Essays in Macroeconomic and Macroprudential Policies

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ESSAYS IN MACROECONOMIC AND MACROPRUDENTIAL POLICIES

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In this dissertation, I focus on macroeconomic and macroprudential policies. In Chapter 1, I study the effectiveness of macroprudential policy tools on bank risk. The findings show that although macroprudential policy tools can stabilize the financial system, under certain conditions, they might have perverse effects. In Chapter 2, I examine monetary aggregates, and show that once measured correctly, they can be useful in gauging the stance of monetary policy. In Chapter 3, by studying the determinants of sovereign debt crises, I aim at improving our understanding of sovereign debt distress, and also strengthening the toolkit for crisis prevention.

Chapter 1: Following the 2007-2009 financial crisis, there has been an increase in the use of macroprudential policy tools – such as loan-to-value ratio caps and interbank exposure limits – to achieve financial stability. Existing research on the effectiveness of macroprudential policy has focused on country-level variables such as total credit growth and house price inflation. In *"The Effectiveness of Macroprudential Policy on Bank Risk,"* I study how the effectiveness of macroprudential policy varies across banks and policy tools. Using system GMM on bank-level data from 30 European countries for the time period between 2000 and 2014, I document that stricter regulation in the form of exposure limitations tends to decrease banks' risk levels whereas capital-based tools tend to induce higher risk-taking. After a policy tightening, loan loss provisions and non-performing loans ratios of banks suffering losses can increase substantially, up to five percentage points, while they are likely to decrease for profitable banks. Constraining activities by stricter regulation can lead to a search for yield. Therefore, policy designers should pay particular attention to the increase in risk-taking following policy tightening, especially by banks suffering losses.

Chapter 2: It is crucial for policymakers to successfully gauge the stance of monetary policy and understand the mechanisms through which it affects the economy.

Conventional models focus on interest rates alone, and omit monetary aggregates from policy discussions. In *"Do Monetary Aggregates Belong in a Monetary Model? Evidence from the UK,"* I examine whether augmenting the measure of monetary policy with monetary aggregates helps in drawing more robust links between policy and economic fluctuations. After constructing the Divisia money index for the United Kingdom, I employ structural vector autoregression to identify two different episodes of UK monetary policy regimes. Inclusion of this (correct) measure of the quantity of money and disentangling money supply from money demand remedy the price and liquidity puzzles which frequently appear in the vector autoregression literature. The results point to the informational content embedded in monetary aggregates, and suggest that monetary aggregates should be taken into account while evaluating monetary policy.

Chapter 3: In assessing debt sustainability for advanced and emerging markets, the IMF's Market Access Countries' Debt Sustainability Analysis (MAC DSA) compares the levels of debt and gross financing needs (GFNs) against benchmarks separately derived from the noise-to-signal approach. In *"Determinants of Sovereign Debt Crises,"* I identify the main factors that contribute to sovereign debt crises. I take into account a broad range of debt distress drivers, including debt levels and gross financing needs, but also debt composition, macroeconomic fundamentals, and country characteristics such as whether the country is a small state or member of a currency union. By using the estimation results, I first derive an indicative cutoff probability of debt distress level. Then, I calculate the corresponding thresholds for debt variables, above which countries are predicted to experience an episode of debt distress.

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THE EFFECTIVENESS OF MACROPRUDENTIAL POLICY ON BANK RISK

1 Introduction

This chapter studies the effectiveness of macroprudential policy on bank risk, measured by the loan loss reserves ratio and the non-performing loans ratio. I show that the effectiveness of macroprudential policy tools depends on bank characteristics such as specialization and profitability. Stricter regulation in the form of exposure limitations tend to decrease banks' risk levels whereas capital-based tools tend to induce higher risk-taking. Moreover, upon facing stricter regulation, banks already suffering losses are more likely to increase their risk levels.

Governments regulate financial institutions to ensure that they are safe and able to honor their obligations. Traditional regulation has consisted of firm-level oversight, which is concerned with the stability of individual financial institutions. Since the financial crisis between 2007 and 2009, traditional regulation has come under scrutiny as it contributed to the global financial crisis by allowing financial vulnerabilities to grow. The bankruptcy of the investment bank Lehman Brothers, a systemically important financial institution (SIFI), led market disturbances to spread to the rest of the financial system, and brought limiting "contagion" to the forefront of financial regulation.[1] As a result, authorities in many countries have started to explore a more systemic approach to financial regulation. This holistic approach is called macroprudential policy. However, as Blanchard et al. (2014) note, "*Macroprudential tools are new, and little is known about how effective they can be. They are exposed*

[1]See Acharya and Öncü (2013) for the channels through which the failure of SIFIs could pose a systemic risk to the financial system.

to circumvention and subject to thorny political economy constraints." As the use of macroprudential policy tools gains popularity, evaluating the effectiveness of different tools becomes crucial for policy making purposes.

Existing studies in the literature focus on the effects of macroprudential policy on aggregate macroeconomic variables such as total credit in the economy, asset prices (particularly housing prices), and leverage ratios. For example, in a recent study, Akinci and Ohmstead-Rumsey (2017) show that macroprudential policy tightenings are associated with lower bank credit growth, housing credit growth, and house price inflation. Similarly, Cerutti et al. (2015) find that stricter macroprudential regulation is associated with lower credit growth, especially in household credit. However, using aggregate variables might mask important facts, especially when the policy can affect different institutions in opposite directions. If following macroprudential policy tightening, risk levels are increasing for certain institutions and decreasing for others, the overall risk levels might be unaffected. This might result in drawing the wrong conclusion that macroprudential policy does not affect the financial institutions' risk levels. Employing micro-level data allows us to account for the heterogeneity across financial institutions.

I employ bank-level data from 30 European countries for the time period between 2000 and 2014 and combine these with the macroprudential policy data gathered by the International Banking Research Network (IBRN).[2] IBRN data account for various instruments utilized by policy makers: capital requirements, loan-to-value ratio limits, interbank exposure limits, concentration limits, reserve requirements on foreign currency-denominated accounts, reserve requirements on local currency-denominated accounts, and sector-specific capital buffers.

My findings suggest that interbank exposure limits, concentration limits, and capital based instruments affect overall risk levels of all three type of banks: commercial, savings, and cooperative banks. I document that stricter regulation in the form of exposure limitations tends to decrease banks' risk levels whereas capital-based tools

[2]See Cerutti et al. (2016) for the detailed description of the IBRN Prudential Instruments Database.

tend to induce higher risk-taking. Furthermore, after a macroprudential policy tightening, loan loss provisions and non-performing loans ratios of banks suffering losses can increase substantially, up to five percentage points, while they are likely to decrease for profitable banks. These differential effects depending on profitability levels are particularly visible when loan-to-value ratio limits are employed on commercial banks, concentration limits are employed on savings banks, and interbank exposure and concentration limits are employed on cooperative banks.

These findings point to the perverse effects macroprudential policy tightenings could have on bank risk. Constraining business activities by stricter regulation can lead to a search for yield and higher risk-taking, especially by banks suffering losses. Differential effects depending on profitability highlight the importance of evaluating the effectiveness of macroprudential policy tools at the micro (bank) level as opposed to the aggregate (market) level. Using aggregate level data might result in opposing effects to cancel each other, and thus, conceal the true nature of the relationship between macroprudential policy tools and financial institutions. Policy designers should take into account that certain tools such as exposure limitations are more effective in decreasing risk levels. Furthermore, they should reconsider subjecting all banks to the same regulations, independent of their profitability levels, as banks suffering losses are more inclined to "double down" and increase their risk-taking.

The rest of this chapter is organized as follows. Section 2 provides a review of the literature on bank risk and macroprudential policy. Section 3 explains commonly used macroprudential policy tools in detail. Section 4 provides information on different types of banks studied in this chapter, namely commercial, savings, and cooperative banks. Section 5 explains the data by providing variable definitions, data sources, and summary statistics. Section 6 summarizes the results, and the last section provides concluding remarks.

2 Literature Review

The relationship between bank risk and policy has been studied in the context of monetary policy. Recent work on the effect of monetary policy on bank risk-taking documents higher risk levels at times of lower interest rates, but also stresses the importance of bank characteristics such as capital ratio. Altunbas et al. (2010) study the relationship between short-term interest rates and bank risk by using a unique database that includes quarterly balance sheet information for listed banks operating in the European Union and the United States from 1998 to 2008. Their findings suggest that unusually low interest rates over an extended period of time contributed to an increase in banks' risk levels. Maddaloni and Peydro (2011) use a unique data set of the Euro area and U.S. bank lending standards, and find that low short-term interest rates weaken standards for household and corporate loans. Securitization activity, weak supervision for bank capital, and longer duration for low interest rates exacerbate this softening, especially for mortgages. De Nicolo et al. (2010) argue that financial intermediaries' degree of limited liability and financial health play an important role in their risk taking. When the policy rate is low, well-capitalized banks increase risk-taking and poorly capitalized banks do the opposite. Delis and Kouretas (2010) uses data from Euro area banks over the period 2001-2008 and present evidence that low interest rates substantially increase bank risk-taking. This negative relationship is shown to be weaker for banks with high levels of capitalization and stronger for banks that engage in non-traditional banking activities with a higher volume of off-balance sheet items.

Use of macroprudential policy gained popularity since the global financial crisis of 2007. Researchers assembled comprehensive databases and studied the effectiveness of these policies, particularly for credit levels and house prices. Akinci and Ohmstead-Rumsey (2017) construct a novel index of domestic macroprudential policies in 57 advanced and emerging economies covering the period from 2000:Q1 to 2013:Q4, with macroprudential tightenings and easings recorded separately. Their findings show that macroprudential policies have been used far more actively after the global financial crisis in both advanced and emerging market economies, and usually in tandem with changes in bank reserve requirements, capital flow management measures, and monetary policy. The housing sector was the prime target of macroprudential policy changes, especially in the advanced economies. Their empirical analysis suggests that macroprudential tightenings are associated with lower bank credit growth, housing credit growth, and house price inflation. Targeted policies such as those specifically intended to limit the growth of housing credit are shown to be more effective. Cerutti et al. (2015) examine the use of macroprudential policies for 119 countries over the 2000-2013 period. They find that emerging economies use macroprudential policies most frequently, particularly foreign exchange related ones, and advanced countries use borrower-based policies more often. Macroprudential tightenings are generally associated with lower growth in credit, especially in household credit.

In particular, capital- and borrower-based tools drew attention of researchers studying the effectiveness of macroprudential policy. Buchholz (2015) investigates the effect of caps on banks' leverage (a capital-based macroprudential tool) on domestic credit to the private sector since the global financial crisis. He shows that real credit grew after the crisis at considerably higher rates in countries which had implemented the leverage cap prior to the crisis, which suggests that banks were able to draw on buffers built up prior to the crisis. Igan and Kang (2011) study the Korean experience with macroprudential measures and find that loan-to-value and debt-to-income limits (two borrower-based tools) are associated with a decline in house price appreciation and transaction activity.

Macroprudential policy is subject to leakages and avoidance, and this could render it ineffective at country level. Cerutti et al. (2015) find that macroprudential policy is less effective in financially more developed and open economies. It is associated with greater cross-border borrowing, suggesting avoidance. Reinhardt and Sowerbutts (2015) study whether macroprudential regulations affect international banking flows. Their findings suggest that borrowing by the domestic non-bank sector from foreign banks increases after domestic authorities take a macroprudential capital action, but no increase in borrowing from foreign banks is observed after a macroprudential action which tightens lending standards, such as limits on loan-to-value ratios for house purchase. Cizel et al. (2016) find evidence of substitution effects towards nonbank credit when macroprudential policy restricts bank credit. The substitution effect is especially strong in advanced economies, and reduces the effectiveness of macroprudential policy. Their findings highlight the need to extend macroprudential policy beyond banking, especially in advanced economies. Finally, by employing the IBRN Prudential Instruments Database, Berrospide et al. (2017) show that stricter foreign prudential regulation shifts lending away from the countries of origin and increases total lending into the U.S. However, the identified spillovers are of small magnitudes.

Macroprudential policy could also cause risk-shifting. Jiménez et al. (2017) study the impact of dynamic provisioning, which implies pro-cyclical bank capital regulation, on credit supply cycles and the associated spillovers on real activity by employing Spanish credit register data. They find that the level at which banks are affected by the policy change has important compositional effects in credit supply and risk. Pro-cyclical bank capital regulation is shown to result in a credit supply contraction in good times. However, firms are shown to substitute credit from less affected banks, and therefore no impact on firm total assets, employment, or survival is found. The banks with higher capital requirements focus their credit supply to firms with a higher ex-ante interest paid and leverage, and with a higher ex-post default, suggesting that higher capital requirements may increase bank risk-taking and searching-for-yield. The negative impact of higher requirements on credit is stronger for smaller firms and banks, which have difficulty in absorbing the shock.

3 Macroprudential Policy Tools

The IBRN Prudential Instruments Database contains data for various prudential instruments. These instruments are classified under five broad categories:

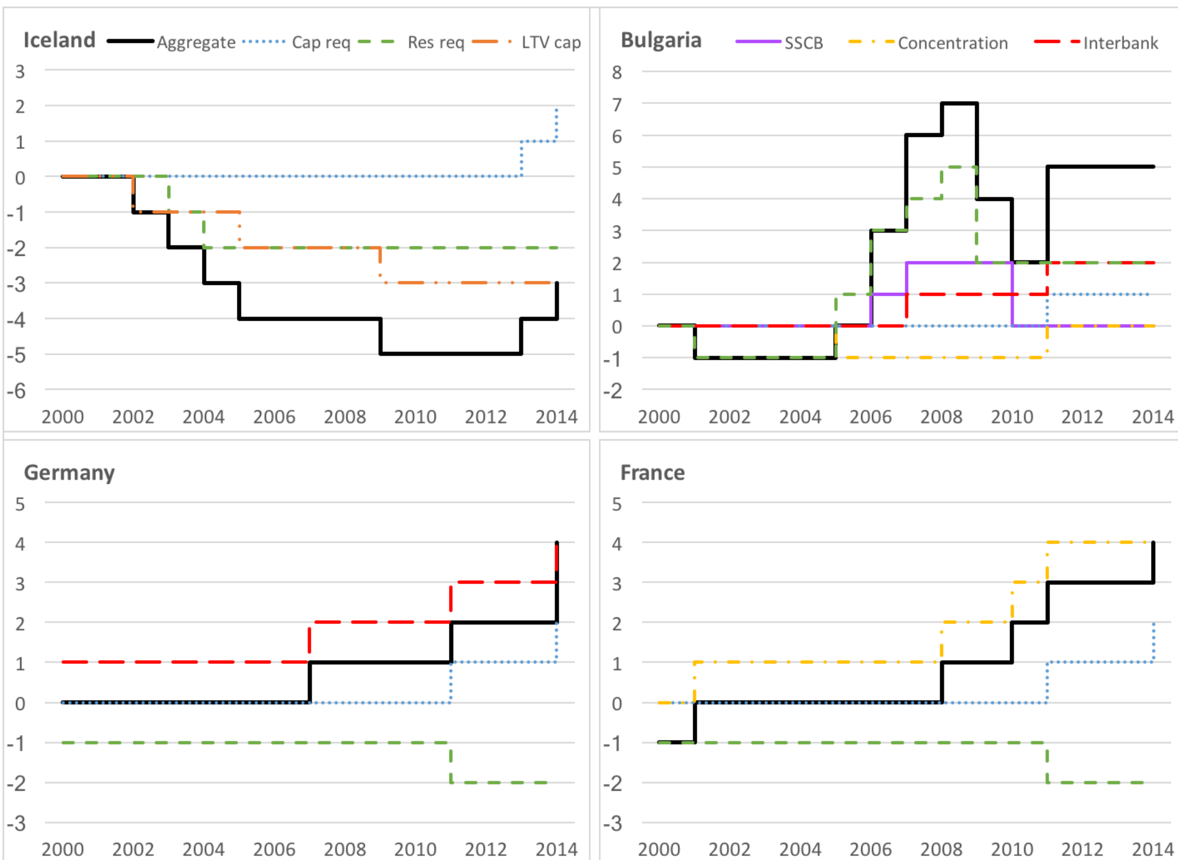
General capital requirements

Financial institutions are required to maintain a certain amount of capital to enable them to absorb losses on loans or securities. The amount of required capital is given by the capital adequacy ratio. The general capital requirements index records the implementation of Basel Accords, which govern capital requirements for banks. The Basel Committee, established by the central bank governors of the Group of Ten countries at the end of 1974 and headquartered at the Bank for International Settlements in Basel, was established to enhance financial stability, to improve banking supervision quality, and to serve as a forum for regular international cooperation on banking supervision. The Committee has established a series of international standards for bank regulation. Its most notable publications are the accords on capital adequacy known as Basel I, Basel II, Basel II.5, and Basel III. The general capital requirements index records adoption of each accord as a tightening of capital requirements, with the exception of Basel II, which was considered as neutral over minimum capital requirements. It is important to emphasize the index records the policy changes when the laws are implemented in each country, not when they are passed.

A brief timeline of the Basel Accords is as follows. Basel I, adopted in 1988, called for a minimum ratio of capital to risk-weighted assets of 8% for banks to be implemented by the end of 1992. By introducing a standardized definition of capital adequacy, it raised awareness for prudent capital management across the financial industry. The Accord evolved over time and started to address not only credit risk, but also market risk. The 1997 amendment allowed banks to use internal models (value-at-risk models) for the first time as a basis for measuring their market risk capital requirements. In 2004, a revised framework for capital management, known as Basel II, was adopted. Basel II broadened the focus of risk assessment and management by improving the way regulatory capital requirements reflected underlying risks and by addressing the financial innovation that had occurred in recent years. Additional supervisory oversight on calculating capital requirements, required assessment of both credit and operational risks, and enhanced levels of disclosures regarding banks' risk profiles, capital structures, risk management and capital adequacy were required. However, the aggregate level of minimum capital requirements were broadly maintained (Basel Committee on Banking Supervision, 2006). Basel II was further fortified in 2009 by the adoption of Basel II.5, which introduced tougher regulations that required banks to hold larger amounts of capital against the market risks they incurred in their trading operations. Basel II and Basel II.5 were criticized for not doing enough to prevent the financial crisis of 2008 and the ensuing financial meltdown.

In particular, the view that internal models employed by banks to measure their risk exposure were more successful than external models employed by external supervisory agencies was challenged. In 2010, Basel III, which endorses new capital and liquidity standards, was adopted. It required banks to maintain healthier amounts of "true" capital by regulating Tier 1 capital ratios which exclude preferred equity and other hybrid capital instruments.[3]

Figure 1.1: Use of Macroprudential Policy Tools for Selected Countries: 2000-2014



Note: The vertical axis measures the tightenings and loosenings in the macroprudential policy tool indexes.

Sector-specific capital buffers (SSCB)

The sector-specific capital buffers index records capital based regulatory changes

[3]For more details on Basel accords, see http://www.bis.org/bcbs/history.htm and http://www.advisoryhq.com/articles/basel-i-2-2-5-3/

aimed at curtailing credit growth in specific sectors. This type of prudential changes require adding to bank capital when there are signs of unusually strong credit growth or when there are signs of a credit-driven asset price boom. They are usually implemented by changing the risk-weights of real estate and consumer credits while calculating capital adequacy. The tying of changes in capital buffers to the financial cycle is often referred as *dynamic capital buffers*. Examples of this type of regulation are the increase of risk weights on foreign-exchange denominated retail credit exposures to 100% in Poland in 2012 and the increase in the risk weight floor on mortgages from 15% to 25% in Sweden in 2014.

