Grandmont et al. (1972)) is refined. Second, by developing an alternative method for the micro level discovery of funding liquidity there is a close association with the market and funding liquidity literature.

[10]For the sake of simplicity, a lagged contract would work for modeling choice also.

4.3.7.3 Inside and outside Money

Following Lagos (2006), *inside money* is an asset backed by any form of private credit that circulates as a medium of exchange. *Outside money* is either of a fiat nature or backed by some asset that is not in zero net supply within the private sector. Thus, there can be fiscal transfers, as in Dubey and Geanakoplos (2006), but which are not modeled here.

Inside money is modeled as the interventions of the Central Bank in the interbank lending market. In this simple case it only represents the intra-temporal lending that the Central Bank makes to the banking sector. These liquidity injections must exit the system (with accrued interest and net of default) when borrowing commercial banks repay their obligations. Inside money level is modeled as changes to the steady state level of open market operations (OMOs), as in (4.15).

$$M_t = \eta_t^{CB}\bar{M} \tag{4.15}$$

Where:

$$\ln(\eta_t^{CB}) = \rho^{CB}\ln(\bar{\eta}^{CB}) + (1-\rho^{CB})\ln(\eta_{t-1}^{CB}) + \varepsilon_{CB,t} \tag{4.16}$$

and $\bar{\eta}^{CB} = 1$, is the growth of gross monetary operations at the same rate as that of the steady state economy. Outside money in this framework is modeled exactly as in Dubey and Tsomocos (2003) and Geanakoplos (2006).

4.3.8 Production

The model includes a production technology for agents $h \in \{\alpha, \beta\}$. As entrepreneurs only produce one type of good, they must trade to maximize their utility. The production technology is assumed to be a Cobb-Douglas type and linear for exogenous total factor productivity. Productivity is subject to shocks defined in (4.17). Recall there are only two factors available: own labour and capital (that comes from the commodity endowments).

$$\ln(a_t^h) = \rho_a^h \ln(\bar{a}^h) + (1-\rho_a^h)\ln(a_{t-1}^h) + \varepsilon_{a,t}^h \quad \text{for } h \in \{\alpha, \beta\} \tag{4.17}$$

The introduction of production requires a law of motion for capital and allows defining GDP (see the expression in (4.18)). Note that this definition aggregates the investment and consumption of both agents. Thus the resulting GDP - a cumulative indicator of economic performance - allows this model to be interpreted in a national and international economy setting.

$$GDP_t = \tilde{b}_{2,t}^{\alpha} + \tilde{b}_{1,t}^{\beta} + \tilde{i}_t^{\alpha} p_{1,t} + \tilde{i}_t^{\beta} p_{2,t} \tag{4.18}$$

Where $\tilde{p_{1,t}}$ and $\tilde{p_{2,t}}$ are the normalized (by inflation) commodity prices; $q_{1,t}^{\alpha}$ and $q_{2,t}^{\beta}$ are the quantities sold by α and β; $y_{1,t}^{\alpha}$ and $y_{2,t}^{\beta}$ are the quantities produced by α and β; $\tilde{b}_{2,t}^{\alpha}$ and $\tilde{b}_{1,t}^{\beta}$ are the money spending in commodities and $\tilde{i}_t^{\alpha} p_{1,t}$ + $\tilde{i}_t^{\beta} p_{2,t}$, are the investment amounts by α and β.

4.3.9 Inflation

The model uses the inflation index developed by Martinez and Tsomocos (2011). The gross rate of inflation obeys equation (4.19).

$$\pi_t = \frac{P_t}{P_{t-1}} \tag{4.19}$$

The definition of inflation uses a Laspeyres price index, with a convenient set of weights:

$$\pi = (1+\hat{\pi}_t) = \frac{p_{1,t}\bar{q}_1^{\alpha} + p_{2,t}\bar{q}_2^{\beta}}{p_{1,t-1}\bar{q}_1^{\alpha} + p_{2,t-1}\bar{q}_2^{\beta}} \tag{4.20}$$

Where $\bar{q}_1^{\alpha}$ and $\bar{q}_2^{\beta}$, are the quantities traded in steady state (the basis); and π is the gross inflation index, whereas $\hat{\pi}$, is the net inflation growth.

4.4 Equilibrium

This section presents the equilibrium of the model and depends on the definitions of: decision variables, macroeconomic variables, parameters and budget sets. The endogenous variables and those variables, which are subject to shocks, are defined to keep track of the simulation procedures performed later.

4.4.1 Decision Variables

$$\Sigma^{\alpha} = \left\{\tilde{\mu}_t^{\alpha}, \tilde{b}_{2,t}^{\alpha}, \upsilon_t^{\alpha}, q_{1,t}^{\alpha}, k_t^{\alpha}, \lambda_t^{\alpha}\right\}_{t=0}^{\infty}$$

$$\Sigma^{\beta} = \left\{\tilde{\mu}_t^{\beta}, \tilde{b}_{1,t}^{\beta}, \upsilon_t^{\beta}, q_{2,t}^{\beta}, k_t^{\beta}, \lambda_t^{\beta}\right\}_{t=0}^{\infty}$$

$$\Sigma^{\theta} = \left\{\tilde{\Pi}_t^{\theta}, \tilde{\mu}_t^{\theta}, \tilde{l}_t^{\theta}, \upsilon_t^{\theta}\right\}_{t=0}^{\infty}$$

4.4.2 Macroeconomic variables

$$\zeta = \left\{M_t, \pi_t, r_t^c, r_t^{IB}, R_t, \tau_t^{\alpha}, \tau_t^{\beta}, \tau_t^{\theta}\right\}_{t=0}^{\infty}$$

4.4.3 Parameters

$$\kappa = \left(\bar{\eta}^{CB}, \bar{\tau}^{\alpha}, \bar{\tau}^{\beta}, \bar{\tau}^{\theta}, \bar{a}^{\alpha}, \bar{a}^{\beta}, \beta^{CB}, \hat{\beta}^{CB}, \rho^{CB}, \rho_e^{\alpha}, \rho_e^{\beta}, \rho^{\alpha}, \rho^{\beta}, \rho^{\theta}, \bar{M}, \delta, s_{\theta}^{\alpha}, s_{\theta}^{\beta}, m^{\alpha}, m^{\beta}, \phi_{\alpha}, \phi_{\beta}, N^{\alpha}, N^{\beta}\right)$$

4.4.4 Budget sets

$$B^h(\kappa) = \left\{\Sigma^h : (4.1) - (4.2) \text{ hold}\right\}$$
$$B^{\theta}(\kappa) = \left\{\Sigma^{\theta} : (4.5) - (4.6) \text{ hold}\right\}$$

4.4.5 Endogenous Variables

$$\chi = \left\{\tilde{p}_{1,t}, \tilde{p}_{2,t}, \pi_t, r_t^c, r_t^{IB}, R_t, \tilde{\mu}_t^{\alpha}, \tilde{b}_{2,t}^{\alpha}, \upsilon_t^{\alpha}, q_{1,t}^{\alpha}, \eta_{1,t}^{\alpha}, \eta_{2,t}^{\alpha}, k_t^{\alpha}, i_t^{\alpha}, y_t^{\alpha}, \lambda_t^{\alpha}, n_t^{\alpha}, \tilde{\mu}_t^{\beta}, \tilde{b}_{1,t}^{\beta}, \upsilon_t^{\beta}, q_{2,t}^{\beta}, \eta_{1,t}^{\beta}, \eta_{2,t}^{\beta}, k_t^{\beta}, i_t^{\beta}, i_t^{\beta}, y_t^{\beta}, \lambda_t^{\beta}, n_t^{\beta}, \tilde{\Pi}_t^{\theta}, \tilde{\mu}_t^{\theta}, \tilde{l}_t^{\theta}, \upsilon_t^{\theta}, \eta_{1,t}^{\theta}, \eta_{2,t}^{\theta}, GDP_t\right\}_{t=0}^{\infty}$$

4.4.6 Variables being shocked

$$\varphi = \left\{ M_t, a_t^{\alpha}, a_t^{\beta}, \tau_t^{\alpha}, \tau_t^{\beta}, \tau_t^{\theta} \right\}_{t=0}^{\infty}$$

4.4.7 Definition of Equilibrium

These model elements allow the definition of ELDP (equilibrium with liquidity, default and production), for both the short and long run. In this model, the economy converges to its steady state in the long run.

4.4.7.1 Short run

In our model, $(\Sigma^{\alpha}, \Sigma^{\beta}, \Sigma^{\theta}, \zeta)$ is a short run **ELDP** iff:

(i) All agents optimize given their budget sets:

(a) $\Sigma^h \in \text{Argmax}_{\Sigma^h \in B^h(\phi)} U\left(C^h\right)$, for h $\in \{\alpha, \beta\}$ and $\forall t \in T$.

(b) $\Sigma^{\theta} \in \text{Argmax}_{\Sigma^{\theta} \in B^{\theta}(\phi)} U\left(\Pi^{\theta}\right)$, $\forall t \in T$.

(ii) All markets (4.9)-(4.12) clear.

(iii) Expectations are rational, (i.e. (4.13) holds).

4.4.7.2 Long run

In this model, at a steady state, in addition to the conditions for short run equilibrium, a long run **ELDP** requires that;

(i) All real and nominal variables do not grow, thus

$$x_t = x, \quad \forall\, t \,\in\, T \quad x_t \,\in X_t = \left\{\Sigma^{\alpha}, \Sigma^{\beta}, \Sigma^{\theta}, \phi\right\}$$

Where Σ^H are the decision variables and ϕ are the parameters.

(ii) The economy is not subject to any shock, thus

$$e_t = 0, \quad \forall\, t \,\in\, T \quad e_t \in \left\{\varepsilon_{CB,t}, \varepsilon_{a,t}^{\alpha}, \varepsilon_{a,t}^{\beta}, \varepsilon_{\alpha,t}^{\tau}, \varepsilon_{\beta,t}^{\tau}, \varepsilon_{\theta,t}^{\tau}\right\}$$

That is, there are no shocks on monetary base, endowment or default penalties.

4.4.8 Characterization of Equilibrium

In this subsection are described the results obtained from the FOCs (i.e. First Order Conditions). This provides insights about important trade-offs that are present in this model: on-the-verge conditions, and market liquidity vs credit.

4.4.8.1 Proposition 1: On the verge condition 1

Suppose that for $\alpha, \beta \in H$, $b_t^h > 0$, for commodities x and $z \in \{1,2\}$, $\lambda_t^h \in [0,1)$ and some state of nature defined by the set of shocks at t. We have that at a **ELDP**, the on-the-verge condition for default penalties, for agents α, β and bank θ, respectively, is given by

$$\frac{1}{1+r_t^c}\frac{\partial u\left(c_{1,t}^{\alpha}, c_{2,t}^{\alpha}\right)}{\partial c_{2,t}^{\alpha}}\frac{1}{\tilde{p}_{2,t}} = \beta\mathbb{E}_t\left(\frac{\tau_{t+1}^{\alpha}}{\pi_{t+1}}\right) \tag{4.21}$$

$$\frac{1}{1+r_t^c}\frac{\partial u\left(c_{1,t}^{\beta}, c_{2,t}^{\beta}\right)}{\partial c_{1,t}^{\beta}}\frac{1}{\tilde{p}_{1,t}} = \beta\mathbb{E}_t\left(\frac{\tau_{t+1}^{\beta}}{\pi_{t+1}}\right) \tag{4.22}$$

$$\frac{\partial u\left(\Pi_t^{\theta}\right)}{\partial \Pi_t^{\theta}} = \tau_t^{\theta} \tag{4.23}$$

Whereas, in the steady state the optimal default penalties, for agents α, β and bank θ, in **ELPD** will be determined as follows,

$$\frac{1}{1+\bar{r}^c}\frac{\partial u\left(c_1^{\alpha}, c_2^{\alpha}\right)}{\partial c_2^{\alpha}}\frac{1}{\bar{\tilde{p}}_2} = \beta\left(\frac{\bar{\tau}^{\alpha}}{\bar{\pi}}\right) \tag{4.24}$$

$$\frac{1}{1+\bar{r}^c}\frac{\partial u\left(c_1^{\beta}, c_2^{\beta}\right)}{\partial c_1^{\beta}}\frac{1}{\bar{\tilde{p}}_1} = \beta\left(\frac{\bar{\tau}^{\beta}}{\bar{\pi}}\right) \tag{4.25}$$

$$\frac{\partial u\left(\bar{\Pi}^{\theta}\right)}{\partial \bar{\Pi}^{\theta}} = \tau^{\theta} \tag{4.26}$$

These conditions imply that the optimal amount of default is defined when the marginal utility of defaulting equals the marginal dis-utility from incurring in default.

There are three cases to analyze for agents α, β and bank θ (in this case $\hat{h} \in \hat{H} = \{\alpha, \beta, \theta\}$).

i. $u^{\hat{h}\prime}(\cdot) > \tau^{\hat{h}}$. This condition implies that the agent $\hat{h} \in \hat{H}$ will default completely. Consequently, the asset will not be traded.

ii. $u^{\hat{h}\prime}(\cdot) \ll \tau^{\hat{h}} \left(\text{i.e. } \tau^{\hat{h}} \rightarrow \infty \right)$. This condition implies that buyers will anticipate full delivery, but sellers of the asset (i.e. borrowers) will realize that with some probability they will not be able to avoid a crushing penalty. Consequently, the asset will not be traded.

iii. $u^{\hat{h}\prime}(\cdot) = \tau^{\hat{h}}$. An intermediate level of default penalties can make everyone better-off. This condition implies that there is trading in assets.

These results are obtained from combining the FOCs in (4.39) to (4.41), for agent α. The result is found analogously for β and θ $\square$.

4.4.8.2 Proposition 2: On the verge condition 2

Suppose that for $\alpha, \beta \in H$, $b_t^h > 0$, for commodities x and z, $\lambda_t^h \in [0,1)$ and some state of nature defined by the set of shocks at t. We have that at a **ELDP**, the on-the-verge condition (2) for default penalties, for agents α, β, respectively, is given by

$$\frac{\partial u\left(c_{1,t}^{\alpha}, c_{2,t}^{\alpha}\right)}{\partial c_{1,t}^{\alpha}} \frac{\partial c_{1,t}^{\alpha}}{\partial q_{1,t}^{\alpha}} - \frac{\partial u\left(c_{1,t}^{\alpha}, c_{2,t}^{\alpha}\right)}{\partial c_{2,t}^{\alpha}} \frac{\partial c_{2,t}^{\alpha}}{\partial b_{2,t}^{\alpha}} = \beta \mathbb{E}_t \left(\frac{\tau_{t+1}^{\alpha}}{\pi_{t+1}} \cdot \tilde{p_{1,t}} \left(1 - \lambda_t^{\alpha}\right) \right) \tag{4.27}$$

$$\frac{\partial u\left(c_{1,t}^{\beta}, c_{2,t}^{\beta}\right)}{\partial c_{2,t}^{\beta}} \frac{\partial c_{2,t}^{\beta}}{\partial q_{2,t}^{\beta}} - \frac{\partial u\left(c_{1,t}^{\beta}, c_{2,t}^{\beta}\right)}{\partial c_{1,t}^{\beta}} \frac{\partial c_{1,t}^{\beta}}{\partial b_{1,t}^{\beta}} = \beta \mathbb{E}_t \left(\frac{\tau_{t+1}^{\beta}}{\pi_{t+1}} \cdot \tilde{p_{1,t}} \left(1 - \lambda_t^{\beta}\right) \right) \tag{4.28}$$

These results are obtained from combining the FOCs in (4.40) to (4.42), for agent α. The result is found analogously for β $\square$.

This condition indicates that that there is a trade-off between net trade and default. Agents will default until the marginal utility of net trade (sales - purchases) equates the marginal dis-utility from defaulting. Note that this condition applies to the non liquid portion of sales. If we further work on this expression, and use the first order conditions on (4.39) to (4.41), we obtain a simplified version of this proposition, that allows us to concentrate on the trade-off between sales and purchases.

$$\frac{\partial u\left(c^{\alpha}_{1,t}, c^{\alpha}_{2,t}\right)}{\partial c^{\alpha}_{1,t}} \frac{\partial c^{\alpha}_{1,t}}{\partial q^{\alpha}_{1,t}} = \frac{\partial u\left(c^{\alpha}_{1,t}, c^{\alpha}_{2,t}\right)}{\partial c^{\alpha}_{2,t}} \frac{\partial c^{\alpha}_{2,t}}{\partial b^{\alpha}_{2,t}} \left(1 + \frac{\tilde{p_{1,t}}\,(1-\lambda^{\alpha}_{t})}{1+r^{c}_{t}}\right) \tag{4.29}$$

$$\frac{\partial u\left(c^{\beta}_{1,t}, c^{\beta}_{2,t}\right)}{\partial c^{\beta}_{2,t}} \frac{\partial c^{\beta}_{2,t}}{\partial q^{\beta}_{2,t}} = \frac{\partial u\left(c^{\beta}_{1,t}, c^{\beta}_{2,t}\right)}{\partial c^{\beta}_{1,t}} \frac{\partial c^{\beta}_{1,t}}{\partial b^{\beta}_{1,t}} \left(1 + \frac{\tilde{p_{2,t}}\left(1-\lambda^{\beta}_{t}\right)}{1+r^{c}_{t}}\right) \tag{4.30}$$

In the expressions above we can disentangle the trade-off within net trade. In equilibrium, the marginal (dis)utility of sales (i.e. the amount that the agents lose if they sell an additional unit) should be equal to the marginal utility from purchases (consumption) times the premium from credit financing. That is, what agents lose by selling an additional unit of production should be compensated by the utility they get from consumption, weighted by the cost of credit financing.

4.4.8.3 Proposition 3: On the verge condition 3

Suppose that for $\alpha, \beta \in H$, $b^{h}_{t} > 0$, for commodities x and z, $\lambda^{h}_{t} \in [0,1)$ and some state of nature defined by the set of shocks at t. We have that at a **ELDP**, the on the verge condition (3), for agents α and β, respectively, is given by

$$\frac{\partial u\left(c^{\alpha}_{1,t}, c^{\alpha}_{2,t}\right)}{\partial c^{\alpha}_{2,t}} \frac{\partial c^{\alpha}_{2,t}}{\partial b^{\alpha}_{2,t}} - \frac{\partial\,(LiqCost)^{\alpha}_{t}}{\partial \lambda^{\alpha}_{t}} \frac{1}{\tilde{p}_{1,t} q^{\alpha}_{1,t}} = \beta \mathbb{E}_{t}\left(\frac{\tau^{\alpha}_{t+1}}{\pi_{t+1}}\right) \tag{4.31}$$

$$\frac{\partial u\left(c^{\beta}_{1,t}, c^{\beta}_{2,t}\right)}{\partial c^{\beta}_{1,t}} \frac{\partial c^{\beta}_{1,t}}{\partial b^{\beta}_{1,t}} - \frac{\partial\,(LiqCost)^{\beta}_{t}}{\partial \lambda^{\beta}_{t}} \frac{1}{\tilde{p}_{2,t} q^{\beta}_{2,t}} = \beta \mathbb{E}_{t}\left(\frac{\tau^{\beta}_{t+1}}{\pi_{t+1}}\right) \tag{4.32}$$

These results are obtained from combining the FOCs in (4.40), (4.41) and (4.47), for agent α. The result is found analogously for β □.

This condition indicates that agents will default until the marginal dis-utility from default equates the utility obtained from consumption of the purchased good, net from the marginal cost of market liquidity (per-unit). If we incorporate first order condition

(4.39) to (4.41), we obtain a simplification that allows us to analyze the trade-off between liquidity cost and purchases.

$$\frac{\partial u\left(c_{1,t}^{\alpha}, c_{2,t}^{\alpha}\right)}{\partial c_{2,t}^{\alpha}} \frac{\partial c_{2,t}^{\alpha}}{\partial b_{2,t}^{\alpha}} \left(1 - \frac{\beta}{1+r_t^c}\right) = \frac{\partial \left(LiqCost\right)_t^{\alpha}}{\partial \lambda_t^{\alpha}} \frac{1}{\tilde{p}_{1,t} q_{1,t}^{\alpha}} \tag{4.33}$$

$$\frac{\partial u\left(c_{1,t}^{\beta}, c_{2,t}^{\beta}\right)}{\partial c_{1,t}^{\beta}} \frac{\partial c_{1,t}^{\beta}}{\partial b_{1,t}^{\beta}} \left(1 - \frac{\beta}{1+r_t^c}\right) = \frac{\partial \left(LiqCost\right)_t^{\beta}}{\partial \lambda_t^{\beta}} \frac{1}{\tilde{p}_{2,t} q_{2,t}^{\beta}} \tag{4.34}$$

From the expression above we can infer that in equilibrium, the marginal utility derived from liquidity-financed consumption equals the marginal cost of liquidity.

4.4.8.4 Proposition 4: Optimal investment and consumption

Suppose that for $\alpha, \beta \in H$, $b_t^h > 0$, for commodities x and z, $\lambda_t^h \in [0,1)$ and some state of nature defined by the set of shocks at t. We have that at a **ELDP**, the optimal investment and consumption condition, for agents α and β, respectively, is given by

$$\frac{\partial u\left(c_{1,t}^{\alpha}, c_{2,t}^{\alpha}\right)}{\partial k_t^{\alpha}} = \beta(1-\delta)\mathbb{E}_t \left(\frac{\partial u\left(c_{1,t+1}^{\alpha}, c_{2,t+1}^{\alpha}\right)}{\partial c_{2,t+1}^{\alpha}} \frac{\partial c_{2,t+1}^{\alpha}}{\partial b_{2,t+1}^{\alpha}}\right) p_{1,t+1} - \frac{\partial u\left(c_{1,t}^{\alpha}, c_{2,t}^{\alpha}\right)}{\partial c_{2,t}^{\alpha}} \frac{\partial c_{2,t}^{\alpha}}{\partial b_{2,t}^{\alpha}} p_{1,t} \tag{4.35}$$

$$\frac{\partial u\left(c_{1,t}^{\beta}, c_{2,t}^{\beta}\right)}{\partial k_t^{\beta}} = \beta(1-\delta)\mathbb{E}_t \left(\frac{\partial u\left(c_{1,t+1}^{\beta}, c_{2,t+1}^{\beta}\right)}{\partial c_{1,t+1}^{\beta}} \frac{\partial c_{1,t+1}^{\beta}}{\partial b_{1,t+1}^{\beta}}\right) p_{2,t+1} - \frac{\partial u\left(c_{1,t}^{\beta}, c_{2,t}^{\beta}\right)}{\partial c_{1,t}^{\beta}} \frac{\partial c_{1,t}^{\beta}}{\partial b_{2,t}^{\beta}} p_{2,t} \tag{4.36}$$

These results are obtained from combining the FOCs in (4.41) and (4.43), for agent α. The result is found analogously for β $\square$.

