European University Institute

DEPARTMENT OF ECONOMICS

Three Essays in Macroeconomics

Noëmie Lisack

Thesis submitted for assessment with a view to obtaining the degree of Doctor of Economics of the European University Institute

Florence, 17 November 2016

European University Institute
Department of Economics

Three Essays in Macroeconomics

Noëmie Lisack

Thesis submitted for assessment with a view to obtaining the degree of Doctor of Economics of the European University Institute

Examining Board

Prof. Árpád Ábrahám, EUI, Supervisor
Prof. Ramon Marimon, EUI
Prof. Raul Santaeulàlia-Llopis, MOVE-UAB and Barcelona GSE
Dr. Mark Wright, Federal Reserve Bank of Chicago

European University Institute

DEPARTMENT OF ECONOMICS

Researcher declaration to accompany the submission of written work

I Noëmie Lisack certify that I am the author of the work Three Essays in Macroeconomics I have presented for examination for the PhD thesis at the European University Institute. I also certify that this is solely my own original work, other than where I have clearly indicated, in this declaration and in the thesis, that it is the work of others.

I warrant that I have obtained all the permissions required for using any material from other copyrighted publications.

I certify that this work complies with the *Code of Ethics in Academic Research* issued by the European University Institute (IUE 332/2/10 (CA 297).

The copyright of this work rests with its author. [quotation from it is permitted, provided that full acknowledgement is made.] This work may not be reproduced without my prior written consent. This authorisation does not, to the best of my knowledge, infringe the rights of any third party.

Statement of inclusion of previous work (if applicable):

I confirm that chapter 3 was jointly co-authored with Mr Gustavo Adler and Rui Mano and I contributed 70% of the work.

Signature and Date:

October 5, 2016
Noëmie Lisack

Acknowledgements

Florence and the European University Institute may seem like a dream place to spend a few years thinking about credit distribution, alternative finance and foreign exchange intervention. And it is true. But that does not mean that writing this dissertation was a "long fleuve tranquille". Like everyone, I had times of doubt, times where my relationship to computers – and especially to Matlab and Knitro – was rocky, times where I could not stand looking at a single equation any more. Those close to me have all heard about it.

My first thanks go to my supervisors. Both of them, through their comments and suggestions, have played a very important role in guiding my research. Over these five years, Árpád Ábrahám has always been incredibly available to give me advice on all kinds of issues, from broad research directions to technical difficulties, via job application strategies. Without these intense and fertile discussions, this dissertation would not be what it is now. Through his ability to listen and to help me clarify my thoughts, Ramon Marimon has greatly contributed to shaping my work into more intelligible and clear-cut papers than I would have achieved otherwise. His remarks always proved wise and stimulating.

The whole administration team of the Economics Department has been incredibly helpful in creating a comfortable and productive working environment. Jessica and Lucia have always been there to quickly resolve any question I had, both on the administrative and personal side. On multiple occasions, Riccardo gave his time and expertise to help me make the best possible use of the department's computers, and that turned out to be invaluable for me.

I might not have started this journey towards macroeconomics, had I not met Matthieu Bussière. His advice and support, while I was at the Bank of France and once I had settled in Florence, proved extremely relevant and encouraging. Similarly, Romain Rancière kindly encouraged me to pursue this path. To all my co-authors, Matthieu again, Gong Cheng, Gustavo Adler and Rui Mano, it has been a great pleasure to work with you! I have learned a lot from our discussions on common projects, and I found our cooperation very enriching and fruitful.

Writing this thesis also meant meeting many wonderful friends, who helped me cope with stress and enjoy my life. All of them, from various EUI cohorts, further contributed to this work by their remarks, questions and advice. I thank them for making my time in Florence an incredible experience, for their supporting and comforting words when needed, and for their ability to turn into a nice and fun experience what was also tough working times. I tried so hard to follow Rana that we now end up living again in the same city and working at the same place, for the third time! My experience in Florence would not be the same without these late night problem set sessions of the first year, and all the crazy moments spent together with John – whether drinking beers in the city, chatting in the kitchen, or extinguishing an unexpectedly burning shirt. Paweł Doligalski was always there, whether sharing my office or not, to answer my stupid questions, compensate for my lack of organization and share a drink after a hard day of work.

When not talking about economics, Benedetta, Laura and Janine filled my evenings with beautiful songs, and were the very first ones to introduce me to Italian. Climbing helped me expand further my Italian vocabulary! Thanks to the EUI duri, and especially to Omar, I now know what are a *rinvio*, an *imbrago*, and many other pieces of a climber's equipment. Climbing sessions have been a great way to get rid of my excess energy. Wojteck initiated it, Omar took it further... and was the patient witness of my stupid jokes for the last three years. I taught you him not to "fly", some time he will have to convince me to try "flying".

Non-florentine friends should not be forgotten. Anastassia and Florence have been following my life sometimes from far away, sometimes meeting unexpectedly in random locations. Hopefully such occasions will keep showing up, even after submitting this dissertation.

Finally, I would not be there without the constant support of my family. My parents, always ready to come and visit, always willing to learn about my life, and prompt to help when needed, have greatly contributed to my happiness during these years. Gaëlle and Lucille, who know what writing a dissertation means, were always able to subtly ask, enough but not too much, about the general progress of mine, and to have a chat about it, or about everything else, depending on my mood. Quentin did not complain when he came to visit and I took him... to the EUI library to spend the day working! My grand-mother was always eager to know how was Italy and how my work was progressing. Last but not least, Thibaud jumped on the bandwagon, just in time to enjoy the worst though most exciting moments, including the whole job market process and the thesis submission. Every time I needed it, you were there: to fill in application forms on my behalf on their due date, to prevent me from getting crazy over a simple Excel sheet, to spend hours on Skype talking about life plans while at the other end of the world, to take me for beers when necessary and, lastly, to spend entire days in an empty flat waiting for randomly-timed furniture deliveries. You know it, I would never have managed otherwise. Merci!

Abstract

Two different themes, both within Macroeconomics, are tackled in this work. The first and second chapters study how enterprises access financial resources to finance their investment. The third chapter relates to international macroeconomics, analysing the effect of foreign exchange interventions on the exchange rate level.

How do Chinese small- and medium-sized enterprises manage to bypass financial constraints and invest, despite their limited access to formal bank loans? What is the impact of the recent banking sector reforms in China? In my first chapter, I show evidence of the crucial role played by alternative sources of funding - namely family, friends, non-listed equity and further informal institutions - in supplementing usual financing sources like bank loans and reinvested profits. I conclude that liberalizing the banking sector significantly increases steady-state aggregate production and capital levels. Tightening the regulation of the alternative finance sector remains detrimental to small, young enterprises, even if simultaneous to liberalizing the banking sector.

The second chapter suggests a theoretical mechanism driving fluctuations in the ability of newcomer enterprises to obtain financial resources for their investment projects. I examine the differentiated impact of a shock in commercial banks' refinancing cost on loan distribution, distinguishing among borrowers according to their previous loan history with the bank. Since loan officers have more information on incumbent borrowers than on newcomers, they may prioritize loans to incumbents against loans to newcomers, as a response to the shock.

The last chapter (joint with G. Adler and R. C. Mano) studies the impact of foreign exchange intervention for a large panel of countries. We find robust evidence that foreign exchange intervention affects the level of the exchange rate in an economically meaningful way: a country purchasing (selling) its own domestic currency appreciates (depreciates) it. In addition, these effects are found to be quite persistent.

Contents

1 Alternative Finance and Credit Sector Reforms: the Case of China

Abstract

This paper studies firms' optimal investment decisions and their choice of financing sources in a general equilibrium framework with heterogeneous firms. Besides retained earnings and bank loans, I focus on the crucial role played by alternative sources of funding, including family, friends, non-listed equity and informal banking institutions. While small young enterprises face important difficulties to finance their investment, these alternative financing sources allow them to partially bypass credit constraints. The model I develop can account for the financing patterns observed in Chinese data. In this framework, I quantify the impact of various reforms of the credit distribution sector on the aggregate economy and enterprise trajectories. Liberalizing the banking sector increases the steady-state aggregate level of capital by 10%, and the steady-state aggregate production by 5%. In addition, the short-term production growth of small, new-born firms increases by up to 7 percentage points on average. Tightening the regulation of the alternative finance sector, even if simultaneous to a bank liberalization, remains detrimental to small, young enterprises.

Introduction

Over recent decades, emerging market economies have seen a tremendous economic growth: China's GDP has increased by 9.6% per year on average since 1995, India's GDP by 6.8% over the same period. Since the institutional environment in these countries is relatively poor, this fact tends to contradict the relationship between legal environment, financial institutions and economic growth highlighted by, among others, Levine (1999) and Demirguç-Kunt and Maksimovic (1998). How can we account for these flourishing economies, given the fundamental uncertainties on property rights, access to financing and law enforcement? How would reforms towards a more competitive credit distribution impact the economy both in terms of aggregate situation and enterprise trajectories?