Reserve requirements (RR)

Reserve requirements are usually used for conducting monetary policy. However, developing countries employ them as countercyclical macroprudential tools as well. Based primarily on IMF's Global Macroprudential Policy Instruments Survey, changes in reserves requirements aiming at prudential objectives are recorded under two subcategories: reserve requirements on local-currency denominated accounts, and reserve requirements on foreign-currency denominated accounts. Reserve requirement ratios are usually reported as a number, however the requirements may depend on the type of accounts and on the maturity of deposits. The indexes defined for reserve requirements capture the overall levels within the broad categories of local-currency denominated accounts and foreign-currency denominated accounts. As an example, the central bank of Bulgaria expanded the coverage of reserve requirements to include all liabilities previously excluded from the deposit base, except subordinated debt, debt-capital hybrid instruments, and repo agreements among banks. The reserve requirement ratio for the newly included liabilities was set at 4%, a ratio lower than the regular ratio of 8%.

Concentration limits and interbank exposure limits

Limits on concentrated exposures and on exposures to other banks are policies which affect claims between banks and their borrowers. These limits are changed by modifying the elements that characterize the exposures. For example, the definition of "large exposure" can be revised. The Basel Committee on Banking Supervision (2014) classifies an exposure as large when "the sum of all exposure values of a bank to a counterparty or to a group of connected counterparties... is equal to or above 10% of the bank's eligible capital base." However, this definition changes from country to country. Aggregate concentration limits, which restrict the sum of all large exposures as a share of eligible capital, are another way of changing the limits. Another method of limitation would be differentiating counterparties by using the perceived riskiness and the duration of the claims for determining the weights on exposures. Lastly, sectors and assets that are covered by the regulation could be changed. The regulation may cover the exposures of depository institutions only or it may include those of non-bank financial institutions as well. On the counterparty side, certain sectors or certain assets such as interbank lending could be excluded from the concentration limits. An example of changing concentration limits is the abolition of the sum of large exposure limits in Norway in 2010, which was equal to 800 percent of bank's capital. An example of changing interbank exposure limits is the U.K.'s exemption policy for interbank exposures. Before 31 December 2010, interbank exposures shorter in outstanding maturity of one year were exempted in the U.K. From 31 December 2010 onwards, the exemption was reduced to intraday exposures.

Loan to value (LTV) ratio limits

The loan to value ratio ratio determines the amount that can be borrowed against the value of collateral. The LTV index records the tightenings and loosenings on LTV ratio limits, regardless of the type of the lender. These limits are most commonly employed in restricting the amount of mortgages given against the value of real estate. Although the index records changes in LTV ratio limits affecting real estate transactions, changes in banks' risk weights associated with LTV ratios are not included as they do not necessarily change the maximum borrowing capacity for borrowers. The temporary reduction of maximum loan-to-value ratio from 90% to 80% of the house sale price in Iceland on 1 July 2006 is an example of use of LTV ratio limits as a macroprudential tool, and is recorded as a tightening by LTV index.

4 Bank Specialization

I divide banks into three categories according to their specializations: commercial, savings, and cooperative banks.

A commercial bank is a type of financial institution which provides services such as accepting deposits, making business loans, and offering basic investment products. Services provided by commercial banks can be split into two categories such as core banking services and other functions. Core banking services include accepting money through various types of deposit accounts, lending money in the form of cash or documentary (letters of credit, guarantees, performance bonds, securities, etc.), cash and treasury management for businesses, and private equity financing. Other functions include collection and clearing cheques, dealing in foreign exchange transactions, purchasing and selling securities, and providing money transfer facility. In addition to dealing with deposits and loans from the individual members of the public (retail banking), commercial banks also have corporations or large businesses among their clientele.

A savings bank is a financial institution whose primary purpose is accepting savings deposits and paying interest on those deposits. Savings banks keep their focus on retail banking services such as payments, savings products, credits and insurances for individuals or small and medium-sized enterprises, and also differ from commercial banks by their local and regional outreach, which is a result of their broadly decentralized distribution network. Savings banks are smaller than major commercial banks, and more community-focused. Low-cost funding through government allows them to offer customers higher savings account yields.

Cooperative banking is retail and commercial banking carried out by cooperatives. As such, they are often subject to both banking and cooperative legislation. Cooperative banks are regional, privately-owned and government-sponsored banks that make loans to farmer-owned cooperatives, and rural utilities. They are owned by their customers (cooperative members), and provide services to both members and non-members. In addition to providing savings and loan services, some cooperative bank might participate in the wholesale markets for bonds, money and equities. As a result of being traded on public stock markets, many cooperative banks become partly owned by non-members, and such cooperative banks can be regarded as semi-cooperative. While local branches of cooperative banks select their own boards of directors and manage their own operations, strategic decisions are subject to approval of the central office.

5 Data

The sample consists of yearly data over the period 2000-2014. The initial sample includes information from an unbalanced panel of more than 7,219 banks from 30 countries: Austria, Belgium, Bulgaria, Croatia, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, and the United Kingdom.

5.1 Bank-Level Data

Bank-level data come from Bankscope, a database reporting balance sheet statements of more than 30,000 worldwide financial institutions which is provided by Bureau van Dijk. The dependent variables measure the change in bank risk and have bank and time dimensions, with $\Delta Risk_{i,t}$, defined as the change in the risk measure of bank i at year t. Two different variables accounting for bank risk are employed: The loan loss reserves ratio $\left(\equiv \frac{\text{loan loss reserves}_{i,t}}{\text{net loans}_{i,t}}\right)$, and the non-performing loans ratio $\left(\equiv \frac{\text{non-performing loans}_{i,t}}{\text{net loans}_{i,t}}\right)$. "Loan loss reserves" are accounting entries banks make to cover estimated losses on loans due to defaults and nonpayment. "Non-performing loans" are the sum of the loans for which the debtors have not made their scheduled payments for at least 90 days. "Net Loans" represents total loans to customers, reduced by possible default losses and unearned interest income.

Multiple bank-level variables ($BankChar_{i,t}$) are employed as explanatory variables: bank size captured by the log of total assets, the percentage of a bank's portfolio of assets that is liquid, the bank's total equity to assets ratio (in percentages), and the bank's net income to assets ratio (in percentages). Among these variables, only the net income to assets ratio systematically picks up significant coefficients, and is therefore included in the final set of regressions.

Table 1.1: Summary Statistics of Variables: 2000-2014

Variable	*mean*	*st.dev.*	*min*	*p1*	*median*	*p99*	*max*
$LLR\%$	3.38	4.95	0.00	0.00	1.94	26.18	41.93
$NPL\%$	5.83	7.46	0.00	0.00	3.26	40.00	46.60
MP	2.30	2.19	-0.09	0.03	2.00	9.50	35.00
ΔGDP	1.39	2.47	-14.81	-5.62	1.60	7.20	11.90
$TermPr$	1.55	1.33	-17.70	-1.74	1.55	4.99	21.75
$size$	6.41	1.83	-3.47	2.85	6.18	12.21	14.61
liq	20.11	18.84	-5.09	0.80	13.82	91.26	100.00
cap	9.80	10.10	0.00	1.19	7.48	63.64	100.00
inc	0.40	1.86	-66.67	-3.82	0.31	4.13	33.33

Sources: Bankscope and Datastream.

Table 1.1 contains summary statistics for bank characteristics. The mean and median for loan loss reserves ratio are 3.38% and 1.94%, respectively. These statistics are 5.83% and 3.26% for the non-performing loans ratio. The log of assets (expressed in millions of euros) for the average bank in the sample is 6.41. As indicated by the liquidity ratio, banks keep 20.11% of their assets liquid on average. The capital to assets ratio is 9.8%. Finally, net income to assets ratio, the measure of profitability, is 0.4% for the average bank in the sample.

Table 1.2 reports the mean values of the same variables according to the bank types. We can see that commercial banks have the highest loan loss reserve ratios and non-performing loans ratios on average, indicating that they have the highest risk levels. Meanwhile, savings banks have the lowest loss reserve ratios and non-performing loans ratios on average, making them the safest banks. Furthermore, we see that commercial banks are also larger, more liquid, better capitalized, and more profitable than the other two types of banks. Savings banks are the least liquid, least well capitalized, and least profitable. However, they are larger than cooperative banks in terms of their total assets.

Table 1.3 contains the correlation matrix for bank characteristics. We can see that

Table 1.2: Comparison of Mean Values for Commercial, Savings and Cooperative Banks: 2000-2014

Variable	*Commercial*	*Savings*	*Cooperative*
$LLR\%$	4.57	1.86	3.33
$NPL\%$	7.06	2.93	7.00
MP	2.82	2.02	2.12
ΔGDP	1.88	1.43	1.01
$TermPr$	1.50	1.42	1.68
$size$	7.06	6.55	5.87
liq	31.85	13.31	16.19
cap	13.39	7.53	8.71
inc	0.54	0.34	0.35

Sources: Bankscope and Datastream.

Table 1.3: Correlation Matrix of Variables: 2000-2014

	$LLR\%$	$NPL\%$	MP	ΔGDP	$TermPr$	$size$	liq	cap	inc
$LLR\%$	1.000								
$NPL\%$	0.783	1.000							
	0.000								
MP	0.089	-0.018	1.000						
	0.000	*0.009*							
ΔGDP	-0.072	-0.215	0.336	1.000					
	0.000	*0.000*	*0.000*						
$TermPr$	0.162	0.299	-0.583	-0.462	1.000				
	0.000	*0.000*	*0.000*	*0.000*					
$size$	-0.014	-0.040	-0.039	-0.007	0.025	1.000			
	0.020	*0.000*	*0.000*	*0.110*	*0.000*				
liq	0.182	0.063	0.121	0.113	-0.044	-0.046	1.000		
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*			
cap	0.178	0.178	0.047	0.013	0.036	-0.296	0.273	1.000	
	0.000	*0.000*	*0.000*	*0.002*	*0.000*	*0.000*	*0.000*		
inc	-0.184	-0.258	0.032	0.087	-0.076	0.008	0.037	0.125	1.000
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.044*	*0.000*	*0.000*	

Sources: Bankscope and Datastream.
Notes: Three types of banks are included: Commercial, cooperative, savings. p-values in italics.

the loan loss reserves ratio and the non-performing loans ratio are highly correlated. They are also positively correlated with liquidity and capital ratios, and negatively correlated with bank size and profitability. More profitable banks are more liquid and better capitalized.

5.2 Data on Prudential Instruments

The prudential instruments included in the IBRN Prudential Instruments Database are: general capital requirements, sector-specific capital buffers, reserve requirements on local currency denominated accounts, reserve requirements on foreign currency denominated accounts, concentration ratio limits, interbank exposure limits, and limits on LTV ratios. Although the full database covers 64 countries, I made use of the data pertaining to the 30 countries in the country set. I also annualized the data which were given originally in a quarterly format.

5.3 Country-Level Macroeconomic Data

Datastream is the source of all country-level macroeconomic data. The monetary policy rate $MP_{k,t}$ is the official policy rate set by the monetary authority in country k at year t. $GrowthGDP_{k,t}$ gives the real GDP growth rate. The term premium $TermPremium_{k,t}$ is calculated as the difference between the ten-year government bond yield and the monetary policy rate.

6 Econometric Specification and Methodology

Policymakers have been employing macroprudential policy tools, however effectiveness of these tools on bank risk remains an open question. I form the following hypothesis regarding the relationship between macroprudential policy tools and bank risk:

Hypothesis: The use of macroprudential policy tools does not affect the change in bank risk.

The effectiveness of macroprudential policy can also depend on factors such as bank type, bank-level variables, and macroprudential policy tools chosen by the policymakers. The following corollaries follow the above hypothesis:

Corollary 1. The effectiveness of macroprudential policy does not depend on bank type.

Corollary 2. The effectiveness of macroprudential policy tools does not depend on bank-level variables.

Corollary 3. The effectiveness of macroprudential policy does not depend on the choice of tools being employed.

The baseline empirical model is given by the following equation:

$$\begin{aligned}\Delta Risk_{i,t} = \eta_i + \chi_t + \beta_j MP_{k,t} + \phi_j GrowthGDP_{k,t} + \psi_j TermPremium_{k,t} \\ + \theta BankChar_{i,t} + \delta MAPP_{k,t-1} + \varepsilon_{i,t}\end{aligned} \tag{1.1}$$

$\Delta Risk_{i,t}$: Change in risk measure for bank i in year t. Risk measures used are non-performing loans ratio and loan loss reserves ratio.

η_i: Bank fixed effect

χ_t: Year fixed effect

$MP_{k,t}$: Monetary policy indicator (official policy rate) for country k in year t.

$GrowthGDP_{k,t}$: Real GDP growth rate for country k in year t.

$TermPremium_{k,t}$: The difference between returns on 10 year government bonds and the official policy rate for country k in year t.

$BankChar_{i,t}$: Bank characteristics for bank i in year t. The variables included are log assets (in millions of euros), liquid assets-to-total assets ratio, capital-to-total assets ratio, and net income-to-assets ratio.

$MAPP_{k,t}$: Macroprudential policy tool index for country k in year t.

After employing the above baseline model, I determine that profitability, measured by the net income-to-assets ratio, is the most significant bank characteristic. Therefore, I run a second regression in which profitability is the only bank characteristic included. Furthermore, I allow profitability to interact with macroprudential policy tool index:

$$\Delta Risk_{i,t} = \eta_i + \chi_t + \beta_j MP_{k,t} + \phi_j GrowthGDP_{k,t} + \psi_j TermPremium_{k,t} + \theta Profitability_{i,t} + \delta MAPP_{k,t-1} + \gamma(MAPP_{k,t-1} * Profitability_{i,t}) + \varepsilon_{i,t} \tag{1.2}$$

The expression that is interest to us is the marginal effect of macroprudential policy given by $\delta + \gamma Profitability_{i,t}$.

I employ system GMM to estimate the coefficients in equation (1.1). To simplify the notation, we can write down the equation to be estimated as:

$$Y_{i,t} = \eta_i + \chi_t + \alpha_1 A_{i,t} + \alpha_2 X_{i,t} + \varepsilon_{i,t}, \tag{1.3}$$

where χ_t denotes common time effects. The bank-specific and the idiosyncratic components of the error term, η_i and $\varepsilon_{i,t}$, are independently distributed across i, and have the standard error component structure in which $E(\eta_i) = 0$, $E(\varepsilon_{i,t}) = 0$, $E(\eta_i \varepsilon_{i,t}) = 0$, and $E(\varepsilon_{i,t}\varepsilon_{i,s}) = 0$ for $s \neq t$. $Y_{i.t}$ is the outcome variable which denotes the bank risk. $A_{i,t}$ is the vector of bank characteristics that are endogenously determined with the outcome variable. Just as the bank characteristics affect the bank risk, bank risk affects other characteristics such as profitability, liquidity, and capital ratio. $X_{i,t}$ is the vector of other time varying variables that influence the outcome variable, but do not suffer from endogeneity.

We can eliminate the bank-specific time-invariant component by taking first differences:

$$\Delta Y_{i,t} = \Delta\chi_t + \alpha_1 \Delta A_{i,t} + \alpha_2 \Delta X_{i,t} + \Delta\varepsilon_{i,t}. \tag{1.4}$$

System GMM builds a system of two equations – the original equation as well as the transformed one. To address the endogeneity issue, this approach uses internal instruments where lagged values of $A_{i,t}$ are employed as instruments for the equation in difference, and of its differences for the equation in levels. As Roodman (2006) suggests, by introducing first differences as additional instruments and building a system, system GMM approach can substantially improve efficiency.

7 Results

Table 1.4 contains the regression results between 2000 and 2014 for commercial banks. The dependent variable is the change in bank risk measured by the change in loan loss reserves ratio and non-performing loans ratio. In these regressions, I include all four bank characteristics (net income to assets ratio, capital to assets ratio, liquid assets ratio and log of total assets), and there is no interaction between macroprudential policy tools and bank characteristics. Although I have run the regressions for each macroprudential policy tool, I only report those in which macroprudential policy tool picks up significant coefficients. We see that there is strong evidence of higher interest rates corresponding to higher bank risk. This makes sense in economic terms as higher interest rates can result in higher default rates on loans given by banks. There is also strong evidence for a negative relationship between real GDP growth rates and bank risk. As one would expect, banks are performing better in good times as they would have fewer debtors defaulting. The term premium systematically picks up positive and significant coefficients, pointing to higher bank risk at times in which the yield curve has a steeper slope. The bank characteristic that systematically enters into the equations with a significant coefficient is the income to assets ratio, which points to a negative relationship between bank profitability and bank risk. There is some evidence of a positive relationship between the liquidity ratio and bank risk for commercial banks when the change in NPL ratio is used as the dependent variable. Among macroprudential policy tools, use of sector-specific capital buffers is associated with higher risk whereas use of concentration limits is associated with lower risk.

Table 1.5 contains the regression results between 2000 and 2014 for savings banks. As before, the dependent variable is the change in bank risk measured by the change in loan loss reserves ratio and non-performing loans ratio. The positive relationship between interest rates and bank risk which we observed for commercial banks is present for savings banks as well. Real GDP growth is negatively associated with bank risk whereas term premium has a positive association. The net income to assets still has a negative association with bank risk, but the relationship is not as robust as it was for commercial banks and cooperative banks. There is evidence that better capitalized and more liquid banks have lower risk. The log of total assets also occasionally enters the equations with a significant and negative coefficient, suggesting larger banks are subject to lower risk. Among macroprudential policy tools, use of sector-specific capital buffers is associated with higher risk whereas use of interbank exposure limits is associated with lower risk.

Table 1.6 contains the regression results between 2000 and 2014 for cooperative banks. Once again, the dependent variable is the change in bank risk measured by the change in the loan loss reserves ratio and the non-performing loans ratio. These initial regressions for cooperative banks include all four bank characteristics. However, there is no interaction between macroprudential policy tools and bank characteristics. Unlike the cases with commercial and savings banks, the link between interest rates and bank risk is weak for cooperative banks. Lower interest rates could lead banks to search for higher yield and hence, higher risk-taking, which could negate the positive role lower interest rates play by lowering loan defaults. As before, real GDP growth has a negative coefficient whereas the term premium has a positive one. The net income to assets systematically enters into the equations with negative coefficients, and occasionally, the liquidity ratio and the log of total assets attain significant and negative coefficients. Among macroprudential policy tools, tightening in the form of capital requirements is associated with higher risk whereas tightening via interbank exposure limits is associated with lower risk.