This condition indicates that agents will invest in capital until the marginal utility derived from this decision equates the expected additional utility obtained from purchases of consumption goods.

4.4.8.5 Proposition 5: Optimal capital labor allocation

Suppose that for $\alpha, \beta \in H$, $b_t^h > 0$, for commodities x and z, $\lambda_t^h \in [0,1)$ and some state of nature defined by the set of shocks at t. We have that at a **ELDP**, the optimal capital labor allocation condition, for agents α and β, respectively, is given by

$$\frac{\partial u\left(c_{1,t}^{\alpha}, c_{2,t}^{\alpha}\right)}{\partial k_t^{\alpha}} = \frac{\partial u\left(N^{\alpha} - n_t^{\alpha}\right)}{\partial n_t^{\alpha}} \tag{4.37}$$

$$\frac{\partial u\left(c_{1,t}^{\beta}, c_{2,t}^{\beta}\right)}{\partial k_t^{\beta}} = \frac{\partial u\left(N^{\beta} - n_t^{\beta}\right)}{\partial n_t^{\beta}} \tag{4.38}$$

These results are obtained from using the FOC in (4.47), for agent α. The result is found analogously for β $\square$.

This condition indicates that in equilibrium the agents will decide the optimal allocation of capital and labor when the marginal productivities of these production factors are equal.

4.5 Numerical results

4.5.1 Calibration

The model is calibrated for three distinct cases. The first is base case with a pure cash-in-advance economy; the second describes an extended symmetric cash-in-advance economy, where the cost of raising liquidity is the same for both agents. The third case is that with asymmetric liquidity, where the cost of trading in a liquid market is lower for one of the agents. The objective of this exercise is to provide a policy tool in order to get insights about direction, duration and magnitude of shocks in the real and financial economy rather than to replicate a particular economy or to match any type of observed shock.

The parameters (see table (4.2)) the steady state, with a plausible annual commercial bank interest rate (i.e. 12%) in the basic setting. In the symmetric and asymmetric cases, the interest is lower (3%). The figure used in the symmetric case is the annual commercial interest rate for loans, up to 3 months, and over USD230,000[11].

Table 4.2: Parametrization

Parameter	Base	Symmetric liquidity	Asymmetric liquidity
ζ^{α}	-	0.55	0.55
ζ^{β}	-	0.55	0.30
$\bar{\eta}^{CB}$	1	1	1
$\bar{\tau}^{\alpha}$	1.1	1.1	1.1
$\bar{\tau}^{\beta}$	1.1	1.1	1.1
$\bar{\tau}^{\theta}$	100	100	100
$\bar{a}^{\alpha}$	1.1	1.1	1.1
$\bar{a}^{\beta}$	1.1	1.1	1.1
β^{h}	0.97	0.97	0.97
$\hat{\beta}^{CB}$	0.98	0.98	0.98
ρ^{CB}	0.3	0.3	0.3
ρ_e^{α}	0.3	0.3	0.3
ρ_e^{β}	0.3	0.3	0.3
ρ^{α}	0.3	0.3	0.3
ρ^{β}	0.3	0.3	0.3
ρ^{θ}	0.3	0.3	0.3
$\bar{M}$	1.8	1.8	1.8
δ	0.01	0.01	0.01
s_{θ}^{α}	0.5	0.5	0.5
s_{θ}^{β}	0.5	0.5	0.5
m^{α}	0.05	0.38	0.38
m^{β}	0.05	0.38	0.38
ϕ^{α}	0.8	0.8	0.8
ϕ^{β}	0.8	0.8	0.8
ψ^{α}	1	1	1
ψ^{β}	1	1	1
N^{α}	1	1	1
N^{β}	1	1	1

Default penalties are equal for both entrepreneurs. It should be noted that the commercial bank penalty for default is much higher, in order to align incentives and to obtain a lower interest rate.

As in Martinez and Tsomocos (2011), betas, or time impatience parameters for

[11] Information at www.sbif.cl, the Chilean Banking Supervisor.

entrepreneurs and commercial bank follow the common values in literature. Here, as in practice, banks have a higher value for the impatience parameter (i.e. lower impatience) than households.

To maintain comparable and smooth dynamics the shock parameters are set at 30%. While capital depreciation is set at 1%.

Inside and outside money (i.e. monetary base and monetary endowments) are established to determine interest rates, while the bank profits are equally shared between entrepreneurs.

The proportion of capital to labour is established at the ratio of 80-20% to match that of a commodity producer that relies mostly on capital (e.g. oil or copper). Labour endowment is set to 1% for both entrepreneurs and the labour/leisure trade-off elasticity is 1%, also.

Finally, the liquidity cost parameter (ζ^h) is set to define the level of market liquidity at equilibrium. This parameter determines how much cash is earned immediately from sales; it defines symmetric and asymmetric equilibrium in terms of liquidity.

4.5.2 Steady state

The steady state is obtained by using a standard Newton-Raphson algorithm applied to the set of first order conditions, market clearing and rational expectations equations, as in Martinez and Tsomocos (2011). The steady state solution is to be found in table (4.3).

As described in the calibration section, the commercial bank interest rate is used as a pivot, calibrated for the symmetric liquidity case, and with consequences for the basic and asymmetric cases. The interbank market interest rate (i.e. that charged by the Central Bank) also depends on the cost of raising market liquidity. It is lower than the commercial bank interest rate for all liquidity cases.

Table (4.3) shows the steady state at equilibrium. It is important to note that the base model produces higher interest and default rates at the steady state. Reduced liquidity costs will encourage higher market liquidity. This parameter will also determine the level of interest rates, default, investment, trade, commodity prices and growth. In the asymmetric case, this parameter has a lower value for the good produced by agent β (i.e. good 2). Consequently, the quantity produced of good 2 on offer will be relatively higher, (compared to the quantity of good 1) and its price lower when compared to the symmetric case. The good with lower liquidity cost is subject to greater investment in capital and labour, as the entrepreneur has more cash available to spend.

The marginal utility from default decreases in the asymmetric case, together with the increasing tightness of budget constraints, as measured by the Lagrange multipliers. This is explained by increased trade, resulting in more resources for repayment, so ensuring that the agents do not default. Further, as trade increases in the asymmetric liquidity case, so too does GDP. It can be observed that there is a close relationship between GDP and financial stability - an improvement in stability is accompanied by an increase in growth. The simulation section further develops this point.

The steady state equilibrium is robust since it is calculated in an interior region of the equilibria. Interiority of the maximum implies bounded aggregate profits and consumption. This follows an economically sensible array of parameters that avoid non-convexities or severe non-linearities. The utilities for all the agents are concave and budget sets are convex. Thus, for a given parameterization (that includes a selection of individual and aggregate endowments), an interior solution is guaranteed.

4.5.3 Simulations

This section describes the simulation exercises. The shock transmission mechanism is described in figure (4.6). In this exercise a standard perturbation method is applied[12].

[12] See Marimon (1999) and Schmitt-Grohé(2005), for an excellent review of these methods.

Table 4.3: Steady state

Variable	Base	Symmetric liquidity	Asymmetric liquidity
p_1	0.132	0.123	0.123
p_2	0.132	0.123	0.123
r^c	0.120	0.034	0.033
r^{IB}	0.013	0.010	0.010
R	0.904	0.977	0.978
μ^α	1.008	0.931	0.953
b_2^α	0.862	0.933	0.934
υ^α	0.904	0.977	0.977
q_1^α	6.547	7.565	7.572
η_1^α	-1.068	-1.068	-1.068
η_2^α	-1.161	-1.071	-1.070
μ^β	1.008	0.931	0.907
b_1^β	0.861	0.933	0.934
υ^β	0.904	0.977	0.978
q_2^β	6.547	7.565	7.583
η_1^β	-1.068	-1.068	-1.068
η_2^β	-1.161	-1.071	-1.070
π^θ	0.01	0.01	0.01
μ^θ	1.823	1.818	1.818
l^θ	1.8	1.8	1.8
υ^θ	0.994	0.994	0.994
η_1^θ	-100	-100	-100
η_2^θ	-9.637	-9.610	-9.610
η^{CB}	1	1	1
π	1.03	1.03	1.03
k^α	32.859	37.043	37.082
k^β	32.859	37.043	37.111
i^α	0.329	0.370	0.371
i^β	0.329	0.370	0.371
y^α	13.882	15.367	15.380
y^β	13.882	15.367	15.392
GDP	1.757	1.901	1.903
n^α	0.275	0.283	0.283
n^β	0.275	0.283	0.283
λ^α		0.080	0.057
λ^β		0.080	0.104

The principal assumption is that variables will converge to the original steady state after a shock.

The impulse-response graphs show percent change with respect to the steady state. The simulations in this work are constructed as percentage deviations from the steady state of the selected group of variables where the time of convergence is measured in monthly terms.

The external sources of uncertainty are found in the graphs at the left. These shocks are divided into two categories - aggregate and idiosyncratic. Aggregate uncertainty includes monetary policy shocks (funding liquidity), while the idiosyncratic shocks, the productivity and regulatory actions (default penalties) of entrepreneurs are separate (recall equations (4.17) and (4.14)).

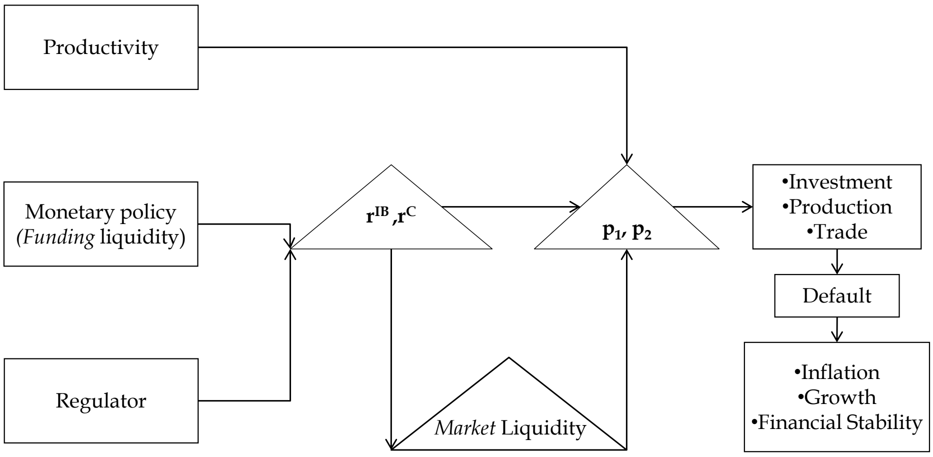
Once a financial shock (monetary or regulatory) occurs, it is then transmitted to interest rates, so affecting the cost of credit. The cost of credit will influence the demand for goods. In turn this affects the supply of commodities, since investment, (and so production and supply), is financed with liquid revenues and credit. There is also an impact on liquidity because as it depends inversely on the commercial bank interest rate, there will be a feedback effect on prices. With market clearing, all prices are affected and reach a new temporary equilibrium.

If there is a productivity shock, the supply of goods changes so resulting in price changes. Market liquidity is determined by aggregate and idiosyncratic shocks, affecting the interplay between prices and interest rates. This determines investment and production, affecting the marginal utility of default. As a result decisions about default have to be made. These dynamics will determine inflation, production and financial stability.

After a perturbation, the system converges to the steady state. The analysis examines the dynamics of four key economic aggregates: inflation, growth, employment and financial stability (characterized by probabilities of default of entrepreneurs and commercial bank).

As previously described, inflation is calculated considering the commodity prices using a Laspeyres type of index. Growth is measured by the constructed GDP variable (see equation (4.18)). In this framework, financial stability is measured by the aggregate

Figure 4.6: Shock transmission



entrepreneur and commercial bank repayment rates.

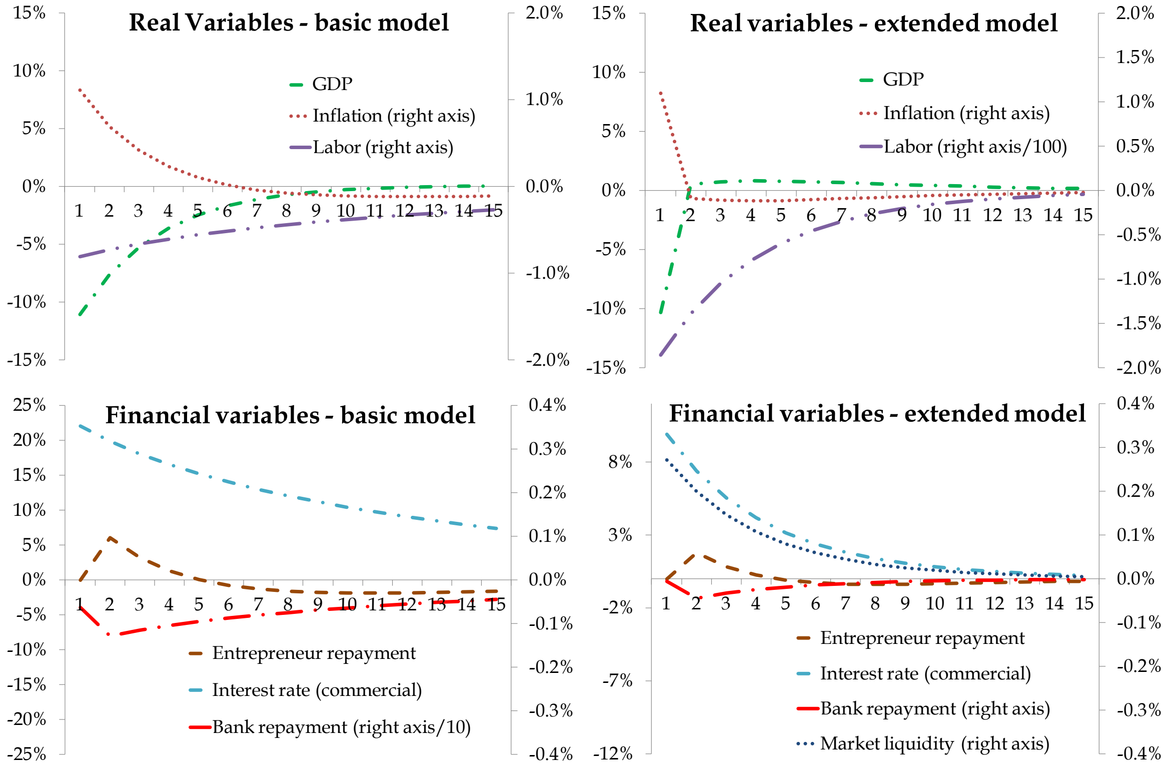
When compared to the endowment economy in Martinez and Tsomocos (2011) this simulation demonstrates some important differences with broad economic consequences. From this exercise, for example, it is possible to provide an explanation of the tradeoff between the real and financial economy.

As an example, this section shows the dynamics of real and financial variables after a funding liquidity shock as, for example, where there is a 5% decrease in the growth of the monetary base (M). Figure (4.7) shows the dynamics of real and financial variables after this shock for the three cases; base model, with symmetric liquidity costs, and with asymmetric liquidity costs.

There is a clear pattern for GDP behaviour. Once there is a funding liquidity shortage credit costs increase. As investment and consumption in this model are financed by liquid revenues from sales and credit, GDP declines because the overall cost of financing increases. The post-shock lack of funding influences the interbank market rate, which in turn affects the commercial bank interest rate. Thus, GDP growth decreases.[13] With consumption declines, incentives to use labour are reduced. Although labour is not a monetary cost in this model, it does subtract utility from leisure. Further, if there

[13]See Tille (2001) for evidence supporting this type of dynamics in an international economy setting. In this work, monetary shocks have a different impact in trading partners, depending on the substitutability of the goods that they trade.

Figure 4.7: Impulse responses on real and financial variables variables after a 5% negative shock in money (M) base growth



Note: On the left hand side we find the plots for the basic case *without liquidity*. Whereas on the right hand side plots we find those of the case *with symmetric liquidity*. The first row of plots refer to the real variables and the second row refers to financial variables. The x-axis refers to time measured in months.

is an increase in labour use, this could be regarded as an inefficient allocation of resources.

Inflation dynamics require special attention. A monetary shock affects both the demand and supply of commodities; for that, it affects market liquidity and the cost of credit, so changing relative prices. This exercise examines the case when the impact on supply is greater than on demand in the short and medium term. Thus, inflation increases in the short run, immediately after the shock, and lasts high up to the medium run. In the long run, as expected, it decreases. This is because supply is more constrained, compared to the demand, during these periods.

As a result, given the nature of the economy and the shock applied, stagflation emerges in the medium term. The result is an increase in prices and unemployment with lower production. How, in this context, does this affect financial stability?

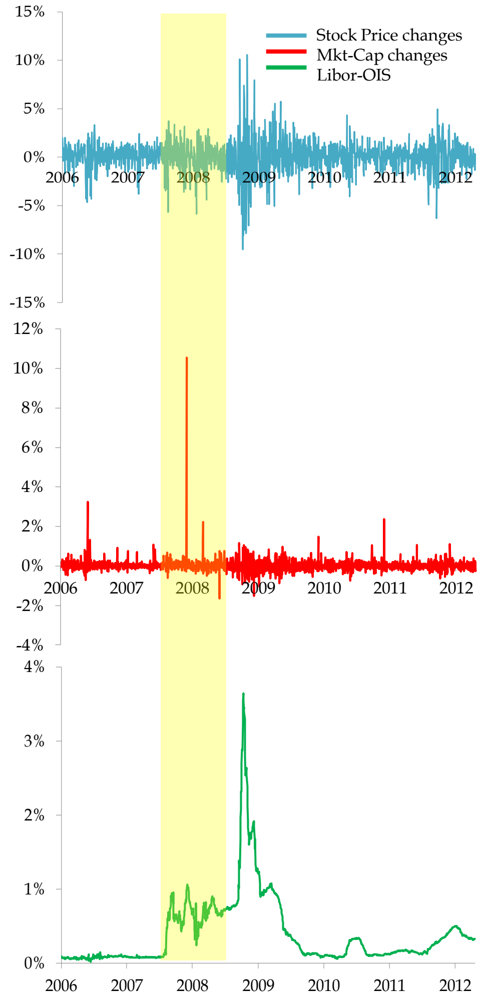
As we observed in figure (4.7), real variables are depressed once a negative funding liquidity shock occurs. However, in the case of financial variables the evidence is mixed.

Asset prices (commercial bank interest rates) and market liquidity increase. The commercial bank interest rate grows as the supply of funds is lowered. Whereas market liquidity increases slightly in the short run, as there are more incentives to sell assets in liquid markets to obtain scarce credit market funds, even with increasing transaction costs. This result partially replicates the findings of Li et.al. (2010). In summary, when funding liquidity (M) decreases, there is an inefficient allocation of resources, caused by a reduction in credit and increase in market liquidity. Market liquidity increases when agents are constrained in terms of funding, and this is why they pay higher costs to obtain new funding to finance consumption and investment. When there is sufficient funding opportunities, these inefficiencies are eliminated.

The commercial bank repayment rate decreases and slowly returns to the steady state levels, and entrepreneurs' aggregate repayments increase temporarily. This improvement is caused by an important reduction in credit. Entrepreneurs will now be able to repay more because their debt has been reduced. However, as credit costs continue to be high and market liquidity decreases, entrepreneurs will have less money to repay. Hence, entrepreneur repayments decrease in the medium term and do not recover until the long run. Even though the entrepreneurial default rate decreases, the commercial bank reduces its repayments. The reason is that there is considerable lower funding available to repay. The reduction in credit will increase the marginal utility of default for the commercial bank, making it relatively less costly.

Another feature comes when comparing the dynamics of the base versus the extended liquidity case. As figure (4.7) shows, most of the variables have a very rapid response to shocks. Further, in most simulations, the impact of shocks is lower in the extended version than the base model. The market liquidity possibility smoothes the response to shocks, since it provides an alternative source of financing when funding conditions get tight. This market liquidity has its counterpart in reality - the equity market, as can be seen in figure (4.8), where there is a funding liquidity shortage.[14] At this point, the private sector increases its financing in the equity market, measured by changes in market capitalization. It is important to note that price volatility begins almost a year after the funding liquidity dry-up.

Figure 4.8: Emerging economies stock market vs Aggregated liquidity



Summarizing the results with respect to a negative monetary shock, there is a strong relationship between growth and financial stability.

When the monetary base is reduced, GDP declines, inflation increases and financial stability continues mixed in the short run. These results have implications for monetary

[14]Proxied by the LIBOR-OIS spread, following the IMF Global Financial Stability Report (2008).

policy based on the Taylor rule, which gives only partial guidance to the monetary authorities.

The following sections contain more details about different shocks applied to the system and their implications.

4.5.3.1 Asset prices

The only financial asset available for both entrepreneurs (α and β) is credit, which they can obtain from the Commercial bank θ. This asset works exactly as a 1-period maturity bond and it is priced in the commercial loans market. For its pricing, we analyze the interest rate fluctuations, since it is the inverse of the price and it has meaningful and comparable results. Figure (4.9) depicts the results of the application of different shocks to the asset price available - that is the commercial bank interest rate. After a negative shock to the monetary base, the commercial bank interest rate increases. As funding liquidity supply decreases, and with demand continuing to be relatively high, interest rates increase. The inter-bank interest rate grows, dragging up the commercial bank rate. The rise in interest rates will be more pronounces in the base case, since in this setting there are fewer funding alternatives, as market liquidity is not as available when compared to the asymmetric case.

In the short run, a positive productivity shock will increase the interest rate, because higher productivity increases the supply of commodities and reduces prices in the short run. Consumption becomes more attractive and the demand grows, resulting in an increased demand for credit and a temporary increase in the commercial loans interest rate.

Higher default penalties for entrepreneurs decrease the commercial bank interest rate in the short run. Demand for credit decreases since default is now more costly. Entrepreneurs incorporate this temporary additional non-pecuniary credit cost, reducing their demands in the short run. However, there is a low but persistent increase of interest rates that starts in the middle run.

A shock in commercial bank default penalties increases commercial bank interest rate in the medium term. Default makes lending more costly because funding is less attractive for the bank. It decreases the marginal utility for commercial bank default. Hence, credit supply is reduced and interest rates increase. The impact of this shock is smaller than other shock effects.

4.5.3.2 Inflation

Figure (4.10) shows the impact on inflation of the different shocks. A negative shock to the monetary base increases inflation in the short run. This result is driven by a more pronounced shortage of the supply of commodities when compared to demand. Note that this result is considerably lower than the impact of other shocks to inflation.