Answering these questions requires to fully understand the patterns of investment financing. To be able to invest and grow, enterprises must find ways to bypass the limitations of financial institutions. As suggested by Allen et al. (2005), when facing important obstacles in obtaining bank loans or issuing equity, enterprises may resort to alternative sources of funding, like family, friends, or other external sources. In China, the well-known example of the prosperous city Wenzhou shows how a clan-like social organisation and strong mercantile traditions spurred the creation and growth of enterprises. For the (mostly small) firms that face difficulties accessing the credit market, the presence of alternative financing sources through family or friends, trade credit, non-listed equity and moneylenders is crucial to bypass credit constraints and finance investment.

The role of such alternative sources of funding in alleviating financial constraints and the influence of credit sector reforms are at the center of this paper. I propose modelling alternative funding sources and quantifying the impact of a banking liberalization for firms' investment, with a specific focus on the Chinese case. Misallocations are indeed well-rooted in the history of Chinese formal credit markets, which renders the study of alternative financing and banking reforms especially interesting in this country. Retail banking interest rates have long been set by the government, while banks were advised to direct loans towards large state-owned enterprises.[1] Reforming the banking sector towards a more market-based functioning is an on-going process in China, and interest rates are not fully liberalized yet. To model this situation, I first set up a general equilibrium framework where heterogeneous firms choose how much to invest and how to finance it, between retained earnings, official bank loans and alternative funding. This model focuses on credit markets as one specific cause for capital misallocation. I then calibrate the model's parameters according to stylized facts for China. In this framework, I investigate how a liberalization of banks' interest rates, coupled or not with a tighter regulation of alternative finance, impacts firms' investment opportunities and the aggregate economy.

[1] As will be detailed in section 1.1.1, loan applications from private enterprises have long been disregarded by Chinese state-owned banks – who control the bulk of the credit distributed in China. This is one of the main reasons why small private firms still face significant obstacles when looking for financing.

The contribution of this paper is twofold. First, while the current literature considers only equity, bonds and retained earnings, I add the possibility for firms to access alternative sources of funding, including family and friends, non-listed equity, and informal sources in the model. In my set-up, firms have unequal access to this additional funding source, to reflect the randomness of contacts and networks. Many papers have dealt with resource misallocation and its impact on the aggregate economy (see, for instance, Restuccia and Rogerson, 2008 and Hsieh and Klenow, 2009); however they tend not to study alleviation mechanisms carefully. Second, for the case of China, I evaluate quantitatively the impact of reforming the credit sector on the aggregate economy and enterprises development, accounting for this alternative funding source. Such an evaluation has not been done before, as studies on investment financing in China have either been only qualitative, or have focused on financial constraints faced by firms rather than on how to bypass those constraints and potential reforms.

I compare four scenarios of reforms where the bank interest rates are fully liberalized and set competitively: (i) while alternative funding is never allowed; (ii) while alternative funding is always allowed; (iii) while access to alternative funding is shut down; and (iv) while access to alternative funding is more tightly regulated (partially shut down). The results show that the presence of alternative financing sources increase aggregate production and consumption by 6.6% and 6.2% respectively, and that a liberalization of the banking sector increases aggregate production and consumption by 5.5% and 3.1% respectively. In terms of development of small young firms over the first 6 years of their activity, the liberalization implies an average production growth from 2 percentage points slower to 7 percentage points faster (depending on their initial productivity), and an average capital growth from 1 percentage points slower to 13 percentage points higher. It also improves resource allocation, as more productive new-born firms grow faster in terms of production and capital after the liberalization, whereas their less productive peers grow slower. By alleviating financial constraints before the reforms, the presence of alternative financing sources dampens the reforms impact on the Chinese aggregate consumption. Furthermore, I show that liberalizing the banking sector can compensate for a tighter regulation of the alternative finance sector, but only partially. On the one hand, liberalizing the banking sector while shutting down all alternative funding increases aggregate production and consumption by respectively 5.61% and 3.05%; on the other hand, such a combined reform lowers the average growth of small young firms by up to 14 percentage points in terms of production, and up to 23 percentage point in terms of capital.

As highlighted by the above results, alternative funding renders small young firms more dynamic in terms of production and capital growth, and contributes to a higher long-run level of aggregate production and capital. This partly explains the surprising coexistence of a tremendous economic growth and malfunctioning formal credit institutions in emerging countries. In the case of China, liberalizing the banking sector has a clear positive impact, although possibly not as high as expected due to the presence of alternative financing. Tightening the regulation standards of non-bank lending institutions could be detrimental to this economic dynamism, and should go hand in hand with a liberalization of the banking sector and a more efficiently allocated bank credit, in order to prevent regulation from having a biased impact on young private firms.

The remainder of this section reviews related literature. Section 1.1 presents the data and some important stylized facts. Section 1.2 describes the program of the heterogeneous enterprises at the core of the theoretical model. Section 1.3 closes the model by inserting the firms' program into a general equilibrium framework. Section 2.4 turns to the calibration of the model and section 1.5 presents the results.

Related literature

This study is connected to three strands of literature. The first relates to theoretical and structural papers that tackle resource allocation, development of firms and economic growth. Second, many qualitative studies examine the link between institutions' general quality and development. Third, numerous papers focusing on China provide empirical evaluations of the presence of financial constraints faced by local enterprises, and of its alleviating factors.

First, focusing on resource allocation, Restuccia and Rogerson (2008) and Hsieh and Klenow (2009) look at the impact of misallocations that can be triggered by political preferences, regulation or credit constraints. They model misallocation by imposing heterogeneous tax rates on output, capital and labor in a macroeconomic set-up. Greenwood et al. (2013) further provide a microfounded framework based on incomplete information and costly monitoring technology. In their set-up, all funding for capital investment is obtained through financial intermediaries, within a single competitive sector for financial intermediation. The allocation of financial resources is also tackled by Song et al. (2011), who model the Chinese economic transition through a reallocation of resources from financially integrated (i.e. state-owned) firms to entrepreneurial (i.e. private and credit constrained) ones. Song et al. (2014) further take into account the government's action through capital controls, government bond rate, deposit rate and exchange rate policies. They conclude among others that liberalizing the deposit rate relaxes firms' credit constraints and fastens the economic transition. The model I present here emphasizes a different aspect of capital misallocation and fund-raising decision: it includes alternative funding sources accessible by credit constrained firms, and studies firms' constrained choice of funding source. My objective is to quantify not the impact of capital misallocation, but to what extent a bank liberalization could alleviate this misallocation, accounting for the presence of alternative sources of funding. In this regard, my study is closer to Moll (2014) and Song et al. (2011), although entrepreneurs in my model use access to alternative funding sources on top of self-financing to bypass financial constraints. I focus here on investment financing sources and credit sector reforms in the pre-crisis context, until 2007. More recently, Cong and Ponticelli (2016) study the impact of the "Chinese Economic Stimulus Plan" on credit distribution across firms after the start of the global financial crisis. They show evidence that the stimulus favors state-owned firms against private ones, thus partially counteracting the effects of previous financial reforms shown in this paper.

Other theoretical papers provide abundant literature related to heterogeneous agent models. The theoretical framework used here is relatively close to Arellano et al. (2012), who set up a model where heterogeneous firms choose between debt and equity to finance investment. Financial development, represented by a cost of access to credit, is at the center of their work, while mine focuses on the presence of alternative financing sources alleviating credit constraints. Further papers investigate firms' financing constraints and choices: Cabral and Mata (2003) explain the size distribution of firms by the presence of financial constraints; Cooley and Quadrini (2001) use financial frictions in a firm dynamics model to explain stylized facts about the link between firm age, size and growth. While related to these studies in terms of firms' modelling and credit constraints, my paper includes additional financing mechanisms and focuses on reforms' impact rather than on the general age and size distribution of firms.

Second, from a more qualitative viewpoint, the finance-growth nexus and more generally the importance of institutions' quality has been studied among others by Allen et al. (2010), who compare China and India's institutional frameworks. In a similar direction, Allen et al. (2012) examine the role of informal finance in the economic development of China. The latter support the view that the alternative financing sector, which they define as every non-bank source of funds, plays an essential role in explaining the high growth observed in China for more than a decade. Drawing on the qualitative evidence provided by these studies, I suggest a theoretical model to quantify more precisely the impact of alternative financing sources on firms' development.

The third strand of literature regards empirical estimations of the extent of financial constraints in China. For instance, Ayyagari et al. (2010) analyze the performance difference between Chinese firms financed by banks and through informal sources. They show that the collateral required by formal banks is an important obstacle for private firms to obtain loans and that firms using bank loans are associated with higher sales growth. Du and Girma (2009), Girma et al. (2008) and Demetriades et al. (2008) conduct similar studies on the relationship between firm size, firm growth and source of finance. They conclude that formal and alternative finance sources are complementary in supporting different types of firms, and that the financial sources have a significant impact on firms' growth. More recently, Degryse et al. (2013) empirically show that informal finance has a positive impact on sales growth of small Chinese firms, and no impact for large ones. Poncet et al. (2010) and Héricourt and Poncet (2009) suggest methods to test if Chinese firms are credit constrained, separating between private and state-owned firms. My model, calibrated on the Chinese situation, builds on this empirical evidence.