Table 1.4: Regression Results for Commercial Banks: 2000-2014

	(1) Δ(LLR/NL)	(2) Δ(NPL/NL)	(3) Δ(LLR/NL)	(4) Δ(NPL/NL)
Interest Rate	0.24***	0.38***	0.18***	0.35***
	(0.05)	(0.06)	(0.03)	(0.06)
RGDP Growth	-0.07**	-0.16***	-0.09***	-0.22***
	(0.03)	(0.04)	(0.02)	(0.04)
Term Premium	0.18***	0.30***	0.17***	0.31***
	(0.03)	(0.07)	(0.03)	(0.06)
Inc to Asset	-0.17**	-0.46***	-0.40***	-0.54**
	(0.08)	(0.15)	(0.08)	(0.22)
Cap to Asset	0.00	0.00	0.03	0.02
	(0.03)	(0.04)	(0.02)	(0.04)
Liq to Asset	0.00	0.01	0.01	0.03***
	(0.01)	(0.01)	(0.01)	(0.01)
Log Assets	0.07	0.11	0.03	0.10
	(0.09)	(0.11)	(0.07)	(0.08)
Concent.	-0.02	-0.11**		
	(0.04)	(0.05)		
SSCB			0.00	0.20**
			(0.05)	(0.09)
No Groups	1,000	786	1,585	1,156
No Obs.	4,895	3,721	8,587	5,739

Sources: Bankscope, Datastream, IBRN Prudential Instruments Database.
Notes: Dependent variables are the change in loan loss reserves over net loans and in non-performing loans over net loans. Coefficients on time fixed effects are omitted for conciseness. Standard errors are in parentheses. * p<0.1, ** p<0.05, *** p<0.01

Table 1.5: Regression Results for Savings Banks: 2000-2014

	(1)	(2)	(3)	(4)
	Δ(LLR/NL)	Δ(NPL/NL)	Δ(LLR/NL)	Δ(NPL/NL)
Interest Rate	0.13**	0.62***	0.12***	0.31***
	(0.06)	(0.15)	(0.02)	(0.05)
RGDP Growth	-0.04	-0.09***	-0.04***	-0.05**
	(0.02)	(0.04)	(0.01)	(0.03)
Term Premium	0.12***	0.24***	0.15***	0.35***
	(0.04)	(0.07)	(0.03)	(0.06)
Inc to Asset	-0.16*	-0.19	-0.16**	-0.14
	(0.10)	(0.13)	(0.07)	(0.13)
Cap to Asset	-0.01	-0.02	-0.01	-0.04**
	(0.01)	(0.01)	(0.01)	(0.02)
Liq to Asset	0.00	-0.02***	0.00	-0.01
	(0.00)	(0.01)	(0.00)	(0.01)
Log Assets	-0.07**	-0.03	-0.05**	0.01
	(0.03)	(0.04)	(0.02)	(0.03)
Int. Exp.	-0.19***	-0.34***		
	(0.04)	(0.07)		
SSCB			0.03*	0.06*
			(0.02)	(0.04)
No Groups	879	832	1,272	1,134
No Obs.	3,781	3,256	6,510	5,206

Sources: Bankscope, Datastream, IBRN Prudential Instruments Database.
Notes: Dependent variables are the change in loan loss reserves over net loans and in non-performing loans over net loans. Coefficients on time fixed effects are omitted for conciseness. Standard errors are in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$

Table 1.6: Regression Results for Cooperative Banks: 2000-2014

	(1) Δ(LLR/NL)	(2) Δ(NPL/NL)	(3) Δ(LLR/NL)	(4) Δ(NPL/NL)
Interest Rate	-0.34	0.11	-0.22	-0.19
	(0.25)	(0.18)	(0.17)	(0.23)
RGDP Growth	-0.12***	-0.25	0.02	-0.22
	(0.04)	(0.16)	(0.08)	(0.14)
Term Premium	0.29***	0.65***	0.19***	0.46***
	(0.04)	(0.19)	(0.06)	(0.13)
Inc to Asset	-0.86***	-1.65***	-0.87***	-1.63***
	(0.14)	(0.20)	(0.15)	(0.20)
Cap to Asset	0.01	0.09	-0.05	-0.06
	(0.03)	(0.06)	(0.04)	(0.06)
Liq to Asset	-0.01	0.01	-0.02**	0.00
	(0.01)	(0.01)	(0.01)	(0.01)
Log Assets	0.04	0.10	-0.14***	-0.12
	(0.03)	(0.07)	(0.05)	(0.08)
Cap. Req.	0.54*	2.08***		
	(0.31)	(0.78)		
Int. Exp.			-0.42***	-0.55***
			(0.07)	(0.10)
No Groups	1,981	1,787	1,892	1,715
No Obs.	7,994	6,400	7,572	6,121

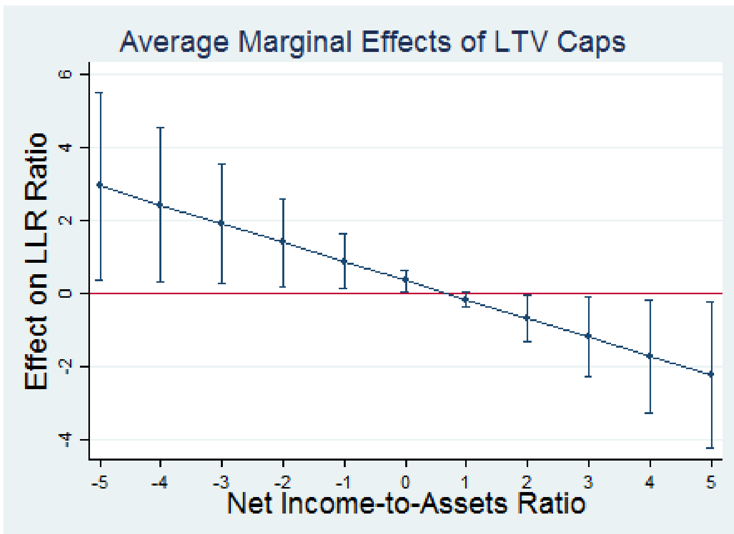
Sources: Bankscope, Datastream, IBRN Prudential Instruments Database.
Notes: Dependent variables are the change in loan loss reserves over net loans and in non-performing loans over net loans. Coefficients on time fixed effects are omitted for conciseness. Standard errors are in parentheses. * p<0.1, ** p<0.05, *** p<0.01

Table 1.7 repeats the regressions in Table 1.4, but this time by including the net income to assets ratio as the only bank characteristic, and allowing for an interaction term between this variable and LTV caps. The findings for macroeconomic variables continue to hold. Table 8 reports the corresponding average marginal effects of the macroprudential policy tool at net income to assets ratios varying between -5% and 5%. My findings suggest a differential role for macroprudential policy depending on bank profitability. Policy tightening in the form of LTV caps increases bank risk for commercial banks with low profitability whereas the risk decreases for highly profitable banks. This relationship is visualized in Figure 1.2, panels a and b.

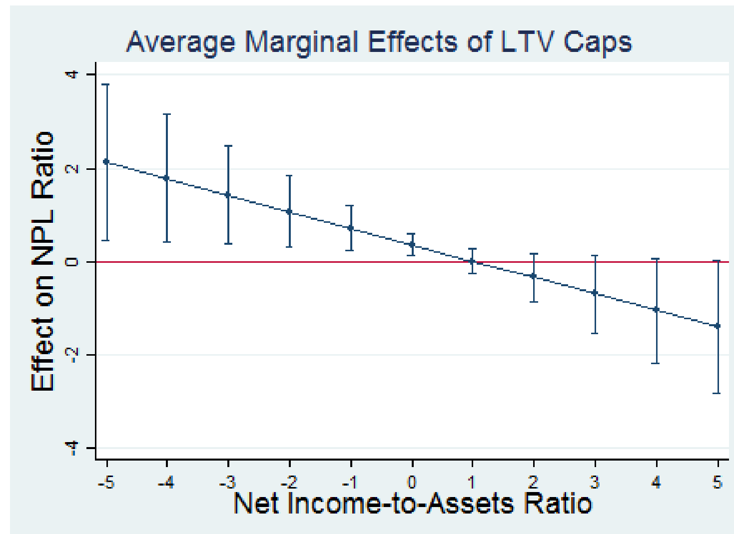
Table 1.9 repeats the regressions in Table 1.5 with a single bank characteristic (the net income to assets ratio) and with an interaction term between this variable and concentration limits. The findings for macroeconomic variables remain the same. Table 1.10 reports the corresponding average marginal effects of macroprudential policy tools at net income to assets ratios varying between -5% and 5%. The differential role of macroprudential policy for savings banks is captured by concentration limits. A tightening by using concentration limits is associated with higher bank risk at low profitability levels, and with lower bank risk at high profitability levels. This relationship is visualized in Figure 1.3, panels a and b.

Finally, Table 1.11 repeats the regressions in Table 1.6 by including the net income to assets ratio as the only bank characteristic, and allowing for an interaction term between this variable and macroprudential policy tools. The findings for macroeconomic variables remain the same. Table 12 reports the corresponding average marginal effects of macroprudential policy tools at net income to assets ratios varying between -5% and 5%. Macroprudential policy plays a differential role for cooperative banks as well. Interbank exposure limits and concentration limits associate a tightening with higher bank risk at low profitability levels, and with lower bank risk at high profitability levels. These relationships are visualized in Figure 1.4, panels a and b for interbank exposure limits, and panels c and d for concentration limits.

Figure 1.2: Average Marginal Effects of Macroprudential Tools for Commercial Banks



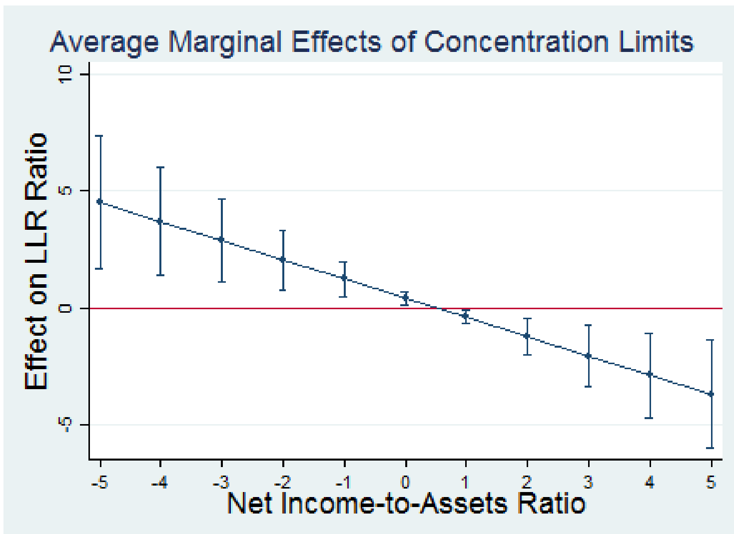
(a) LTV on LLR ratio



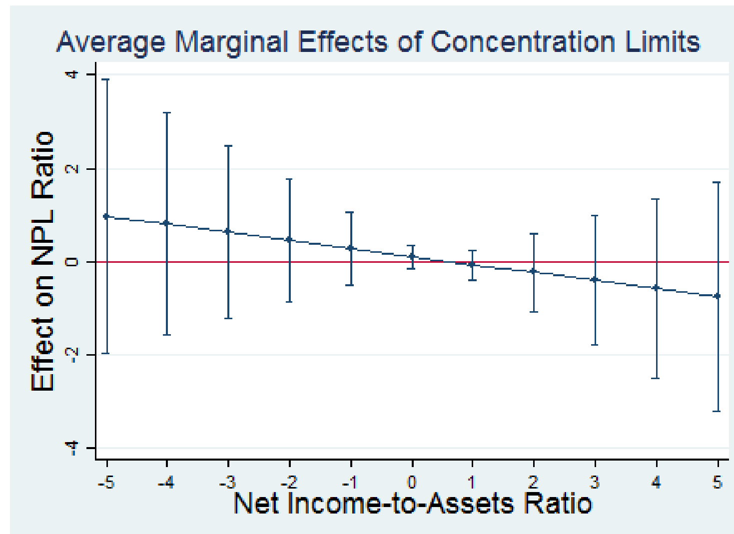
(b) LTV on NPL ratio

Note: The brackets are the 90 percent confidence intervals.

Figure 1.3: Average Marginal Effects of Macroprudential Tools for Savings Banks



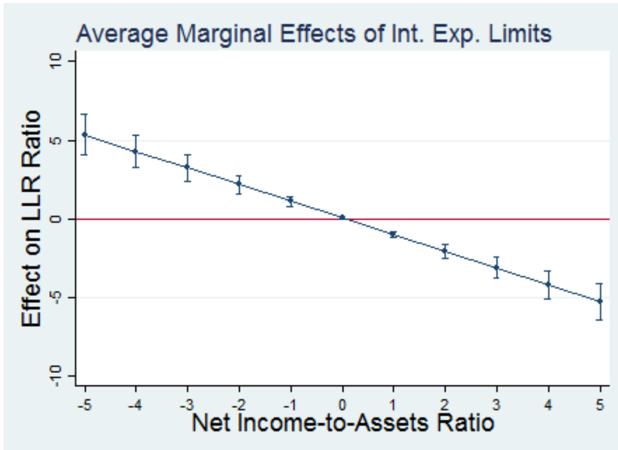
(a) Concentration limits on LLR ratio



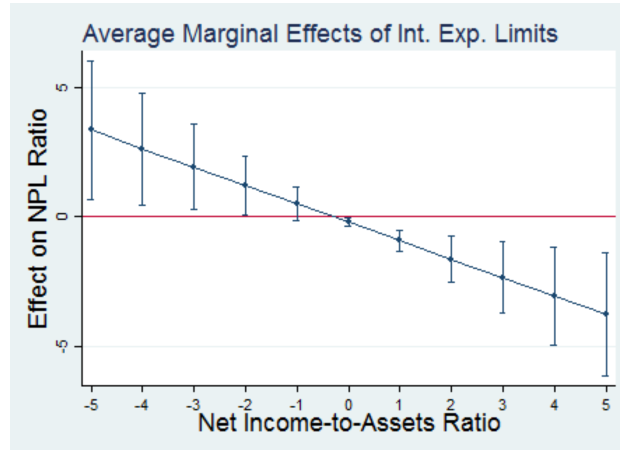
(b) Concentration limits on NPL ratio

Note: The brackets are the 90 percent confidence intervals.

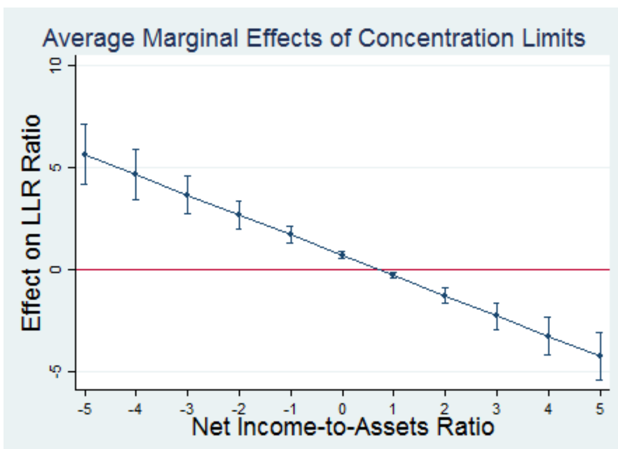
Figure 1.4: Average Marginal Effects of Macroprudential Tools for Cooperative Banks



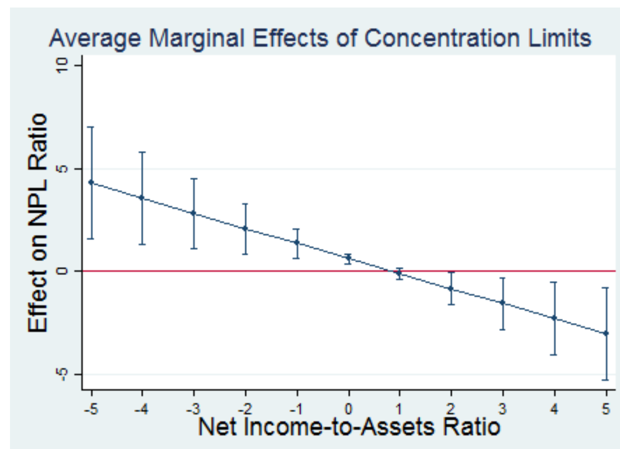
(a) Interbank exp. limits on LLR ratio



(b) Interbank exp. limits on NPL ratio



(c) Concentration limits on LLR ratio



(d) Concentration limits on NPL ratio

Note: The brackets are the 90 percent confidence intervals.

Table 1.7: Regression Results for Commercial Banks: 2000-2014

	(1) Δ(LLR/NL)	(2) Δ(NPL/NL)
Interest Rate	0.06	0.12
	(0.05)	(0.11)
RGDP Growth	-0.14***	-0.40***
	(0.05)	(0.11)
Term Premium	0.13**	0.22**
	(0.06)	(0.11)
Inc to Asset	-0.28	-0.71***
	(0.21)	(0.12)
LTV cap	0.35*	0.36***
	(0.18)	(0.13)
LTV cap×Inc to Asset	-0.52*	-0.35*
	(0.28)	(0.19)
No Groups	520	362
No Obs.	2,194	1,441

Sources: Bankscope, Datastream, IBRN Prudential Instruments Database.
Notes: Dependent variables are the change in loan loss reserves over net loans and in non-performing loans over net loans. Coefficients on time fixed effects are omitted for conciseness. Standard errors are in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$

Table 1.8: Average Marginal Effects of LTV Caps for Commercial Banks: 2000-2014

Inc to Asset	(1) Δ(LLR/NL)	(2) Δ(NPL/NL)
-5%	2.95*	2.14**
	(1.56)	(1.01)
-4%	2.43*	1.78**
	(1.29)	(0.83)
-3%	1.91*	1.43**
	(1.01)	(0.64)
-2%	1.39*	1.07**
	(0.73)	(0.46)
-1%	0.87*	0.72**
	(0.45)	(0.28)
0%	0.35*	0.36***
	(0.18)	(0.13)
1%	-0.17	0.01
	(0.13)	(0.16)
2%	-0.69*	-0.34
	(0.39)	(0.32)
3%	-1.21*	-0.70
	(0.67)	(0.50)
4%	-1.73*	-1.05
	(0.94)	(0.68)
5%	-2.25*	-1.41
	(1.22)	(0.87)

Sources: Bankscope, Datastream, IBRN Prudential Instruments Database.
Notes: Dependent variables are the change in loan loss reserves over net loans and in non-performing loans over net loans. Average marginal effects of prudential policies are calculated at net income to assets ratios between -5% and 5%. Standard errors are in parentheses. * p<0.1, ** p<0.05, *** p<0.01

Table 1.9: Regression Results for Savings Banks: 2000-2014

	(1)	(2)
	Δ(LLR/NL)	Δ(NPL/NL)
Interest Rate	0.10***	0.21***
	(0.03)	(0.06)
RGDP Growth	-0.02	-0.06
	(0.02)	(0.04)
Term Premium	0.10***	0.23***
	(0.03)	(0.05)
Inc to Asset	-0.16**	-0.35*
	(0.07)	(0.20)
Concent.	0.41***	0.11
	(0.16)	(0.15)
Concent.×Inc to Asset	-0.82***	-0.17
	(0.31)	(0.33)
No Groups	1,068	1,011
No Obs.	4,676	4,202

Sources: Bankscope, Datastream, IBRN Prudential Instruments Database.
Notes: Dependent variables are the change in loan loss reserves over net loans and in non-performing loans over net loans. Coefficients on time fixed effects are omitted for conciseness. Standard errors are in parentheses. * p<0.1, ** p<0.05, *** p<0.01

Table 1.10: Average Marginal Effects of Concentration Limits for Savings Banks: 2000-2014

	(1)	(2)
Inc to Asset	Δ(LLR/NL)	Δ(NPL/NL)
-5%	4.53***	0.97
	(1.72)	(1.77)
-4%	3.71***	0.79
	(1.40)	(1.45)
-3%	2.88***	0.62
	(1.09)	(1.12)
-2%	2.06***	0.45
	(0.78)	(0.80)
-1%	1.24***	0.28
	(0.47)	(0.47)
0%	0.41***	0.11
	(0.16)	(0.15)
1%	-0.41**	-0.07
	(0.17)	(0.19)
2%	-1.23***	-0.24
	(0.48)	(0.51)
3%	-2.05***	-0.41
	(0.79)	(0.84)
4%	-2.88***	-0.58
	(1.10)	(1.16)
5%	-3.70***	-0.75
	(1.41)	(1.49)

Sources: Bankscope, Datastream, IBRN Prudential Instruments Database.
Notes: Dependent variables are the change in loan loss reserves over net loans and in non-performing loans over net loans. Average marginal effects of prudential policies are calculated at net income to assets ratios between -5% and 5%. Standard errors are in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$