With a positive productivity shock, inflation decreases in the short run. However, it increases in the medium term although it declines to the steady state level in the long run. When productivity increases, there is, for the relatively more productive entrepreneur, short term increase in the supply of commodities. The less productive entrepreneur will produce less in the medium term. However, demand is also affected by the increase in supply, for now prices seem more attractive in the short term. This process pushes prices upward in the medium run, but adjusting to the steady state level in the long run.

For the entrepreneur directly affected by the shock, an increase in default penalties reduces inflation in the short run. As credit is relatively more costly after the shock of default penalties, then credit and consumption decrease in the immediate period/horizon. The shock affects both demand and supply. In the medium term, the effect is stronger on the supply of commodities. Thereafter, inflation adjusts towards positive growth in the medium term and converges to the steady state level in the long run. The effect of the commercial bank penalty shock is positive, but much lower and far less important when compared to the entrepreneurs' penalty shock.

4.5.3.3 Repayment rates

Figure (4.11) and (4.12) show the results of different shocks to repayment rates. These variables define financial stability in this framework. A reduction in the monetary base impacts entrepreneur repayments positively. A lower demand for credit[15] combined with a higher market liquidity cost (as a product of the increase in interest rates) determines that there is considerably less money to be repaid. Thus entrepreneurs' repayment rates increase in the mid term, but then decrease and stay persistently at levels below the steady state after this. When credit becomes more attractive, as a result of cost decreases in the middle run, then agents assume more debt and the marginal utility of default increases.

A positive productivity shock increase aggregate entrepreneur defaults in the middle run. Higher productivity increases commodity supply, generating attractive prices that increase demand at the same time; higher demand is financed with additional credit. It becomes optimal to repay a smaller amount of obligations, since consumption generates comparatively greater utility than losses generated by the default penalty. The effect is more pronounced in the symmetric and asymmetric liquidity cases, as entrepreneurs have relatively more resources, used to consume and produce more but less resources to repay when compared to the base case.

A positive shock in default penalties increases entrepreneur repayment rates because marginal dis-utility from defaulting increases. This effect is especially pronounced in the asymmetric liquidity case. Commercial bank repayment rates decrease in the medium run. A reduction in commercial bank credit extensions, as a product of the higher penalty costs that the bank has to bear, results in a reduction in demand for credit. However, the reduction in demand is less than the decrease in supply. Hence, default pressures for the entrepreneurs increase when the commercial bank faces a higher default penalty.

[15]It should be noted that the reduction in credit demand is comparatively more pronounced than the reduction in revenues from production.

In the case of the commercial bank repayment rates the evidence is similar to the case of entrepreneurs, although with a smaller magnitude.

4.5.3.4 Trade

Figure (4.13) shows the results of the application of different shocks to trade. The evidence is consistent with results previously presented. After a monetary shock, the quantities traded are reduced, since the credit becomes more scarce, increasing its cost. This decreases the demand for goods hence trade.

The evidence from a positive productivity shock is that entrepreneurs will trade more commodities, although the effect is more pronounced in the case where there is an idiosyncratic shock to the entrepreneur's production function.

There are interesting differences between the base and extended model. First, for the base model, if one of the entrepreneurs receives a default penalty shock, it reduces the demand for credit, because of the comparatively higher default cost. The amount produced will decrease and so the supply of commodities. The effect of an increase in the default penalty to the other entrepreneur is the opposite, because his/her good becomes comparatively more attractive. Thus the first entrepreneur's produced good will be traded less. Second, in the extended model, when agents rely on other sources of financing, they can trade even more in the middle run, for while credit is scarce, market liquidity is more attractive.

Although the effect is not significant, a shock to the commercial bank interest rate reduces trade, as credit costs are higher and the supply and demand of the commodity is reduced.

4.5.3.5 Investment

Figure (4.14) shows the effects of different shocks to investment. The investment in this economy is similar to that of a commodity producer country (see Trade).

When a negative monetary shock hits the system, resources become scarcer, with a (temporarily) lower investment rate which is most pronounced in the base model framework.

If there is a positive productivity shock, investment becomes more attractive, since it will generate greater output. Investment grows in the medium run. However, for the base setting, a productivity shock has a smaller influence on investment, since agents have reduced financial opportunities.

Credit costs increase with higher default penalties applied to entrepreneurs, and so a temporary decrease in short run investment. However, in the medium term case, interest rate reductions lower the cost of funds making them relatively cheaper so that entrepreneurs invest more. If the shock is applied to the other producer, the results would be reversed, since this entrepreneur gets relatively cheaper finance.

Finally, after a commercial bank default penalty shock, interest rates increase, credit becomes scarce and so there is a temporary reduction of investment.

4.5.3.6 Labour

Figure (4.15) shows the impact on labor of different shocks. and the trade-offs between capital, investment and labour; labor, recall, is not contracted but modeled in this exercise as dependent on the entrepreneur. In the case where there is a negative monetary shock, labour inputs decrease. When consumption decreases because of the increasing cost of credit, entrepreneurs value their own leisure more highly and provide less labour, particularly in the base model (that is without market liquidity).

After a positive productivity shock, there is a temporary decrease in labour. As capital is comparatively more productive, agents are less prone to provide labor for production, since it contributes less to overall marginal productivity.

When there is a shock to the entrepreneur (α) such as a default penalty, labor is used more, since the higher cost of financing makes capital more expensive. If the other entrepreneur (β) receives the shock, then the reaction of entrepreneur (α) is to reduce labour inputs since demand for his/her good becomes comparatively lower, so that his/her production will decrease requiring less labour. The same effect is generated by an increase in the commercial bank default penalty. As credit becomes temporarily more expensive, commodity demand will decrease in the short and medium run.

4.5.3.7 Welfare: GDP

Figure (4.16) shows the results of the application of different shocks to GDP. The welfare analysis is presented in terms of GDP and employment. The advantage of this approach, as compared to that followed in Martinez and Tsomocos (2011), is that it is not necessary to analyze individual utilities. Similar to Martinez and Tsomocos (2011), this paper presents a model with incomplete markets. There is only 1 asset available to transfer wealth across time and a distribution, which requires 2 moments to be estimated. Hence, complete diversification of risks is not possible. As markets are incomplete, it is not possible to aggregate the individual agents' utilities to construct a welfare function. Consequently, second welfare theorem does not apply; it is not possible to find an appropriate set of weights to construct a welfare function. Instead of presenting individual utilities, aggregate welfare information is provided by GDP. While this metric has limitations, (e.g. accounting for concentration or distribution of the resources generated by an economy), it can be considered to be a reasonable indicator for economic performance.

The results are consistent with the previously described simulation exercises of this section.

When a negative monetary shock hits the economy the interest rate increases which in turn causes credit and market liquidity costs to increase. The result is reduced investment, since the amount of cash to invest decreases. Further, a negative monetary shock also brings a reduction in production and consumption.

If a positive shock on productivity affects the system, then GDP tends to increase in the short and medium run. This dynamic is explained by the behavior of production, consumption and investment. Production increases since the technology becomes momentarily more productive and prices decrease, even after discounting for inflation. Investment increases, with the decrease in credit costs and there are greater amount available for investment. Finally as a consequence, the demand for commodities and consumed monetary amount increase. Thus, GDP growth increases in the short run and converges to the steady state in the long run.

The results of productivity shocks to GDP occur earlier in the base model given a lack of funding to support a long term increase in consumption and investment. This impact is concentrated in the initial short period when compared to the cases where market liquidity is available.

When there is a default penalty shock to the entrepreneur α, credit becomes more expensive but at the same time more labor is employed, increasing production and hence spending in the immediate horizon with a low liquidity environment (base and extended - symmetric - cases). If the other entrepreneur - β - also suffers from the shock, then the reaction of entrepreneur α is to employ less labour and so reduce production in the immediate period. However, these results are reversed in the medium and long run. The same effect is generated by an increase in the commercial bank default penalty. As credit becomes temporarily more expensive, commodity demand will decrease in the short and medium run and will drive GDP down.

4.5.4 Market Liquidity

Figure (4.17) shows the results of the application of different shocks to market liquidity. After a negative monetary shock, market liquidity increases. Even though costs increase, it is still more attractive than credit in the medium term. Therefore, agents decide to sell in liquid markets in order to gain more resources to invest and consume. This endogenous decision increases financial stability in the short and medium term, but it contributes to long run instability, since agents allocate comparatively more resources to investment and consumption and less to repayment.

A positive shock in productivity generates a higher demand for market liquidity in the short run. This effect is caused by an increase in interest rates produced by growing demand for credit. This in turn makes the search for liquidity more costly but it remains a better alternative.

An increase in entrepreneurs' default penalties decreases the demand for credit and cause that commercial bank interest rates to be reduced and creates the incentive to hold money; if Commercial bank default penalty increases, then credit becomes scarce and market liquidity is more attractive and is in greater demand.

4.6 Concluding Remarks

Consistent with Martinez and Tsomocos (2011), the results show the need to analyze liquidity and default simultaneously. Liquidity and default reinforce each other. Furthermore, these concepts should not be defined separately. If market liquidity is to be endogenous then liquidity (funding and market), default risk, and economic performance should be connected.

This paper suggests that once funding liquidity within entrepreneurs becomes scarce, market liquidity becomes an expensive alternative but less than bank credit. Financial stability brings mixed results. Entrepreneur defaults decrease in the short and medium run, but increase after the medium run, remaining high until the long period convergence to the steady state, while the commercial bank repayment rate decreases in the medium run, converging slowly to the steady state level over time. Finally, a negative monetary shock lowers GDP.

The model produces stagflation in equilibrium. This appears to be the current state in world economic performance for both emerging and developed economies. In this model, endogenous liquidity explains the non-trivial dynamic relationship between financial stability and economic performance.

The results suggest that a negative monetary shock helps explain a phase with low production, increasing inflation and long lasting financial instability. Further, the results show that the relaxation of the budget constraints smoothes the response of the majority of financial and real economic variables to various types of shocks.

The most important policy implications concern timing and response of monetary and regulatory actions. If there is a negative monetary shock, the regulator should examine the market's liquidity conditions and improve funding opportunities; the alternative is reduced growth. The model results suggest that there is little scope for a policy of monetary contraction in these cases. It is also possible to regulate the financial market to ensure that payments will be honoured in the future. The overall effect would be better economic performance.

This model examines two different types of economic situations. First, it can be applied to the international trade for commodity producing economies. The optimal decisions after unexpected shocks are subsumed in this work, in a simple and clear form. Second, this model could be applied to a small open economy that depends on external sources of funding. In these cases, the internal sources of financing become depressed when an aggregate international shock (M in this case) hits the economy, causing a temporary economic slump. Although financial stability does increase in the medium term, as measured by default rates.

A broader definition of financial stability that includes liquidity risk, can explain that in aggregate, liquidity shortages are themselves a source of risk. Even when some defaults are reduced, the system becomes financially unstable, since it does not generate the resources agents need to consume and produce and cause lower possibilities to repay.

There are a number of interesting further explanations suggested by this model, particularly with regard to monetary policy and default penalties as endogenous decisions. Additionally, the application of this framework to different types of default (collateral) would be very useful in this field. However, these suggestions will be followed up at a later time.

4.7 Appendix 1: First Order Conditions

In this section we present the first order conditions for the cases including liquidity as a decision variable. The basic case (without liquidity) uses the same equations with two differences: i) equations (4.46) and (4.55) are not considered, since those are the FOCs with respect to the liquidity decision and ii) the liquidity decision variable (λ_t^h) is set to zero.

4.7.1 FOCs for Entrepreneur α

$$-\frac{\eta_{2,t}^{\alpha}}{1+r_t^c}-\beta\mathbb{E}_t\left(\frac{\tau_{t+1}^{\alpha}\left(1-\upsilon_{t+1}^{\alpha}\right)}{\pi_{t+1}}-\eta_{1,t+1}^{\alpha}\upsilon_{t+1}^{\alpha}\right)=0 \tag{4.39}$$

$$\frac{\tau_t^{\alpha}}{\pi_t}+\eta_{1,t}^{\alpha}=0 \tag{4.40}$$

$$\frac{1}{\tilde{b}_{2,t}^{\alpha}}+\eta_{2,t}^{\alpha}=0 \tag{4.41}$$

$$\frac{1}{a_t^{\alpha}(k_t^{\alpha})^{\phi\alpha}(n_t^{\alpha})^{(1-\phi\alpha)}-q_{1,t}^{\alpha}-i_t^{\alpha}}+\eta_{2,t}^{\alpha}\lambda_t^{\alpha}\tilde{p}_{1,t}+\beta\mathbb{E}_t\left(\eta_{1,t+1}^{\alpha}\tilde{p}_{1,t}\left(1-\lambda_t^{\alpha}\right)\right)=0 \tag{4.42}$$

$$\beta\left(\frac{a_t^{\alpha}\phi_{\alpha}(k_t^{\alpha})^{(\phi\alpha-1)}(n_t^{\alpha})^{(1-\phi\alpha)}}{a_t^{\alpha}(k_t^{\alpha})^{\phi\alpha}(n_t^{\alpha})^{(1-\phi\alpha)}-q_{1,t}^{\alpha}-i_t^{\alpha}}+1-\delta\right)-\frac{1}{a_{t-1}^{\alpha}\left(k_{t-1}^{\alpha}\right)^{\phi\alpha}(n_{t-1}^{\alpha})^{(1-\phi\alpha)}-q_{1,t-1}^{\alpha}-i_{t-1}^{\alpha}}=0 \tag{4.43}$$

$$\upsilon_t^{\alpha}\tilde{\mu}_{t-1}^{\alpha}-\tilde{p}_{1,t-1}q_{1,t-1}^{\alpha}\left(1-\lambda_{t-1}^{\alpha}\right)-m^{\alpha}=0 \tag{4.44}$$

$$\tilde{b}_{2,t}^{\alpha}-\frac{\tilde{\mu}_t^{\alpha}}{1+r_t^c}-\lambda_t^{\alpha}\cdot\tilde{p}_{1,t}q_{1,t}^{\alpha}+\zeta^{\alpha}\lambda_t^{\alpha\,2}r_t^c-s_{\theta}^{\alpha}\frac{\tilde{\Pi}_{t-1}^{\theta}}{\pi_t}=0 \tag{4.45}$$

$$\tilde{p}_{1,t}q_{1,t}\left(\eta_{1,t+1}^{\alpha}-\eta_{2,t}^{\alpha}\right)+2\cdot\eta_{2,t}^{\alpha}\zeta^{\alpha}\lambda_t^{\alpha}r_t^c=0 \tag{4.46}$$

$$\frac{a_t^{\alpha}(1-\phi_{\alpha})(n_t^{\alpha})^{(-\phi\alpha)}}{a_t^{\alpha}(k_t^{\alpha})^{\phi\alpha}(n_t^{\alpha})^{(1-\phi\alpha)}-q_{1,t}^{\alpha}-i_t^{\alpha}}-\frac{\psi_{\alpha}}{N^{\alpha}-n_t^{\alpha}}=0 \tag{4.47}$$

4.7.2 FOCs for Entrepreneur β

$$-\frac{\eta_{2,t}^{\beta}}{1+r_t^c}-\beta\mathbb{E}_t\left(\frac{\tau_{t+1}^{\beta}\left(1-\upsilon_{t+1}^{\beta}\right)}{\pi_{t+1}}-\eta_{1,t+1}^{\beta}\upsilon_{t+1}^{\beta}\right)=0 \tag{4.48}$$

$$\frac{\tau_t^{\beta}}{\pi_t}+\eta_{1,t}^{\beta}=0 \tag{4.49}$$

$$\frac{1}{\tilde{b}_{1,t}^{\beta}}+\eta_{2,t}^{\beta}=0 \tag{4.50}$$

$$\frac{1}{a_t^{\beta}(k_t^{\beta})^{\phi_{\beta}}(n_t^{\beta})^{\left(1-\phi_{\beta}\right)}-q_{2,t}^{\beta}-i_t^{\beta}}+\eta_{2,t}^{\beta}\lambda_t^{\beta}\tilde{p}_{2,t}+\beta\mathbb{E}_t\left(\eta_{1,t+1}^{\beta}\tilde{p}_{2,t}\left(1-\lambda_t^{\beta}\right)\right)=0 \tag{4.51}$$

$$\beta\left(\frac{a_t^{\beta}\phi_{\beta}\left(k_t^{\beta}\right)^{\left(\phi_{\beta}-1\right)}(n_t^{\beta})^{\left(1-\phi_{\beta}\right)}}{a_t^{\beta}\left(k_t^{\beta}\right)^{\phi_{\beta}}(n_t^{\beta})^{\left(1-\phi_{\beta}\right)}-q_{2,t}^{\beta}-i_t^{\beta}}+1-\delta\right)-\frac{1}{a_{t-1}^{\beta}\left(k_{t-1}^{\beta}\right)^{\phi_{\beta}}(n_{t-1}^{\beta})^{\left(1-\phi_{\beta}\right)}-q_{2,t-1}^{\beta}-i_{t-1}^{\beta}}=0 \tag{4.52}$$

$$\upsilon_t^{\beta}\tilde{\mu}_{t-1}^{\beta}-\tilde{p}_{2,t-1}q_{2,t-1}^{\beta}\left(1-\lambda_{t-1}^{\beta}\right)-m^{\beta}=0 \tag{4.53}$$

$$\tilde{b}_{1,t}^{\beta}-\frac{\tilde{\mu}_t^{\beta}}{1+r_t^c}-\lambda_t^{\beta}\cdot\tilde{p}_{2,t}q_{2,t}^{\beta}+\zeta^{\beta}\lambda_t^{\beta\,2}r_t^c-s_{\theta}^{\beta}\frac{\tilde{\Pi}_{t-1}^{\theta}}{\pi_t}=0 \tag{4.54}$$

$$\tilde{p}_{2,t}q_{2,t}\left(\eta_{1,t+1}^{\beta}-\eta_{2,t}^{\beta}\right)+2\cdot\eta_{2,t}^{\beta}\zeta^{\beta}\lambda_t^{\beta}r_t^c=0 \tag{4.55}$$

$$\frac{a_t^{\beta}\left(1-\phi_{\beta}\right)\left(n_t^{\beta}\right)^{\left(-\phi_{\beta}\right)}}{a_t^{\beta}\left(k_t^{\beta}\right)^{\phi_{\beta}}\left(n_t^{\beta}\right)^{\left(1-\phi_{\beta}\right)}-q_{2,t}^{\beta}-i_t^{\beta}}-\frac{\psi_{\beta}}{N^{\beta}-n_t^{\beta}}=0 \tag{4.56}$$

4.7.3 FOCs for Bank θ

$$\frac{1}{\tilde{\Pi}_t^{\theta}} + \eta_{1,t}^{\theta} = 0 \tag{4.57}$$

$$-\frac{\eta_{2,t}^{\theta}}{1+r_t^{IB}} - \hat{\beta}\mathbb{E}_t\left(\frac{\tau_{t+1}^{\theta}\left(1-\upsilon_{t+1}^{\theta}\right)}{\pi_{t+1}} - \eta_{1,t+1}^{\theta}\frac{\upsilon_{t+1}^{\theta}}{\pi_{t+1}}\right) = 0 \tag{4.58}$$

$$\tau_t^{\theta} + \eta_{1,t}^{\theta} = 0 \tag{4.59}$$

$$-\hat{\beta}\mathbb{E}_t\left(\frac{\eta_{1,t+1}^{\theta}R_{t+1}^{\theta}\left(1+r_t^c\right)}{\pi_{t+1}}\right) + \eta_{2,t}^{\theta} = 0 \tag{4.60}$$

$$\tilde{\Pi}_t^{\theta} - \frac{R_t\tilde{l}_{t-1}^{\theta}\left(1+r_{t-1}^c\right)}{\pi_t} + \upsilon_t^{\theta}\frac{\tilde{\mu}_{t-1}^{\theta}}{\pi_t} = 0 \tag{4.61}$$

$$\tilde{l}_t^{\theta} - \frac{\tilde{\mu}_t^{\theta}}{1+r_t^{IB}} = 0 \tag{4.62}$$

4.7.4 Market Clearing conditions and rational expectations

$$\tilde{b}_{1,t}^{\beta} - \tilde{p}_{1,t}q_{1,t}^{\alpha} = 0 \tag{4.63}$$

$$\tilde{b}_{2,t}^{\alpha} - \tilde{p}_{2,t}q_{2,t}^{\beta} = 0 \tag{4.64}$$

$$1+r_t^c - \frac{\tilde{\mu}_t^{\alpha}+\tilde{\mu}_t^{\beta}}{\tilde{l}_t^{\theta}} = 0 \tag{4.65}$$

$$1+r_t^{IB} - \frac{\tilde{\mu}_t^{\theta}}{M_t} = 0 \tag{4.66}$$

$$R_t - \frac{\upsilon_t^{\alpha}\tilde{\mu}_t^{\alpha}+\upsilon_t^{\beta}\tilde{\mu}_t^{\beta}}{\tilde{\mu}_t^{\alpha}+\tilde{\mu}_t^{\beta}} = 0 \tag{4.67}$$

4.7.5 Static variables

$$i_t^\alpha = k_{t+1}^\alpha - (1-\delta)\,k_t^\alpha \tag{4.68}$$

$$y_t^\alpha = a_t^\alpha\,(k_t^\alpha) \tag{4.69}$$

$$i_t^\beta = k_{t+1}^\beta + (1-\delta)\,k_t^\beta \tag{4.70}$$

$$y_t^\beta = a_t^\beta \left(k_t^\beta\right)^{\phi_\alpha} \left(n_t^\beta\right)^{(1-\phi_\alpha)} \tag{4.71}$$

$$\tilde{GDP} = \tilde{p}_{1,t}\left(y_t^\alpha - q_{1,t}^\alpha\right) + \tilde{p}_{2,t}\left(y_t^\beta - q_{2,t}^\beta\right) + \tilde{b}_{2,t}^\alpha + \tilde{b}_{1,t}^\beta + \tilde{i}_t^\alpha + \tilde{i}_t^\beta \tag{4.72}$$