1.1 Data and stylized facts

1.1.1 Chinese context

With the coming to power of Deng Xiaoping in 1978, China has gradually opened up and entrepreneurship has developed tremendously. The progressive loosening of regulatory constraints, coupled with privatizations, mergers and closures of State-Owned Enterprises (hereafter, SOE), favored the growth of the private sector, consisting mainly in young, small and medium enterprises.[2]

Still, the current characteristics of the Chinese credit market go hand in hand with resource misallocations that may impact output production and efficiency. This situation is deeply rooted in Chinese post-World War II history. Until 1998, state-owned banks did not grant credit to private enterprises, observing what is known as the "political pecking order". Since then, the official stand regarding credit distribution has changed, but credit constraints are still present. As found by Du and Girma (2009), the "big four" State-owned Chinese banks tend to grant more credit to large firms than to Small and Medium Enterprises (hereafter, SME), discriminating not only against private firms, but also against smaller firms in general.

The size of a firm is indeed crucial to obtain formal financial credit for many reasons. First, Chinese banks usually require collateral when granting a loan, and generally accept only land or buildings. Given the specific features of the Chinese land ownership system, in particular that the land is mainly owned by the state, private SME are unlikely to be able to provide land as collateral. Second, interest rates charged by the banks and the amount of credit available in the Chinese economy are mainly set by the monetary authorities until 2004.[3] Hence, banks are not able to

[2]The number of State-owned and State-holding industrial enterprises in China Mainland has decreased by 72% within 15 years, from 64737 in 1998 to 34280 in 2003 and 18197 in 2013. Over the same period, the number of private industrial enterprises has been multiplied by 18, increasing from 10667 in 1998 to 67607 in 2003 and 194945 in 2013. However, with average total assets per enterprise amounting to 276 million yuan in 2003 (up from 116 millions yuan in 1998), state-owned enterprises remain much larger than private enterprises, that reach an average level of total assets per enterprise equal to 21 million yuan (up from 14 million yuan in 1998). Source: Chinese Statistical Yearbook 2014.

[3]Until 2004, the People's Bank of China imposed to domestic banks a ceiling and a floor rates for loans (and deposits): lending rates were allowed to move between 0.9 and 1.1 times the benchmark rate for loans to large enterprises, and between 0.9 and 1.3 times the benchmark rate for loans to SME. In 2004, the ceiling rate for loans (and the floor rate for deposits) were suppressed, allowing banks to better price the riskiness of the borrowers by adjusting lending rates upwards. Furthermore, Chinese monetary policy is also implemented through "window guidance", guiding credit allocation in terms of credit volumes and sectoral distribution. For more details, see, for instance, Laurens and Maino (2007).

match their interest rates with the risk profile of the borrower and are instead forced to modify their credit supply by adjusting quantity or selecting their borrowers. Since large enterprises, and even more SOE, often beneficiate from an implicit government guaranty, banks tend to favor them when distributing loans.

To bypass these credit constraints, SME may want to turn to financial markets. Indeed, SME are often viewed as more productive than large ones – which are often SOE – and should therefore attract more investment, and be able to raise more funds through bank credit and financial markets. However, access to financial markets remains insufficiently developed to offer enough capital to Chinese enterprises, and those that cannot obtain bank loans either resort to retained earnings to finance themselves, or need to find funding through alternative non-market sources.

Besides retained earnings, SME use more informal funding sources to finance their investment: family and friends, non-listed outside equity, or informal banking institutions, from trust companies to pawnshops, via clan organizations (e.g. entrepreneurs from the coastal city Wenzhou[4]). These alternative sources are key for the growth of enterprises in China, and are at the center of this paper. Obtaining funding from family or friends has the advantage that it generally requires neither collateral nor very high interest payments. Similarly, informal lenders usually do not require the same kind of collateral as banks, though they often use other means to insure repayment, like reputation, trust or violence. They further require higher interest rates, close to 100% per year in some extreme cases, which limits the amount and loan duration the borrower can get. The data presented in the next section give us more details regarding these alternative ways to finance investment.

1.1.2 Data presentation

Firm-level data come from the Enterprise Surveys conducted by the World Bank[5] in many countries in the 2000s. These surveys mainly focus on SME, although they include some large enterprises too. In China, surveys were conducted over 1548 enterprises in 2002 and 2400 enterprises in 2003. Since the liberalization of retail banks interest rates was initiated in 2004, it is relevant to use data obtained just before the start of the reforms and I decided to focus on the situation of firms at the start of the 21^{st} century.[6] The samples used by the World Bank in 2002 and 2003 correspond broadly to the overall distribution of Chinese enterprises. They provide firm-level data on many aspects of the firms' situation, including the ownership structure, production, labor, investment and

[4] See for instance Liu (1992) and more recently Wei et al. (2007) for more details.

[5] These data are available at `http://www.enterprisesurveys.org/`.

[6] A new survey (data from 2012) has been released recently; however the variables included in it are not easily comparable with previous surveys.

financing. Not all variables are filled in for both years. Consequently, I will be using data from 2002 to estimate the production function and data from 2003 regarding investment's financing. Both samples (2002 and 2003) are very similar regarding their composition (see Table 3.1 in Appendix 1.A for a comparison), so I can use both of them without inconsistency.

Detailed data on sources of financing are available only in the 2003 survey, and are presented across firm size in Table 1.1. I define firm size categories as follows: small firms have less than 50 employees, medium ones between 50 and 250, large ones between 250 and 1000, and very large ones above 1000 employees. Since SOE and collective enterprises may have objectives that differ from the usual dividend maximization, I focus here on private firms only, in order to keep consistency between my theoretical model and the stylized facts observed in the data.[7,8] Similar statistics are presented in Appendix 1.A in Table 1.A.3, using total sales to determine the size of a firm.

Table 1.1: Sources of funding for new investment, by firm size (% of total new investment), across private firms

		All	Small	Medium	Large	Very large
Internal/retained earnings		24.21	20.37	26.01	26.98	21.41
Bank	Local banks	28.83	17.65	25.86	39.53	45.11
	Foreign-owned banks	0.23	0.06	0.47	0.13	0.00
	Special development financing	0.51	1.02	0.36	0.40	0.00
Alternative	Family, friends	11.69	18.16	13.55	5.30	1.64
	Equity, sale of stock to employees	5.65	6.87	6.19	4.31	3.39
	Equity, sale of stock to legal-persons	13.41	20.69	12.98	10.48	2.02
	Informal sources	3.02	3.27	3.18	2.99	1.77
	Trade credit	1.66	2.08	1.17	1.21	3.61
Equity, public issue of marketable share to outside investors		2.12	0.76	1.42	2.18	8.74
Others		8.66	9.07	8.82	6.48	12.31
Observations		630	172	247	149	61

In the raw data, the highest contribution to investment funding is attributed to "others", which accounts for about 40%. This high share is mainly driven by enterprises that declare obtaining 100% of their funding from other sources than the ones enumerated in the survey. Since it is not possible to obtain any further detail on the content of these other sources, I consider firms declaring 100% funding from "others" as missing values[9]. Table 1.1 presents statistics including only the enterprises

[7] For the ownership status, I consider the owner of the largest share of the firm and distinguish between state-owned, private, collective and foreign enterprises in the following way: a firm is classified in a category when 50% or more are owned by this category of owners. For collective firms, I refer to the share of the firm that is collectively owned. For almost all the firms present in the sample, this rule is sufficient to determine their ownership status. The unsettled cases are classified one by one.

[8] Very similar patterns are obtained when keeping all firms in the sample. Table 1.A.2 in Appendix 1.A shows financing patterns across ownership status.

[9] I loose 314 observations from this manipulation. The firms dropped have similar characteristics to the firms kept

getting less than 100% of their financing from "other" sources. The highest source of funds is bank loans, with 29% of investment funds coming from local banks. The share of investment financed through bank loans is clearly increasing with size. Smaller firms compensate this fact by a more intensive use of retained earnings and alternative sources of funding, notably funds provided by family and friends, and non-listed outside equity. Retained earnings are relatively low compared to other developed countries where similar surveys have been conducted.[10] However, this pattern is consistent across developing countries, where enterprises are younger, were not able to accumulate wealth yet and hence cannot use retained earnings intensively.[11] Note that the shares financed by foreign banks or investment funds are very small, which confirms the limited presence of foreign banks in the country in 2003, and the slow introduction of financial innovations.

To define some stylized facts able to drive the model set-up, I regroup these various sources of funding into 3 categories as summarized in Table 1.2:

- retained earnings: this corresponds to the retained earnings defined in the data;
- bank loans: it contains loans from local banks, foreign banks and investment funds;
- alternative sources: this regroups family and friends, non-listed outside equity, trade credit and informal sources.

In the remainder of the paper, I will use these three categories to study more in detail investment financing across firms.

Table 1.2: Sources of funding for new investment, by firm size (% of total new investment), across private firms

	All	Small	Medium	Large	Very large
Internal/retained earnings	26.64	22.23	28.63	28.72	26.43
Bank	34.34	21.50	30.80	45.06	57.59
Alternative	39.03	56.27	40.58	26.22	15.98
Observations	624	171	244	147	61

in the data in terms of size, total sales and age. In this regards, the statistics shown here can be considered as a lower bound for the use of retained earnings and alternative finance.