Table 1.11: Regression Results for Cooperative Banks: 2000-2014

	(1) Δ(LLR/NL)	(2) Δ(NPL/NL)	(3) Δ(LLR/NL)	(4) Δ(NPL/NL)
Interest Rate	-0.12	-0.62	-0.74	-0.78
	(0.16)	(0.62)	(0.47)	(0.48)
RGDP Growth	-0.03	-0.25	-0.12**	-0.30***
	(0.07)	(0.17)	(0.05)	(0.11)
Term Premium	0.22***	0.47***	0.18***	0.57***
	(0.06)	(0.15)	(0.05)	(0.11)
Inc to Asset	-0.64***	-1.40***	-0.65***	-1.34***
	(0.12)	(0.31)	(0.14)	(0.23)
Int. Exp.	0.05	-0.22**		
	(0.05)	(0.10)		
Int. Exp.×Inc to Asset	-1.06***	-0.71**		
	(0.15)	(0.31)		
Concent.			0.70***	0.61***
			(0.10)	(0.14)
Concent.×Inc to Asset			-0.99***	-0.73**
			(0.16)	(0.30)
No Groups	1,892	1,715	1,959	1,772
No Obs.	7,572	6,121	7,818	6,314

Sources: Bankscope, Datastream, IBRN Prudential Instruments Database.
Notes: Dependent variables are the change in loan loss reserves over net loans and in non-performing loans over net loans. Coefficients on time fixed effects are omitted for conciseness. Standard errors are in parentheses. * p<0.1, ** p<0.05, *** p<0.01

Table 1.12: Average Marginal Effects of Macroprudential Tools for Cooperative Banks: 2000-2014

	Int. Exp.		Concent.	
	(1)	(2)	(3)	(4)
Inc to Asset	Δ(LLR/NL)	Δ(NPL/NL)	Δ(LLR/NL)	Δ(NPL/NL)
-5%	5.35***	3.35**	5.65***	4.27***
	(0.79)	(1.62)	(0.90)	(1.66)
-4%	4.29***	2.64**	4.66***	3.54***
	(0.64)	(1.31)	(0.74)	(1.35)
-3%	3.23***	1.92*	3.67***	2.81***
	(0.49)	(1.01)	(0.57)	(1.05)
-2%	2.17***	1.21*	2.68***	2.08***
	(0.34)	(0.70)	(0.41)	(0.75)
-1%	1.11***	0.50	1.69***	1.34***
	(0.19)	(0.40)	(0.25)	(0.44)
0%	0.05	-0.22**	0.70***	0.61***
	(0.05)	(0.10)	(0.10)	(0.14)
1%	-1.00***	-0.93***	-0.29***	-0.12
	(0.11)	(0.23)	(0.09)	(0.17)
2%	-2.06***	-1.64***	-1.28***	-0.85*
	(0.26)	(0.53)	(0.24)	(0.47)
3%	-3.12***	-2.36***	-2.27***	-1.58**
	(0.41)	(0.84)	(0.40)	(0.77)
4%	-4.18***	-3.07***	-3.26***	-2.32**
	(0.56)	(1.15)	(0.56)	(1.08)
5%	-5.24***	-3.78***	-4.25***	-3.05**
	(0.71)	(1.45)	(0.72)	(1.38)

Sources: Bankscope, Datastream, IBRN Prudential Instruments Database.
Notes: Dependent variables are the change in loan loss reserves over net loans and in non-performing loans over net loans. Average marginal effects of prudential policies are calculated at net income to assets ratios between -5% and 5%. Standard errors are in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$

8 Conclusion

The use of macroprudential policy tools became widespread after the 2007-2009 financial crisis. However, there is no consensus on their effectiveness. While recent research documented their effectiveness on lowering credit levels and house prices, there is also evidence for avoidance and risk-shifting. Using country-level variables such as total credit amount or house prices might be misleading for evaluating the stability of the financial system. Following a macroprudential policy tightening, it is possible for certain financial institutions to increase their risk levels while others do the opposite. Studying the potential heterogeneity across risk levels of different institutions requires use of micro level data.

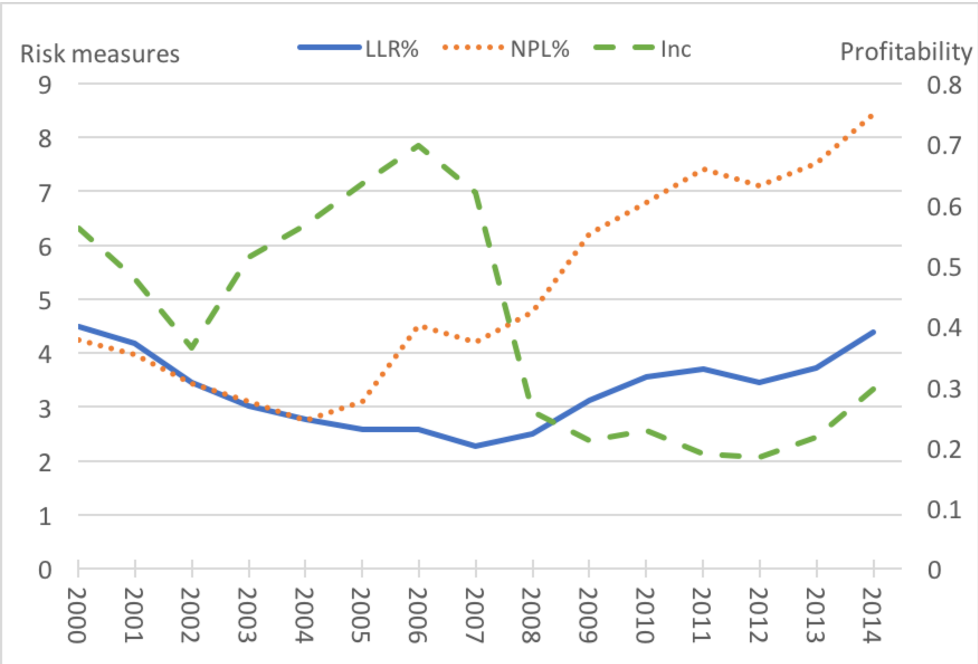
By employing bank level data from 30 European countries for the time period between 2000 and 2014, I show that interbank exposure limits, concentration limits, and capital based instruments affect overall risk levels of commercial, savings, and cooperative banks. While risk levels tend to decrease following a macroprudential policy tightening through stricter exposure limitations, they tend to increase following a tightening through the use of capital-based tools. These results point to the fact that constraining business activities by stricter regulation can lead to a search for yield and higher risk-taking. Furthermore, I document differential effects of macroprudential policy depending on banks' profitability levels. A macroprudential policy tightening can result in up to a five percentage points increase in the loan loss provisions and non-performing loans ratios of banks suffering losses. Meanwhile, profitable banks tend to decrease their risk levels when they are subject to stricter regulation.

Policymakers should pay closer attention to the perverse effects stricter regulation could have on banks' risk levels, particularly for banks with lower profitability levels. They should consider subjecting banks to different restrictions according to their profitability levels. Future research should focus on examining the channels and financial activities through which banks increase their risk levels upon facing stricter regulation. Furthermore, it is worthwhile to study the behavior of non-bank financial institutions vis-à-vis that of banks in a more regulated environment.

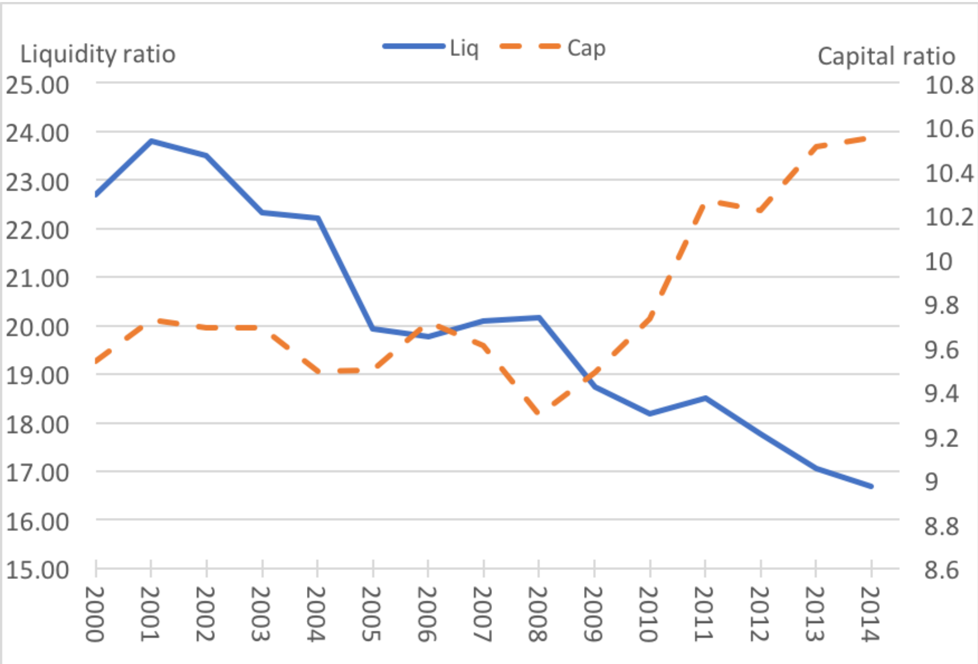
APPENDIX

1.A Figure

Figure 1.5: Bank Characteristics Over Time



(a) Risk measures and profitability



(b) Liquidity and capital ratios

1.B Table

Table 1.13: Descriptive Statistics by Country: 2000-2014

Country	LLR/NL	NPL/NL	MP	ΔGDP	$TermPr$	$size$	liq	cap	inc	all banks	commercial	savings	cooperative
Austria	3.65	7.13	2.02	1.53	1.66	2,830	24.93	10.11	0.40	367	100	143	124
Belgium	1.69	3.87	2.38	1.64	1.68	28,915	22.56	9.71	0.55	76	51	16	9
Bulgaria	6.32	13.37	2.77	3.81	2.82	1,024	32.14	14.11	0.94	46	43	1	2
Croatia	9.11	13.82	8.33	1.82	-1.54	1,352	27.29	13.77	0.39	58	55	2	1
Czechia	4.54	7.66	2.14	2.77	2.10	5,852	31.10	10.75	0.72	39	34	0	5
Denmark	6.04	7.03	2.14	0.82	1.56	8,176	18.40	13.64	0.50	175	90	75	10
Estonia	4.90	9.37	1.97	4.44	4.03	2,927	33.23	14.33	1.26	10	10	0	0
Finland	0.62	0.93	1.20	0.36	1.55	20,860	18.08	12.13	0.61	55	38	16	1
France	4.60	5.35	2.18	1.38	1.62	41,237	25.43	11.30	0.60	495	227	57	211
Germany	1.74	4.02	2.10	1.27	1.31	3,774	14.88	7.19	0.24	2,207	204	660	1,343
Greece	5.97	15.27	2.28	0.89	4.10	17,238	17.79	9.93	-0.25	41	38	2	1
Hungary	7.06	12.68	7.58	2.13	-0.24	3,157	28.24	12.36	0.18	50	46	2	2
Iceland	5.82	7.50	11.16	3.83	-7.01	2,562	15.01	12.97	1.35	41	12	29	0
Ireland	5.41	10.53	2.32	3.86	2.58	34,966	27.96	9.90	-0.35	39	38	1	0
Italy	3.90	7.88	2.15	0.26	2.38	4,295	20.12	12.03	0.47	1,451	291	115	1,045
Latvia	5.82	13.51	3.49	4.30	2.34	982	44.23	11.89	0.03	35	35	0	0
Lithuania	4.35	10.93	2.08	4.23	3.79	1,648	26.98	10.57	0.89	15	15	0	0
Luxembourg	1.75	3.57	2.38	3.25	0.37	7,683	53.55	7.49	0.62	141	136	3	2
Malta	2.59	8.29	2.21	2.08	2.39	1,740	31.13	20.02	0.68	14	12	1	1
Netherlands	1.97	2.91	2.08	1.21	1.56	70,271	30.18	10.25	0.63	78	74	2	2
Norway	1.04	1.48	2.75	1.58	1.12	3,443	6.70	9.56	0.66	212	43	169	0
Poland	5.84	10.71	6.24	3.61	0.53	4,630	20.35	12.85	0.80	112	106	3	3
Portugal	6.11	6.95	1.65	-0.14	4.37	9,060	26.78	13.63	0.37	106	60	41	5
Romania	7.49	16.16	14.12	3.63	-0.26	1,974	31.69	15.34	-0.56	47	42	3	2
Slovakia	5.00	7.28	2.33	4.13	2.64	3,099	25.49	9.68	0.68	26	22	4	0
Slovenia	8.47	14.19	2.04	1.90	3.21	2,174	15.41	8.61	-0.39	29	23	2	4
Spain	2.53	3.97	2.11	1.56	2.30	21,297	20.68	12.47	0.44	384	159	122	103
Sweden	1.29	2.12	2.10	2.07	1.50	6,396	12.35	13.90	1.03	135	45	89	1
Switzerland	1.42	2.03	1.06	1.97	1.19	4,700	20.28	8.85	0.52	477	215	253	9
U.K.	4.07	6.84	2.84	1.91	1.19	43,899	43.84	16.74	0.60	258	252	5	1
Total	3.38	5.83	2.30	1.39	1.55	9,123	20.11	9.80	0.40	7,219	2,516	1,816	2,887

Sources: Bankscope and Datastream.

Notes: Bank variables are loan loss reserves over net loans, non-performing loans over net loans, size given by total assets in millions of euros, liquid assets over total assets, capital over total assets, and net income over total assets. Macroeconomic variables are indicator of monetary policy (official policy rate), real GDP growth rate, and term premium. Bank and macroeconomic variables are the mean values for each country. Last four columns give the number of banks in each category for the given country.

CHAPTER 2

DO MONETARY AGGREGATES BELONG IN A MONETARY MODEL? EVIDENCE FROM THE UK

1 Introduction

Monetary policy is one of the most important tools that economic policy makers use while attempting to shape the economy, and therefore, it is crucial to successfully gauge its stance and understand the mechanisms through which it affects the variables in the economy.

Friedman and Schwartz (1963) documented evidence which showed that money stock was not only pro-cyclical, but also its movements were leading the movements of output, suggesting a causal relationship between these two variables. Later studies, however, showed a weakening correlation structure between the money stock and output. Combined with the expanding real business cycle (RBC) literature which attributed the fluctuations in the economy to real variables, this weakening correlation structure resulted in a diminishing interest in analyzing the behavior of the money stock. New Keynesian models that were developed later[1] studied monetary policy and its effects by focusing on the role of interest rates, particularly the short-term nominal interest rate, in line with empirical studies conducted in the 1980s and the 1990s.[2] However, the transmission mechanism of monetary policy consists of various channels, and short-term nominal interest rates play only an indirect role in affecting the output level.[3]

The money stock could be an alternative or complementary measure to short-term

[1] Woodford (2003) provides examples of such models.
[2] See Estrella and Mishkin (1997), and Stock and Watson (1999) for example.
[3] Mishkin (2007) summarizes the channels through which monetary policy affects output.

nominal interest rates for understanding the stance and the role of monetary policy, but the challenge here is to disentangle money demand and money supply, as they together determine the level of the money stock. As the proponents of RBC theory observed, the money stock itself might be affected by movements in output, creating reverse causality where the business cycle drives the money stock, rather than vice versa.[4]

In a recent study, Belongia and Ireland (2016) show that monetary aggregates do have the ability to explain aggregate fluctuations in the US economy, but only when measured properly. "Proper measurement" requires using Divisia aggregates instead of the simple-sum quantities of money. They first show that the correlation structure that was suggested by Friedman and Schwartz (1963) is still there. By utilizing a structural vector autoregression (SVAR) model, they draw tight links between monetary policy and economic fluctuations. The user cost (price dual) series of their preferred money stock measure, Divisia aggregates, enables them to disentangle money demand's behavior from that of the money supply. Their analysis suggests that monetary aggregates should be taken into account while evaluating the stance of monetary policy and quantifies the contribution of monetary policy to instability in the US economy between 1967 and 2013.

Three questions naturally arise: Is the discrepancy between the simple-sum and Divisia quantities present for other economies? Is there further evidence that the monetary aggregates should be taken into account for understanding the stance of monetary policy? Can augmenting the measure of monetary policy with monetary aggregates help in drawing more robust links between monetary policy and economic fluctuations?

Following Barnett's critique (1980), many monetary authorities started calculating Divisia indexes as well as simple-sum measures of money. However, these measures are mostly meant only for internal use. The Bank of England is one of the few monetary authorities that makes Divisia indexes publicly available, and this enables us to study the questions at hand for the UK economy.

[4] See King and Plosser (1984) and Plosser (1989).

We can examine the UK data by conducting a SVAR analysis à la Belongia and Ireland (2016), which would allow us to estimate monetary policy rules and money demand equations. Such an analysis would answer the question of what type of monetary policy rule better fits the data. Alternatives would be a Taylor rule without money (standard in most new-Keynesian models), a Taylor rule with money, and a money-interest rate rule similar to what Leeper and Roush (2003) and Sims and Zha (2006) advocate.

The rest of this chapter is organized as follows. Section 2 provides a review of the literature. Section 3 explains how the Divisia index is constructed, and compares it with the simple-sum monetary aggregate. Section 4 presents the model and the employed methodology. Section 5 provides the results from SVAR analysis, and the last section concludes.

2 Literature Review

Bernanke and Blinder (1992) argue that the interest rate on Federal funds is a good indicator of monetary policy actions, and therefore, is informative about future movements of real macroeconomic variables. The role of money is minimized once the Federal funds rate is introduced into the empirical framework. Estrella and Mishkin (1997) suggest that monetary aggregates can play roles as information variables, as indicators of policy actions, and as instruments in a policy rule. However, these roles would require a stable relationship between the aggregates and the final policy targets. By studying the US data from 1979 to 1995, they show that such a relationship did not exist in that time period. Stock and Watson (1999) study inflation forecasts and suggest that there are no gains from including money supply into their analysis.

Belongia (1996) highlights the importance of choosing the right monetary index. He replicates five studies analyzing the effects of money on aggregate activity, and shows that in four of the five cases, the qualitative inference in the original study is reversed when the simple-sum monetary aggregate is replaced by the corresponding Divisia index. Hendrickson (2014) provides further evidence on the Divisia index being a better measure of money stock. He suggests that the conclusions of previous studies arguing that monetary aggregates are not useful as an intermediate target for monetary policy or as an information variable might have been driven by mismeasurement.

Belongia and Ireland (2015) show that Divisia measures of money help in forecasting movements in key macroeconomic variables. Furthermore, the statistical fit of a structural vector autoregression improves significantly when these measures of money are included when identifying monetary policy shocks. Their results challenge the adequacy of conventional models, which focus solely on interest rates. Lastly, Leeper and Roush (2003) model supply and demand interactions in the money market and find evidence of an important role for money in the transmission of policy. Their findings suggest that the money stock and the interest rate jointly transmit monetary policy. Furthermore, for a given exogenous change in the nominal interest rate, the estimated impact of policy on economic activity increases monotonically with the response of the money supply.

3 Constructing the Divisia Index

Conventional simple sum monetary aggregates are obtained by simply summing up all the monetary assets included in an aggregate. Divisia indexes, however, acknowledge that components of monetary aggregates are imperfect substitutes for each other, and hence, the growth rates of these indexes are calculated by weighting the growth rates of the components by their average expenditure shares over the two periods. These expenditure shares are based on the components' user cost, which is measured as the difference between a benchmark interest rate and their own interest rate.

The UK money stock is split into three sectors: household, private non-financial corporate, and other financial corporate. Following Hancock (2005), who shows that financial corporations' Divisia data have high variance and that their volatility may be telling us little about near-term spending plans, I only use household and private non-financial corporate sectors' monetary assets to construct the index.