4.7.6 Equations of shocks

$$M_t = \eta_t^{CB}\bar{M} \tag{4.73}$$

$$\ln(\eta_t^{CB}) = \rho^{CB}\ln(\bar{\eta}^{CB}) + (1-\rho^{CB})\ln(\eta_{t-1}^{CB}) + \varepsilon_{CB,t} \tag{4.74}$$

$$\ln(a_t^\alpha) = \rho_a^\alpha\ln(\bar{a}^\alpha) + (1-\rho_a^\alpha)\ln(a_{t-1}^\alpha) + \varepsilon_{a,t}^\alpha \tag{4.75}$$

$$\ln(a_t^\beta) = \rho_a^\beta\ln(\bar{a}^\beta) + (1-\rho_a^\beta)\ln(a_{t-1}^\beta) + \varepsilon_{a,t}^\beta \tag{4.76}$$

$$\ln(\tau_t^\alpha) = \rho^\alpha\ln(\bar{\tau}^\alpha) + (1-\rho^\alpha)\ln(\tau_{t-1}^\alpha) + \varepsilon_{\alpha,t}^\tau \tag{4.77}$$

$$\ln(\tau_t^\beta) = \rho^\beta\ln(\bar{\tau}^\beta) + (1-\rho^\beta)\ln(\tau_{t-1}^\beta) + \varepsilon_{\beta,t}^\tau \tag{4.78}$$

$$\ln(\tau_t^\theta) = \rho^\theta\ln(\bar{\tau}^\theta) + (1-\rho^\theta)\ln(\tau_{t-1}^\theta) + \varepsilon_{\theta,t}^\tau \tag{4.79}$$

4.8 Appendix 2: Impulse response experiments

4.8.1 Asset prices

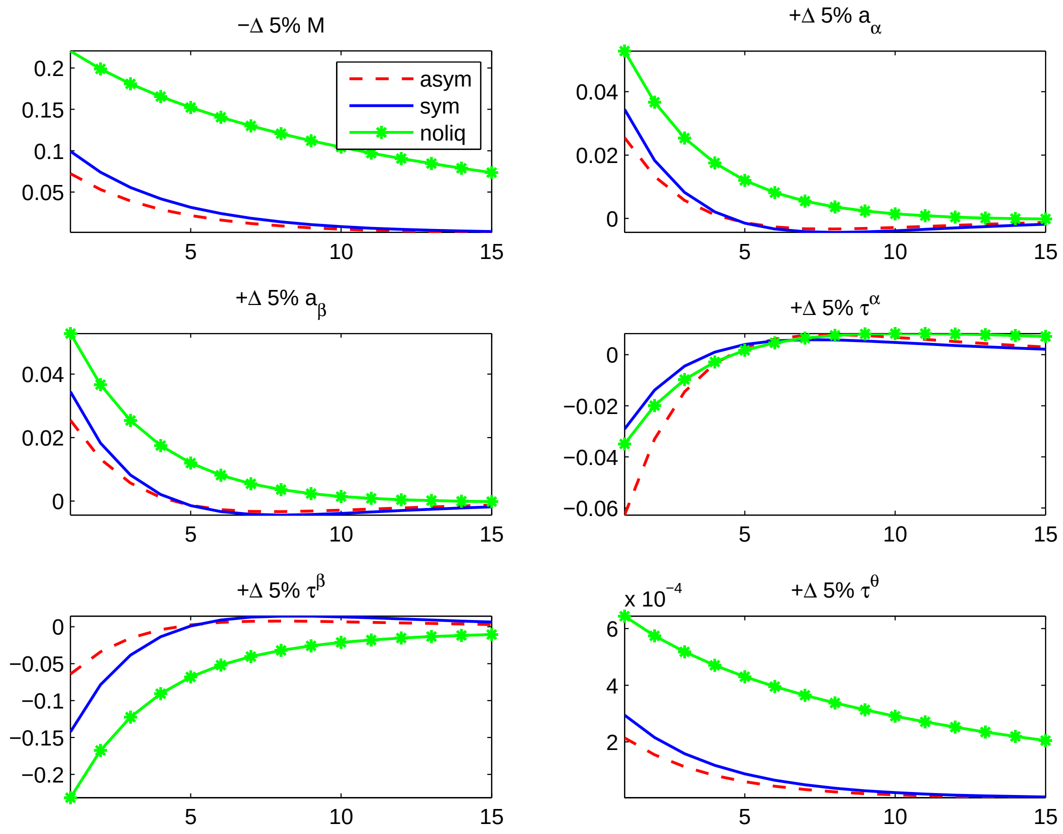


Figure 4.9: Impulse responses on commercial bank interest rate (r_t^c), % deviations from steady state

4.8.2 Inflation

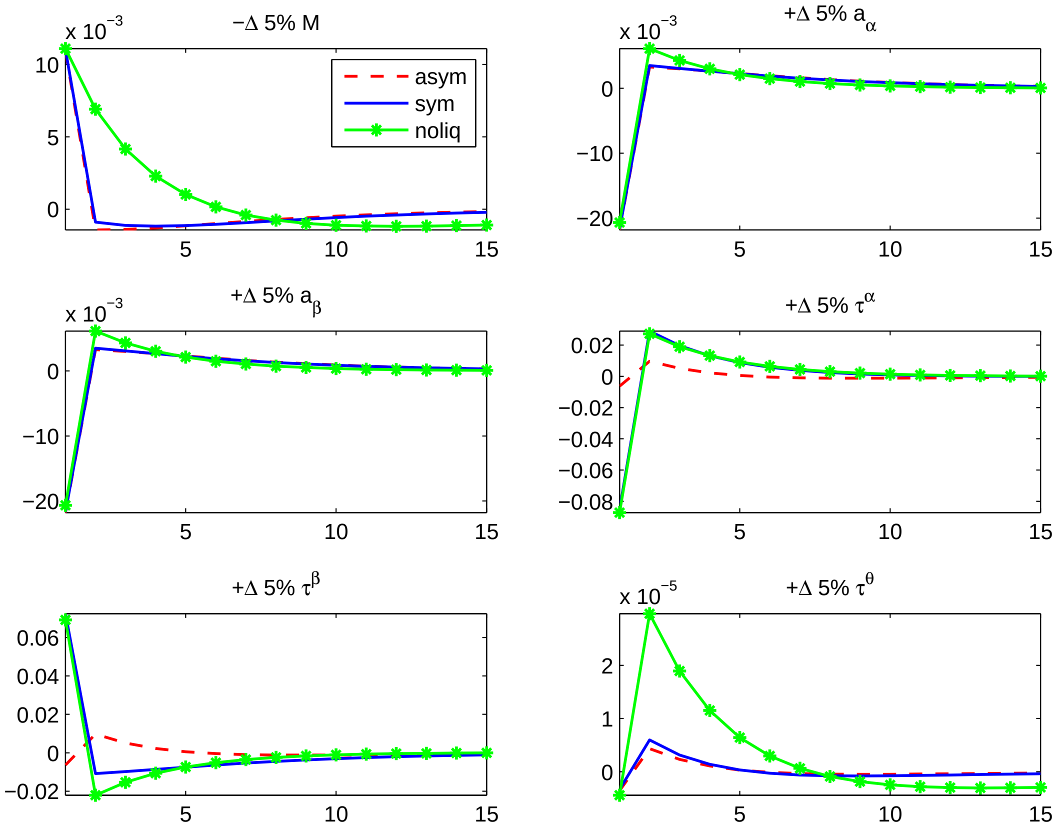


Figure 4.10: Impulse responses on inflation (π_t), % deviations from steady state

4.8.3 Repayment rates

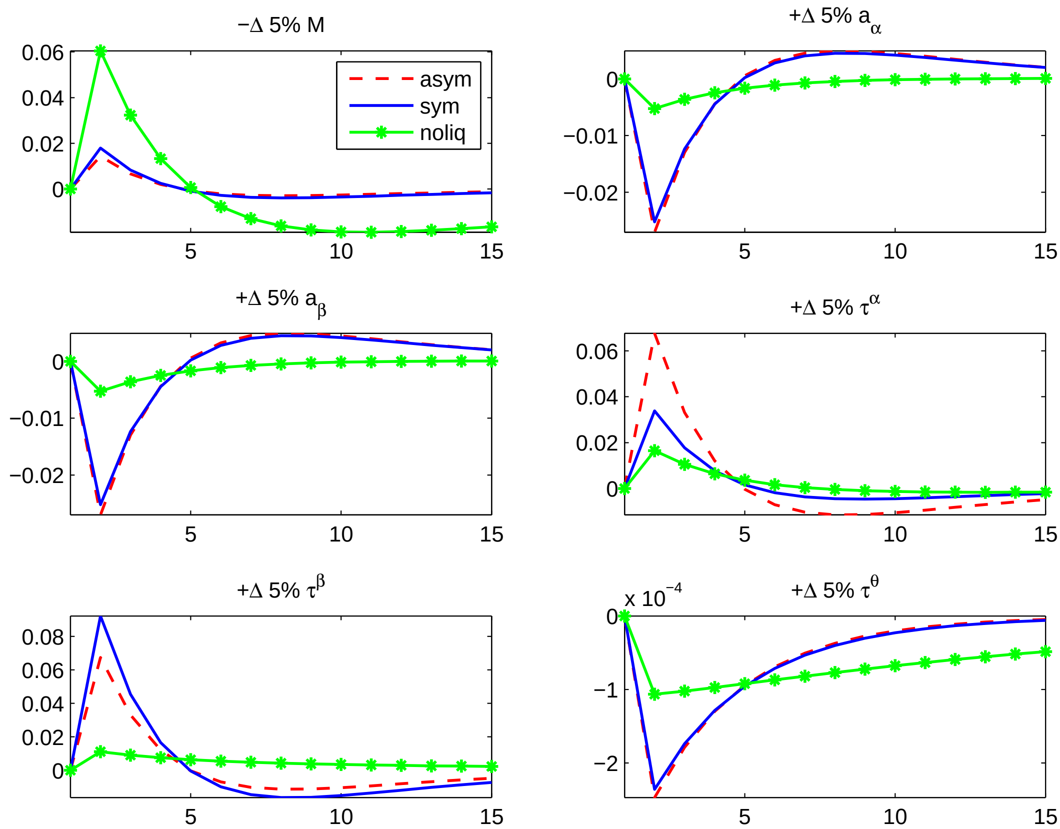


Figure 4.11: Impulse responses on average repayment rate (R_t), % deviations from steady state

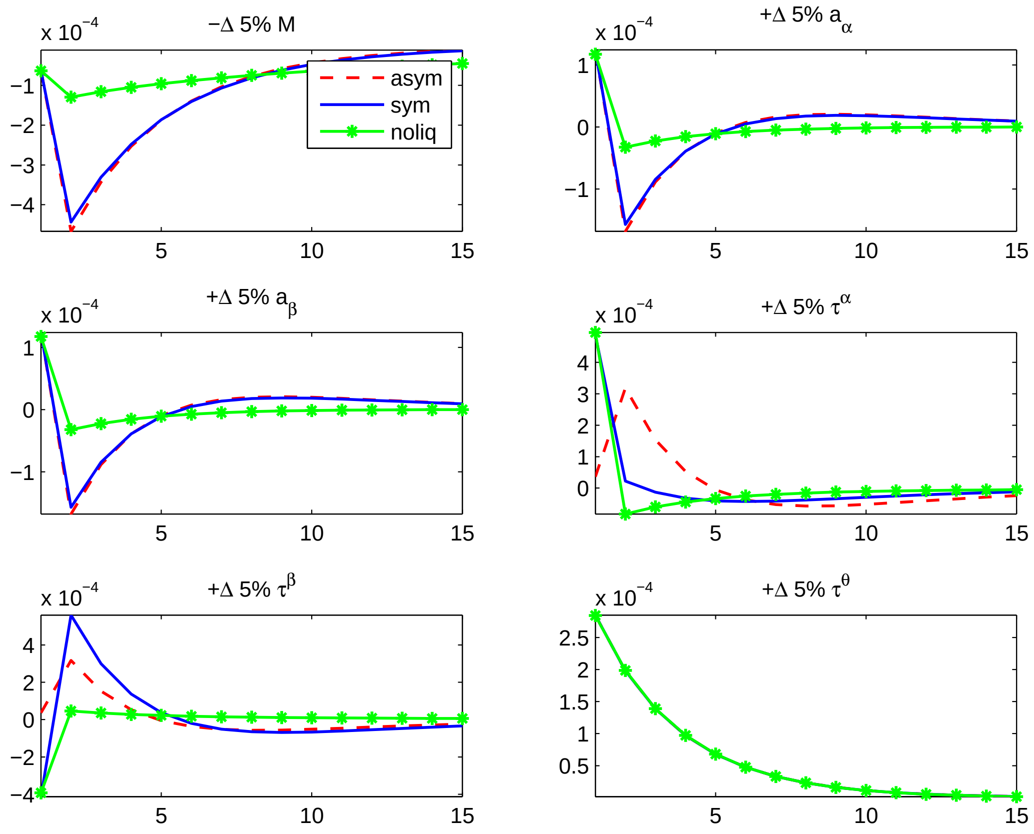


Figure 4.12: Impulse responses on commercial bank repayment rate (υ_t^θ), % deviations from steady state

4.8.4 Trade

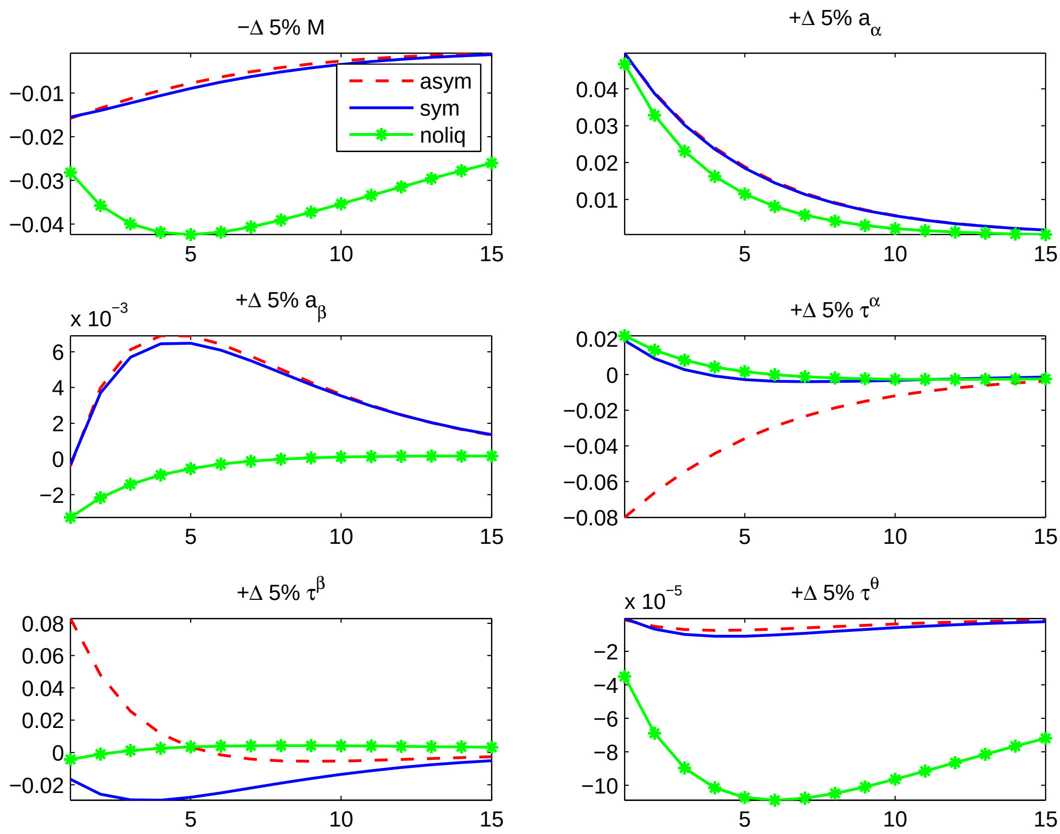


Figure 4.13: Impulse responses on quantity of good 1 traded by agent α ($q^{\alpha}_{1,t}$), % deviations from steady state

4.8.5 Capital Investment

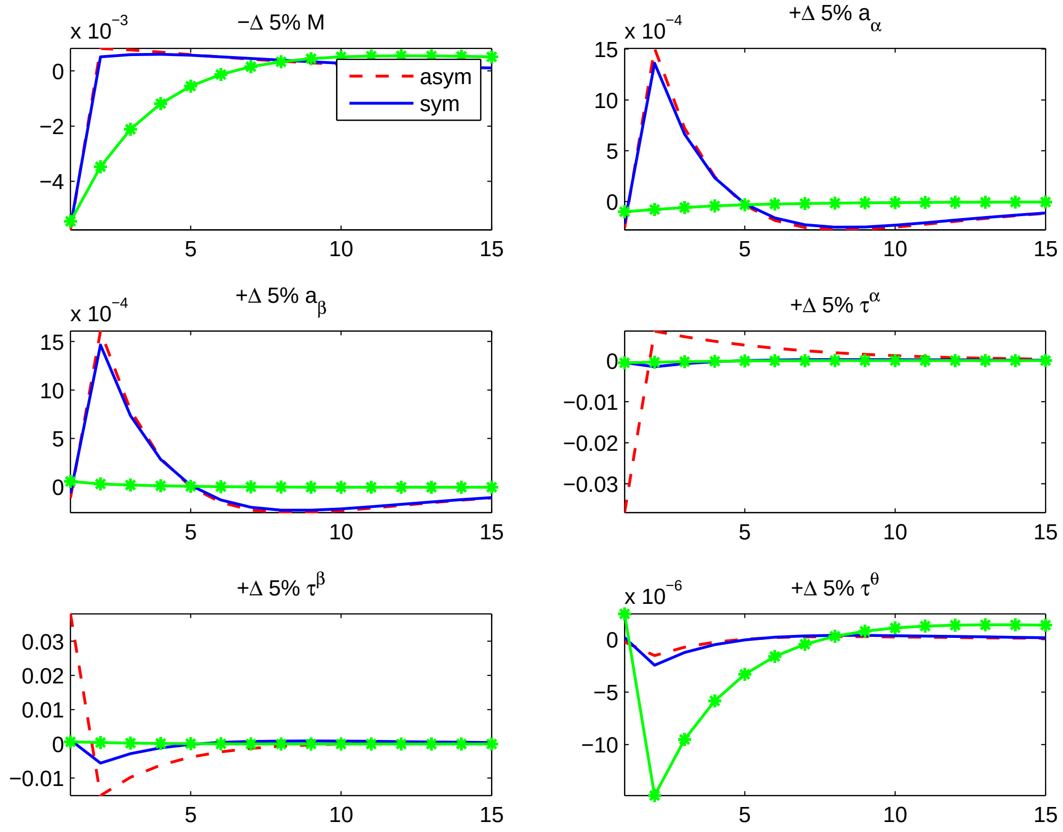


Figure 4.14: Impulse responses on capital investment (i_t^α), % deviations from steady state

4.8.6 Labour

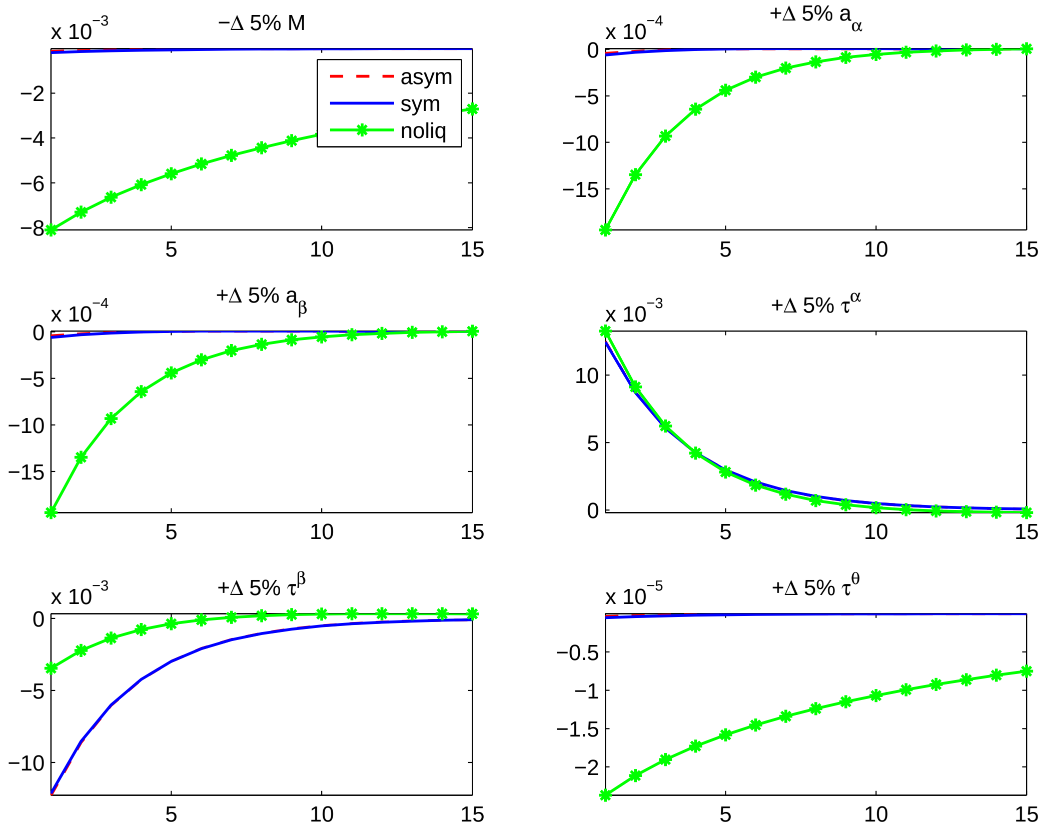


Figure 4.15: Impulse responses on labour (n^{α}), % deviations from steady state

4.8.7 Welfare: GDP

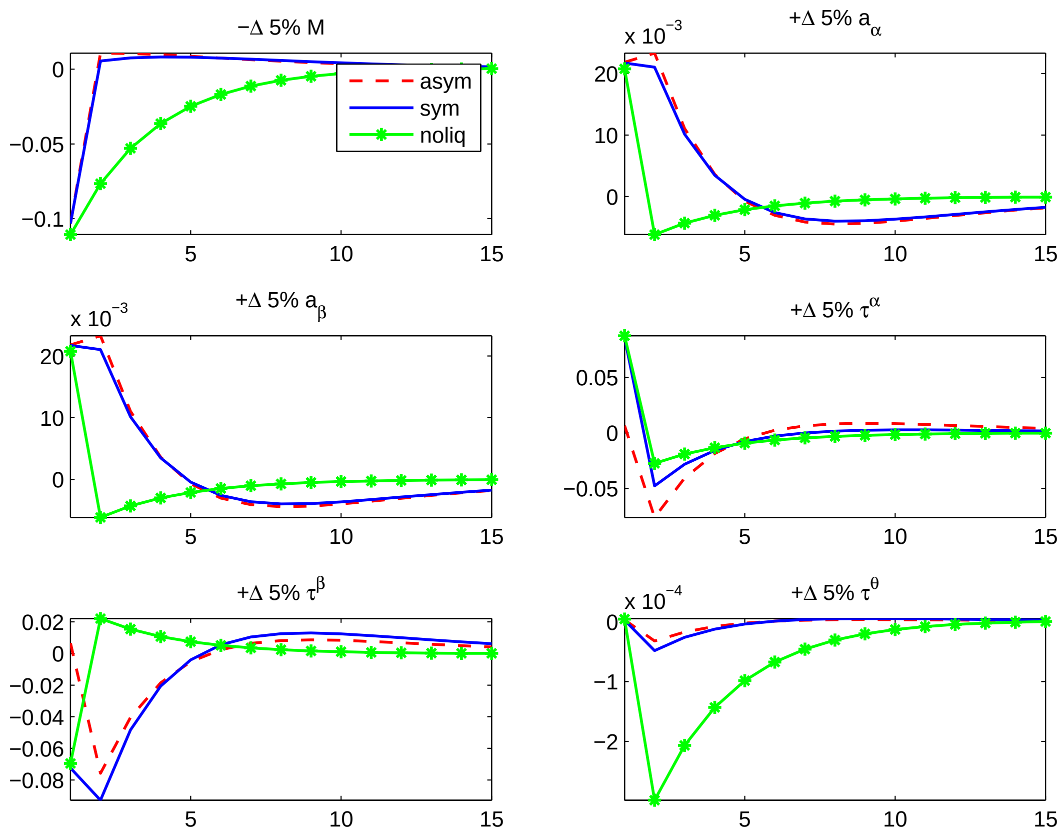


Figure 4.16: Impulse responses on real economy (*GDP*), % deviations from steady state