[10]See Table 1.A.4 in Appendix 1.A for the break down of funding sources in Germany in 2005. Using similar size categories as for China, retained earnings are more heavily used by firms of all sizes, and leasing (nonexistent in China in 2003) is also used. On the opposite, family and friends are almost nonexistent as source of funding in Germany and informal sources disappear. Note that equity in the German case mostly corresponds to listed equity and is therefore only used by very large firms.

[11]Tables 1.A.5 and 1.A.6 show similar statistics for India in 2005 and Colombia in 2006, where retained earnings finance respectively 52% and 33% of investment. Vietnam also has a similar share of retained earnings in 2005 (results available upon request).

1.1.3 Distribution of firms across uses of finance sources

The average shares of financing sources presented in Table 1.1 hide large discrepancies across firms: most of them tend to use only a subset of the available sources, with a non-negligible proportion financing their investment using only one source of funds. Table 1.3 reports, by size for each financing possibility, the share of enterprises not using it at all (declaring 0% of their investment funds coming from it), and the share of enterprises using only one of the sources to finance their investment. Similar results are presented in Tables 1.A.7 and 1.A.8 in Appendix 1.A, using total sales to define firms' size and separating firms across ownership status.

Table 1.3: Sources of financing: share (%) of private enterprises declaring not using one financing source, or using only one finance source, by size

		All	Small	Medium	Large	Very large
not using (0%)	internal/retained earnings	60.19	69.59	59.02	53.06	55.74
	bank loans	56.02	71.35	60.25	41.50	31.15
	alternative	51.36	34.50	51.64	61.22	73.77
using only (100%)	internal/retained earnings	19.26	18.13	22.54	16.33	16.39
	bank loans	22.63	14.04	21.72	28.57	36.07
	alternative	29.21	45.61	29.92	15.65	13.11
	observations	623	171	244	147	61

More than half of the firms do not use all the financing sources available. This share is the highest for funds coming from retained earnings, which 60% of the enterprises do not use, followed by bank loans and alternative financing, which are not used by respectively 56% and 51% of the firms. Combining this with the fact that 29% of the firms use only alternative funding to finance their investment, only 20% of firms partially use alternative sources to finance their investment.

In section 1.2, I will set up a theoretical model that is flexible enough to reproduce for the various financing patterns observed in the data. The model's flexbility should both allow for variety of potential financing sources for investment, and for a limited mix across these sources for some of the firms.

1.1.4 Bank loans and collateral

Bank loan applications and accessibility are addressed in the Enterprise Survey through many questions. Table 1.4 provides the average answers to a subset of these questions, focusing on the collateral requirements. Clearly, providing collateral seems to be a bigger obstacle for smaller firms. 80% of the loan applications of small firms were turned down because of lack of collateral, whereas this was the case for only 40% of very large firms. Furthermore, 29% of small firms that did not apply for a loan were discouraged because some collateral was required. Among firms currently having a loan, collateral was less often required for smaller firms: this can be explained by the fact that smaller firms did not obtain loans when collateral was required. The impact of the firm status on the loan application (cf. Table 1.A.9 in Appendix 1.A) is slightly weaker than that of size. Similar results, separating firms by total sales, are provided in Table 1.A.10 in Appendix 1.A.

Table 1.4: Bank loans requirements and applications, by size (% of private firms)

		Small	Medium	Large	Very large
if having a loan, was collateral needed?	Yes	39.62	60.40	68.83	68.18
if did not apply for a loan, is it because of collateral requirements?	Yes	28.54	27.84	23.68	23.08
if application rejected, was it because of lack of collateral?	Yes	80.00	68.83	70.00	40.00

The mean of the interest rate charged on bank loans, as well as the average collateral pledged as a share of granted loan, are presented in Table 1.5. The interest rate charged varies only slightly across firm size. This confirms that, interest rates being set by the government, banks have little leeway to adjust them with respect to the risk profile of the borrower. Banks tend therefore to adjust the quantity, by providing less credit to SME, considered as riskier. The pattern of interest rates varies also little across status, sales and amount invested (see Tables 1.A.11 to 1.A.13 in Appendix 1.A).

Table 1.5: Average interest rate and collateral required for bank loans, by firm's size

	All mean	Small mean	Medium mean	Large mean	Very large mean
interest rate	5.29	5.35	5.37	5.06	5.53
collateral (% of loan)	84.58	90.28	85.62	82.38	79.00
Observations	456	65	201	136	53

Smaller firms tend to provide more collateral as a share of their loan (see Table 1.5). This is related to the size of the loan provided: if the amount lent is smaller, it is more easily covered by collateral. However, this can also reflect the constraints faced by SME: if they face higher collateral requirements, they may have to reduce the total amount of the loan to satisfy them. Looking at Table 1.A.13 gives similar results: enterprises investing smaller amounts (note that those firms are also smaller in size) provide a collateral covering 90% of their loan, whereas those investing higher amounts cover only 77% of their loan with collateral.

The information gathered in this section comfirms that collateral availability is crucial in China to obtain a loan from the formal banking sector, and that smaller firms are more credit constrained due to their lack of collateral. For these reasons, as will be detailed in the next section, I will model the credit constraint faced by enterprises as a collateral constraint.

1.2 The firm side: investment decision and financing choice

I set up here the program of the heterogeneous firms, focused on their investment decision and its financing at the firm level. The objective of each firm is to maximize its discounted stream of dividends. At each period, each firm produces using capital and labor, pays wages and reimburses its debt. It also decides how much to invest to build up tomorrow's capital, and how to finance it. To achieve this goal, it plans its investment and has three different ways of financing it: it can (i) use retained earnings (which are thus subtracted from its dividends), (ii) borrow from the formal banking sector at a fixed interest rate, or (iii) obtain funding from an alternative source (this regroups all external financing means that are not included in the official banking sector: non-listed outside equity, family and friends, trade credit, informal moneylenders...) at a variable cost. The firms may be credit constrained in the formal sector: banks require collateral and are only willing to grant a loan equal to some share of this collateral. If a firm wants to obtain more funds than that, it will turn to alternative providers of funds. The collateral of the firm consists in its capital from the current period, which it can pledge to obtain a loan today. The main features of the model are described in more details in subsections 1.2.1 to 1.2.4.

1.2.1 Firm's current production and profit

The firms are heterogeneous with respect to their stock of capital and debt in the current period, their ease of access to alternative funding and their current productivity shock, which are the four state variables of the firm's program. The firm's production function is a usual Cobb-Douglas function using capital k and labor l as inputs: $f(A, k, l) = Ak^{\alpha}l^{\gamma}$. A is the shock faced by the firm at each period. It encompasses its productivity, as well as other non-specified inputs (intermediate inputs for instance). α and γ are respectively the elasticities of output with respect to capital and labor, with $\alpha + \gamma \leq 1$. All firms produce the same homogenous good regardless of their type, and this good is defined as the numeraire. w is the wage that prevails on the labor market, and is taken as given by the firm. The current capital stock of the firm has been decided at the previous period through investment, while the firm chooses today how much labor to employ to maximize its profit, given its capital and technology shock. The current profits of the firm are therefore:

$$\Pi_E(A, k, d) = \max_l Ak^{\alpha}l^{\gamma} - wl - d \tag{1.1}$$

Since the labor demand decision is intratemporal, I can solve for it separately and obtain an analytical solution function of the firm's productivity, capital, and the wage prevailing on the labor market.

$$l^D(A,k) = \left(\frac{\gamma}{w}Ak^\alpha\right)^{\frac{1}{1-\gamma}} \tag{1.2}$$

$$\Pi_E(A,k,d) = Ak^\alpha(l^D(A,k))^\gamma - wl^D(A,k) - d \tag{1.3}$$

$$= (Ak^\alpha)^{\frac{1}{1-\gamma}}\left(\frac{\gamma}{w}\right)^{\frac{\gamma}{1-\gamma}}(1-\gamma) - d \tag{1.4}$$

Profits can be either positive or negative: if the firm faces a bad productivity shock, it may not be able to produce enough to cover its labor costs and its debt liabilities. In that case, to be able to distribute non-negative dividends, the firm has to roll over part of its debt through new borrowing. If it cannot borrow enough to cover its losses (negative profits), it defaults and exits the market.

1.2.2 Sources of finance for investment

The firm can finance its investment using three different sources: retained earnings from its own profit, bank loans, and loans from alternative sources. Investment allows the firm to accumulate capital that depreciates at a rate δ.

Retained earnings

When the firm makes positive profits, it can use these profits to distribute positive dividends or reinvest them to finance investment and increase its capital stock tomorrow. Reinvested profits are called retained earnings and denoted e'. If the firm is patient enough, using retained earnings is the cheapest way to invest, since it does not bear any interest rate. However, the amount of retained earnings the firm can use for investment cannot be larger than its current profits. Hence, the use of retained earnings to finance investment is constrained as follows:

$$0 \leq e' \leq \max(\Pi_E(A,k,d), 0) \tag{1.5}$$

Obviously, if the firm makes negative profits, it cannot reinvest nor distributed any of them, and both dividends and retained earnings are forced to be zero.[12]

[12] A firm cannot use loans from the bank or from alternative sources to increase its reinvested retained earnings or its dividends. Imposing this constraint avoids indeterminacy when solving for optimal investment and financing sources, and prevents Ponzi schemes.