Monetary data for the UK must be adjusted for breaks which occur when building societies change classifications to become banks. Hancock (2005) explains that leaving data unadjusted would report large flows out of building societies and into banks. As Bissoondeeal et al. (2010) point out, break-adjusted levels data take this fact into account, and adjust the prior data by reallocating the past deposits at a building society that subsequently became a bank into the bank series. As a result, I use non-break-adjusted levels data and break-adjusted flows to correctly weight each component asset.

$M_{i,t}$ denotes the unadjusted amounts outstanding (unadjusted level) of the ith monetary asset for period t. $\Delta M_{i,t}$ gives the difference between successive amounts outstanding, and $\Delta M_{i,t}^{BA}$ denotes the break-adjusted flows for the ith monetary asset for period t.

$u_{i,t} = (r_{B,t} - r_{i,t}) / (1 + r_{B,t})$ is the user cost of the ith asset where $r_{i,t}$ is the own rate of the asset and $r_{B,t}$ is the rate of return on a non-monetary benchmark asset. Consequently, the expenditure shares for each asset are calculated as:

$$W_{i,t} = \frac{u_{i,t} M_{i,t}}{\sum_{j=1}^{N} u_{j,t} M_{j,t}}$$

The Bank of England uses the following formula to compute its Divisia index, D_t:

$$\frac{D_t - D_{t-1}}{D_{t-1}} = \sum_{i=1}^{N} \frac{1}{2} (W_{i,t} + W_{i,t-1}) \frac{\Delta M_{i,t}^{BA}}{M_{i,t-1}}$$

which means that the growth rate of the Divisia index weights the component growth rates by their average shares. Using the fact that average shares add up to one, I rearrange the above equation and obtain the following iterative formula for computing the level of the Divisia index:

$$D_t = D_{t-1} \sum_{i=1}^{N} \frac{1}{2} (W_{i,t} + W_{i,t-1}) \frac{M_{i,t-1} + \Delta M_{i,t}^{BA}}{M_{i,t-1}}$$

The Bank of England's household and private non-financial corporate sector Divisia index includes the following components as of January 2008:

- notes and coins;

- non interest-bearing deposits;
- interest-bearing bank sight deposits;
- interest-bearing bank time deposits;
- interest-bearing building society sight deposits;
- interest-bearing building society time deposits.

The Bank of England's household sector data also include Tax Exempt Special Savings Accounts (TESSAs) and Individual Savings Accounts (ISAs) that were introduced in 1991 and 1999, respectively. I do not incorporate these assets into the index I construct as they are primarily a form of savings for households as Hancock (2005) explains.

The components constituting the Divisia index change over time. Interest-bearing deposits of the private non-financial corporate sector at building societies are introduced to the index in July 1996. Non interest-bearing deposits in both sectors have been included in the index since July 1997. Starting from January 1999, household sector deposits at building societies are broken into two categories as instant access and notice accounts. The last change for building societies data occurs in January 2008, in which deposits in building societies started to be published as sight and time deposits for all sectors.

While calculating the user costs of the components of the Divisia index, I use the quoted interest rates of assets until 1999, and from that year and onward, I use the effective rates[5]. As for the benchmark rate, I follow Bissoondeeal et al. (2010) and adopt an envelope approach similar to that used by the Bank of England. I add 250 basis points to the three-month Treasury bill rate and compare it with the interest rates of the assets included in the Divisia index. Every period, the highest rate provides the benchmark rate for my calculations.

Figure 2.1 plots the year-over-year growth rates of the Divisia and simple sum series. The two series move in the same direction. However, the discrepancy between

[5]See the explanatory notes for sectoral deposits and Divisia money in the Bank of England's website (http://www.bankofengland.co.uk/statistics/Pages/iadb/notesiadb/divisia.aspx).

Figure 2.1: Divisia and Simple-Sum Year-over-Year Growth Rate Comparison in Percentages

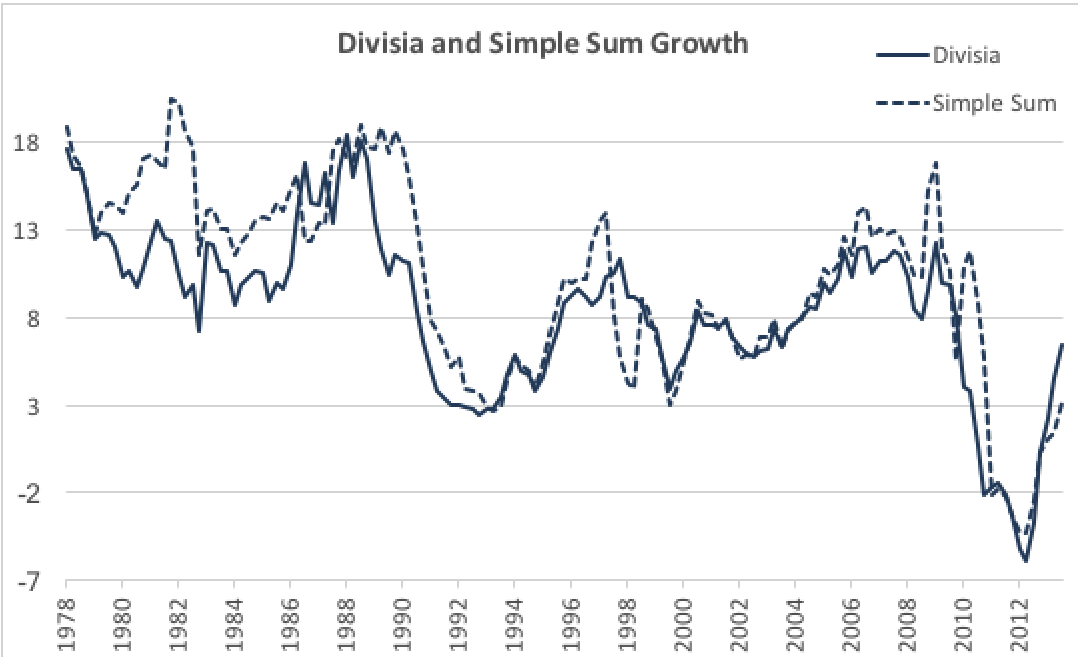
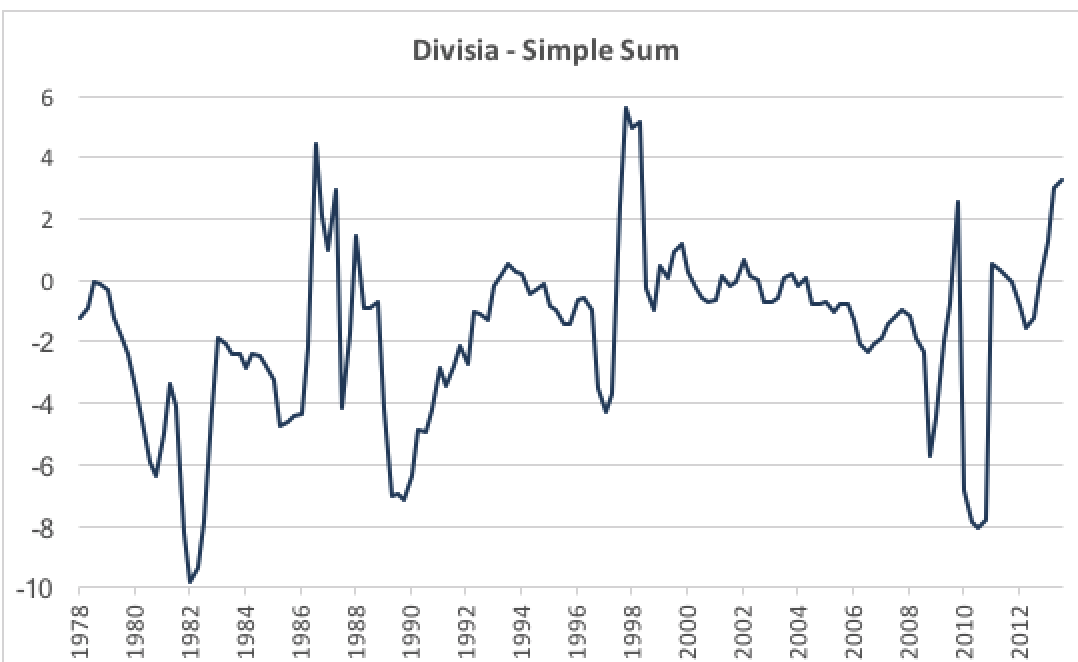


Figure 2.2: Differences in Year-over-Year Growth Rates of Divisia and Simple-Sum Monetary Aggregates, in Percentage Points.



them can get quite large in certain years. Figure 2.2 shows that the difference between the year-over-year growth rates of simple sum and Divisia money can be as large as 10 percentage points. This discrepancy highlights the importance of using the right measure for money and indicates that using the simple sum measures of money instead of the Divisia index could potentially lead to misleading results.

4 The Model and The Methodology

Following Belongia and Ireland (2016), I employ a vector autoregression (VAR) model to describe the behavior of six variables: output Y_t as measured by real GDP, the price level P_t as measured by the GDP deflator, money M_t as measured by the Divisia index, the short-term nominal interest rate R_t as measured by the official bank rate, the user cost of money U_t is given by $R_t - R_t^M$ where R_t^M is the weighted average return on different components of money, and finally, commodity prices CP_t as measured by the CRB/BLS spot index. Output, price level, money, and commodity prices enter our model in log-levels, whereas the short-term nominal interest rate and Divisia user cost are expressed in terms of decimals.

Stacking the variables at each period into the following 6×1 vector:

$$X_t = [P_t \;\; Y_t \;\; CP_t \;\; R_t \;\; M_t \;\; U_t]', \tag{2.1}$$

we can build a structural model of the following form:

$$AX_t = \mu + \sum_{j=1}^{q} \Phi_j X_{t-j} + \Sigma \varepsilon_t, \tag{2.2}$$

where A is a 6×6 matrix of coefficients with ones along the diagonal, μ is a 6×1 vector of constant terms, each Φ_j, $j = 1, 2, ..., q$, is a 6×6 matrix of slope coefficients, Σ is a 6×6 matrix with standard deviations of the structural disturbances along its diagonals and zeros elsewhere, and ε_t is a 6×1 vector of serially and mutually uncorrelated structural disturbances, normally distributed with zero means and

$$E\varepsilon_t\varepsilon_t' = I. \tag{2.3}$$

The reduced form associated with equations (2.2) and (2.3) is

$$X_t = \nu + \sum_{j=1}^{q} \Gamma_j X_{t-j} + \eta_t, \tag{2.4}$$

where the constant term $\nu = A^{-1}\mu$ is 6×1, each $\Gamma_j = A^{-1}\Phi_j$, $j = 1, 2, ..., q$, is a 6×6 matrix of slope coefficients, and the 6×1 vector of zero mean disturbances η_t is such that

$$E\eta_t\eta_t' = \Omega. \tag{2.5}$$

The structural and reduced-form disturbances are linked via

$$A^{-1}\Sigma\varepsilon_t = \eta_t,$$

such that

$$A^{-1}\Sigma\Sigma'(A^{-1})' = \Omega. \tag{2.6}$$

As the covariance matrix Ω for the reduced-form innovations has 21 distinct elements, at least 15 restrictions must be imposed on the 36 elements of A and Σ that have not been normalized to equal to zero or one in order to identify the structural disturbances from the information in the reduced form.

In order to solve the identification problem, I follow Sims (1980) and assume that A is lower triangular. If the variables are ordered as in (2.1), then the fourth element of ε_t can be interpreted as the monetary policy shock ε_t^{mp}, which suggests that aggregate price level, output, and commodity prices respond with a lag to monetary policy and the Bank of England adjusts the official bank rate contemporaneously in response to the movements in these variables according to the equation

$$a_{41}P_t + a_{42}Y_t + a_{43}CP_t + R_t = \sigma_{44}\varepsilon_t^{mp}, \tag{2.7}$$

where a_{ij} denotes the coefficient from row i and column j of A and σ_{44} is the fourth element along the diagonal of Σ. The terms involving the constant μ and lagged values X_{t-j} in (2.2) are suppressed in (2.7) in order to focus on the contemporaneous links between variables. Similarly, the fifth row of the triangular model yields to the following equation

$$a_{51}P_t + a_{52}Y_t + a_{53}CP_t + a_{54}R_t + M_t = \sigma_{55}\varepsilon_t^{md}, \tag{2.8}$$

which can be interpreted as a money demand equation, linking money demand to the price level, output, commodity prices, and the short-term interest rate as the opportunity cost of holding money. Equation (2.7) depicts the official bank rate being targeted without any reference to the money stock, and (2.8) assumes that money stock expands and contracts to accommodate the shifts in money demand for the given interest rate.

I make use of a second, alternative identification scheme, in which money stock plays a larger role in the making and transmission of monetary policy. In this scheme, A is allowed to take the following non-triangular form:

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} & a_{36} \\ 0 & 0 & 0 & 1 & a_{45} & 0 \\ -1 & a_{52} & 0 & 0 & 1 & a_{56} \\ -a_{65} & 0 & 0 & a_{64} & a_{65} & 1 \end{bmatrix}. \tag{2.9}$$

In the alternative identification, the first two rows of (2.9) are similar to the triangular identification, in which aggregate price level and output respond to the other shocks hitting the economy with a one-period lag. Row three of (2.9) indicate that commodity prices are assumed to react immediately to every shock hitting the economy.

The monetary system, in particular, is modeled by the last three rows of (2.9). The monetary policy rule described by row four is similar to rules employed in Sims

(1986), and in Leeper and Roush (2003):

$$R_t + a_{45}M_t = \sigma_{44}\varepsilon_t^{mp}. \tag{2.10}$$

Such a monetary policy rule associates a monetary policy shock with simultaneous movements in the interest rate and the nominal money supply. For a positive a_{45} coefficient, such a rule associates monetary policy tightening with immediately increasing interest rates and a decreasing money stock.

This policy rule can be expanded so that it includes prices and output, which would mean that the interest rate immediately responds to changes not only in the money supply, but also in the price level and output:

$$a_{41}P_t + a_{42}Y_t + R_t + a_{45}M_t = \sigma_{44}\varepsilon_t^{mp}. \tag{2.11}$$

Row five in (2.9) suggests a money demand equation of the following form:

$$a_{52}Y_t + (M_t - P_t) + a_{56}U_t = \sigma_{55}\varepsilon_t^{md}, \tag{2.12}$$

which links the real value of Divisia index to output and the user cost as the associated price.

The behavior of the private financial institutions can be characterized by row six of (2.9):

$$a_{64}R_t + a_{65}(M_t - P_t) + U_t = \sigma_{66}\varepsilon_t^{ms}, \tag{2.13}$$

which suggests that both the official bank rate and the quantity of real monetary services created get passed along to user cost.

I employ the maximum likelihood method to estimate the described SVAR model as outlined by Hamilton (1994) and Lutkepohl (2006). Fully efficient estimates of the reduced-form constant and slope coefficients in (2.4) can be obtained by applying ordinary least squares, equation by equation. Then, I need to compute the estimate of the reduced-form innovations' covariance matrix as suggested by (2.5):

$$\widehat{\Omega} = (1/T) \sum_{t=1}^{T} \eta_t \eta_t'.$$

By maximizing the following concentrated log-likelihood function, I obtain estimates for the parameters of A and Σ:

$$-3T \ln(2\pi) + (T/2) \ln\left(|A|^2\right) - (T/2) \ln\left(|\Sigma\Sigma'|\right) - (T/2) \left\{ \left[A'(\Sigma\Sigma')^{-1} A\right] \widehat{\Omega} \right\}.$$

This approach can be employed for estimating both the over-identified case suggested by (2.9) and the just-identified triangular model (although, for the latter case, the usual approach of using the Cholesky decomposition for $\widehat{\Omega}$ would yield the same result).

5 SVAR Results

Below is a timeline for official monetary policy regimes pursued by the Bank of England, and recessions that took place in the UK:

- July 1976 to April 1979: Monetary targeting ($M3$)
- May 1979 to February 1987: Monetary targeting
- 1980:1 - 1981:1 Recession
- March 1987 to September 1990: Informal linking of the pound to the Deutsche Mark
- 1990:3 - 1991:3 Recession
- October 1990 to September 1992: Membership in the Exchange Rate Mechanism
- October 1992 to April 1997: Inflation targeting prior to the operational independence of the Bank of England
- 2008:2 - 2009:2 Recession

Running the SVAR analysis for different samples and factoring in the above developments show that the UK data can be split into two samples: An early sample that spans 1978:Q3 to 1990:Q1, and a recent sample that spans 1993:Q1-2011:Q3. I exclude the time period in between as the data include too much noise due to the UK's exchange rate mechanism membership in that time period. Similarly, the period after 2011:Q3 is not included as it was a tumultuous time period in which unconventional monetary policy tools such as quantitative easing were applied.

Estimated monetary policy, money demand and monetary system equations are provided in Table 2.1 to Table 2.4. Tables 2.1 and 2.2 provide the regression results for the early sample when the data are in log levels and in growth rates, respectively. Tables 2.3 and 2.4 do the same for the recent sample. I use a likelihood ratio test to see whether including monetary aggregates into the monetary policy rule improves the fit[6]. The restriction of excluding the monetary aggregates from the monetary policy rule given by equation (2.11) is rejected at the 99 percent confidence level for all samples. The constraint of excluding prices and output from equation (2.11), however, does not cause much deterioration in the model's fit. These results point to a monetary policy rule including the monetary aggregates.

The results in Table 2.1 to Table 2.4 suggest that variables other than the money stock (i.e., output and prices) do not enter the monetary policy equation significantly. As a result, there is little support for a Taylor-rule depiction of UK monetary policy in either sample period. Instead, interest rate-money rule provides the preferred specification. The estimates suggest that the interest rate responds positively to increasing levels of the money stock. Money demand usually increases with income level, and the user cost of money increases with interest rates. As one would expect, money demand falls when the cost of money increases.

An important difference between the early and recent samples is the reaction of the interest rate to the stock of money, as can be seen from the monetary policy equations. The coefficient on money stock is much larger in the early sample compared to the

[6]The test is conducted by multiplying the difference of the maximized likelihood values with 2, and then comparing it with the critical chi-squared value, for which the degrees of freedom is equal to the number of restrictions.

recent sample. However, in terms of significance, the coefficient on money stock in monetary policy equation fares better after 1993.

Impulse responses in percentage points to one-standard deviation monetary policy shocks are provided in Figures 2.3 and 2.4. Since interest rate-money rule is the preferred specification, I compare the impulse responses from the interest rate-money rule to those obtained from the triangular model. There are two established puzzles in the VAR literature that need to be addressed here. Following a positive shock to the interest rates, it is common to observe an increase in the price level (price puzzle) and an increase in the money stock (liquidity puzzle). The estimated monetary policy rules for both samples suggest that incorporating monetary aggregates into the monetary policy rule helps to solve both puzzles and following a monetary policy shock, price level and monetary aggregates behave more in line with what macroeconomic theory suggests.

6 Conclusion

It is very important to successfully gauge the stance of monetary policy and understand the mechanisms through which it affects the variables in the economy. In order to achieve these goals, we can use the money stock as an alternative or complementary measure to short-term nominal interest rates, as long as the stock of money is properly measured.

I start with constructing the Divisia index for the United Kingdom for the period between 1978 and 2011. I estimate the monetary policy equation for the early and recent samples by employing structural vector autoregression. My results show that there is little support for a Taylor-rule depiction of UK monetary policy, and suggest the use of interest rate-money rule as the preferred formulation for the conduct of monetary policy. Inclusion of the (correct) measure of quantity of money into the monetary policy equation, and disentangling money supply from money demand remedy the price and liquidity puzzles: two well-established puzzles in the VAR literature. Furthermore, I show that the reaction of the interest rate to the stock of money was quite strong for the period between 1978 and 1990, but this relationship weakens from 1993 and onwards. The findings of this chapter point to the informational content embedded in monetary aggregates, and suggest that they should be taken into account while evaluating monetary policy.