4.8.8 Market Liquidity

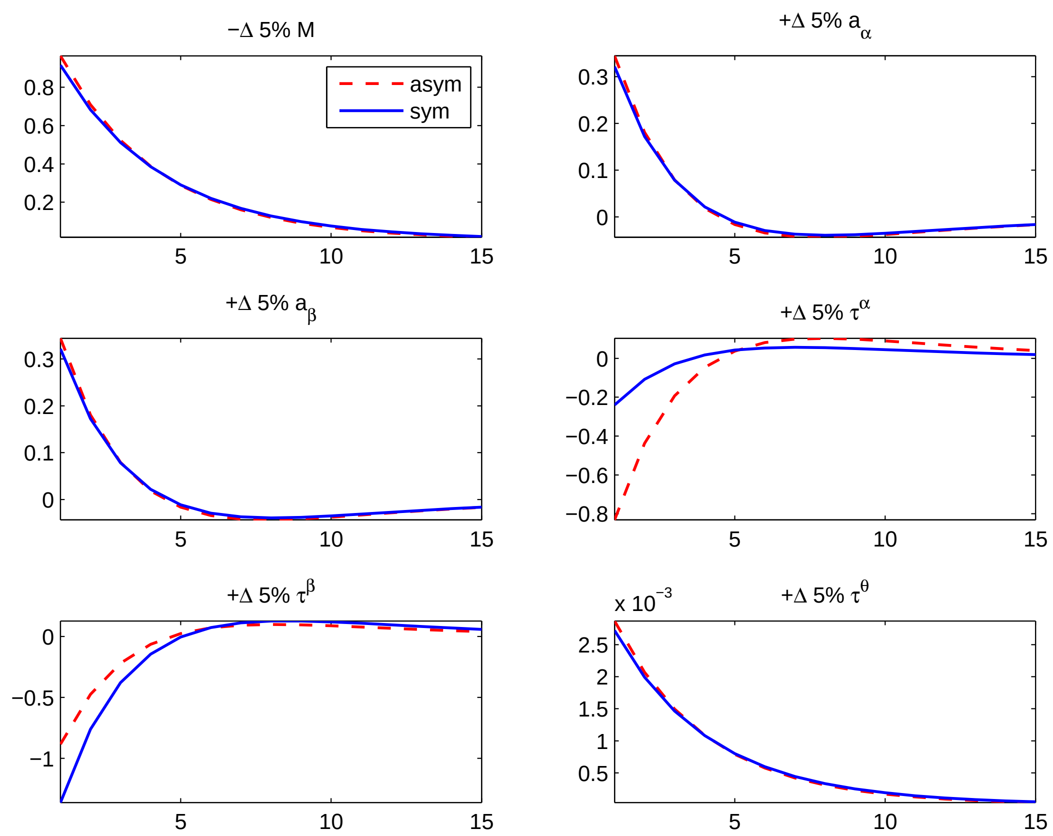


Figure 4.17: Impulse responses on liquidity (λ^α), % deviations from steady state

Chapter 5

Financial stability, liquidity and the pricing of sovereign debt

This chapter presents the application of a novel metric of financial fragility and tests its effects on the emerging markets sovereign debt spreads. Default probabilities and banking profit conditions are some times used to define financial stability. In this paper we work on the empirical estimation of these quantities and assess their impact on the determination of emerging market sovereign debt spreads. We further investigate the role of liquidity and fundamental variables in this context.[1]

5.1 Introduction

In this study we explore the link between sovereign bond spreads and domestic financial stability. Yield spreads, defined as the difference between the interest rate sovereign countries pay on their U.S. dollar denominated debt and the rate offered by the U.S. Treasury on debt of comparable maturity are a common measure of a country's borrowing cost in international capital markets. We are interested in answering the following questions: Do metrics of domestic financial stability help in explaining the cross sectional and times series pattern of emerging markets sovereign spreads? Do the liquidity conditions matter?

[1]This chapter is based entirely on Martinez, Juan Francisco, *Financial stability and the impact of shocks in emerging economies debt spreads*. Working Paper, Saïd Business School University of Oxford, this version: 2012. Based on a broader joint project with Dr. Jose Martinez (Faculty at Saïd Business School). However, all the work presented here is my exclusive authorship.

Domestic financial stability, which we proxy by the expected loss of the domestic banking system, should matter for sovereign yield spreads and bond pricing because in the event of a large financial meltdown sovereigns may decide to bail out failing domestic financial institutions. As Acharya and Hassan (2011) note, and as past (e.g. Argentina in the 80's) and recent (e.g. Ireland, Iceland) experience suggest, when countries bail out a failing banking sector, they dilute existing government bondholders, and their creditworthiness deteriorates. Financial stability measures with forecasting power over future financial and banking crises, and therefore over costly bailouts, should therefore contain information that one would expect to be immediately incorporated into sovereign bond yields (prices).[2]

We choose to concentrate on emerging economies that regularly raise dollar denominated debt. The impact of costly bailouts on bonds spreads can be especially large for an emerging country in which domestic bond markets are thin (Obstfeld et al., 2008).[3] We take as a starting point traditional models of sovereign bond spreads (Edwards, 1986, Gonzalez Rosada and Levy Yeyati, 2006, Hilscher and Nosbusch, 2010) who explain sovereign spreads as a function of country and global fundamentals (levels and variability). We argue that, domestic financial stability should also feature in these regressions (e.g. Ireland and Iceland were countries with otherwise good fundamentals in the recent past but the collapse of their banking sector, and the decision to bail it out, had catastrophic consequences for public finances). Additionally, we should control for international liquidity, since emerging economies are sensitive to variations in international financing costs (See Martinez, 2010).

The expected loss of the domestic banking system can be interpreted as the direct cost of financial instability/distress for the domestic public sector intent on bailing it out. Thus, it should be considered as part of the yield spread of emerging economies sovereign bonds. On the other hand, the international liquidity is an indicator of the

[2]Kaminsky and Reinhart (1999) find that problems in the banking sector typically precede currency crisis and falls of reserve backing.

[3]The fact that banks play a much larger role in emerging than in mature economies, as argued by Chang and Velasco (2001), further suggest that the impact on banking crisis on country creditworthiness could be even higher for this group of countries.

international demand for emerging market debt, if we think (as in Martinez, 2010) of a crowding out occurring when international investors face liquidity shortages. Both sources of risk (financial stability and liquidity) are behind a financial crisis, and if we follow Reinhart and Rogoff (2009), these are the source of a long period of credit depression and economic downturn.

As in Hartmann (2010), we acknowledge that the aggregation of the different types of financial risks do matter. Although we are not aggregating the risks, we are considering all of them simultaneously in the estimation section. We argue that in this way we can find the marginal contributions to the overall risk. Which in this case are found to be part of the emerging market sovereign debt risk premium. Our proposed methodology for the measurement of the expected losses of the banking system gives us the advantage to consider the *marginal* contributions to the overall risk. As opposed to just add arithmetically the individual losses, our metric captures the systemic component of risk that is intensified in cases of joint distress

The rest of the paper is organized as follows. The second section contains the motivation of our study. The third section contains a description of our proposed financial stability metric. In the fourth section, we include the data description. The fifth section contains the estimation results. Finally, the sixth section concludes.

5.2 Motivation

From the last financial crisis we can draw important lessons. One of particular interest for financial authorities is the need for operationalization of financial stability metrics as well as the correct procedure to relate and aggregate the different sources of risk. Depending on the impact on financial stability for each economy, authorities need to apply tailored policy responses to internal and external shocks. Thus, it is crucial to develop metrics with high predictive power and simple implementation, but also to assess their effect on countries asset prices and macroeconomic performance.

The development of theories supporting the generation of metrics of financial stability (or fragility) is key to the understanding of the elements that should be included in its definition and how they relate to each other. Financial stability metrics must be consistent with the financial economics theory, and should also illuminate the financial regulators, supervisors, and central banks decision making processes. Aspachs et al. (2007), Dubey et al. (2003, 2005), Espinoza et al. (2009, 2011), Goodhart et al. (2006), Goodhart and Segoviano (2009) and Tsomocos (2003), among others[4], have made efforts towards the characterization of financial stability empirically and theoretically. However, the majority of studies have focused on developed economies. Thus, there are still issues to be resolved, especially for emerging countries, where the heterogeneity and liquidity dependance are critical.

In this work we propose novel semi-parametric financial stability metric, and test its effect on emerging market bond spreads, controlling for fundamental variations and liquidity. That allows us to rationalize the risk premium elements of emerging market debt, connect them with economic performance, and derive macro-prudential policy recommendations, accordingly.

5.3 Measurement of financial fragility

Following Aspachs et al. (2007), a model-based financial fragility metric should include an estimate of the joint probabilities of default and profits of the banking sector. That allows us to obtain the credit and market components of risk. In this paper, as in Segoviano et al. (2009), we implement a metric of credit risk, based on a joint distributional estimation. The procedure considers the insights of that work about the usefulness and precision of a semi-parametric estimation, as opposed to the problems of making to many distributional assumptions. However, in contrast to the method mentioned in Segoviano et al. (2009) or Espinoza et al. (2011), our metric involves lower computer intensity.

[4] For a comprehensive literature review on systemic risk analysis, see Bisias et al, (2012).

According to Aspachs et al. (2007), we implement empirical tests based on both elements in financial stability: default and profits. We extend the default metric in Aspachs et al. (2007) and Segoviano et al. (2009) to an estimation of the expected *joint* loss (*JLoss*) of the banking sector (after recovery). On the other hand, we use information of banking profit margins. Additionally, as in Martinez (2010), we include an estimate to control for international liquidity risk.

5.3.1 Calculation of the JLoss

The *JLoss* calculation uses as inputs the expected default frequencies generated on a Merton (1974) contingent claims approach. We calculate these by using stock market and balance sheet data of commercial banks that are present in the stock market of a set of emerging economies. This is a standard approach. However, it has some limitations, since is relies on market information which does not have a high predictive power. Yet, these indicators of default are significantly more precise and reliable than those derived exclusively from accounting variables. In this analysis, we overcome another limitation of a Merton-like modelling of financial fragility, by considering the correlation structure, using a Vasicek (1977) approach.

Using the individual default probabilities we calculate at individual banks level, we apply an innovative semi-parametric method for calculating the overall JLoss for the banking sector of each country in the sample of emerging economies. This method is the *saddle point* approximation. It uses as inputs the individual probabilities recently described, the exposure in case of default, a loss given default (LGD) parameter, a correlation parameter with a systemic risk factor for each bank in a particular country, and some other parameters we will describe in detail. After we obtain the JLoss, and following Martin (2001) we calculate each country's marginal contribution to the total risk and relativize it with respect to the total liabilities. An overview of the methodology is presented in figure (5.1).

[Insert Figure (5.1) here]

5.3.2 Individual probabilities: distance-to-default

We describe how we calculate the default probabilities following a standard modification of the widely used Merton (1974) contingent claims distance-to-default approach. The modification we use appears in Kealhofer (2000), which is basically the popular Moody's KMV approach. The disadvantages of this approach include the need of a somewhat subjective estimation of the input parameters, the normality distribution assumption, the lack of use of some important accounting data and the difficulty to distinguish among the assets intrinsic characteristics, such as maturity and collateral. However, despite the disadvantages we mention, it is the relatively best procedure we can follow given the information available. The algorithm is described as follows.

We need information of the banks balance sheets and market prices: long and short term liabilities (L_{ST}, L_{LT}), short term assets (A_{ST}), average interest rates (r), time horizon (T), volatility of firm (bank) realized returns (σ_V), market capitalization (E) as a percentage. With this data we start constructing the default point (D^*), from equation (5.1) that comes from US historical data performed by KMV in Kealhofer (2000) and others.

$$D^* = L_{ST} + \frac{1}{2} \cdot L_{LT} \tag{5.1}$$

On the other hand, we solve a system of two non-linear equations, for the projected value of the assets ($\hat{V}$) and the projected implied asset volatility ($\hat{\sigma_A}$) of the banks. The first equation is the equity value as a function of the value and volatility of the equity (σ_E), which is calculated following a realized variance approach[5], the leverage (K), the average coupon paid (c) assumed equal to zero, and the average interest rate (r). Whereas the second equation relates the asset and equity volatility. The calculations we perform are consistent with our quarterly database. The system we solve appears in (5.2) and (5.3).

[5]We use the realized variance approach to estimate the quarterly equity volatility. Following Barndorf-Nielsen et al. (2002), we compute square root of the sum of squared daily equity returns over a quarter. That is, for every quarter and bank, we calculate $\sigma_E = \sqrt{\sum_{t=1}^{Q} r_t^2}$, where Q is the number of days in a particular quarter.

$$\frac{V}{E}\cdot\Phi(d_1)-\frac{e^{-rT}\cdot\Phi(d_2)}{E/D^*}-1=0 \tag{5.2}$$

$$\Phi(d_1)\cdot\frac{V}{E}\sigma_A-\sigma_E=0 \tag{5.3}$$

Where $d_1 = \log\left(V\cdot\frac{E}{D^*}\right)+\frac{\left(r+\frac{1}{2}\sigma_E^2\right)\cdot T}{\sigma_E\cdot\sqrt{T}}$, $d_2 = d_1-\sigma_E\cdot\sqrt{T}$ and Φ stands for the cumulative normal distribution function. The above system is solved numerically by using the Newton-Raphson algorithm, already programmed in Matlab ®, following Press et al. (2007).

Once we get the projected values $\hat{V}$ and $\hat{\sigma_A}$, we insert them into the distance to default DD equation (5.4). This is a function of the forecasted value of the value of the assets of bank and its forecasted asset volatility. Finally, we obtain the expected default frequency (EDF) as in equation (5.5), by assuming normality.

$$DD=\frac{\frac{\hat{V}}{E}-D^*}{\frac{\hat{V}}{E}\cdot\hat{\sigma_A}} \tag{5.4}$$

$$EDF=\Phi(-DD) \tag{5.5}$$

We compute this quantity for all of the banks in every country and time periods of our sample, and associate the expected default frequency value to the *unconditional* probability of default (p_{def_i}), one of the inputs for the saddle point method.

5.3.3 Saddle point method

We use the semi-parametric saddle point method to obtain an aggregate measure of bank projected losses. [6] Our goal is to estimate the complete distribution of potential banking system losses, and use this as a measure of credit risk at the national level for emerging economies.

[6]This section heavily relies on Martin et al. (2001). However, as opposed to the individual counterparts focus followed in that work, we apply it to the aggregate financial system.

Despite being quite useful, the usual way of calculating the credit risk losses (as the one proposed in Basel II accord) has some shortcomings. That methodology, requires a functional form of the distribution of losses (i.e. Normal distribution). Therefore, one should assume that losses are adjusted to it and also assume that this distribution will contain each of the defaults with the frequency assigned. This assumption is quite strong, because the estimated parameters of the distribution can lead to important errors in the calculation of losses. Being a method that works in the space of real numbers, it lacks a simple mathematical treatment that allows closed form calculations. The saddle point procedure allows simple calculations because it has the ability to provide statistical measures associated directly with credit risk. Another advantage is the speed of calculation in the computational implementation, because it can be presented in analytical formulas. It is also quite advantageous when trying to analyze large numbers of credit units.

The saddle point methodology procedure allows us to get a measure of the aggregated distribution of losses, which in turn depends on the individual default probabilities, the level of exposure and the loss given a default event. All of these are taken as given and consequently not further modelled. The individual probabilities of default are calculated following a Merton (1974) *distance to default* approach, based on market data for equity and assets, and book data for liabilities. On the other hand, exposure is proxied by the amount of liabilities at the moment of default and the loss given default (LGD) is set to a 45% as suggested by the Bank of International Settlements (BIS, 2006) for banking debt.

The key assumption in this approach is that individual risks are uncorrelated, conditional on being correlated to a systemic factor (or a reduced number of them). The systemic factors can be interpreted as real and/or financial variables. Some natural examples of these components are production or overall stock market performance.

The saddle point procedure allows us to simplify the calculations by previously working in a different space. We move from the real numbers to the moment generating functions space and work on the formulation of the losses there. By making some natural assumptions we apply a transform to go back getting a result in the real numbers space.

The saddle point method allows to calculate the distribution of a random variable P that represents the losses for a portfolio of a portfolio of N credit debt-holders.

$$P = \sum_{i=1}^{N} e_i \mathbb{1}_{D_i} \tag{5.6}$$

Where e_i is the exposure of counterpart i, and $\mathbb{1}_{D_i}$ is the indicator function that takes a value of zero if the client maintains its repayment capacity and it is equal to one otherwise.

The calculation of the losses will be determined by the distribution of the variable P, previously described (recall figure (5.1)).

We call for a workable description of the problem in the space of Moment Generating Functions (MGF). For it, we need to have the input data, and apply the necessary transform to get the equivalent exposure. Then it is required to determine the MGF, assuming a feasible functional form. That is statistically equivalent to the problem in the real numbers space. Although MGF do not have a direct economic interpretation, they are useful, since they can be easily constructed. The distribution functions (in $\mathbb{R}$) are equivalent to the MFG. The Laplace transform naturally connects the two spaces (from $\mathbb{R}$ to MGF). The *Bromwich integral* does the reverse process (from MGF to $\mathbb{R}$). From the last calculation it is obtained the name of the procedure, because it uses a mathematical property of this integral, which is that it accurately estimated in the region close to the *saddle point*.

For an arbitrary credit portfolio, the relationship between the probability density functions and the MGF is described in equation (5.7). The MGF is the expected value of exponential function (e^{sx}), where random variable is x, and s stands for the arbitrary Laplace transform parameter and f represents the probability density function.

$$M_x(s) = \mathbb{E}(e^{sx}) = \int e^{sx} f(x)\, dx \tag{5.7}$$

If we consider two states for the random variable (default and no default), we have a discrete MGF, described in (5.8)

$$M_i(s) = \mathbb{E}\left(e^{si}\right) = \sum_{\mathbb{1}_{D_i}=0,1} f(\mathbb{1}_{D_i})\, e^{s\cdot \text{expos}_i \cdot \mathbb{1}_{D_i}} = 1 - p_{def_i} + p_{def_i} e^{s\cdot \text{expos}_i} \tag{5.8}$$

In this case p_{def_i} is the *unconditional* default probability and expos_i is the exposure in the defined time horizon for counterpart i. If we assume *conditional independence*[7], under a discrete set of values of an underlying systemic factor, we can write the expression in (5.9) for the relationship between the *unconditional* (p_{def_i}) and *conditional* ($p_{def_i}(\vec{V})$) probabilities of default.

$$p_{def_i} = \sum_k p_{def_i}\left(\vec{V}_k\right) h\left(\vec{V}_k\right) \tag{5.9}$$

In the previous expression, $\vec{V}_k$ represents the k^{th} set of values of the underlying group of M systemic factors, $\vec{V} = \left\{V^1, V^2, ..., V^M\right\}$. Among these systemic factors or *credit drivers* we find variables of the economic cycle or fundamentals of the economy. On the other hand, $h(\vec{V})$ are the probability density of the credit drivers. Following Koyluoglu and Hickman (1996), we can write $h(\vec{V}) = h^1(V^1) \cdot h^2(V_2)...h^M(V^M)$, since the systemic factors are assumed to be uncorrelated.

Without loss of generality, and consistent with our method of estimation for the individual probabilities of default, we consider a unifactorial Merton-style model.[8] Assuming that $h(\vec{V})$ follows a Normal distribution, we have that based on Vasicek(2002), the condi-

[7]Conditional independence means that conditional on being correlated to a systemic factor, the counterparts have uncorrelated probabilities of default.

[8]This method can be easily extended to allow for multi-factor models.

tional probability in (5.9) can be written as in (5.10).

$$p_{def_i}(V) = P\left(Z \leq \Phi^{-1}\left(p_{def_i}|V\right)\right) = \Phi\left(\frac{\Phi^{-1}\left(p_{def_i}\right) - \rho \cdot V}{\sqrt{1-\rho^2}}\right) \tag{5.10}$$

Where ρ is the correlation to the systemic factor. In our case we use the correlation of the individual counterparts' (banks in our exercise) stock market returns, to the stock market index of its specific country of domicile. After these calculations, we are able to define the conditional and unconditional MGF, as a function of the underlying credit driver.

$$M(s|V) = \prod_{i=1}^{N} M_i(s) = \prod_{i=1}^{N} \left(1 - p_{def_i}(V)\left(e^{\text{expos}_i \cdot s}\right)\right) \tag{5.11}$$

In order to further simplify the calculations, we use the *cumulant* generating functions (K), defined as the logarithm of the MGF. Thus, $K(s|V) = \log(M(s|V))$. The useful property of this function is that all of the moments of the distribution described by the probability density $f(\cdot)$, can be generated by calculating the derivatives evaluated at $s = 0$. For instance, for the two first moments, we have $K'(s=0) = \mathbb{E}(x)$ and $K''(s=0) = \mathbb{V}\mathrm{ar}(x)$.