Bank loans

A second possibility to finance investment is to borrow an amount b from the formal banking sector. As seen in section 1.1.4, the interest rate charged by banks varies very little across firm's size, status and amount invested. Hence, it seems reasonable to define a unique interest rate $1+r$ in the model, which is charged to all types of firms. All firms also need to pledge some collateral to be able to borrow, and face a collateral constraint written as[13]:

$$qb' \leq \theta k$$

where b' is the amount to be reimbursed tomorrow, $q = \frac{1}{1+r}$ the price of the loan, k the firm's capital today and θ an exogenous parameter determining the tightness of the collateral constraint.

Where does this collateral constraint come from? Since smaller firms are expected to be more risky and the interest rate charged cannot be adjusted, banks tend to impose collateral requirements. As seen in table 1.4, this collateral constraint is often binding, especially for smaller enterprises. Hence, setting up a collateral requirement in this model reflects quite well the banks' behavior.

Alternative funding

The last possibility for financing investment is to resort to alternative sources of funding. To be able to access alternative funding, a firm has to pay up front a variable cost of access. It then pays an interest rate on the loan obtained.

As seen in section 1.1.3, the use of alternative financing is quite heterogeneous across firms, not only across firm's size, but also within size categories. While some enterprises use only alternative sources to finance investment, others never use them. To be able to reproduce this heterogeneity, I consider different types of firms $j \in J$, where J is the set of all possible types. To borrow an amount a, a firm of type j has to pay up front a quadratic access cost $x^j(a) = \eta^j a^2$, and then obtains a loan at the price $q_a^j = \frac{1}{1+r_a^j}$, where η^j and r_a^j are positive constants.

Firms' types

Each type of firms is characterized by its easiness to access the alternative financing market. This

[13] There are many ways to define collateral in this setting: current profit (today), expected profit (tomorrow), personal cash invested, capital owned today, capital owned tomorrow. I choose to define the firm's collateral constraint in terms of the capital currently owned by the firm. Since capital is mainly constituted of seizable assets, it seems well suited to be pledged as collateral by the firms. Furthermore, as seen in section 1.1, banks tend to favor loans granted to larger firms, even when profit opportunities of SME are higher, so that a collateral constraint related to expected profit would not correspond well to this situation.

easiness of access can also be thought of as the degree of anonymity in the relationship between the lender and the borrower. Indeed, access to alternative funding sources depends on family, friends, networks that help firms in finding potential lenders. A "lucky" entrepreneur (say of type j_1) has investors in his close social circle – for instance a rich uncle, accesses alternative financing for a lower cost and obtains a loan at a lower interest rate. On the opposite, an "unlucky" entrepreneur (of type j_2) has to go beyond his social circle, maybe through costly intermediaries, to find a lender, and therefore faces both a higher access cost to alternative financing and a higher interest rate, such that: $\eta^{j_1} < \eta^{j_2}$ and $r_a^{j_1} < r_a^{j_2}$ implying $q_a^{j_1} > q_a^{j_2}$.

This easiness to find a lender outside the formal banking system can be considered as some stable random ability of the entrepreneur: it is related to the social and wealth background of the entrepreneur's family, his relationships, and is not directly linked to his productivity as an entrepreneur. Since the social network of an entrepreneur is mostly related to stable external conditions, I model the firms' types as follows. At its birth, each firm draws a type realization $j \in J$ from the (exogenous) types distribution. The type j of the firm remains fixed for its entire activity period, until it exits the market. As already mentioned, these different types also help the model reproducing the fact that some enterprises do not use alternative financing, while others use only alternative finance.

Access cost

The quadratic access cost reflects two facts: first, when resorting to family or friends to finance investment, the amount you can obtain is clearly bounded, since family and friends have a limited wealth. Second, when issuing non-listed outside equity, a firm can only reach a limited number of potential lenders, because it does not beneficiate from the easy accessibility and guaranties provided by public financial markets, and the issue cost increases with the amount to be issued.

While the interest rate has to be paid by the firm at the time the loan is reimbursed, the access cost $x^j(a)$ is an upfront cost, paid at the time the firm is obtaining the loan. To pay this cost, the firm can use part of its profits (if positive), or part of the bank loan it currently borrows. This implies the following constraint:

$$x^j(a') \leq qb' + \max[\Pi_E(A, k, d) - e', 0] \tag{1.6}$$

1.2.3 Default

This model can allow for two types of default. First, the firm may default if it makes negative profit and cannot borrow enough to roll-over its debt. The firm is constrained on the total amount of debt it can roll-over for the following reasons: (i) investment is irreversible, so that previous period's capital cannot be sold to reimburse debt; (ii) the loan from the bank is limited by the collateral constraint (at most $qb' = \theta k$); and (iii) the amount borrowed from the alternative sources is constrained by the cost of access: at most $x^j(a') = qb' = \theta k$ so that the highest possible loan from alternative sources amounts to $a' = \sqrt{\frac{\theta k}{\eta^j}}$. If the losses to be rolled over are larger than $\theta k + q_a^j\sqrt{\frac{\theta k}{\eta^j}} - x^j(a') = q_a^j\sqrt{\frac{\theta k}{\eta^j}}$, the firm cannot roll over (its feasible decision set is empty) and has to default and exit the market. This corresponds to involuntary default, since it does not result from an arbitrage decision but comes from the firm's borrowing constraints.

Second, the firm may also want to default if repaying or rolling over its debt is possible, but implies capital and debt tomorrow such that its value is lower than some reservation value u. Then the enterprise prefers to default and obtains his outside option equal to $u \geq 0$.

In both cases, when the firm defaults, it exits the market forever and obtains 0. Its creditors' debts are reimbursed up to a share $\kappa \geq 0$ of the firm's capital. To keep the set-up simple, I set $u = 0$: given that the value of the firm is always non-negative, there is no voluntary default, only involuntary default occurs.

1.2.4 The program of firm

Given the set-up described above, we can now write the optimization program of the firm. The value of a firm at each period depends on its productivity shock A, its current capital k, its outstanding debt d, and its easiness of access to alternative financing j. It can be written as the following value function, where V^D and V^{ND} are respectively the values of defaulting and not defaulting:

$$V(A, k, d; j) = \begin{cases} V^D(A, k, d; j) & \text{if the firm defaults} \\ V^{ND}(A, k, d; j) & \text{otherwise.} \end{cases} \tag{1.7}$$

The corresponding definitions of default and non-default values are specified below in equations (1.8) to (1.19). The firm faces an exogenous death probability denoted ξ at every period. If it dies, the firm exits the market and obtains 0 as dividend for the death period and all successive periods. Its creditors are partially reimbursed similarly to the case of default detailed above. As mentioned earlier, since capital and debt tomorrow are decided today and the type j is stable across time, the only uncertainty faced by the firm today regarding its value tomorrow comes from its productivity tomorrow and the eventuality of death. The firm may roll-over part of its debt, which implies to get new loans to repay old debt. New loans can be used partly to repay old debt, and partly to invest more. To have a coherent decision set-up and avoid any Ponzi-like behavior, some additional assumptions are needed, that may differ if the firm is making positive or negative profit today and are reflected in the constraints of the firm's maximization. Given these assumptions, the program of the firm can be written as follows ($\mathbb{E}$ stands for the expectation operator):

$$\begin{aligned} V^{ND}(A,k,d;j) = \max_{e',b',a'} \Big\{ & \max\left[\Pi_E(A,k,d) - x^j(a') - e', 0\right] \\ & + \beta(1-\xi)\mathbb{E}V(A',k',d';j)\Big\} \end{aligned} \tag{1.8}$$

such that

$$\begin{aligned}
\Pi_E(A,k,d) &= \max_l Ak^\alpha l^\gamma - wl - d = (Ak^\alpha)^{\frac{1}{1-\gamma}}\left(\frac{\gamma}{w}\right)^{\frac{\gamma}{1-\gamma}}(1-\gamma) - d && (1.9)\\
k' &= (1-\delta)k + e' + qb' + q_a^j a' + \min[\Pi_E(A,k,d) - e' - x^j(a'), 0] && (1.10)\\
d' &= b' + a' && (1.11)\\
qb' &\leq \theta k && (1.12)\\
e' &\leq \max[\Pi_E(A,k,d), 0] && (1.13)\\
x^j(a') &\leq qb' + \max[\Pi_E(A,k,d) - e', 0] && (1.14)\\
-(qb' + q_a^j a') &\leq \Pi_E(A,k,d) - x^j(a') && (1.15)\\
e' &\geq 0 && (1.16)\\
b' &\geq 0 && (1.17)\\
a' &\geq 0 && (1.18)
\end{aligned}$$

$$V^D(A,k,d;j) = 0 \tag{1.19}$$

Depending on its profit today and its investment financing decision, the firm distributes positive or null dividends. As mentioned earlier, conditional on productivity A, capital k and the wage w, the labor demand is an intratemporal decision, so that the optimal labor demand can be determined analytically and plugged in the profit equation as done in equation (1.9). Equations (1.10) and (1.11) respectively specify the laws of motion of future capital and debt. Equation (1.12) defines the collateral constraint, imposing that the firm cannot borrow from the formal banking sector more than a share θ of its current capital. The additional assumptions and corresponding constraints are detailed below.