Table 2.1: Maximum Likelihood Estimates from SVARs
Data in Log Levels, Early Sample: 1978:3 - 1990:1

A. Triangular Identification		L=2856.2
Monetary Policy	R = 0.11P - 0.19Y - 0.00CP	σ = 0.0070
	(0.26) (0.27) (0.03)	(0.0004)
Money Demand	M = 0.42P + 0.48Y + 0.05R + 0.02CP	σ = 0.0077
	(0.26) (0.28) (0.15) (0.04)	(0.0005)
B. Interest Rate-Money Rule		L=2852.2
Monetary Policy	R = 2.19M	σ = 0.0143
	(1.64)	(0.0036)
Money Demand	M - P = 0.88Y - 11.97U	σ = 0.0873
	(1.75) (20.43)	(0.0708)
Monetary System	U = 0.64R + 0.17(M-P)	σ = 0.0145
	(0.07) (0.06)	(0.0040)
C. Taylor Rule with Money		L=2853.7
Monetary Policy	R = - 0.83P - 1.23Y + 2.46M	σ = 0.0157
	(1.25) (1.37) (2.54)	(0.0044)
Money Demand	M - P = 0.92Y - 15.88U	σ = 0.0776
	(2.17) (48.91)	(0.0577)
Monetary System	U = 0.64R + 0.16(M-P)	σ = 0.0147
	(0.08) (0.06)	(0.0041)
D. Taylor Rule without Money		L=2823.9
Monetary Policy	R = 0.11P - 0.18Y	σ = 0.0070
	(0.25) (0.26)	(0.0004)
Money Demand	M - P = 0.75Y - 0.01U	σ = 0.0100
	(0.25) (0.34)	(0.0007)
Monetary System	U = 0.46R + 0.10(M-P)	σ = 0.0050
	(0.05) (0.05)	(0.0005)

Table 2.2: Maximum Likelihood Estimates from SVARs
Data in Growth Rates, Early Sample: 1978:3 - 1990:1

A. Triangular Identification		L=1193.2
Monetary Policy	R = 0.19P - 0.05Y + 0.00CP	$\sigma = 0.0089$
	(0.18) (0.18) (0.03)	(0.0008)
Money Demand	M = 0.15P + 0.14Y - 0.08R - 0.01CP	$\sigma = 0.0075$
	(0.19) (0.18) (0.16) (0.03)	(0.0007)
B. Interest Rate-Money Rule		L=1191.3
Monetary Policy	R = 3.70M	$\sigma = 0.0222$
	(3.58)	(0.0113)
Money Demand	M - P = 2.24Y - 23.62U	$\sigma = 0.0409$
	(4.40) (48.31)	(0.0264)
Monetary System	U = 0.66R + 0.16(M-P)	$\sigma = 0.0099$
	(0.08) (0.06)	(0.0027)
C. Taylor Rule with Money		L=1193.2
Monetary Policy	R = - 0.40P - 0.61Y + 4.02M	$\sigma = 0.0206$
	(1.07) (1.12) (4.69)	(0.0085)
Money Demand	M - P = 2.49Y - 26.97U	$\sigma = 0.0420$
	(5.84) (70.49)	(0.0248)
Monetary System	U = 0.68R + 0.16(M-P)	$\sigma = 0.0099$
	(0.08) (0.06)	(0.0027)
D. Taylor Rule without Money		L=1172.9
Monetary Policy	R = 0.19P - 0.05Y	$\sigma = 0.0089$
	(0.18) (0.18)	(0.0008)
Money Demand	M - P = 0.48Y - 0.60U	$\sigma = 0.0102$
	(0.22) (0.48)	(0.0010)
Monetary System	U = 0.43R + 0.13(M-P)	$\sigma = 0.0050$
	(0.05) (0.05)	(0.0006)

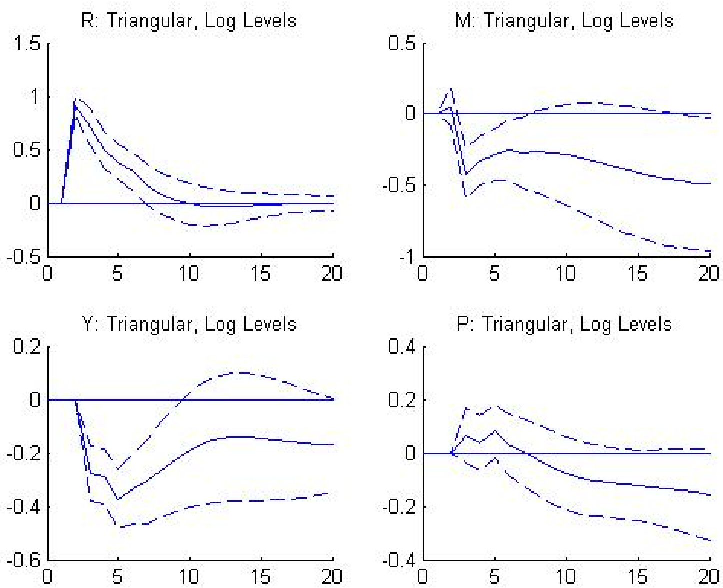
Table 2.3: Maximum Likelihood Estimates from SVARs
Data in Log Levels, Recent Sample: 1993:1 - 2011:3

A. Triangular Identification		L=1027.5
Monetary Policy	R = 0.10P + 0.03Y + 0.02CP	σ = 0.0020
	(0.07) (0.10) (0.01)	(0.0002)
Money Demand	M = 0.38P - 0.24Y - 0.27R + 0.03CP	σ = 0.0050
	(0.19) (0.26) (0.29) (0.02)	(0.0005)
B. Interest Rate-Money Rule		L=1021.7
Monetary Policy	R = 0.62M	σ = 0.0074
	(0.30)	(0.0079)
Money Demand	M - P = - 0.21Y - 12.81U	σ = 0.0171
	(0.63) (5.78)	(0.0084)
Monetary System	U = 0.51R + 0.06(M-P)	σ = 0.0083
	(0.06) (0.02)	(0.0052)
C. Taylor Rule with Money		L=1022.5
Monetary Policy	R = - 0.33P + 0.31Y + 1.19M	σ = 0.0426
	(0.51) (0.45) (1.23)	(0.3015)
Money Demand	M - P = - 0.27Y - 21.12U	σ = 0.0148
	(0.97) (18.57)	(0.0066)
Monetary System	U = 0.55R + 0.04(M-P)	σ = 0.0086
	(0.07) (0.03)	(0.0053)
D. Taylor Rule without Money		L=1019.1
Monetary Policy	R = 0.10P + 0.04Y	σ = 0.0020
	(0.08) (0.10)	(0.0002)
Money Demand	M - P = - 0.13Y - 1.10U	σ = 0.0055
	(0.25) (0.34)	(0.0006)
Monetary System	U = 0.32R + 0.02(M-P)	σ = 0.0023
	(0.04) (0.02)	(0.0005)

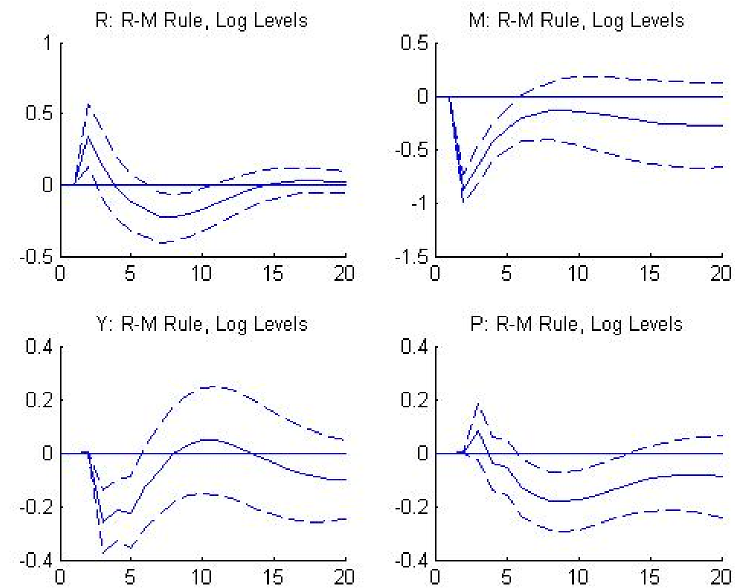
Table 2.4: Maximum Likelihood Estimates from SVARs
Data in Growth Rates, Recent Sample: 1993:1 - 2011:3

A. Triangular Identification		L=897.3
Monetary Policy	R = 0.07P + 0.04Y + 0.02CP	σ = 0.0015
	(0.07) (0.09) (0.01)	(0.0002)
Money Demand	M = 0.37P - 0.14Y - 0.35R + 0.04CP	σ = 0.0045
	(0.18) (0.22) (0.29) (0.02)	(0.0005)
B. Interest Rate-Money Rule		L=891.5
Monetary Policy	R = 0.68M	σ = 0.0078
	(0.34)	(0.0092)
Money Demand	M - P = - 0.09Y - 12.51U	σ = 0.0331
	(0.53) (5.18)	(0.0318)
Monetary System	U = 0.56R + 0.05(M-P)	σ = 0.0074
	(0.07) (0.02)	(0.0035)
C. Taylor Rule with Money		L=894.1
Monetary Policy	R = - 0.54P + 0.28Y + 1.69M	σ = 0.0037
	(0.95) (0.56) (2.42)	(0.0018)
Money Demand	M - P = - 0.19Y - 22.30U	σ = 0.0458
	(0.90) (20.38)	(0.0569)
Monetary System	U = 0.60R + 0.04(M-P)	σ = 0.0071
	(0.07) (0.03)	(0.0034)
D. Taylor Rule without Money		L=882.2
Monetary Policy	R = 0.09P + 0.05Y	σ = 0.0016
	(0.07) (0.09)	(0.0002)
Money Demand	M - P = 0.04Y - 1.18U	σ = 0.0072
	(0.24) (0.95)	(0.0016)
Monetary System	U = 0.34R + 0.01(M-P)	σ = 0.0025
	(0.04) (0.02)	(0.0003)

Figure 2.3: Early Sample. Log Levels. Impulse Responses to One-Standard Deviation Monetary Policy Shock.

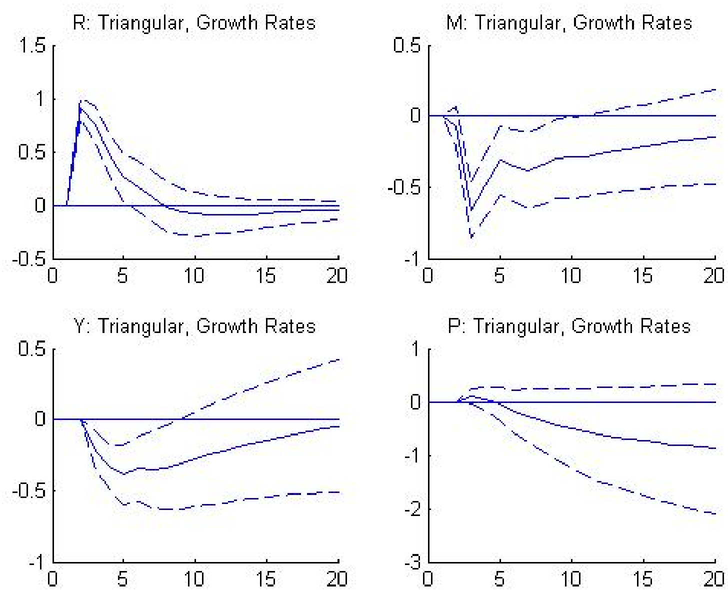


(a) Triangular, log level

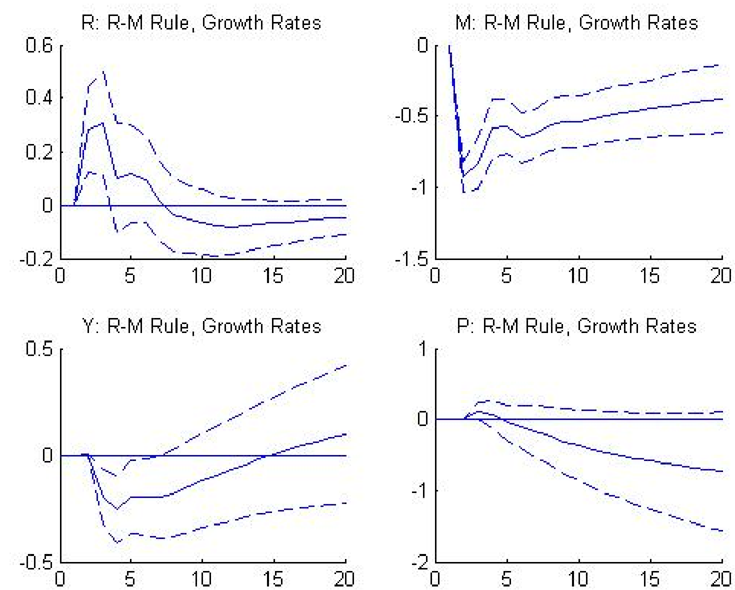


(b) R-M rule, log level

Figure 2.4: Early Sample. Growth Rates. Impulse Responses to One-Standard Deviation Monetary Policy Shock.

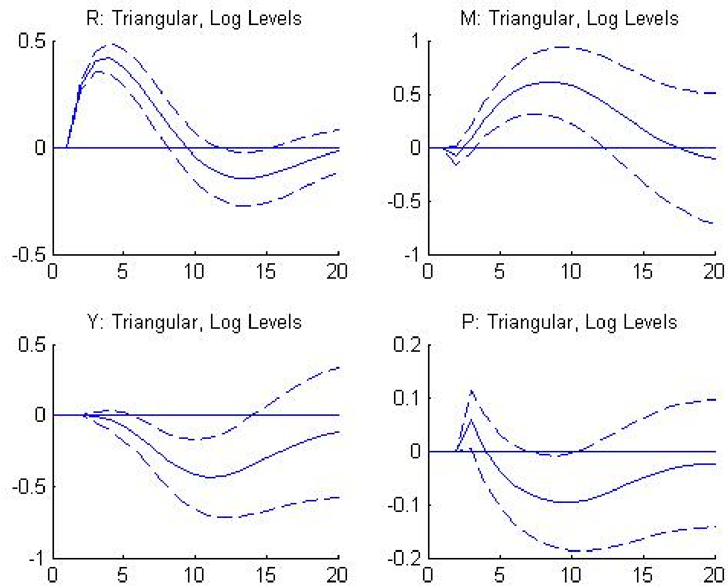


(a) Triangular, growth rates

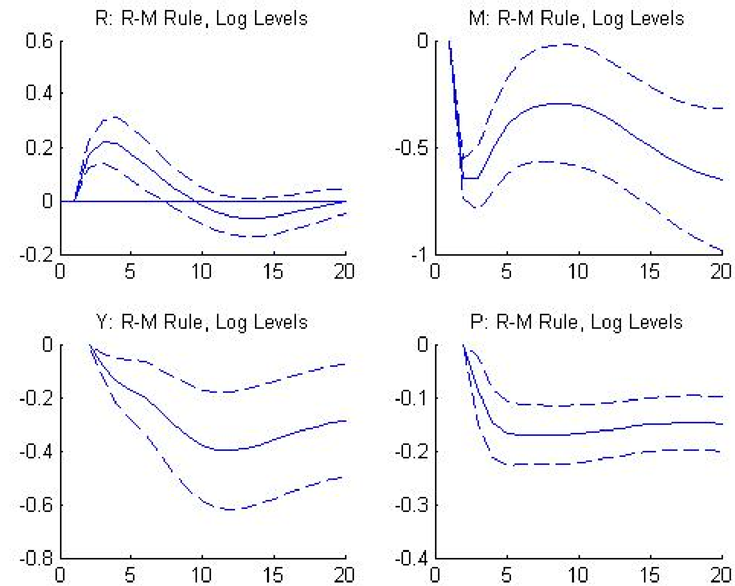


(b) R-M rule, growth rates

Figure 2.5: Recent Sample. Log Levels. Impulse Responses to One-Standard Deviation Monetary Policy Shock.

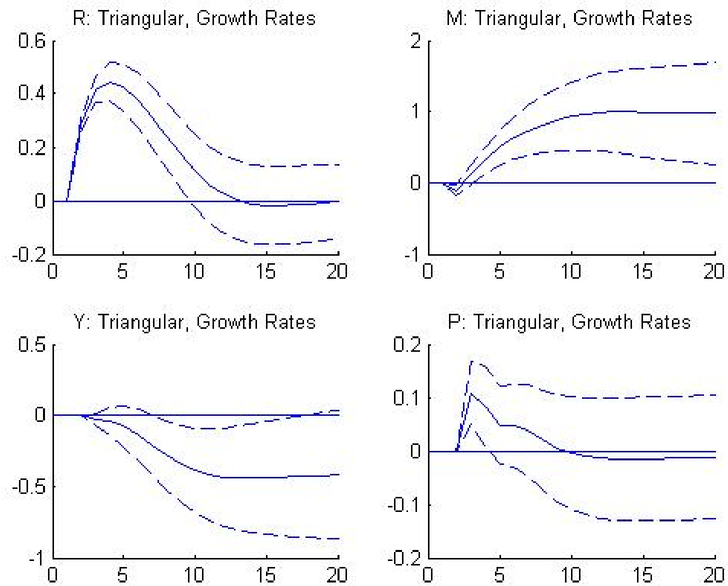


(a) Triangular, log level

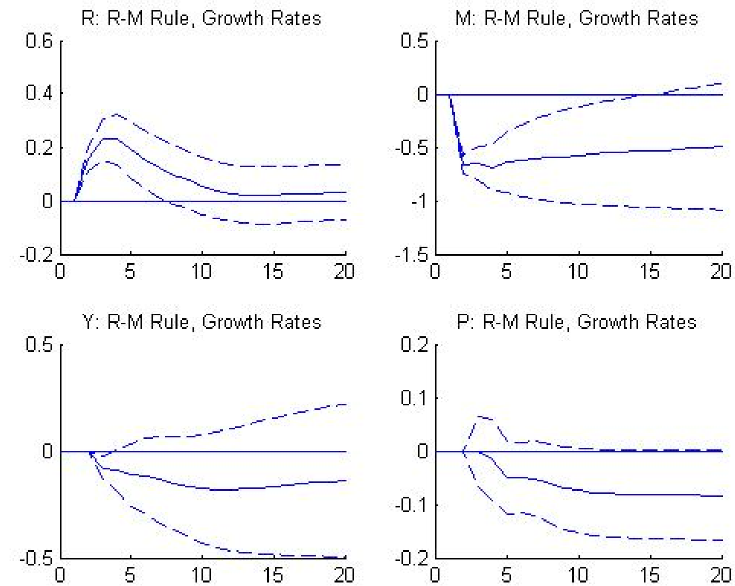


(b) R-M rule, log level

Figure 2.6: Recent Sample. Growth Rates. Impulse Responses to One-Standard Deviation Monetary Policy Shock.