Once processed, the information for the individual counterparts, the calculations performed, and estimated the correlation structure, we are able to obtain the MGF in (5.11). After this, we need to reverse the process to come back to the space of real numbers and get the joint probability density of losses. To do that we need to calculate the inverse process of the Laplace transform. That is, the *Bromwich* integral. Under our *conditional independence* assumption, this integral takes the form in (5.12).

$$f(x) = \frac{1}{2\pi i}\int_{-\infty}^{+\infty}\left(\int_{-i\infty}^{+i\infty} e^{K(s|V) - s \cdot x} ds\right) h(V)\, dV \tag{5.12}$$

In order to solve the above integral, we need to use a particular property of this integral. Close to the saddle point of the argument of the exponential function in (5.12), the integral can be approximated with high level of accuracy. If we obtain the first order conditions for the argument of the exponential, we obtain that $\frac{d}{ds}(K(s) - s \cdot x)$, solving we have that $K'(s = \hat{t_V}) = x$. In the previous expression $\hat{t}$ is the saddle point of the integral. Also recall that s is the Laplace transform parameter and x is the random variable representing the losses due to default.

The expression in equation (5.9) in the continuous case appears in equation (5.13).

$$P(L > x) = \int_{-\infty}^{+\infty} P(L > x|V)\, h(V)\, dV = \frac{1}{2\pi i} \int_{-\infty}^{+\infty} \left(\int_{-i\infty}^{+i\infty} e^{K(s|V) - s \cdot x} ds \right) h(V)\, dV \quad (5.13)$$

With the use of the saddle point property, the distribution of portfolio losses can be approximated by (5.14).

$$P(L > x) \approx \begin{cases} e^{\left(K(\hat{t_V}|V) - x \cdot \hat{t_V} + \frac{1}{2}\hat{t_V} K''(\hat{t_V})\right)} \Phi\left(-\sqrt{\hat{t_V}^2 K''(\hat{t_V})}\right), & \text{if } x \leq \mathbb{E}(L) \\ \frac{1}{2}, & \text{if } x = \mathbb{E}(L) \\ 1 - e^{\left(K(\hat{t_V}|V) - x \cdot \hat{t_V} + \frac{1}{2}\hat{t_V} K''(\hat{t_V})\right)} \Phi\left(-\sqrt{\hat{t_V}^2 K''(\hat{t_V})}\right), & \text{if } x > \mathbb{E}(L) \end{cases} \quad (5.14)$$

In order to be able to manage the integral approximation, we need to discretize the expression in (5.13). For the general case, in a multi-factor setting, we would have the formula in (5.15). Recall that in our case M, the number of systemic factors is set to one.

$$P(L > x) \approx \sum_{k_1} \dots \sum_{k_M} P\left(L > x | \vec{V} = \{V_{k_1}, \dots, V_{k_M}\}\right) h(V_{k_1}) \dots h(V_{k_M}) \quad (5.15)$$

To solve the the expression in (5.15) it is necessary to use a quadrature. In our case we are using the Gauss-Hermite. By applying the Bayes theorem in (5.15), we get the expression in (5.16).

$$P(L > x) \approx \sum_j P(j)\, P(L > x|j)\, h(V_{k_1}) \ldots h(V_{k_M}) \tag{5.16}$$

Where j is the state of the underlying systemic factor, thus $P(L > x|j)$ is the probability that the losses are greater than x for the systemic credit factor configuration V. On the other hand $P(j)$ is the probability that the economy latent variable V is in the state j and it corresponds to the quadrature weight h_{k_i}. Finally, the marginal contributions to the overall risk (from a particular bank, to the entire financial system of a country) are obtained following Martin (2001). [9]

5.4 Data and variable construction

As described in section (5.3) we calculate our proposed financial stability metric. That is, we obtain the individual probabilities of default by using a distance to default approach. Using individual probabilities of default for each bank in the country, we generate an aggregate measure of the systemic credit risk at the country level. The procedure used to calculate the credit risk, the JLoss, is based on the saddle point approximation technique discussed in Martin (2001). This procedure requires as inputs the individual probabilities of default, the exposure (banks' liabilities), loss given default (LGD) coefficient, and an estimate of the correlation between assets and the systemic component.

[Insert table (5.1) here]

Table (5.1) shows the parametrization we utilize for the construction of our metric. These are characterizations of the resulting distribution and precision of the method. The time horizon is set to 1 quarter; the number of systemic factors will be 1; the number of nodes of the integral approximation is 7; we assume that losses upon default of the banking system in a country are between 1% and 4.8%, based on Chilean banking

[9] The Gauss-Hermite quadrature solves integrals of the form $I = \frac{1}{2\pi}\int_{-\inf}^{+\inf} e^{-\frac{x^2}{2}} f(x)dx$, as the sum $I = \sum_{i=1}^{n} w_i \cdot f(x_i)$. In our case we are using $n = 7$. Therefore, we need to compute 7 saddle points. In the standard numeric calculus literature, the quadrature is already tabulated to a generic integral. We have just to adjust it to our particular problem.

data. The precision of the calculations will be at 99%. Finally we assume that the systemic factor is normally distributed, varying between -4% and 4%. This can be easily interpreted as a GDP variation.

[Insert tables (5.2) and (5.3)]

The data used for the JLoss calculation and posterior empirical estimation is described in table (5.2). For the calculation of the Jloss we use a combination of daily and quarterly data for a set of banks distributed among a selected group of emerging economies (see table (5.3)). To obtain the expected default frequency, we need the stock market prices for the banks' shares, we use these to compute the estimated volatility of the equity. In addition, we need long and short term liabilities, short term assets, average interest rates, volatility of firm (bank) realized returns and market capitalization. With this information we construct the default point and estimate the EDF according to the methodology discussed in section (5.3). In tables (5.4) and (5.5) we present the averages of the bank market capitalization and balance sheet information.

[Insert Table (5.4)]

It can be observed that the largest banking system's market capitalizations in our sample are located in China, South Africa, Brazil and Russia. On the other hand, healthy (during the recent years) banking systems present high level of profits (e.g. Chile). In terms of assets' size, the biggest banking systems are located in China, South Africa, Brazil and Russia. Additionally, in order to give an order of magnitude, we also present country average data of the banks' income statement including the whole time horizon, computed quarterly. We can observe that countries that suffered from banking crises during the recent years (e.g. Argentina, Malaysia) present average negative profits.

[Insert table (5.5)]

In case of liquidity and profitability variables, in this study are used as additional controls that could be directly relevant for sovereign bond pricing (see Aspachs et al.

2007; IMF, 2008; or Martinez, 2010) and could also qualify the impact of the joint probability of default on yield spreads. They are perhaps part of a broad definition of financial stability. We use Libor-OIS spread (overnight index swap rate minus the Libor); and ABCP spread (difference between the asset backed commercial paper rate and the US Treasury bill 3M). Our profitability variable is the lagged one year profit margin of the publicly traded banks in each economy.

Additionally, we use the set of more traditional variables capturing fundamentals (country-specific and global financial variables) used in our regressions (see Edwards (1986), Gonzalez-Rozada and Levy-Yeyati 2006 and Martinez 2010). As country-specific fundamentals, the baseline model of sovereign debt yields includes GDP per capita (in logs), inflation, gross central government debt to GDP, volatility of real exchange rate. According to Cantor and Packer (1996), sovereign credit ratings are useful to describe sovereign fundamental variations, in our case we use the sovereign credit rating of bonds traded in foreign currency, delivered by S&P and Moody's credit agencies. We transform this measure to a numerical value from 1 to 21 (SD-AAA), as in Martinez (2010) and Afonso et al. (2007). In case of global financial factors, we include US treasury yield (10Y), US high yield (10Y) and VIX index. The information of our database appears in table (5.2).

5.5 Results

5.5.1 Metric results

We present the results of expected default frequencies for the banks included, across the pool of countries in our sample. In figure (5.2) we show the country average and 95% confidence interval of the EDFs that we computed. We can observe that for countries affected by the Asian crisis (2001-2002) the expected default frequency had values around 1% with a high volatility. The most dramatic cases are Argentina, Mexico and Panama. Additionally, we observe that during the sub-prime crisis (2007-2009) most of the emerging countries included in our sample present an increase in the expected default frequencies. By simple inspection of these plots we can conclude that the latter crisis affected emerging economies more systemically. Although the level of expected default are lower than in the Asian crisis (around 0.5%).

[Insert Figure (5.2) here]

The JLoss calculation results are summarized in figure (5.3). We present the quarterly average metric of JLoss over the period comprehended between the first quarter of 1999 and the second quarter of 2011. It can be observed that the metric starts increasing at the end of 2007, it has a peak in the middle of the sub-prime crisis (3rd quarter of 2008) and it decreases until the beginning of 2010. The peak is around 10% of expected joint losses for emerging economies, a non trivial figure. However, the 95% interval increases around that date, which means that the crisis did not affect all emerging countries with the same impact. The latest financial crisis affected considerably more the vulnerable countries that were driven mostly by systemic variations.

[Insert Figure (5.3) here]

Based on the results obtained, we can corroborate that the Jloss metric we constructed at country level assess has a desirable property. It predicts accurately the intervals of banking financial fragility and consider the systemic component of this variation at the same time. This is relevant, since as Mendoza and Quadrini (2010) observe, this crisis had - is having? - a greater impact into emerging and developed economies because of the more pronounced economic and financial markets globalization. This suggests that this metric can be considered as a factor for emerging market debt. In the next section we present a comprehensive model of emerging market spreads that includes this metric as one of the explanatory variables.

5.5.2 Empirical analysis

We follow the general principles in Edwards (1986), Gonzalez-Rozada and Levy-Yeyati (2006), Powell and Martinez (2008) and Hilscher and Nosbusch (2010), to construct a model for emerging market sovereign debt spreads. The general specification appears in equation (5.17). Note that i stands for countries and t for time periods, that are quarters in our case.

$$\begin{aligned}\log(EMBI\ spread)_{i,t} = \alpha + \beta * \log(fundamentals)_{i,t} \\ + \gamma(financial fragility)_{i,t} \\ + \delta(global financial factors)_{t} \\ + \eta(Liquidity)_{t} + \varepsilon_{i,t}\end{aligned} \tag{5.17}$$

The EMBI spreads constitute our dependant variable. These are defined as the spreads between a composite of emerging market sovereign bonds returns and the US treasury (with similar maturities). As we described in section (5.4), the fundamentals are accounted by a metric of creditworthiness and/or macroeconomic performance. In case of the creditworthiness, as suggested by Cantor and Packer (1996), credit ratings represent sovereign fundamental variations. Accordingly, we use the credit rating for sovereign long term bonds issued in foreign currency, prepared by Standard and Poor's and Moody's credit rating agencies. In order to use this ordinal variable, as in Afonso (2006) and Powell and Martinez (2008), we convert them to a numerical scale from 1 to 21, where 1 stands for sovereign default (SD) rating and 21 is for AAA or Aaa ratings for Standard and Poord and Moody's, respectively. On the macroeconomic indicators, we follow Powell and Martinez (2008), by including debt to GDP ratio, GDP per capita, volatility of exchange rates and inflation in different specifications. The financial fragility will be measured with our JLoss default metric and the banking systems' average profit margins, as suggested by Aspachs et al. (2007). Global financial factors, as in Gonzalez-Rozada and Levy-Yeyati (2006), are measured by the US treasury (10Y) yield, the US High Yield (10Y), and the VIX index of volatility of the stock market. Finally, for the liquidity metric, as suggested by IMF (2008), we use the asset backed commercial paper spread over treasury bill (ABCP spread) and the spread between the overnight index swap and the Libor interbank rate (Libor-OIS spread).

Our identification strategy follows Uribe and Yue (2006). We assume that liquidity and global financial factors are exogenous to emerging market debt spreads, since emerging economies (except for China) would not affect the global financial markets. We also assume that contemporaneous macroeconomic and financial factors performance affect spreads, but not the other way. This implies that credit costs (spreads) have a (relatively) long run impact on the real economy, banking sector, and the global financial markets equilibria. Whereas the spread reaction to these elements happens in the short term.

We conduct a series of panel data regressions for the 20 countries in our sample, on a quarterly basis, from the period comprehended between the first quarter of 1999 and the second quarter of 2011. We use fixed effects (within estimator), to control for country specific effects. We do not include the time effects since the time dimension is mostly captured in our set of global financial factors and fragility metric. It is important to notice that most of the regressions performed have an R-squared (within) that lies above 40%, which is a high indicator of goodness of fit in panel data.

Tables (5.6), (5.7), (5.8) and (5.9) show the results of panel data regressions. Table (5.6) shows the regressions performed when including the S&P credit rating as of a country's fundamental value. We included versions with the current and lagged JLoss metric (we prefer the latter specification, since JLoss is a forward looking variable), with the two different metrics for liquidity (Libor-OIS and ABCP spreads) and with/without the US Treasury (10Y) rate (in absence we avoid multi-colinearity with the US High yield).

[Insert tables (5.6) to (5.9) here]

We observe that a higher creditworthiness (i.e credit rating) implies a reduction in sovereign debt spreads. The results also show a strong relation of spreads with financial fragility, especially with the JLoss metric. Although, as compared to credit ratings, it has a lower economic impact on spreads, the JLoss shows a high statistical significance in all the specifications, and it influences EMBI spreads towards a higher value when banking conditions are more fragile. In case of the profit margin variable, it influences the EMBI spreads towards a lower value when banking profitability increases. This variable is statistically significant for the majority of our specifications. The global financial factors play an important role in the determination of EMBI spreads variations, as measured by their statistical significance. The VIX has the most robust impact. We observe that when there is more volatility in international financial markets (proxied by US), the EMBI spreads increase. Finally, the evidence shows that market (ABCP spread) and funding (LIBOR-OIS) spreads have an impact EMBI spreads. An increase of the Libor-OIS spread (higher illiquidity) determines that EMBI spreads increase, since it reflects the *crowding out* effect (i.e. lower international demand for riskier instruments when liquidity conditions are tighter). The ABCP acts in the opposite direction because it captures *substitutability* between the international markets debt and sovereign instruments. International financial markets become riskier in the middle of a funding liquidity episode, thus, emerging market debt becomes more attractive, increasing its demand and lowering its spreads. See Martinez (2010) - Chapter 2 - for more details.

Table (5.7) uses Moody's credit ratings for sovereign debt issued in foreign currency as part of the fundamental value. It presents similar results than table (5.6). However, the magnitude of effect of the JLoss (lagged) metric on EMBI spreads is lower. This is consistent by the definition of this rating, since it is supposed to capture the expected losses from a sovereign default, not just the default probabilities (as S&P, see Moody's (2004)).

[Insert tables (5.10) to (5.12) here]

Finally, tables (5.8) and (5.9) depict the results by including GDP per capita and inflation as a measure of the sovereign fundamental value. In table (5.8), we can observe that the GDP per capita variable has a high statistical significance and goes in the *right* direction, since an increase in GDP per capita implies a reduction in EMBI spreads. In this specification, as we do not (fully) control for creditworthiness, debt to GDP has a higher statistical significance, as compared to the regressions with ratings. However, it has a somewhat counterintuitive sign, although its explanation is quite natural. A higher debt to GDP ratio seems to be a sign of over-leverage, but it is mainly explained by the fact that safer countries have a wider access to the international financial markets. Hence they can contract - and supposedly - afford to have a high leverage. In this setting, funding liquidity (Libor-OIS) plays a more important role (see columns 9 to 12), and implies that tight international financial conditions are associated to higher emerging market debt, as we previously mentioned. If we include inflation (see table (5.9)), the effect of financial fragility (JLoss) persists. In this case, there is evidence that more inflation is associated with higher EMBI spreads (see columns (6) and (7)). However this effect is not sufficiently robust across specifications.

[Insert Figure (5.4) here]

Additionally, as a robustness check for the possible endogeneity issues in our panel data specification, following Holz-Eakin et al. (1988), and Love and Zicchino (2006), we conduct a panel VAR(vector auto-regression) analysis (in tables (5.10), (5.11) and (5.12)), considering a subset of the variables that appear in (5.17). The estimators are obtained by GMM, based on Arellano and Bover (1995). We can observe that the effects of fundamentals, financial fragility, liquidity and global financial factors are comparatively stronger than the effects in the opposite direction, consistently with our identification strategy. If we focus on table (5.10), we can observe that the effect of financial stability (Jloss metric and profit margins) in the immediate preceding quarter is statistically significant. The higher the estimated JLoss, the riskier the banking sector; hence, it implies a higher EMBI spread the next period. Whereas an increase in current profit margins of the banking sector has a positive impact, by reducing the cost of sovereign debt. However, due to the high volatility of these data, and the lack of sufficient observations, make this effect to reverse its sign in posterior quarters. This pattern is observed also in tables (5.11) and (5.12), but in these cases we also control for fundamental and international liquidity variations, respectively. Finally, in figure (5.4), we show the impulse response plots of a selected group of variables that appear in the basic panel VAR model we show in table (5.10). The results suggest that after a shock on the JLoss, there is an long-lasting increase in emerging market debt spreads, although its magnitude is small (see plot (3)). Consistently with our panel data regressions, we observe that after a positive shock on profit margins, there is a decrease in emerging market debt spreads (see plot (4)). However, it produces an increase of spreads in the long run and the effect is not statistically robust.

5.6 Concluding remarks

In this paper we use a novel metric to assess financial fragility. This is a non-parametric procedure that measures systemic banking default risk. We investigate its properties during the financial crisis and test its relevance for emerging market sovereign debt pricing, controlling for other fundamental values, global financial conditions, and liquidity variations.

Our proposed metric is capable to successfully predict and characterize systemic financial crises in emerging economies.

We observe that financial fragility (measured by the JLoss metric and banking profitability) is suggested to explain cross section and time series patterns of emerging market debt spreads. Additionally, consistently with Martinez and Tsomocos (2011), we detect that, even controlling by specific country fundamentals and global financial conditions, international liquidity remains relevant. This finding stresses the fact that emerging markets are strongly sensitive to international financing conditions, and that liquidity and financial fragility should be studied contemporaneously. This relation is suggested to be absent from reverse causality. Spreads seem to follow financial fragility and liquidity, at least in theory (See Goodhart et al. (2006)). However, there is little empirical evidence in the literature about this direction of causality. Thus, the present study is not absent from reverse causality issues that we leave for future research.

The fact that financial fragility is an important determinant for emerging market debt has policy implications. The treasuries, financial regulators, banking supervisors, and monetary authorities should operate coordinately when measuring financial fragility and issuing debt. The monetary authorities in emerging countries should closely monitor the external liquidity and be prepared to facilitate it when it is needed. The financial regulators and supervisors, in coordination with the monetary authorities should be aware of financial risks, in order to implement appropriate and prompt policies. Finally, when issuing debt, the treasuries should be coordinated with the the other authorities. Analyzing the divergences between sovereign economic fundamentals and the emerging market debt spreads would reduce the cost of credit in emerging economies, where this would highly impact long term macroeconomic performance.

Possible extensions of this work are classified in two dimensions. On the one hand, we propose to further investigate the properties of our proposed metric with more granular data (at banks' clients level; firms or individuals). We should also work in solving the remaining endogeneity issues of the empirical estimation by implementing a co-integration-based approach.

5.7 Appendix

5.7.1 Tables

Table 5.1: Parametrization JLoss calculation (saddle point method)

This is applied to all the countries in our sample

Parameter	Value
Time horizon	1 quarter
LGD	45%
Approximation nodes	7
Number of factors	1
Lower bound losses	0.010
Upper bound losses	0.048
Number of steps	500
Percentile	0.99
Systemic driver	N(0, 0.16%)

Table 5.2: Database

Variable	Level	Frequency	Use	Source
Rating S&P (scale 21 AAA - 1 SD, logs)	country	quarterly	regressions	Bloomberg
Rating Moody's (scale 21 Aaa- 1 SD, logs)	country	quarterly	regressions	Bloomberg
GDP per capita (USD logs)	country	quarterly	regressions	IFS
Debt to GDP (logs)	country	quarterly	regressions	IFS
Inflation (%)	country	quarterly	regressions	IFS
ABCP spread (logs)	country	quarterly	regressions	Bloomberg
Libor-OIS spread (logs)	country	quarterly	regressions	Bloomberg
VIX (logs)	country	quarterly	regressions	Bloomberg
US Treasury 10Y (logs)	country	quarterly	regressions	Bloomberg
US High Yield 10Y (logs)	country	quarterly	regressions	Bloomberg
Profit Margin (MMUSD, logs)	bank	quarterly	regressions	Bloomberg
Volatility exchange rate (%)	country	quarterly	regressions	Bloomberg, own calculations
JLoss metric (Tot Loss/Tot Liab, logs, t-1)	country	quarterly	regressions	Bloomberg, own calculations
JLoss metric (Tot Loss/Tot Liab, logs, t)	country	quarterly	regressions	Bloomberg, own calculations
Exchange rates (in USD terms)	country	daily	regressions	Bloomberg
Inflation (%)	country	daily	regressions	Bloomberg
Stock market index	country	daily	Calculation JLoss	Bloomberg
Stock price returns	bank	daily	Calculation JLoss	Bloomberg
Long term liabilities (MMUSD)	bank	quarterly	Calculation JLoss	Bloomberg
Short term assets (MMUSD)	bank	quarterly	Calculation JLoss	Bloomberg
Average bank interest rates (%)	bank	quarterly	Calculation JLoss	Bloomberg
Market capitalisation (MMUSD, %)	bank	quarterly	Calculation JLoss	Bloomberg
Volatility of stock price returns	bank	quarterly	Calculation JLoss	Bloomberg, own calculations
Correlation to systemic factor (stock returns)	bank	quarterly	Calculation JLoss	Bloomberg, own calculations

Table 5.3: Countries and banks

Total Banks: 287, total number of countries: 20. From 1990 to 2011, depending on availability.

Country	Banks	Country	Banks	Country	Banks
Argentina	7	Egypt	14	Philippines	18
Brazil	23	Indonesia	29	Poland	15
Bulgaria	6	Malaysia	12	Russia	29
Chile	7	Mexico	6	South Africa	8
China	17	Pakistan	23	Turkey	17
Colombia	10	Panama	5	Venezuela	13
Croatia	19	Peru	9		

Table 5.4: Market capitalization

For all banks in every country, quarterly data MMUSD.

Country	Average	Std. Dev.	Country	Average	Std. Dev
Argentina	878	593	Mexico	5.132	3.484
Brazil	6.243	15.725	Pakistan	400	688
Bulgaria	221	242	Panama	462	167
Chile	2.300	2.988	Peru	1.182	1.739
China	40.651	64.955	Philippines	481	773
Colombia	1.532	2.274	Poland	2.614	4.033
Croatia	451	1.169	Russia	4.387	13.355
Egypt	343	595	South Africa	4.897	5.355
Indonesia	1.166	2.590	Turkey	2.728	4.607
Malaysia	2.320	3.526	Venezuela	444	6.358

Table 5.5: Average balance sheet data

For all open banks in every country, quarterly data MMUSD.