Assumption 1.1. *The firm cannot use newly obtained loans to distribute higher dividends.*

If the firm is making negative profits, today's dividends should be exactly zero (otherwise that would be close to running a Ponzi scheme). This implies that losses rolled over through debt are exactly equal to $\Pi_E(A,k,d) - x^j(a')$, and explains the presence of max and min operators in the current returns function in (1.8) and in the law of motion of capital in equation (1.10).

Assumption 1.2. *Retained earnings e' cannot exceed current profit, and additional debt cannot be used to increase retained earnings beyond a firm's positive profits. This corresponds to constraint* (1.13).

Indeed, it is equivalent for the firm to invest using retained earnings financed themselves through additional debt, and to directly use debt b' or a' to finance investment. Imposing retained earnings capped by current profit solves this indeterminacy. Consequently, a firm making negative profits cannot use retained earnings, and e' has to be equal to zero in that case.

Assumption 1.3. *Firms can use part of their new bank loans qb' to pay the cost of access to alternative funding $x^j(a')$, as is specified in constraint* (1.14).

This implies that the cost of access to alternative funding sources can be covered either by today's (positive) profit, or by the bank loans. Without this assumption, loss making firms would not be able borrow from alternative sources ($a' = 0$) and would only use loans from the bank to roll-over debt. With this assumption, firms can also use alternative funding to roll-over debt. Similarly, a firm making positive profit can use its newly obtained bank loan to pay the cost of access to alternative financing $x^j(a')$ if its current profit is not high enough.[14] Note that firms cannot use the loan obtained from the alternative sources $q_a^j a'$ to pay the cost of access to alternative funding $x^j(a')$, since this access cost has to be paid beforehand.

Assumption 1.4. *Investment is irreversible. Only the new loans $qb' + q_a^j a'$ can be used to roll over previous debt, as stated in inequality constraint* (1.15).

Note that the firm can borrow more than the debt to be rolled-over and use the remainder for investment.

1.2.5 Some intuition

As explained above, in case of default, the firm does not produce and obtains a value equal to zero forever. Here, I focus on the case where the firm is able to reimburse or roll-over its debt. To get a better overview of the input and funding choices we can expect from the firm, I provide some further elements regarding its optimal decision. Separating the firm's state in two parts, between positive and zero dividends, the firm's program verifies the assumptions of theorem 9.10 from Stockey and Lucas Jr (1989) in both parts. Hence, the value function is continuously differentiable

[14] Extending this assumption to firms making positive profits ensures the continuity of the feasible set of investment policies.

with respect to capital and debt in both cases, except at the kink point between these two parts. I set up the Lagrangian of the problem below, denoting λ, μ, ν and ζ the multipliers respectively associated with constraints (1.12), (1.13), (1.14) and (1.15). For better readability, I describe the Lagrangian separately for three cases: positive profits and dividends, positive profits and zero dividends, negative profits.

Positive dividends

$$\mathcal{L} = \Pi_E - x^j(a') - e' + \beta(1-\xi)\mathbb{E}V + \lambda(\theta k - qb') + \mu(\Pi_E - e' - x^j(a')) \tag{1.20}$$

Positive profit, zero dividends

$$\mathcal{L} = \beta(1-\xi)\mathbb{E}V + \lambda(\theta k - qb') + \nu(qb' + \Pi_E - x^j(a')) \tag{1.21}$$

Negative profits

$$\mathcal{L} = \beta(1-\xi)\mathbb{E}V + \lambda(\theta k - qb') + \nu(qb' - x^j(a')) + \zeta(\Pi_E - x^j(a') + qb' + q_a^j a') \tag{1.22}$$

From the first order conditions of the problem and the envelop theorem, I obtain equations (1.23) to (1.29) defining the optimal levels of retained earnings, bank loan and alternative funding. To simplify the notations, state variables of the value functions are dropped, so that $\mathbb{E}V^{ND}$ corresponds to $\mathbb{E}V^{ND}(A',k',d';j)$, $\mathbb{E}V^D$ corresponds to $\mathbb{E}V^D(A',k',d';j)$, and so on (note that all these value functions concern the future period, hence the expectation operator $\mathbb{E}$).

Positive dividends

$$\frac{\partial \mathbb{E}V}{\partial k'} = \frac{1+\mu}{\beta(1-\xi)} \tag{1.23}$$

$$\frac{\partial \mathbb{E}V}{\partial k'} = \frac{\lambda}{\beta(1-\xi)} - \frac{1}{q}\frac{\partial \mathbb{E}V}{\partial d'} \tag{1.24}$$

$$\frac{\partial \mathbb{E}V}{\partial k'} = \frac{x^{j\prime}(a')(1+\mu)}{\beta(1-\xi)q_a^j} - \frac{1}{q_a^j}\frac{\partial \mathbb{E}V}{\partial d'} \tag{1.25}$$

Positive profits, zero dividends

$$\frac{\partial \mathbb{E}V}{\partial k'} = \frac{\lambda - \nu}{\beta(1-\xi)} - \frac{1}{q}\frac{\partial \mathbb{E}V}{\partial d'} \tag{1.26}$$
$$\frac{\partial \mathbb{E}V}{\partial k'} = \frac{\nu x^{j\prime}(a')}{\beta(1-\xi)(q_a^j - x^{j\prime}(a'))} - \frac{1}{q_a^j - x^{j\prime}(a')}\frac{\partial \mathbb{E}V}{\partial d'} \tag{1.27}$$

Negative profits

$$\frac{\partial \mathbb{E}V}{\partial k'} = \frac{\lambda - \nu - \zeta}{\beta(1-\xi)} - \frac{1}{q}\frac{\partial \mathbb{E}V}{\partial d'} \tag{1.28}$$
$$\frac{\partial \mathbb{E}V}{\partial k'} = \frac{\nu x^{j\prime}(a')}{\beta(1-\xi)(q_a^j - x^{j\prime}(a'))} - \frac{\zeta}{\beta(1-\xi)} - \frac{1}{q_a^j - x^{j\prime}(a')}\frac{\partial \mathbb{E}V}{\partial d'} \tag{1.29}$$

Each of these equations can be interpreted easily: the left-hand side is the marginal gain obtained from increasing slightly the amount invested today (i.e. the capital tomorrow), while the right-hand side is the marginal cost of increasing the investment today, which depends on how the investment is financed.

Propositions 1.1 to 1.2 give us a better understanding of the firm's funding decisions. Proposition 1.1 considers the case of a firm, distributing positive dividends, and specifies conditions under which we can analytically determine wich financing source s marginally preferred by the firm to finance investment and roll-over debt. Proposition 1.2 explores similar properties int he case where the firms' dividends are zero.

Proposition 1.1. *Provided that the firm distributes positive dividends, it marginally prefers to finance investment:*

(i) through retained earnings rather than through alternative sources, if alternative sources are already used intensively enough (i.e., if $a' \geq \bar{a}$, where the threshold $\bar{a}$ is defined by $x^{j\prime}(\bar{a}') = q_a^j$), provided that it does not hit the non-negative dividends constraint (1.13)*. It is ambiguous if $a' \leq \bar{a}$;*

(ii) through bank loans rather than alternative sources, if the interest rate charged on bank loans is lower than the one of alternative financing (i.e. $r \leq r_a^j$), provided that it does not hit the collateral constraint (1.12)*. It is ambiguous if $r \geq r_a^j$.*

Comparing analytically marginal costs and benefits of investing through retained earnings versus bank loans is inconclusive.

See proof in Appendix 1.B.1. The intuition is the following.

(i) On one hand, the marginal cost of increasing retained earnings is a one for one reduction of the firms current dividends, and its benefit is a one for one increase in tomorrow's capital. On the other hand, increasing alternative funding marginally reduces current dividend by $x^{j\prime}(a')$ and marginally increases capital by less than one, because it bears some interest rate ($r_a^j > 0$). Increasing alternative funding also increases the level of debt tomorrow, while retained earnings do not. When the access cost $x^{j\prime}(a')$ or the interest rate r_a^j are high enough, the total marginal net benefit of increasing retained earnings becomes unambiguously higher than the one of alternative financing, and the firm marginally prefers to finance investment through retained earnings.

(ii) When the interest rate paid on bank loans is lower than the one paid on alternative financing ($r \leq r_a^j$) and the collateral constraint on bank loans does not bind, increasing bank loans rather than alternative sources to finance investment is relatively cheaper in terms of cost. On the one hand, the increase in debt tomorrow due to both bank loans and alternative sources is the same. On the other hand, an increase in bank loans raises capital tomorrow more than a similar increase in alternative funding that also necessitates to pay the access cost $x^j(a')$. Since the expected value of the firm is increasing with future capital and decreasing with future debt, the firm marginally prefers to finance investment with bank loans rather than with alternative sources.