(a) Triangular, growth rates



(b) R-M rule, growth rates

CHAPTER 3
DETERMINANTS OF SOVEREIGN DEBT CRISES

1 Introduction

IMF policy requires an assessment on the degree of sustainability of the member's public debt before providing access to its financial resources. The Fund staff classifies a country's public debt into one of three zones: unsustainable ("red zone" cases), sustainable with high probability ("green zone") or sustainable but not with high probability ("gray zone"). The debt sustainability framework[1] used by the Fund identifies risks to debt sustainability, but it does not provide exact probabilities that could be used for Fund lending decisions. IMF staff have relied on judgment to make an overall assessment of the probability of debt being sustainable. Analytical tools that analyze probabilities of sustainable debt in an objective and systematic way can provide guidance and complement judgment. One analytical tool that has been employed is the noise-to-signal (NTS) approach where signals from different debt burden and liquidity indicators are weighed based on their predictive power, and then used for developing a "risk index." In this chapter, I develop an alternative/complementary probit model that estimates the probability of default as a function of a set of debt burden indicators and other country-specific variables. By using the estimation results, I first derive an indicative cutoff probability of debt distress level. Then, I calculate the corresponding thresholds for debt variables, above which countries are predicted to experience an episode of debt distress.

The econometric model improves our understanding of sovereign debt distress events, and strengthens the toolkit for crisis prevention. The existing NTS approach is

[1] See IMF Staff Guidance Note for Public Debt Sustainability Analysis in Market-Access Countries (2013) for details.

a univariate method and therefore ignores correlation between explanatory variables. The developed probit model is multivariate, statistically-based, and allows for a wide range of explanatory variables. I use the probit model to study what types of debt matter, and what country characteristics contribute to debt distress.

The rest of this chapter is organized as follows. Section 2 provides a review of the literature on the determinants of sovereign debt crises. Section 3 explains how the variable of interest (the dependent variable) is constructed. Section 4 provides information on explanatory variables and data. Section 5 summarizes the regression results. Section 6 explains how the optimal cutoff probability and indicative thresholds for debt variables are determined. The last section provides concluding remarks.

2 Literature Review

The literature has consistently shown that the level of indebtedness matters for debt distress. Institutions, history of debt distress, and short-term debt-to-reserves ratio are also shown to matter for predicting debt distress. The role of primary deficit and debt servicing costs depend on country characteristics such as being an advanced economy or an emerging market.

Manasse and Roubini (2009) find that most debt crises can be classified into three categories: i) episodes of insolvency (high debt and high inflation) or debt unsustainability due to high debt and illiquidity; ii) episodes of illiquidity, in which there are large stocks of short-term liabilities relative to foreign reserves; and iii) episodes of macro and exchange rate weaknesses, which could be generated by large overvaluation and negative growth shocks.

Kohlscheen (2007) shows that presidential democracies are roughly five times more likely than parliamentary democracies to default on external debt. He argues that the confidence requirement creates a credible link between economic policies and the executive's political survival in parliamentary democracies. This, in turn, strengthens opportunistic politicians' commitment to repayment. As a country's form of government is usually chosen at the time of independence and is highly persistent over time, institutions can explain the link between developing countries' debt policies and their individual histories. Similarly, Van Rijckeghem and Weder (2009) show that in democracies, a parliamentary system or sufficient checks and balances prevent defaults on external debt when economic fundamentals or liquidity are strong enough. High stability and tenure play a similar role for default on domestic debt in dictatorships.

Reinhart et al. (2003) argue that history matters. A country's past record at meeting its debt obligations and managing its macroeconomy is useful for forecasting its ability to sustain moderate to high levels of indebtedness. They introduce the concept of "debt intolerance." Debt-intolerant countries (usually, emerging market economies) experience extreme duress at debt levels that are quite manageable for advanced industrial economies. They tend to have weak fiscal structures and weak financial systems. The situation is exacerbated by default as it makes debt-intolerant countries more prone to future default.

Cotarelli et al. (2010) stress the differences between advanced economies and emerging markets. They highlight that when it comes to default, the challenge for the advanced economies stems from large primary deficits, not from a high average interest rate on debt. In contrast, the emerging markets that defaulted in recent decades did so primarily as a result of high debt servicing costs, often in the context of major external shocks.

3 Debt Distress Events

"Debt distress events" data are based on "Fiscal Crises" by Gerling et al. (2017). The following events are considered as a "debt distress event":

- Credit events: This type of events include outright defaults, restructuring, and rescheduling of sovereign debt. As a result of these events, the sovereign reduces the present value of its debt owed to official or other creditors. Small-scale technical defaults which is less than 0.2 percent of GDP are excluded.

- High-access IMF financial arrangements: Instead of outright default or taking other exceptional measures to reduce their debt, countries can obtain large official financing in the form of financial support from the IMF. This support is usually for countries that are experiencing balance of payments problems and unable to make international payments. Usually, the inability to meet its financial obligations is driven by fiscal distress. This criterion captures any year under an IMF financial arrangement in which fiscal adjustment is stated as a program objective, and the country gains access to funds above 100 percent of its quota.

- Loss of market confidence: This criterion captures any year with extreme market pressures in which a sovereign either loses market access and/or experiences a yield spike. "Loss of market access" means the loss of ability to raise funds from the international capital markets either in the form of contracting loans or issuing securities to raise debt. A "yield spike" is when the sovereign bond spreads exceeds 1,000 basis points (bps) for the spreads, which is widely seen as a psychological barrier for market participants'.[2]

- Steep increase in domestic arrears: A steep increase of "other account payables" (OAP) is used as a proxy for domestic arrears. When the OAP-to-GDP ratio grows more than 1 percentage point per year, this is interpreted as an implicit domestic public debt default.

I group the "debt distress events" into "debt distress episodes." Debt distress events usually last longer than a year, and consecutive debt distress events together constitute a debt distress episode. Since I am interested in building an econometric model that predicts the start of a crisis, I only include the start year of a debt distress episode into the analysis. If there is a one year gap between two debt distress events, I treat these events as part of the same debt distress episode. If there is no debt distress event in a year, and that year is not in between two debt distress event years, then that year is also not part of a debt distress episode. Table 3.1 provides an

[2]See Pescatori and Sy (2004), and Baldacci et al. (2011).

example of how I construct debt distress episodes based on debt distress events, and then include them into the analysis. In the given hypothetical example, the country experiences debt distress events from 2010 to 2013, and then again in 2015. This whole period is treated as one debt distress episode. Note that even though there is no debt distress event in 2014, because that year is in between two debt distress events, I still consider it as part of the same debt distress episode. Since I am only interested in predicting the start of debt distress episodes, from the years belonging in the debt distress episode, I only include 2010 into the analysis. The country does not experience debt distress events in 2008 and 2009, thus I include them into the analysis as non-debt distress episodes.

Table 3.1: Example of Debt Distress Events and Debt Distress Episodes

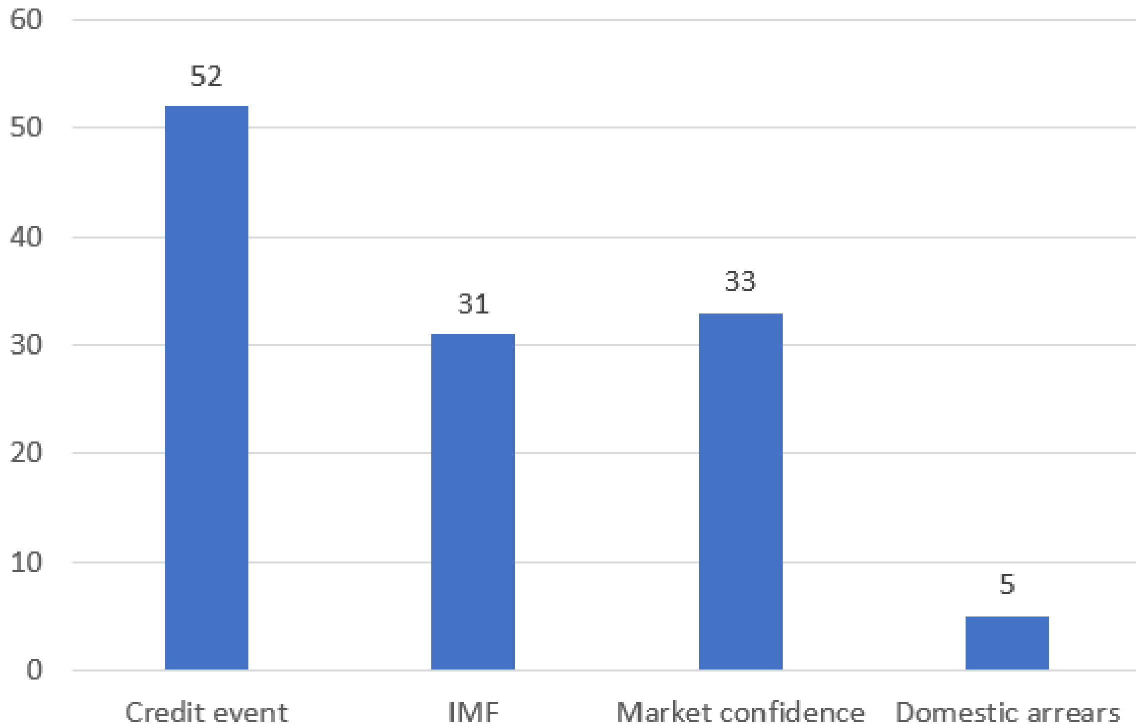
	events	episodes
2008	0	0
2009	0	0
2010	1	1
2011	1	·
2012	1	·
2013	1	·
2014	0	·
2015	1	·

Figure 3.1 gives the distribution of debt distress events in the sample according to different criteria. There are 52 country-years in the sample in which there is a debt distress event according to the credit criterion. There are 31 country-years in which there is a debt distress event as high-access IMF financial arrangements took place. 33 country-years indicate debt distress events due to loss of market confidence, and finally 5 country-years indicate debt distress in the form of a steep increase in domestic arrears.

4 Explanatory Variables and Data

I have examined several variables as predictors of sovereign debt distress episodes. Broadly speaking, these variables fall under three categories.

Figure 3.1: Number of Debt Distress Events According to Different Criteria



(1) Debt indicators: Public debt-to-GDP ratio, 3-year change in public debt-to-GDP ratio, external public debt-to-GDP ratio, external debt of the banking sector-to-GDP ratio, gross financing needs (GFN)-to-GDP ratio, primary deficit-to-GDP ratio.

(2) Macro variables: Real GDP growth, inflation, international reserves-to-imports ratio, 3-year change in private credit-to-GDP ratio, real exchange rate overvaluation, global real GDP growth.

(3) Country characteristics: Per capita real GDP, dummy variable indicating a small state, dummy variable indicating currency union membership.

The sample includes 118 market access countries for the time period between 1990 and 2015. There are 80 country-years in which a debt distress episode started, and 1200 non-debt distress episode country-years. As explained in the previous section, debt distress episodes data are based on Gerling et al. (2017). WEO is the main data source for explanatory variables. Additional data sources for public debt data is

Abbas et al. (2011), Haver Analytics and IMF staff reports for external debt, Mauro et al. (2015) for primary and fiscal deficits, IFS for international reserves and credit data.

Table 3.2 provides the correlation matrix for select variables. As one would expect, there is a significant and high correlation between public debt-to-GDP and external public debt-to-GDP ratios. Furthermore, GFN-to-GDP ratio is highly correlated with public debt-to-GDP and primary deficit-to-GDP ratios.

Table 3.2: Correlation Matrix

	Public debt	Δ in P debt	Ext pub debt	Ext bank debt	Pri deficit	GFN
Public debt	1.00					
Δ in P debt	**0.19**	1.00				
Ext pub debt	**0.65**	**0.04**	1.00			
Ext bank debt	**0.12**	**0.10**	**0.15**	1.00		
Pri deficit	**0.15**	**0.14**	**0.22**	-0.01	1.00	
GFN	**0.54**	**0.15**	**0.35**	**0.11**	**0.45**	1.00

Figure 3.2 shows the density functions for public debt-to-GDP and external public debt-to-GDP ratios. Dashed lines correspond to country-years in which countries experience debt distress events. Solid lines correspond to non-crisis country-years. In both cases, the distributions are more right skewed for non-crisis years, indicating the lower (higher) debt ratios for non-crisis (crisis) country-years.

Similarly, Figure 3.3 shows the density functions for per capita real GDP and inflation levels. As before, dashed lines correspond to country-years in which countries experience debt distress events, and solid lines correspond to non-crisis country-years. We can see that crisis country-years have lower per capita real GDP and higher inflation levels.

Figure 3.4 plots the median values of select variables over time. Time 0 corresponds to the year in which debt distress episode starts. The figure traces the behavior of the selected variables before the debt distress event and also afterwards. Public debt-to-GDP ratio and primary deficit-to-GDP ratio start to increase right before the crisis and peaks at the crisis year. Although the primary deficit-to-GDP ratio starts to decrease right after the crisis, the public debt-to-GDP ratio continues to increase and stays high for an extended time period. Countries experience a real exchange rate appreciation and a build up in their credit-to-GDP ratios long before the crisis starts. Once the crisis takes place, these ratios start to decline gradually.

5 Methodology and Results

In order to analyze the determinants of sovereign debt distress episodes, I estimate a probit model:

$$Pr(DD = 1|X, d) = \Phi(X\beta + d\gamma) \tag{3.1}$$

where $Pr(.)$ is the probability function; DD is a binary variable that takes the value of 1 if the country is experiencing debt distress episode and zero otherwise; Φ is the standard normal cumulative distribution function; β's and γ are the coefficients to be estimated; X is the vector of explanatory variables; d is the debt variable of interest.

Table 3.3 presents the baseline regression results. Notice that the coefficients give the average marginal effects. The original probit coefficients are provided in Table 3.6 in the appendix. Column 1 shows that the public debt-to-GDP ratio, inflation level, per capita real GDP, international reserves-to-imports ratio, 3-year change in credit-to-GDP ratio, real exchange rate overvaluation, and global growth rate are significant variables for predicting sovereign debt distress episodes. In column 2, I add the 3-year change in public debt-to-GDP ratio as an explanatory variable. The results do not change substantially. In columns 3 and 4, I add external public debt-to-GDP and external debt of the banking sector-to-GDP ratios, respectively. Both external debt ratios are significant predictors of debt distress episodes. However, once external debt measures are included, the public debt-to-GDP ratio loses its significance, which is not surprising given the correlation between different debt indicators.

Column 1 of Table 3.4 repeats the final regression in Table 3.3. It includes two additional specifications in which dummy variables for being a small state and being a currency union member are introduced (separately). The results suggest that small states and currency union members are significantly more likely to experience debt distress episodes.

Table 3.3: Baseline Results: Average Marginal Effects

	(1)	**(2)**	**(3)**	**(4)**
(Public debt/GDP)$_{t-1}$	0.078***	0.072***	0.022	0.016
3-year Δ in (Public debt/GDP)$_{t-1}$		0.050	0.076*	0.075*
(Ext public debt/GDP)$_{t-1}$			0.128***	0.117**
(Ext bank debt/GDP)$_{t-1}$				0.050***
(Primary deficit/GDP)$_{t-1}$	0.107	0.051	0.040	0.020
Real GDP growth$_{t-1}$	0.009	0.031	0.114	0.098
Inflation$_{t-1}$	0.089**	0.095**	0.101**	0.096**
Per capita real GDP$_{t-1}$	-0.363***	-0.364***	-0.384***	-0.536***
(Int reserve/imports)$_{t-1}$	-0.094**	-0.088**	-0.070*	-0.077*
3-year Δ in (Credit/GDP)$_{t-1}$	0.166***	0.167***	0.172***	0.117**
Real exc rate overvaluation$_{t-1}$	0.106*	0.100*	0.127*	0.121*
Global growth$_t$	-0.891*	-0.927*	-1.020*	-1.050**
N	1280	1280	1280	1280
Pseudo R-sq	0.128	0.130	0.145	0.157
Obs with dep 1	80	80	80	80

Table 3.4: Results with Dummies: Average Marginal Effects

	(1)	**(2)**	**(3)**
(Public debt/GDP)$_{t-1}$	0.016	0.004	0.016
3-year Δ in (Public debt/GDP)$_{t-1}$	0.075*	0.068*	0.074*
(Ext public debt/GDP)$_{t-1}$	0.117**	0.128***	0.100**
(Ext bank debt/GDP)$_{t-1}$	0.050***	0.058***	0.058***
(Primary deficit/GDP)$_{t-1}$	0.020	0.048	-0.007
Real GDP growth$_{t-1}$	0.098	0.129	0.134
Inflation$_{t-1}$	0.096**	0.096**	0.102**
Per capita real GDP$_{t-1}$	-0.536***	-0.558***	-0.659***
(Int reserve/imports)$_{t-1}$	-0.077*	-0.060	-0.068*
3-year Δ in (Credit/GDP)$_{t-1}$	0.117**	0.111**	0.121***
Real exc rate overvaluation$_{t-1}$	0.121*	0.123**	0.122*
Global growth$_t$	-1.050**	-1.070**	-1.020**
Small state		4.150***	
Currency union$_{t-1}$			5.040**
N	1280	1280	1280
Pseudo R-sq	0.157	0.168	0.164
Obs with dep 1	80	80	80

Table 3.5: Results with GFN: Average Marginal Effects

	(1)	(2)	(3)	(4)
(Public debt/GDP)$_{t-1}$	0.026	-0.014	-0.034	-0.016
3-year Δ in (Public debt/GDP)$_{t-1}$	0.060	0.068*	0.060	0.062
(Ext public debt/GDP)$_{t-1}$	0.142***	0.164***	0.163***	0.133**
(Ext bank debt/GDP)$_{t-1}$	0.035***	0.033**	0.040***	0.040***
(Primary deficit/GDP)$_{t-1}$	0.219			
(GFN/GDP)$_{t-1}$		0.123***	0.161***	0.121***
Real GDP growth$_{t-1}$	0.042	0.046	0.147	0.058
Inflation$_{t-1}$	0.266***	0.269***	0.281***	0.271***
Per capita real GDP$_{t-1}$	-0.383***	-0.357***	-0.353***	-0.442***
(Int reserve/imports)$_{t-1}$	-0.018	-0.016	-0.004	-0.015
3-year Δ in (Credit/GDP)$_{t-1}$	0.207***	0.211***	0.208***	0.198***
Real exc rate overvaluation$_{t-1}$	0.084	0.082	0.077	0.085
Global growth$_t$	-0.813	-0.865*	-0.917**	-0.850*
Small state			4.950***	
Currency union$_{t-1}$				3.460
N	802	802	802	802
Pseudo R-sq	0.205	0.212	0.233	0.215
Obs with dep 1	40	40	40	40

Table 3.5 makes use of gross financing needs instead of the primary deficit. While the primary deficit-to-GDP ratio does not seem to be a significant predictor of sovereign debt distress episodes, the GFN-to-GDP ratio has a positive and significant coefficient. Countries with larger gross financing needs are more likely to experience debt distress episodes.

6 Deriving a Probability Threshold

After estimating the probit model, the optimal cutoff probability is calculated in four steps:

(i) using the estimated model and data for each episode, calculate the fitted probability of debt distress, $\widehat{P}$;

(ii) classify episodes as distress or non-distress by comparing $\widehat{P}$ with candidate cutoff probabilities, $\bar{P}$, such that a distress (non-distress) episode is predicted correctly whenever $\widehat{P} \geq \bar{P}$ ($\widehat{P} < \bar{P}$);

(iii) compare the classification generated in (ii) with actual outcomes to determine type I (failure to predict distress that actually occurred) and type II (incorrectly predicting distress when it did not occur) errors; and

(iv) select the optimal cutoff probability, $\widehat{P}^{*}$, that minimizes a loss function equal to the weighted sum of type I and type II errors.

The loss function can be written as follows:

$$\text{Loss function} = \omega \text{ Type I error} + (1 - \omega) \text{ Type II error}$$

Type I error (t_1): Missed calls

Type II error (t_2): False alarms

Once we have the optimal probability cutoff, we can invert the probit equation to derive some indicative thresholds for debt variables, d^{*}, as follows:

$$\frac{\Phi^{-1}(p^{*}) - X_M \widehat{\beta}}{\widehat{\gamma}} = d^{*} \tag{3.2}$$

where X_M is the vector of median values of explanatory variables.