Country	LT Liabilities	ST Liabilities	Total Assets	Cash and Investments	Net Income	Net Revenues	Profit margin
Argentina	210	1.316	6.375	884	13	148	- 25
Brazil	3.670	5.073	49.292	11.472	216	1.460	16
Bulgaria	442	11	1.430	268	6	22	27
Chile	2.685	1.177	19.432	1.611	71	282	27
China	6.207	33.721	299.260	66.231	1.518	4.257	31
Colombia	1.181	364	11.215	992	67	430	16
Croatia	181	89	1.077	270	8	35	6
Egypt	50	114	3.539	920	18	50	10
Indonesia	206	270	6.820	1.128	32	125	15
Malaysia	819	2.733	21.865	4.101	52	202	- 72
Mexico	491	1.277	20.231	2.674	113	457	16
Pakistan	298	171	3.655	551	20	83	- 7
Panama	925	900	5.066	401	22	52	68
Peru	398	489	5.398	1.097	30	140	8
Philippines	73	304	4.010	693	9	63	- 3
Poland	471	1.547	13.274	1.658	46	204	18
Russia	3.791	1.515	24.971	3.228	87	575	10
South Africa	2.303	2.378	54.315	3.583	342	1.917	23
Turkey	519	2.877	16.501	2.035	92	357	32
Venezuela	213	167	8.649	1.639	72	349	27

Table 5.6: Emerging market bond spreads regressions (I)

Dependant variable: EMBI spreads (rate of return above US Treasury bond 10Y).

Fundamental value: S&P sovereign credit rating foreign currency bonds.

Robust t-statistic in parenthesis. (*,**,***) significant at (10%,5%,1%), respectively.

From 1999 to 2011, depending to availability.

EMBI spread (logs)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Rating S&P (scale 21 AAA - 1 SD, logs)	-1.294	-1.283	-1.372	-1.362	-1.206	-1.184	-1.354	-1.340	-1.419	-1.378	-1.368	-1.368	-1.364	-1.312	-1.364	-1.366
	(32.10)***	(28.84)***	(41.39)***	(43.67)***	(22.68)***	(19.95)***	(39.72)***	(37.44)***	(29.24)***	(32.39)***	(40.15)***	(42.34)***	(32.74)***	(31.89)***	(38.84)***	(37.73)***
Debt to GDP (logs)			-0.006	-0.005			-0.017	-0.017			-0.005	-0.005			-0.015	-0.013
			(0.40)	(0.36)			(0.91)	(0.96)			(0.36)	(0.35)			(0.84)	(0.89)
ABCP spread (logs)	-0.044	-0.038	0.003	-0.019	-0.089	-0.080	-0.040	-0.057								
	(1.95)*	(1.70)*	(0.13)	(0.83)	(4.09)***	(3.84)***	(1.65)*	(2.53)**								
Libor-OIS spread (logs)									0.058	0.028	0.041	0.009	-0.029	-0.039	-0.023	-0.050
									(1.82)*	(0.94)	(1.31)	(0.31)	(0.87)	(1.31)	(0.73)	(1.62)
JLoss metric (Tot Loss/Tot Liab, logs, t-1)	0.162	0.160	0.219	0.206					0.210	0.212	0.231	0.218				
	(4.10)***	(4.01)***	(5.89)***	(5.16)***					(5.67)***	(5.40)***	(6.26)***	(5.45)***				
JLoss metric (Tot Loss/Tot Liab, logs, t)					0.181	0.186	0.246	0.229					0.200	0.212	0.250	0.237
					(4.64)***	(4.73)***	(7.01)***	(6.48)***					(4.37)***	(5.07)***	(6.83)***	(6.19)***
VIX (logs)	0.476	0.384	0.353	0.531	0.483	0.354	0.344	0.477	0.224	0.435	0.288	0.533	0.394	0.455	0.369	0.560
	(5.21)***	(4.62)***	(3.91)***	(7.74)***	(5.28)***	(5.03)***	(4.43)***	(8.17)***	(2.02)**	(4.46)***	(2.83)***	(6.65)***	(3.38)***	(5.61)***	(3.90)***	(7.85)***
US Treasury 10Y (logs)	0.174		-0.365		0.282		-0.286		-0.378		-0.428		-0.139		-0.343	
	(1.43)		(2.80)***		(2.48)**		(2.38)**		(2.54)**		(3.19)***		(0.98)		(2.64)***	
US High Yield 10Y (logs)	0.676	0.717	0.434	0.416	0.666	0.727	0.529	0.513	0.350	0.355	0.342	0.326	0.429	0.432	0.450	0.447
	(5.05)***	(5.04)***	(2.75)***	(2.56)**	(5.13)***	(5.40)***	(3.98)***	(3.93)***	(2.40)**	(2.50)**	(2.11)**	(1.89)*	(2.92)***	(3.06)***	(3.25)***	(3.31)***
Volatility exchange rate (%)	0.021	0.020	0.012	0.037	0.071	0.039	-0.025	0.008	0.026	0.024	0.014	0.040	0.075	0.072	-0.023	0.006
	(4.26)***	(3.99)***	(0.21)	(0.75)	(1.30)	(0.72)	(0.62)	(0.21)	(6.52)***	(5.34)***	(0.24)	(0.82)	(1.15)	(1.27)	(0.56)	(0.14)
Profit Margin (logs)	-0.120	-0.121	-0.057	-0.074	-0.067	-0.067	-0.034	-0.041	-0.092	-0.106	-0.054	-0.074	-0.049	-0.047	-0.035	-0.044
	(3.64)***	(3.69)***	(1.96)*	(2.62)***	(2.21)**	(2.18)**	(1.41)	(1.67)*	(2.45)**	(2.71)***	(1.89)*	(2.66)***	(1.48)	(1.41)	(1.44)	(1.76)*
Constant	5.394	5.780	6.194	5.450	4.702	5.250	5.752	5.168	7.068	6.008	6.458	5.489	5.932	5.394	5.852	5.039
	(9.85)***	(14.00)***	(16.14)***	(18.57)***	(10.87)***	(13.38)***	(16.11)***	(18.90)***	(11.10)***	(13.42)***	(15.20)***	(18.22)***	(10.66)***	(12.64)***	(13.05)***	(15.80)***
Observations	222	222	143	143	231	231	148	148	206	206	142	142	214	214	146	146
Number of group(countries)	14	14	11	11	15	15	11	11	14	14	11	11	15	15	11	11
Rsq-Overall	0.83	0.82	0.92	0.91	0.81	0.80	0.92	0.91	0.85	0.84	0.92	0.91	0.83	0.83	0.92	0.92
Rsq-Within	0.73	0.72	0.88	0.87	0.74	0.73	0.89	0.89	0.75	0.74	0.88	0.87	0.75	0.75	0.89	0.88
Rsq-Between	0.93	0.93	0.92	0.92	0.81	0.80	0.92	0.93	0.94	0.93	0.92	0.93	0.83	0.82	0.92	0.93

Table 5.7: Emerging market bond spreads regressions (II)

Dependant variable: EMBI spreads (rate of return above US Treasury bond 10Y).

Fundamental value: Moody's sovereign credit rating foreign currency bonds.

Robust t-statistic in parenthesis. (*,**,***) significant at (10%,5%,1%), respectively.

From 1999 to 2011, depending to availability.

EMBI spread (logs)	(1)	(2)	(7)	(8)	(9)	(10)	(15)	(16)	(3)	(4)	(5)	(6)	(11)	(12)	(13)	(14)
Rating Moody's (scale 21 Aaa - 1 SD, logs)	-1.724	-1.786	-1.861	-1.881	-1.373	-1.328	-1.843	-1.850	-1.725	-1.731	-1.841	-1.858	-1.628	-1.498	-1.837	-1.842
	(10.86)***	(14.28)***	(10.08)***	(10.31)***	(4.84)***	(4.54)***	(9.95)***	(10.04)***	(13.45)***	(12.73)***	(10.33)***	(10.33)***	(7.90)***	(5.11)***	(9.82)***	(9.75)***
Debt to GDP (logs)			-0.026	-0.026			-0.029	-0.029			-0.026	-0.026			-0.029	-0.029
			(3.24)***	(3.22)***			(3.50)***	(3.48)***			(3.25)***	(3.22)***			(3.50)***	(3.47)***
ABCP spread (logs)	-0.092	-0.100	-0.048	-0.074	-0.118	-0.110	-0.073	-0.092								
	(3.40)***	(3.73)***	(1.42)	(2.22)**	(4.94)***	(4.72)***	(2.87)***	(3.43)***								
Libor-OIS spread (logs)									0.042	0.007	0.033	-0.011	-0.028	-0.040	-0.002	-0.042
									(1.08)	(0.20)	(0.84)	(0.29)	(0.69)	(1.10)	(0.05)	(0.90)
JLoss metric (Tot Loss/Tot Liab, logs, t-1)	0.121	0.090	0.105	0.087					0.138	0.137	0.126	0.105				
	(2.92)***	(2.28)**	(1.73)*	(1.47)					(3.50)***	(3.40)***	(2.29)**	(1.92)*				
JLoss metric (Tot Loss/Tot Liab, logs, t)					0.169	0.175	0.115	0.091					0.140	0.168	0.107	0.085
					(3.43)***	(3.49)***	(1.54)	(1.26)					(2.44)**	(2.90)***	(1.34)	(1.05)
VIX (logs)	0.492	0.403	0.312	0.540	0.499	0.381	0.403	0.552	0.236	0.485	0.235	0.576	0.400	0.485	0.356	0.627
	(4.51)***	(4.32)***	(2.56)**	(5.29)***	(5.12)***	(4.91)***	(3.57)***	(6.36)***	(1.73)*	(4.49)***	(1.68)*	(5.12)***	(2.90)***	(5.19)***	(2.42)**	(6.11)***
US Treasury 10Y (logs)	0.142		-0.463		0.250		-0.314		-0.454		-0.594		-0.216		-0.477	
	(1.05)		(2.52)**		(2.06)**		(1.85)*		(2.61)***		(3.14)***		(1.27)		(2.45)**	
US High Yield 10Y (logs)	0.788	0.919	0.789	0.779	0.637	0.683	0.792	0.800	0.430	0.438	0.595	0.594	0.440	0.383	0.627	0.641
	(4.99)***	(5.67)***	(4.22)***	(3.90)***	(4.65)***	(4.90)***	(4.94)***	(4.80)***	(2.49)**	(2.62)***	(3.40)***	(3.22)***	(2.86)***	(2.56)**	(3.87)***	(3.99)***
Volatility exchange rate (%)	0.014	0.011	-0.020	0.001	0.112	0.088	-0.021	0.003	0.016	0.016	-0.024	0.001	0.095	0.122	-0.015	0.013
	(4.35)***	(3.21)***	(0.42)	(0.02)	(2.13)**	(1.67)*	(0.42)	(0.06)	(4.43)***	(4.84)***	(0.52)	(0.04)	(1.80)*	(2.17)**	(0.28)	(0.25)
Profit Margin (logs)	-0.116	-0.117	-0.067	-0.086	-0.077	-0.076	-0.074	-0.088	-0.107	-0.120	-0.070	-0.096	-0.082	-0.073	-0.078	-0.096
	(3.81)***	(4.09)***	(1.85)*	(2.30)**	(2.37)**	(2.30)**	(1.93)*	(2.31)**	(3.50)***	(3.62)***	(2.00)**	(2.62)***	(2.35)**	(1.98)**	(1.99)**	(2.36)**
Constant	6.519	7.062	7.877	6.973	5.333	5.758	7.462	6.891	8.250	7.092	8.287	6.953	7.159	6.222	7.987	6.882
	(8.67)***	(12.48)***	(9.58)***	(8.65)***	(5.47)***	(5.95)***	(7.76)***	(7.27)***	(9.64)***	(10.58)***	(8.44)***	(8.08)***	(6.54)***	(5.73)***	(6.19)***	(6.04)***
Observations	222	222	143	143	231	231	148	148	206	206	142	142	214	214	146	146
Number of group(countries)	14	14	11	11	15	15	11	11	14	14	11	11	15	15	11	11
Rsq-Overall	0.75	0.75	0.77	0.76	0.72	0.71	0.77	0.77	0.74	0.73	0.77	0.76	0.72	0.71	0.77	0.76
Rsq-Within	0.42	0.41	0.51	0.50	0.46	0.45	0.53	0.53	0.42	0.41	0.51	0.49	0.43	0.43	0.52	0.51
Rsq-Between	0.95	0.95	0.84	0.84	0.83	0.84	0.84	0.85	0.96	0.94	0.84	0.84	0.86	0.84	0.83	0.85

Table 5.8: Emerging market bond spreads regressions (III)

Dependant variable: EMBI spreads (rate of return above US Treasury bond 10Y).

Fundamental value: GDP per capita (logs)

Robust t-statistic in parenthesis. (*,**,***) significant at (10%,5%,1%), respectively.

From 1999 to 2011, depending to availability.

EMBI spread (logs)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
GDP per capita (logs)	-0.562	-0.535	-1.026	-1.026	-0.599	-0.542	-0.845	-0.840	-0.674	-0.579	-0.940	-0.942	-0.677	-0.610	-0.808	-0.813
	(3.70)***	(3.77)***	(4.67)***	(4.52)***	(3.66)***	(3.93)***	(3.92)***	(3.86)***	(4.18)***	(4.01)***	(4.17)***	(4.06)***	(4.20)***	(4.52)***	(3.63)***	(3.60)***
Debt to GDP (logs)			-0.153	-0.153			-0.121	-0.120			-0.136	-0.136			-0.114	-0.115
			(3.46)***	(3.36)***			(2.77)***	(2.74)***			(2.98)***	(2.92)***			(2.56)**	(2.55)**
ABCP spread (logs)	0.029	0.029	0.202	0.194	0.005	-0.004	0.101	0.093								
	(1.03)	(1.05)	(3.15)***	(2.87)***	(0.14)	(0.12)	(1.48)	(1.33)								
Libor-OIS spread (logs)									0.175	0.143	0.213	0.182	0.101	0.081	0.106	0.089
									(3.91)***	(3.66)***	(2.63)***	(2.16)**	(1.93)*	(1.72)*	(1.01)	(0.87)
JLoss metric (Tot Loss/Tot Liab, logs, t-1)	0.204	0.214	0.461	0.432					0.263	0.267	0.441	0.409				
	(3.84)***	(4.06)***	(4.75)***	(4.40)***					(4.96)***	(4.84)***	(4.73)***	(4.31)***				
JLoss metric (Tot Loss/Tot Liab, logs, t)					0.220	0.230	0.488	0.451					0.222	0.230	0.477	0.462
					(4.10)***	(4.33)***	(4.80)***	(4.22)***					(3.03)***	(3.12)***	(4.20)***	(3.86)***
VIX (logs)	0.467	0.531	-0.053	0.166	0.523	0.565	0.090	0.216	0.208	0.363	-0.379	-0.166	0.366	0.458	-0.108	-0.004
	(3.75)***	(4.11)***	(0.16)	(0.54)	(4.43)***	(4.60)***	(0.27)	(0.71)	(1.58)	(2.81)***	(1.05)	(0.47)	(2.85)***	(3.80)***	(0.29)	(0.01)
US Treasury 10Y (logs)	-0.249		-1.172		-0.210		-0.666		-0.756		-1.200		-0.447		-0.555	
	(1.48)		(2.24)**		(1.20)		(1.27)		(2.83)***		(2.03)**		(1.54)		(0.83)	
US High Yield 10Y (logs)	0.190	0.179	-0.303	0.092	0.133	0.138	-0.128	0.110	-0.376	-0.077	-0.176	0.355	-0.110	0.052	0.084	0.331
	(0.72)	(0.66)	(0.61)	(0.17)	(0.50)	(0.53)	(0.25)	(0.21)	(1.08)	(0.25)	(0.29)	(0.61)	(0.33)	(0.19)	(0.13)	(0.60)
Volatility exchange rate (%)	0.092	0.123	0.049	0.108	0.056	0.086	-0.026	0.023	0.125	0.165	0.041	0.094	0.075	0.103	-0.030	-0.004
	(1.13)	(1.41)	(0.69)	(1.57)	(0.88)	(1.17)	(0.30)	(0.28)	(1.35)	(1.70)*	(0.59)	(1.36)	(0.96)	(1.21)	(0.34)	(0.04)
Profit Margin (logs)	-0.085	-0.085	0.129	0.080	-0.048	-0.052	0.068	0.033	-0.029	-0.076	0.138	0.090	-0.035	-0.061	0.071	0.049
	(1.84)*	(1.82)*	(1.46)	(0.95)	(1.14)	(1.22)	(0.83)	(0.42)	(0.50)	(1.44)	(1.57)	(1.09)	(0.62)	(1.14)	(0.85)	(0.60)
Constant	7.008	6.221	11.491	8.822	6.917	6.072	9.258	7.849	9.330	6.867	11.698	8.796	8.399	6.852	9.027	7.705
	(4.22)***	(4.68)***	(4.42)***	(4.10)***	(3.73)***	(4.39)***	(3.23)***	(3.21)***	(4.85)***	(4.82)***	(3.95)***	(3.81)***	(3.68)***	(4.31)***	(2.49)**	(2.76)***
Observations	173	173	116	116	177	177	119	119	157	157	115	115	160	160	117	117
Number of group(countries)	11	11	9	9	11	11	9	9	11	11	9	9	11	11	9	9
Rsq-Overall	0.15	0.16	0.36	0.34	0.15	0.18	0.35	0.34	0.19	0.20	0.36	0.34	0.17	0.19	0.34	0.34
Rsq-Within	0.51	0.50	0.42	0.40	0.53	0.53	0.46	0.46	0.53	0.51	0.45	0.43	0.54	0.53	0.46	0.46
Rsq-Between	0.08	0.10	0.33	0.30	0.13	0.16	0.32	0.29	0.08	0.09	0.31	0.28	0.11	0.13	0.33	0.31

Table 5.9: Emerging market bond spreads regressions (IV)

Dependant variable: EMBI spreads (rate of return above US Treasury bond 10Y).

Fundamental value: GDP per capita (logs) and Inflation(%)

Robust t-statistic in parenthesis. (*,**,***) significant at (10%,5%,1%), respectively.

From 1999 to 2011, depending to availability.

EMBI spread (logs)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GDP per capita (logs)	-0.573	-0.171	-0.947	-0.803	-0.576	-0.233	-0.885	-0.747
	(3.59)***	(3.25)***	(3.83)***	(3.41)***	(3.96)***	(4.36)***	(3.51)***	(3.05)***
Inflation (%)	-0.011	0.011	0.033	0.007	-0.020	0.037	0.037	0.025
	(1.24)	(1.59)	(1.64)	(0.69)	(1.45)	(2.68)***	(1.73)*	(1.61)
Debt to GDP (logs)			-0.149	-0.115			-0.139	-0.113
			(3.19)***	(2.51)**			(2.95)***	(2.43)**
ABCP spread (logs)	0.054	-0.107	0.129	0.084				
	(1.60)	(1.87)*	(1.68)*	(1.21)				
Libor-OIS spread (logs)					0.183	-0.050	0.108	0.072
					(3.08)***	(0.62)	(1.05)	(0.68)
JLoss metric (Tot Loss/Tot Liab, logs, t-1)	0.233		0.374		0.296		0.352	
	(4.58)***		(3.84)***		(5.56)***		(3.71)***	
JLoss metric (Tot Loss/Tot Liab, logs, t)		0.393		0.403		0.353		0.357
		(4.20)***		(3.26)***		(3.22)***		(2.78)***
VIX (logs)	0.521	-0.108	0.269	0.217	0.254	0.138	0.047	0.045
	(4.15)***	(0.44)	(0.80)	(0.72)	(1.85)*	(0.51)	(0.11)	(0.13)
US High Yield 10Y (logs)	0.125	0.956	0.165	0.162	-0.076	0.465	0.408	0.448
	(0.43)	(2.41)**	(0.31)	(0.31)	(0.26)	(1.14)	(0.70)	(0.81)
Volatility exchange rate (%)	0.136	-0.002	0.065	0.033	0.178	0.064	0.045	-0.012
	(1.44)	(0.02)	(0.85)	(0.38)	(1.73)*	(0.77)	(0.59)	(0.13)
Profit Margin (logs)	-0.084	-0.034	0.061	0.015	-0.084	-0.010	0.066	0.010
	(1.82)*	(0.49)	(0.70)	(0.17)	(1.61)	(0.14)	(0.76)	(0.12)
Constant	6.474	3.038	8.337	7.838	7.038	3.388	8.207	7.623
	(4.46)***	(2.74)***	(3.64)***	(3.19)***	(4.59)***	(2.42)**	(3.29)***	(2.72)***
Observations	173	177	116	119	157	160	115	117
Number of group(countries)	11	11	9	9	11	11	9	9
Rsq-Overall	0.15	0.28	0.35	0.34	0.18	0.32	0.35	0.35
Rsq-Within	0.51	0.43	0.36	0.45	0.52	0.38	0.37	0.41
Rsq-Between	0.09	0.42	0.31	0.30	0.07	0.40	0.31	0.35

Table 5.10: Panel VAR regression results (I)

Fundamental value: none

From 1999 to 2011, depending to availability.

No. Observations: 165

	EMBI spread (logs) (t)			Profit margin (logs) (t)			JLoss metric (% of total liab, logs) (t)		
Variable	coefficient	se	t-stat GMM	coefficient	se	t-stat GMM	coefficient	se	t-stat GMM
EMBI spread (logs) (t-1)	1.046	0.137	7.657	0.090	0.271	0.334	0.333	0.222	1.499
Profit margin (logs) (t-1)	-0.012	0.046	-0.270	0.199	0.118	1.684	0.116	0.082	1.405
JLoss metric (% of total liab, logs) (t-1)	0.135	0.074	1.821	-0.198	0.173	-1.143	0.740	0.142	5.203
EMBI spread (logs) (t-2)	-0.154	0.126	-1.220	-0.466	0.310	-1.504	-0.177	0.214	-0.827
Profit margin (logs) (t-2)	0.074	0.031	2.419	0.097	0.075	1.289	0.091	0.059	1.555
JLoss metric (% of total liab, logs) (t-2)	-0.141	0.067	-2.104	-0.029	0.198	-0.144	0.209	0.127	1.640
EMBI spread (logs) (t-3)	0.009	0.112	0.079	0.087	0.237	0.368	0.209	0.197	1.058
Profit margin (logs) (t-3)	-0.051	0.026	-1.951	0.336	0.080	4.201	0.018	0.062	0.283
JLoss metric (% of total liab, logs) (t-3)	0.029	0.057	0.504	0.176	0.139	1.271	0.022	0.105	0.213

Table 5.11: Panel VAR regression results (II)

Fundamental value: Rating S&P (scale 21 AAA - 1 SD, logs)

From 1999 to 2011, depending to availability.