Note that when $r > r_a^j$ and the firm is distributing positive dividends, then its preference between bank loans and alternative sources is ambiguous and depends on the parameters values. Similarly, when $q_a^j - x^{j\prime}(a') \geq 0$, we cannot conclude analytically whether alternative funding or retained earnings are preferred.

Proposition 1.2. *For both positive and negative profit values, provided that the firm distributes zero dividends, it marginally prefers to finance investment:*

(i) through bank loans rather than through alternative sources, if the interest rate on bank loans is low enough or alternative sources are already used intensively enough (i.e., if $a' \geq \underline{a}$, where $\underline{a}$ is defined by $x^{j\prime}(\underline{a}) = q_a^j - q$), provided that it does not hit the collateral constraint (1.12)*;*

(ii) through alternative sources rather than through bank loans, if the interest rates on bank loans is high enough or alternative sources are little used (i.e., if $a' \leq \underline{a}$), provided that it does not hit the access cost constraint (1.14)*.*

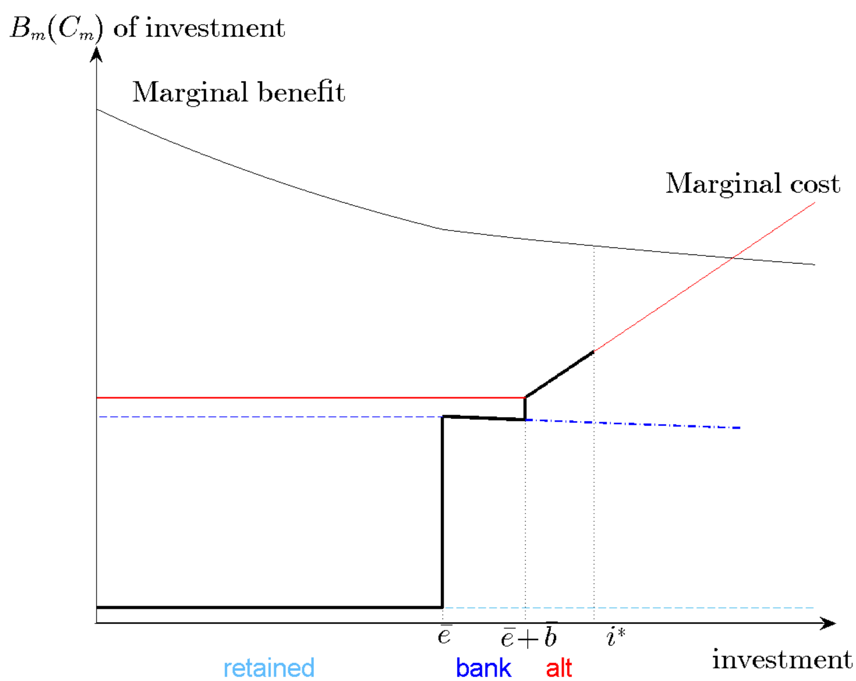
See proof in Appendix 1.B.2. The mechanism is similar to the proof of Proposition 1.1.

(i) Considering the situation of a firm distributing zero dividends, if $q \geq q_a^j - x^{j\prime}(a')$, an increase in bank loans marginally increases capital tomorrow more than alternative sources would do.

On the debt side, both bank loans and alternative funding marginally increase debt by the same amount. Hence, if the marginal access cost to alternative sources $x^{j\prime}(a')$ is high enough, the firm marginally prefers to use bank loans to finance investment, even when bank loans bear a higher interest rate than alternative funding ($q < q_a^j$).

(ii) Similarly, if $q \leq q_a^j - x^{j\prime}(a')$, the marginal benefit of increasing alternative financing is higher than the marginal benefit of increasing bank loans, and their marginal costs are equal. Therefore, firms marginally prefer to use alternative sources, if the access cost constraint does not bind.

Figure 1.1: Case of positive dividends, $r < r_a^j$



Note: The parameter and price values for this graph are as follows: $\beta = 0.9923$ $\xi = 0.082$, $\omega = 0.1$, $A = 2.7$, $\alpha = 0.51$, $\gamma = 0.30$, $\delta = 0.1$, $k = 11$, $d = 6$, $\eta^j = 0.142$, $r = 0.0309$, $r_a^j = 0.095$, $w = 0.80$.

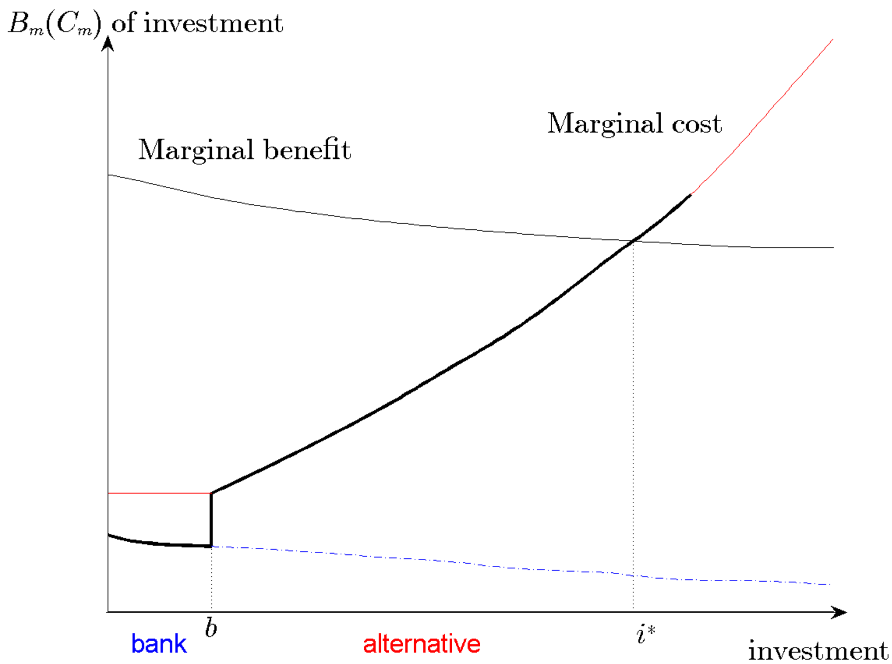
Figures 1.1 to 1.3 illustrate the various financing choices that can be generated by the model, by presenting three different cases. In all figures, the decreasing black curve shows the marginal benefit of investment, while the increasing thick black line is its marginal cost. The firm finances investment until it either hits a constraint, or the marginal benefit of investment is lower than its marginal cost. Figure 1.1 gives a representation of the funding choice when dividends are positive, $r < r_a^j$ and $\eta^j > 0$. In this case, Proposition 1.1 tells us that the firm marginally prefers to finance investment through bank loans rather than through alternative sources, provided that the collateral constraint does not bind. Therefore, the marginal cost for bank loans (dark blue dashed-dotted line) is always smaller than the marginal cost for alternative funding (red solid line). In the specific calibration shown on this graph, we consider a large firm[15] with a very high productivity shock. The decision sequence is as follows: retained earnings are initially marginally preferred to both other sources, until the non-negative dividends constraint (1.13) binds (at investment level $\bar{e}$). The firm then switches to the second cheapest source of financing, namely bank loans (light blue dashed line). Finally, when it hits the collateral constraint (1.12), at investment level $\bar{e} + \bar{b}$, the firm uses alternative sources to finance the residual investment until it cannot finance its cost of access any more, reaching a total investment equal to i^*. This firm finances 69% of its investment with retained earnings, 17% with bank loans and 14% with alternative sources. Comparing to the data seen in section 1.1, this enterprise uses more retained earnings, and less bank loans and alternative sources than the average large firm. This difference can be explained by the fact that the enterprise considered here has a very high productivity shock,and a fairly high capital level, and therefore has a large amount of profits to be reinvested. Given its high level of capital, it does not need to invest massively and can finance most of its investment through retained earnings.

The example shown in Figure 1.1 is useful to understand the pecking order of enterprises facing various financing possibilities, by showing a case where the enterprise uses the three possible funding sources. However, as seen in the data, many enterprises do not use all financing sources. Clearly, on Figure 1.1, if the firm had a lower productivity shock, the marginal benefit curve would shift down, and the enterprise would probably not use alternative financing, maybe even use only retained earnings. Figure 1.2 shows another possible case where the enterprise uses only bank loans and alternative sources, and does not reinvest profits through retained earnings. Here again, $r < r_a^j$, $\eta^j > 0$ and we examine a medium-sized enterprise with a medium-high shock currently making losses. Because of its negative profit, this firm needs to roll-over part of its debt and cannot use retained earnings. From Proposition 1.2, we can conclude that this firm always marginally prefers to use bank loans rather than alternative funding to invest. The firm first uses bank loans until it hits the collateral constraint, financing 26% of its total investment. It then turns to alternative sources to finance the remaining 74% of its total investment i^*. This firm is one of the 59% of medium-sized firms that do not use retained earnings in the data.