I calculate that for $\omega = 0.5$, the optimal cutoff probability is $p^{*} = 0.08$, and the corresponding type I and type II errors are equal to $t_1 = 0.24$ and $t_2 = 0.25$, respectively. By inverting the probit equation, I calculate the indicative thresholds for external public debt-to-GDP ratio, and for the 3-year change in public debt-to-GDP ratio. The thresholds are 54%, and 26 percentage points, respectively. Figure 3.5 plots the predicted probabilities for the debt distress episodes in the sample and the optimal cutoff probability. Debt distress episodes in which the predicted probabilities exceed the optimal cutoff probability are successfully captured by the model. Debt distress episodes in which the predicted probabilities stay below the optimal cutoff probability correspond to type I error (failure to predict distress that actually occurred).

I also calculate the indicative thresholds for external public debt-to-GDP ratio, and for the 3-year change in public debt-to-GDP ratio for countries experiencing low or high inflation. When I use the 5^{th} percentile for inflation (-0.4%) instead of the median value (4%), the indicative thresholds become 59%, and 31 percentage points, respectively. When I use the 95^{th} percentile for inflation (21%), these thresholds become 35%, and 7 percentage points. These results suggest that countries experiencing higher inflation levels have lower debt tolerance.

7 Conclusion

In this chapter, I develop an econometric model to identify the main factors contributing to sovereign debt crises. The model takes into account a broad range of debt distress drivers, including debt levels and gross financing needs, but also composition of the debt, macroeconomic fundamentals, and country characteristics such as whether the country is a small state or a member of a currency union. I show that the external public debt-to-GDP and the external debt of the banking sector-to-GDP are important predictors of sovereign debt episodes. Other predictors are 3-year change in public-debt-to-GDP ratio, inflation level, per capita real GDP, international reserves-to-imports ratio, 3-year change in credit-to-GDP ratio, real exchange rate overvaluation, global growth rate, as well as country characteristics such as being a small state or a member of a currency union. Although the primary deficit-to-GDP ratio does not seem to be an indicator for debt distress episode, there is evidence suggesting that GFN-to-GDP ratio is a predictor.

By using the estimation results, I derive an indicative cutoff probability of debt distress level. Then, I calculate the corresponding thresholds for debt variables, above which countries are predicted to experience an episode of debt distress. When all variables are at their median values, the indicative threshold for external public debt-to-GDP ratio is equal to 54%. Beyond that level, the model predicts that the country will experience a sovereign debt distress episode. Similarly, the threshold for the 3-year change in the public debt-to-GDP ratio is equal to 26 percentage points when all other variables are at their median levels. These figures can provide guidance to practitioners who have been relying on judgement, rather than analytical models, for assessing the probability of sovereigns' debt levels being sustainable.

Figure 3.2: Density Functions for Debt Variables

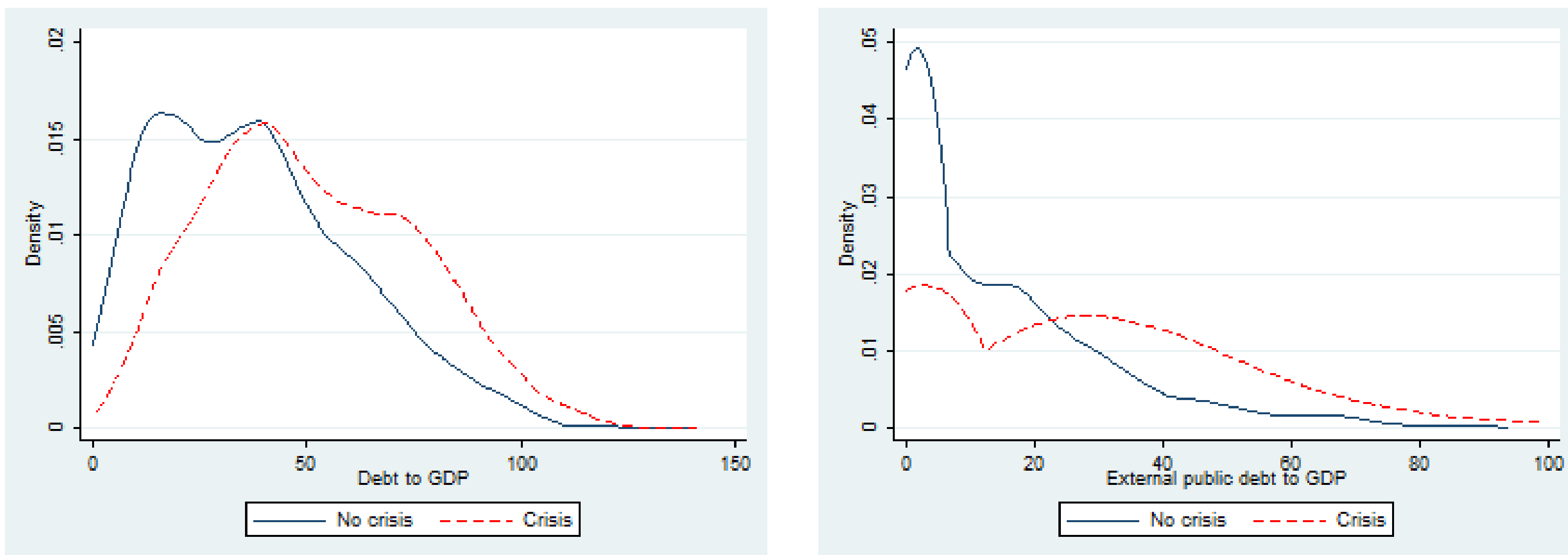


Figure 3.3: Density Functions for Select Variables

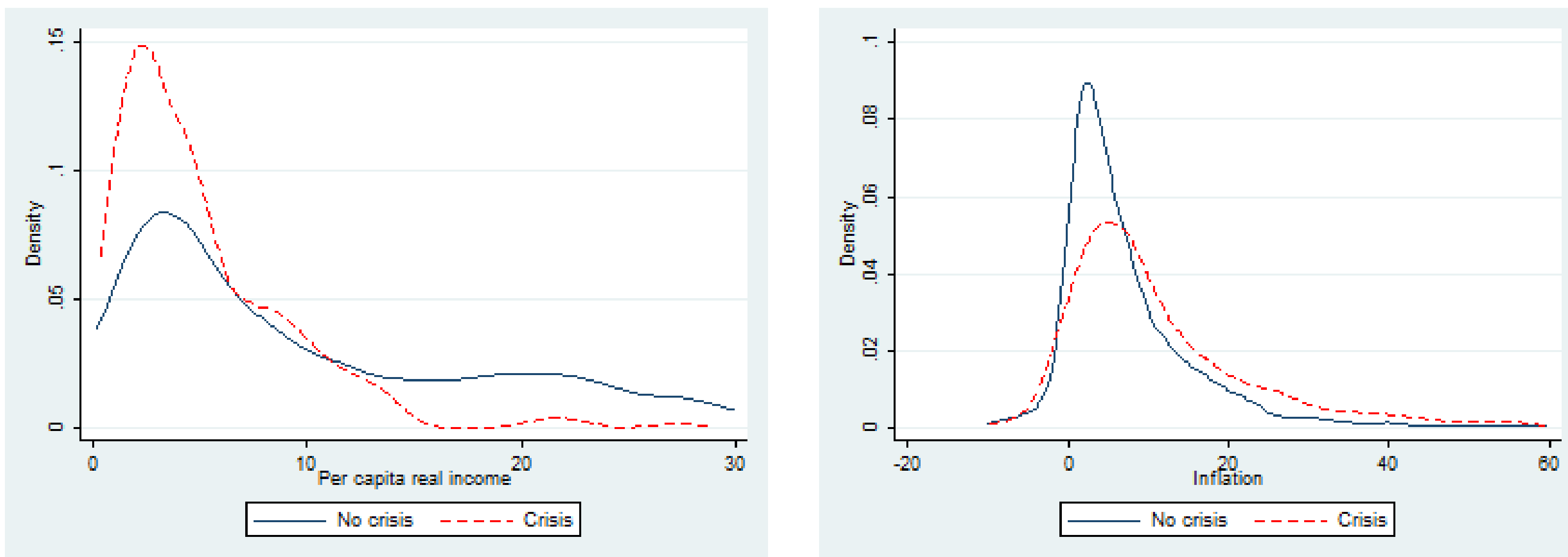


Figure 3.4: Median Indicators Around Debt Distress Episodes

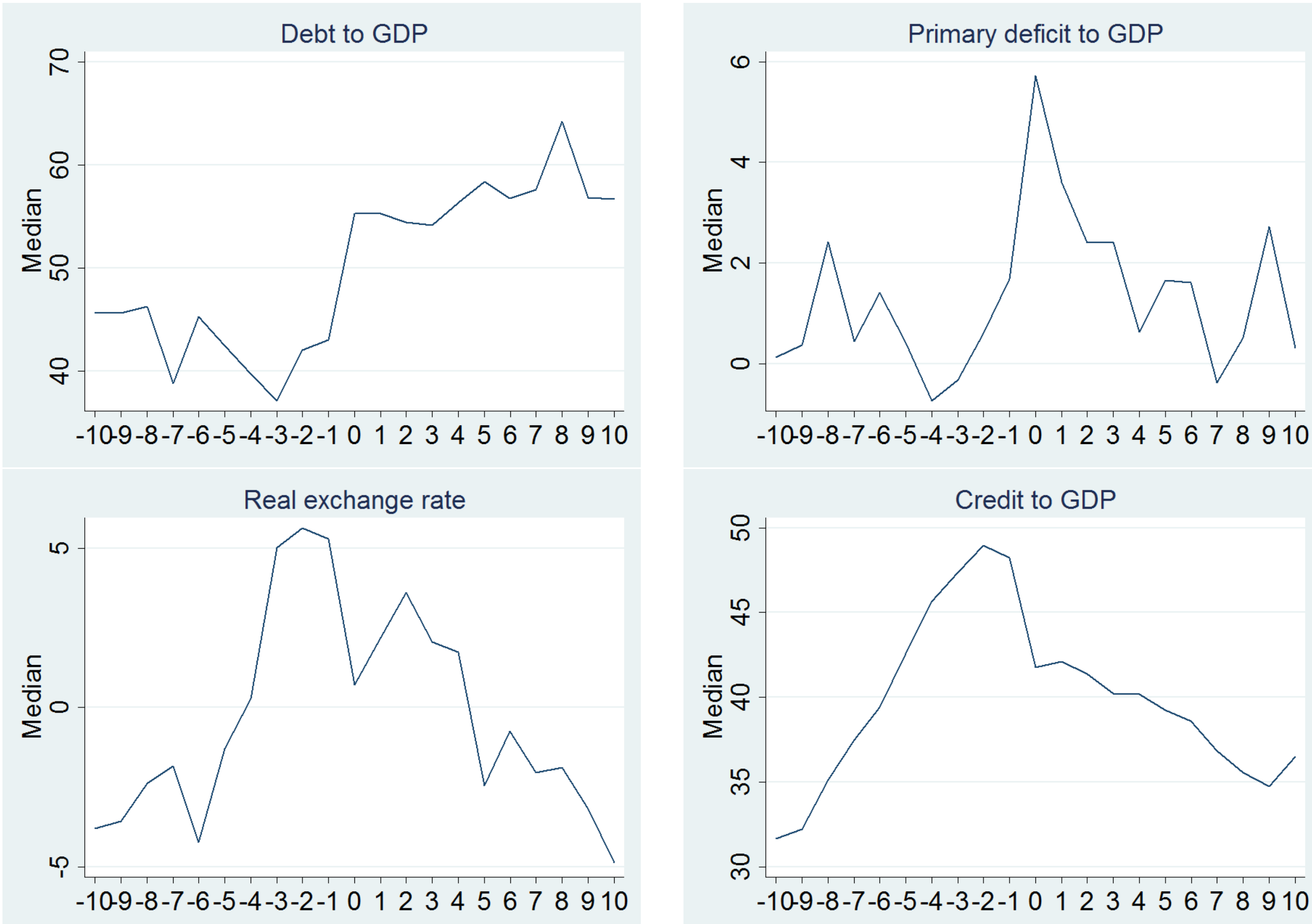
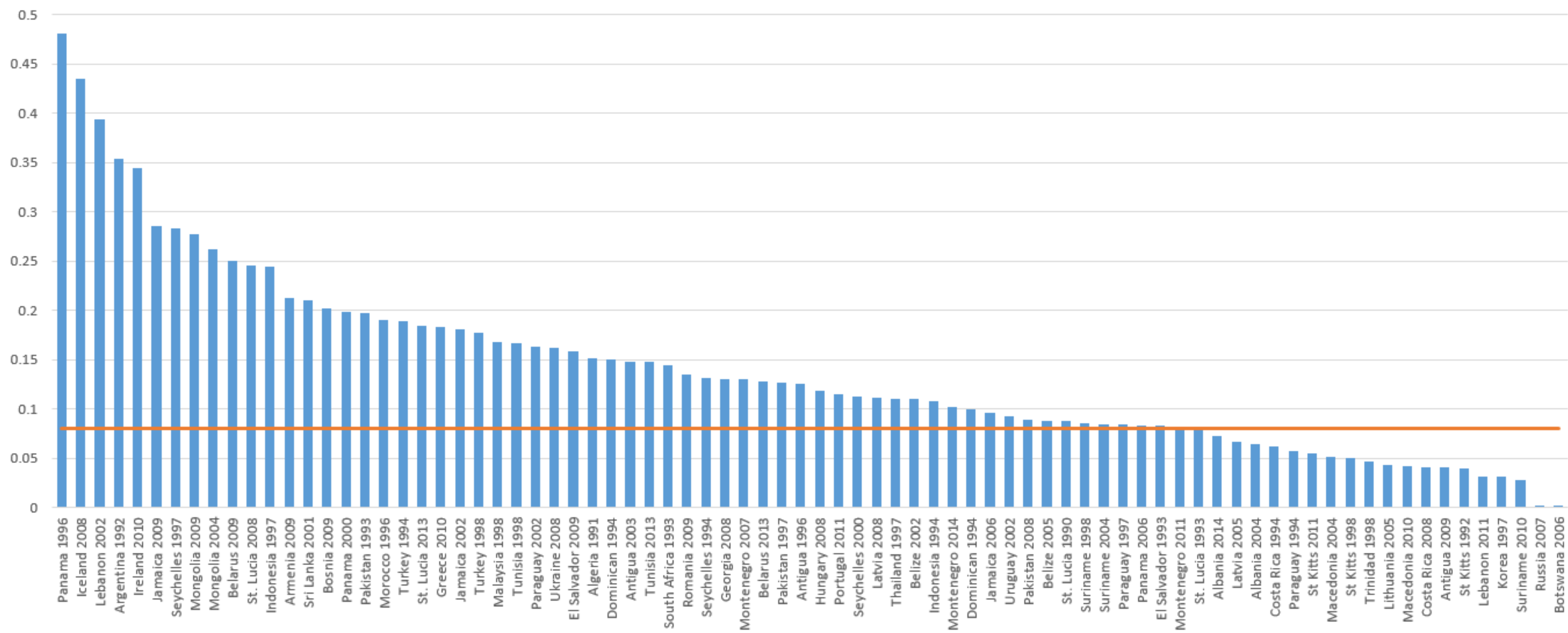


Figure 3.5: Predicted Probabilities of Debt Distress and Optimal Cutoff Probability



APPENDIX

3.A Tables

Table 3.6: Baseline Results: Probit Coefficients

	(1)	(2)	(3)	(4)
(Public debt/GDP)$_{t-1}$	0.007***	0.007***	0.002	0.002
3-year Δ in (Public debt/GDP)$_{t-1}$		0.005	0.007*	0.007*
(Ext public debt/GDP)$_{t-1}$			0.012***	0.011**
(Ext bank debt/GDP)$_{t-1}$				0.005***
(Primary deficit/GDP)$_{t-1}$	0.010	0.005	0.004	0.002
Real GDP growth$_{t-1}$	0.001	0.003	0.011	0.009
Inflation$_{t-1}$	0.008**	0.009**	0.010**	0.009**
Per capita real GDP$_{t-1}$	-0.033***	-0.034***	-0.036***	-0.051***
(Int reserve/imports)$_{t-1}$	-0.009**	-0.008**	-0.007*	-0.007*
3-year Δ in (Credit/GDP)$_{t-1}$	0.015***	0.015***	0.016***	0.011**
Real exc rate overvaluation$_{t-1}$	0.010*	0.009*	0.012*	0.011*
Global growth$_t$	-0.082*	-0.085*	-0.096*	-0.099**
N	1280	1280	1280	1280
Pseudo R-sq	0.128	0.130	0.145	0.157
Obs with dep 1	80	80	80	80

Table 3.7: Results with Dummies: Probit Coefficients

	(1)	(2)	(3)
(Public debt/GDP)$_{t-1}$	0.002	0.000	0.002
3-year Δ in (Public debt/GDP)$_{t-1}$	0.007*	0.007*	0.007*
(Ext public debt/GDP)$_{t-1}$	0.011**	0.012***	0.010**
(Ext bank debt/GDP)$_{t-1}$	0.005***	0.006***	0.006***
(Primary deficit/GDP)$_{t-1}$	0.002	0.005	-0.001
Real GDP growth$_{t-1}$	0.009	0.012	0.013
Inflation$_{t-1}$	0.009**	0.009**	0.010**
Per capita real GDP$_{t-1}$	-0.051***	-0.054***	-0.063***
(Int reserve/imports)$_{t-1}$	-0.007*	-0.006	-0.006*
3-year Δ in (Credit/GDP)$_{t-1}$	0.011**	0.011**	0.012***
Real exc rate overvaluation$_{t-1}$	0.011*	0.012**	0.012*
Global growth$_t$	-0.099**	-0.103**	-0.098**
Small state		0.400***	
Currency union$_{t-1}$			0.482**
N	1280	1280	1280
Pseudo R-sq	0.157	0.168	0.164
Obs with dep 1	80	80	80

Table 3.8: Results with GFN: Probit Coefficients

	(1)	**(2)**	**(3)**	**(4)**
(Public debt/GDP)$_{t-1}$	0.003	-0.002	-0.004	-0.002
3-year Δ in (Public debt/GDP)$_{t-1}$	0.007	0.008*	0.008	0.008
(Ext public debt/GDP)$_{t-1}$	0.017***	0.020***	0.020***	0.016**
(Ext bank debt/GDP)$_{t-1}$	0.004***	0.004**	0.005***	0.005***
(Primary deficit/GDP)$_{t-1}$	0.026			
(GFN/GDP)$_{t-1}$		0.015***	0.020***	0.015***
Real GDP growth$_{t-1}$	0.005	0.006	0.018	0.007
Inflation$_{t-1}$	0.032***	0.032***	0.035***	0.033***
Per capita real GDP$_{t-1}$	-0.046***	-0.043***	-0.044***	-0.054***
(Int reserve/imports)$_{t-1}$	-0.002	-0.002	-0.001	-0.002
3-year Δ in (Credit/GDP)$_{t-1}$	0.025***	0.025***	0.026***	0.024***
Real exc rate overvaluation$_{t-1}$	0.010	0.010	0.010	0.010
Global growth$_t$	-0.097	-0.105*	-0.115**	-0.103*
Small state			0.620***	
Currency union$_{t-1}$				0.419
N	802	802	802	802
Pseudo R-sq	0.205	0.212	0.233	0.215
Obs with dep 1	40	40	40	40

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