No. Observations: 150

	EMBI spread (logs) (t)			Profit margin (logs) (t)			JLoss metric (% of total liab, logs) (t)			Rating S&P (scale 21 AAA - 1 SD, logs) (t)		
Variable	coefficient	se	t-stat GMM	coefficient	se	t-stat GMM	coefficient	se	t-stat GMM	coefficient	se	t-stat GMM
EMBI spread (logs) (t-1)	1.062	0.204	5.213	-0.075	0.435	-0.173	0.686	0.511	1.342	-0.023	0.055	-0.418
Profit margin (logs) (t-1)	-0.016	0.054	-0.287	0.156	0.151	1.030	0.171	0.148	1.161	0.006	0.011	0.501
JLoss metric (% of total liab, logs) (t-1)	0.122	0.066	1.844	-0.196	0.178	-1.102	0.725	0.173	4.196	0.004	0.012	0.341
Rating S&P (scale 21 AAA - 1 SD, logs) (t-1)	-0.017	1.049	-0.016	-2.181	2.354	-0.926	4.399	2.774	1.586	1.044	0.188	5.566
EMBI spread (logs) (t-2)	-0.137	0.125	-1.092	-0.454	0.347	-1.306	-0.197	0.285	-0.690	0.003	0.034	0.101
Profit margin (logs) (t-2)	0.092	0.048	1.909	0.053	0.115	0.465	0.168	0.125	1.352	-0.008	0.012	-0.616
JLoss metric (% of total liab, logs) (t-2)	-0.136	0.071	-1.918	-0.054	0.205	-0.261	0.250	0.193	1.291	-0.005	0.013	-0.366
Rating S&P (scale 21 AAA - 1 SD, logs) (t-2)	0.493	0.481	1.026	0.875	0.904	0.968	-0.526	1.006	-0.523	-0.055	0.242	-0.228
EMBI spread (logs) (t-3)	0.014	0.146	0.097	-0.105	0.342	-0.306	0.452	0.382	1.182	0.005	0.032	0.155
Profit margin (logs) (t-3)	-0.056	0.026	-2.117	0.337	0.095	3.545	0.016	0.094	0.172	0.005	0.007	0.709
JLoss metric (% of total liab, logs) (t-3)	0.040	0.076	0.525	0.081	0.171	0.474	0.154	0.198	0.777	0.025	0.017	1.508
Rating S&P (scale 21 AAA - 1 SD, logs) (t-3)	-0.157	0.459	-0.342	-1.320	0.657	-2.008	0.095	0.938	0.101	0.116	0.254	0.458

Table 5.12: Panel VAR regression results (III)

Fundamental value: Rating S&P (scale 21 AAA - 1 SD, logs). Liquidity control: Libor-OIS spread (logs)

From 1999 to 2011, depending to availability.

No. Observations: 162

	EMBI spread (logs) (t)			Profit margin (logs) (t)			JLoss metric (% of total liab, logs) (t)			Rating S&P (scale 21 AAA - 1 SD, logs) (t)			Libor-OIS spread (logs) (t)		
Variable	coefficient	se	t-stat GMM	coefficient	se	t-stat GMM	coefficient	se	t-stat GMM	coefficient	se	t-stat GMM	coefficient	se	t-stat GMM
EMBI spread (logs) (t-1)	1.159	0.585	1.982	-0.448	1.030	-0.435	1.819	2.135	0.852	0.014	0.095	0.144	1.269	1.470	0.863
Profit margin (logs) (t-1)	0.034	0.086	0.397	0.152	0.153	0.992	0.261	0.308	0.845	0.008	0.015	0.559	0.123	0.218	0.566
JLoss metric (% of total liab, logs) (t-1)	0.111	0.086	1.286	-0.142	0.174	-0.818	0.727	0.325	2.239	0.003	0.015	0.192	0.169	0.198	0.852
Rating S&P (scale 21 AAA - 1 SD, logs) (t-1)	0.724	1.860	0.389	-1.911	3.245	-0.589	6.922	6.710	1.032	1.114	0.257	4.336	2.557	4.713	0.543
Libor-OIS spread (logs) (t-1)	0.139	0.057	2.467	-0.005	0.105	-0.048	0.249	0.185	1.346	0.004	0.009	0.422	0.503	0.131	3.847
EMBI spread (logs) (t-2)	0.001	0.262	0.005	-0.648	0.478	-1.355	0.657	0.961	0.683	0.010	0.040	0.244	-0.079	0.617	-0.129
Profit margin (logs) (t-2)	0.133	0.110	1.208	-0.058	0.177	-0.327	0.408	0.385	1.062	-0.005	0.019	-0.266	0.307	0.271	1.132
JLoss metric (% of total liab, logs) (t-2)	-0.081	0.103	-0.782	0.078	0.182	0.430	0.395	0.348	1.135	-0.002	0.015	-0.136	0.068	0.257	0.267
Rating S&P (scale 21 AAA - 1 SD, logs) (t-2)	0.643	0.720	0.893	0.571	1.151	0.496	0.746	2.211	0.337	0.001	0.269	0.002	1.817	1.818	0.999
Libor-OIS spread (logs) (t-2)	-0.084	0.144	-0.582	0.102	0.230	0.444	-0.480	0.509	-0.944	0.002	0.021	0.070	0.033	0.359	0.091
EMBI spread (logs) (t-3)	0.307	0.283	1.086	-0.134	0.591	-0.227	1.140	1.061	1.074	0.040	0.041	0.962	-0.231	0.714	-0.324
Profit margin (logs) (t-3)	-0.018	0.088	-0.209	0.180	0.148	1.218	0.264	0.318	0.831	0.014	0.012	1.165	0.044	0.223	0.197
JLoss metric (% of total liab, logs) (t-3)	0.095	0.194	0.492	-0.138	0.309	-0.445	0.525	0.688	0.763	0.040	0.030	1.312	0.048	0.476	0.102
Rating S&P (scale 21 AAA - 1 SD, logs) (t-3)	-0.005	0.563	-0.008	-1.846	0.770	-2.396	1.264	1.750	0.722	0.139	0.247	0.560	-1.118	1.543	-0.725
Libor-OIS spread (logs) (t-3)	-0.184	0.209	-0.881	0.301	0.393	0.764	-0.790	0.759	-1.042	-0.034	0.031	-1.095	-0.167	0.522	-0.320

5.7.2 Figures

5.7.2.1 Methodology

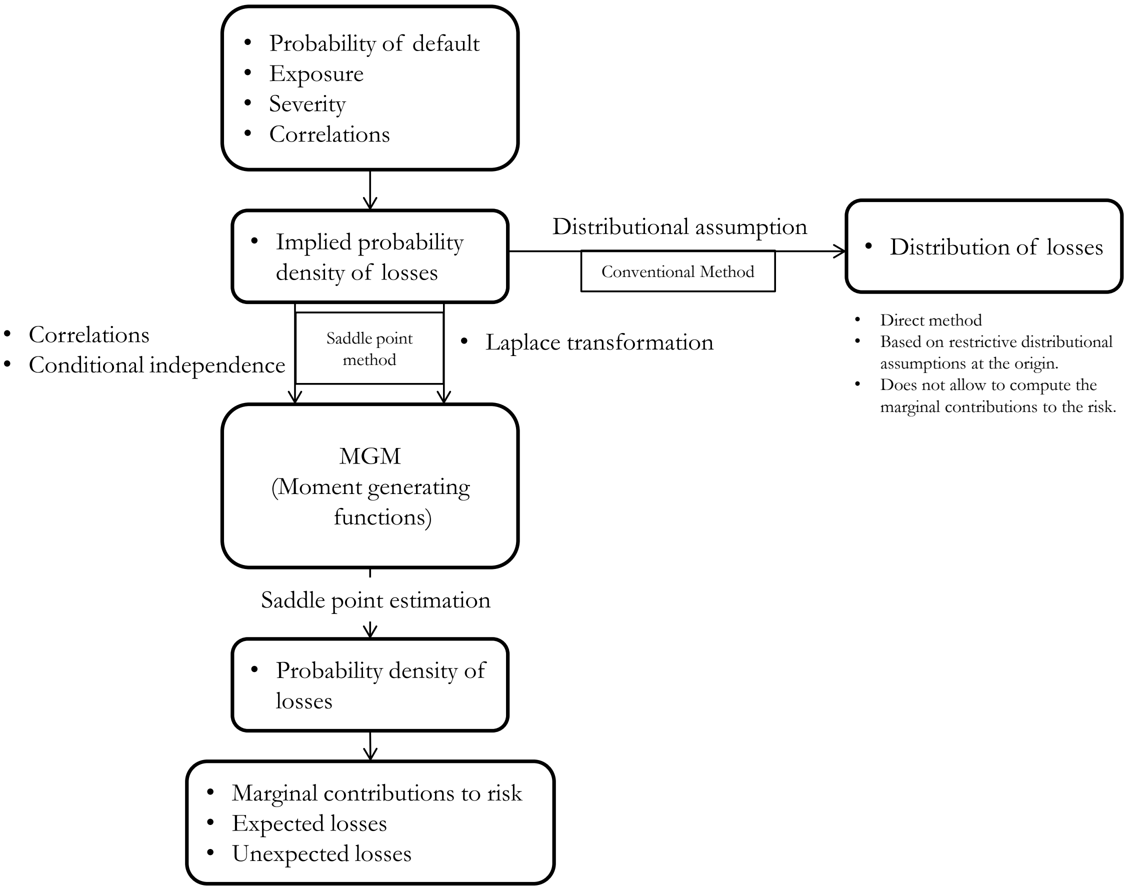


Figure 5.1: Calculation methodology scheme

5.7.2.2 Results: Calculation JLoss

A. Expected default frequency

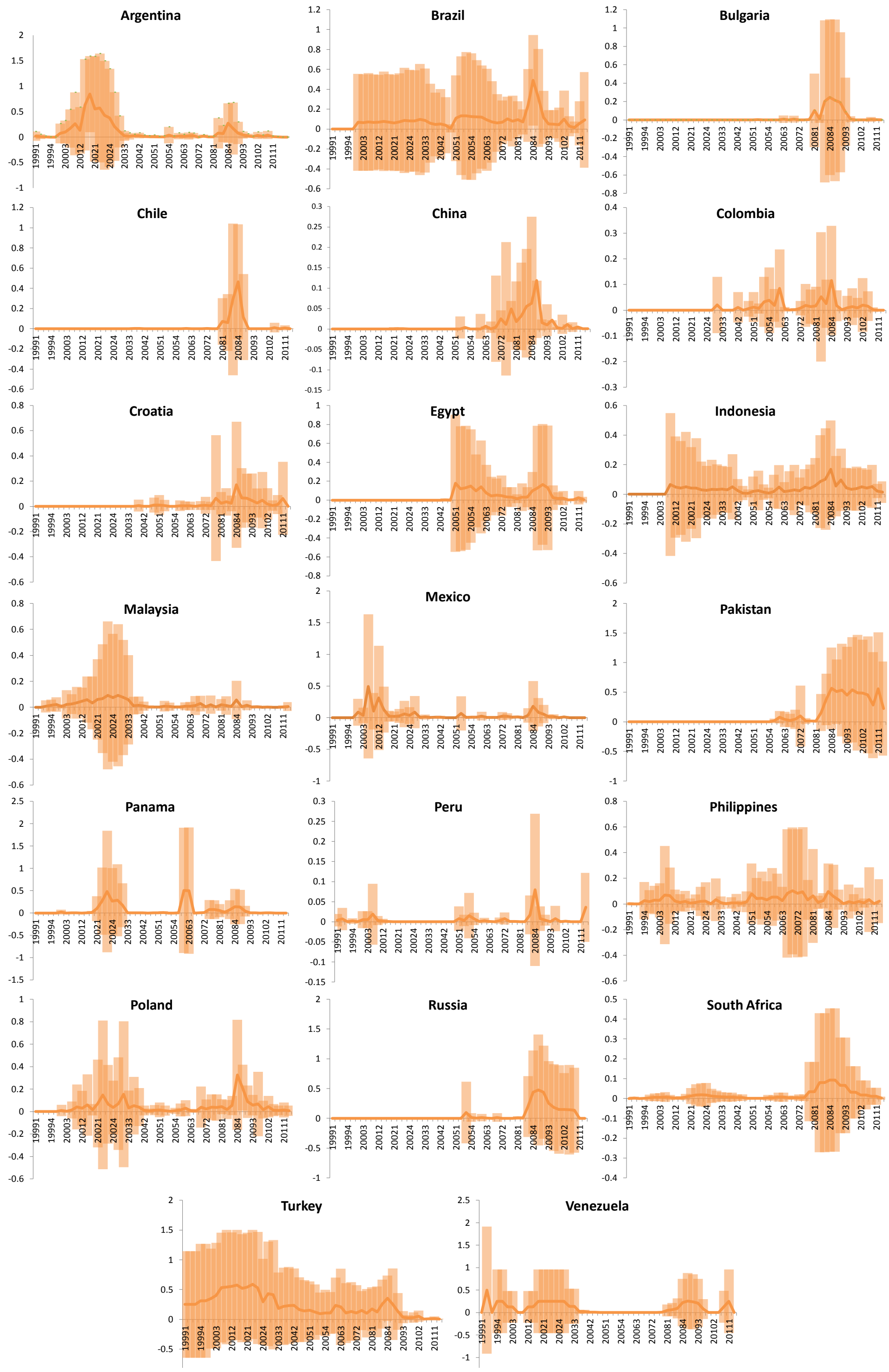


Figure 5.2: Expected default frequencies - Country level

(selected emerging market economies, %. Lines: intra-country averages. Bars: 95% confidence interval)

B. JLoss

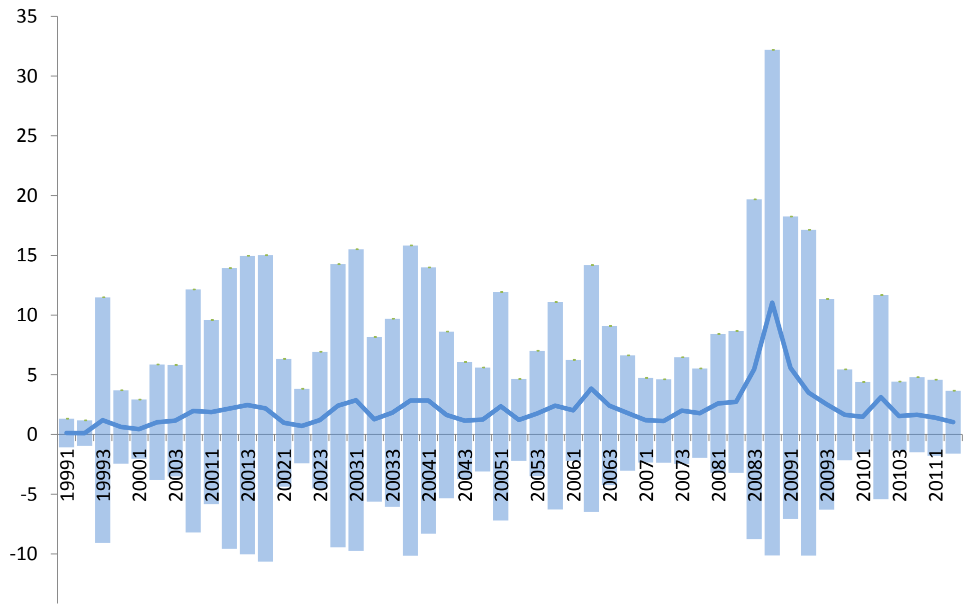


Figure 5.3: Expected default frequencies: JLoss/Exposure

(Line: average banking system for 21 selected emerging market economies, %. Bar: 95% confidence interval.)

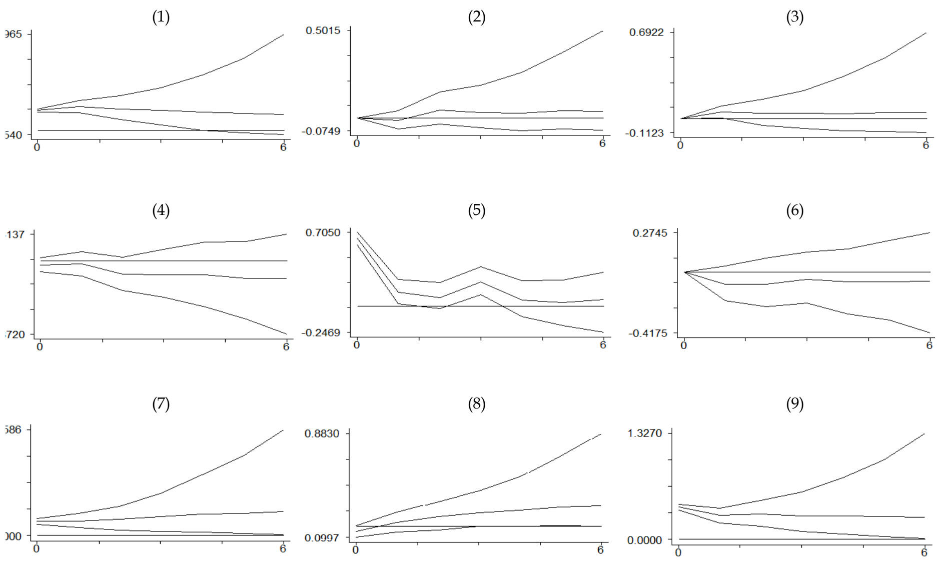


Figure 5.4: Panel VAR. Impulse-response functions

(Includes 95% confidence interval.)

(1): response of spread to spread shock; (2): response of spread to profit margin shock; (3): response of spread to *JLoss* shock; (4): response of profit margin to spread shock; (5): response of profit margin to profit margin shock;(6): response of profit margin to *JLoss* shock; (7): response of *JLoss* to spread shock;(8): response of *JLoss* to profit margin shock; (9): response of *JLoss* to *JLoss* shock

Chapter 6

Conclusion

Monetary policy cannot be thought of in isolation. Although there is a solid theoretical research about the stabilization of price levels, there are important gaps in the study of the assurance of payment systems. This has been demonstrated especially during the last decade of financial fragility. In order to fulfill their objectives, monetary authorities, regulators and banking supervisors are increasingly taking financial stability into account as part of their objectives. However, there is no consensus about its definition, treatment and effects.

In this thesis work I have presented a set of essays which combine empirical and theoretical aspects to develop a comprehensive framework for asset prices, financial stability and economic resilience, under the presence of financial frictions, with a special focus on money, default and liquidity.

The first chapter analyzes the recent events in the global financial markets and its effects on the emerging markets cost of debt. I selected a time horizon around the financial crisis of 2006-2008 where the spread compression and decompression phenomena are defined and described. The spread compression occurred before July of 2007 whereas the decompression started after that date. This work finds the determinants of emerging market spreads through time. Market and funding liquidity started to matter after the beginning of the crisis period. The implied asset pricing model for emerging market debt derived, from this empirical work, incorporates countries' fundamental values and liquidity risk premium, which has increasing importance in periods of highly volatile financial markets. I have demonstrated that emerging market debt spreads are sensitive to international liquidity, which in turn depends on the monetary policy of international investor countries, exemplified by the US economy. Although creditworthiness has been stable for emerging economies during the financial crisis, the international liquidity shortage caused a serious decrease of prices of emerging market debt. From this finding I suggest that during turbulent times for international investors, emerging market countries should implement liquidity oriented policies as a substitute for the scarcity of external financing. Furthermore, I emphasize the timing of those policies. Thus, governments should be prepared to take rapid and appropriate action. And from this I develop a benchmark model that allows policy makers to disentangle the possible adverse consequences produced by liquidity reduction. This type of model would be helpful as a stress test tool especially for the financial sector.

In the second chapter, I have developed a model that includes agent heterogeneity, liquidity and default in a pure exchange economy. I have extended the GEI monetary equilibrium type of models to the infinite horizon and dynamic stochastic setting. This extension allows for an analysis of the medium run effects of real and financial shocks, which is not possible in other models. This model, by including a liquidity friction, is capable of addressing issues of financial stability and its economic consequences. In contrast to the existing mainstream financial macroeconomic models, it does not rely on restrictive assumptions and incorporates money as one of the fundamental elements of analysis. Paradoxically, money is not present in most of the models applied in central banking because most of these models use a representative agent type of economy, where trade is absent, and so there is no reason for the inclusion of means of payment. Consequently, there is no role for liquidity either. That is why default cannot be an equilibrium phenomenon in this type of model. In contrast, the results of this chapter suggest that liquidity and default in equilibrium should be studied contemporaneously. This is an argument indicating, that the model presented in this chapter, is relevant for the analysis of monetary shocks and financial stability. In addition, the presence of financial frictions underlines the importance of studying the impact of shocks on financial variables and welfare. Unlike New-Keynesian models, there is no need to resort to an artificial fixing of prices to obtain equilibria that possess real as well as nominal determinacy. The chapter offers a preliminary analysis of financial stability, and shows that it offers potential for further research.

The third chapter deepens the model by including two additional elements: production technology and endogenous liquidity. The inclusion of production technology permits the construction of a gross domestic product indicator that facilitates the welfare analysis in the presence of incomplete markets. The liquidity analysis is based on a key distinction between funding and market liquidity. Funding liquidity is modeled as inside money, whereas market liquidity is the portion of liquid revenues that agents obtain directly from their sales. This portion is determined by the commodity seller, but it involves a cost. This model allows for the examination of the relation between market and funding liquidity and its effect on financial stability and economic performance. This work suggests that once funding liquidity becomes scarce, market liquidity grows as an expensive alternative, but is comparatively more costly than credit. Because of this increased cost of funds, there is a short run improvement in financial stability, because of the disincentives to over-leverage. However, inflation may increase in the medium term, and produce an inefficient allocation of resources, reducing welfare. This result replicates what appears to be the present situation in advanced and emerging economies, characterized by a stagflation-type of equilibrium.

In Chapters 2 to 4 of this thesis I elucidated several important issues about financial stability. These chapters do not tackle the issue of the operationalization of the financial stability definition. In Chapter 5, I return to the empirical work and apply a novel semi-parametric measure of financial fragility for the banking systems of emerging economies. The chapter includes a discussion and an explanation for the relationship among liquidity, asset prices, financial stability and economic performance.

These chapters provide a complete framework for the analysis of financial stability and economic responses to financial and real shocks in the presence of financial frictions. I suggest plausible explanations for financial and economic issues that conventional models have not dealt with satisfactorily.

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