Finally, Figure 1.3 shows the case where $r > r_a^j$. For small amounts of alternative funding, alternative finance may be cheaper than bank loans, so that the marginal cost of alternative sources is below the marginal cost of bank loans (dark blue dashed-dotted line). In the case represented, the firm is large-sized and has a medium-high productivity shock. It first finances investment through alternative sources, until it becomes more expensive than bank loans due to the quadratic cost

[15]In the model, as in the data, the size of a firm is determined by its labor demand.

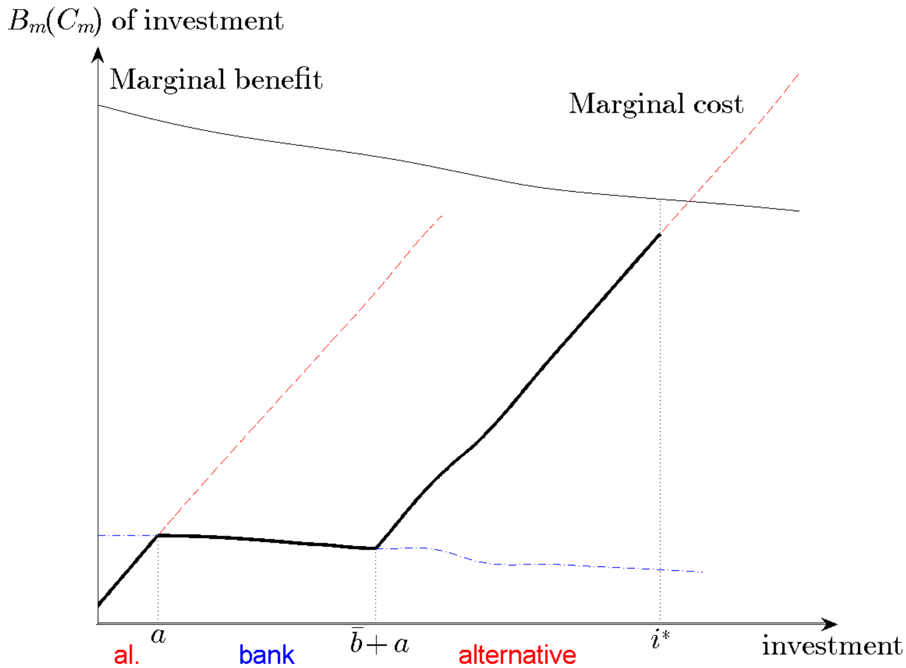
Figure 1.2: Case of zero dividends, $r < r_a^j$



Note: The parameter and price values for this graph are as follows: $\beta = 0.9923$, $\xi = 0.082$, $\omega = 0.1$, $A = 1.6$, $\alpha = 0.51$, $\gamma = 0.30$, $\delta = 0.1$, $k = 2.50$, $d = 1.8276$, $\eta^j = 0.142$, $r = 0.0309$, $r_a^j = 0.095$, $w = 0.80$.

of access (the two curves cross at the investment level a). The firm then uses bank loans until it hits the collateral constraint (1.12) at investment level $\bar{b} + a$, and switches back to alternative sources to reach the total amount invested i^*. 38% of the firm's investment is financed through bank loans, while 61% is financed through alternative finance. Compared to large-sized firms in the data, this firm uses no retained earnings because it currently makes negative profits. It also uses more alternative sources than the average large firm in the data, because it benefits from a cheap access to alternative sources.

Figure 1.3: Case of positive dividends, $r > r_a^j$



Note: The parameter and price values for this graph are as follows: $\beta = 0.9923$, $\xi = 0.082$, $\omega = 0.1$, $A = 1.6$, $\alpha = 0.51$, $\gamma = 0.30$, $\delta = 0.1$, $k = 35$, $d = 14$, $\eta^j = 0.01$, $r = 0.0309$, $r_a^j = 0.01$, $w = 0.80$.

1.3 General equilibrium

To insert the firm's program described above within a general equilibrium framework, I need to add a household and a financial intermediary. Their respective programs are detailed in sections 1.3.1 and 2.3. Throughout this section, for consistency, I keep the price notations used above for the firm's program, so that the household generally saves some amount qs and obtains s the next period, and the bank takes deposits qD and repays D at the next period. To keep the general equilibrium as simple as possible, the household side is represented by a single representative household, which implies some shortcuts. The interested reader can find a general equilibrium version with full-fledged heterogeneous households in Appendix 1.C.

1.3.1 Program of the household

There is one infinitely-lived representative household who supplies labor inelastically for a wage w, and decides how much of his income to consume and save. Importantly, the household does not face any uncertainty in terms of labor income. He is be willing to save if the interest rate he obtains from saving is higher than his discount factor, and willing to borrow otherwise. For a steady state to exist in terms of wealth, consumption and savings levels, I need to assume that the interest rate is exactly equal to the discount factor, which makes the household indifferent between saving and consuming.[16] On top of his labor income, the household owns all firms' shares and earns the dividends of the firms. The shares of the firms are non-transferable and the dividends are a per period lump-sum transfer.

The household can save using different assets:

- *bank deposits*: he can deposit his savings at the bank, and earn a risk-free rate r_d. For notations consistency with the firm's program, I denote the price of this asset $q_d = \frac{1}{1+r_d}$.
- N_J *types of direct firms financing*: he can lend his savings directly to enterprises, which corresponds to the alternative finance obtained by the firms. To match the different types of firm (having a more or less costly access to alternative financing), I distinguish between $N_J = \dim(J)$ types $j \in J$ of direct firms financing that differ in their rate of return and their intermediation cost: to find a firm willing to invest, the household may have to search, and pay some intermediation cost χ^j (accounted for in terms of goods). This cost is higher when households go beyond their close social circle, since more intermediaries are involved to reach a firm needing investment. At the same time, the household can require a higher interest rate when lending to a firm less tightly related to his social circle. For consistency with the notations of the firms' program, I denote $q_a^j = \frac{1}{1+r_a^j}$ the price of type j asset bought by the household. This saving instrument is risky, since firms may default on their loan and not fully reimburse. However, the household knows the average probability of default of a firm, and he holds a fully diversified portfolio of loans to firms, so that from the law of large numbers, he can perfectly anticipate the share of firms that will default and what ex-post return he will obtain. Hence, he does not face any uncertainty on his returns. Denoting $\bar{p}$ the average default probability, a unit portfolio of direct loans to firms bought at price q_a^j yields a return 1 with probability $1-\bar{p}$ and reimburses $\underline{r} < 1$ with probability $\bar{p}$. The household's total return is therefore $1-\bar{p}+\bar{p}\underline{r}$ per amount q_a^j lent.

The program of the household is shown in equations (1.30) to (1.33). As mentioned before, since the household holds a fully diversified portfolio of firms loans and bank deposits are risk-free, he does not face any uncertainty.

$$V(W) = \max_{c, s_b, \{s_a^j\}_{j\in J}} u(c) + \beta V(W') \tag{1.30}$$

[16] For simplicity, I assume that the households cannot borrow. Since I assume that the interest rate is equal the discount factor, this borrowing constraint is never binding.

s.t.

$$W = c + q_d s_b + \sum_{j \in J} q_a^j s_a^j + \sum_{j \in J} \chi^j s_a^j \tag{1.31}$$

$$W' = D_e + w + s_b + \sum_{j \in J} s_a^j (1 - \bar{p} + \bar{p}\underline{r}) \tag{1.32}$$

$$s_a^j, s_b, c \geq 0 \tag{1.33}$$

where W is the current total wealth of the household, c is consumption today, s_b is the amount deposited to the bank, s_a^j is the capital directly supplied to the firm of type j through alternative financing, w is the household's wage, D_e is the dividends obtained from the firms' profit, $\bar{p}$ is the aggregate default probability determined by the firms' program, and $\underline{r}$ the average reimbursement rate in case of default.

The first order conditions of this program imply:

$$q_d u'(c) = \beta V'(W') \tag{1.34}$$

$$\frac{q_a^j + \chi^j}{1 - \bar{p} + \bar{p}\underline{r}} u'(c) = \beta V'(W') \qquad \forall j \in J \tag{1.35}$$

All three saving instruments (bank deposits and the N_J types of direct loans to firms) are risk-free for the household. Hence, if one of them has a higher return, the household will invest all his savings in that asset and will not use the others. To avoid such corner equilibria, I will further assume that all assets have equal returns and that the household is indifferent between investing in one or the other:

$$q_d = \frac{q_a^j + \chi^j}{1 - \bar{p} + \bar{p}\underline{r}} \qquad \forall j \in J \tag{1.36}$$

This property can be easily obtained by adjusting the intermediation costs χ^j or the price q_a^j, as detailed in section 2.4. Given that the household is indifferent between the three types of saving instruments, his decision at each period simplifies to choosing his total consumption c and his total amount used for savings and intermediation costs $\bar{q}\bar{s} = q_d s_b + \sum_{j \in J} q_a^j s_a^j + \sum_{j \in J} \chi^j$, where $\bar{q} = q_d = \frac{q_a^j + \chi^j}{1 - \bar{p} + \bar{p}\underline{r}}$. Rewriting the household's program after this simplification, and assuming a log utility function, there are analytical solutions for the household's value function and optimal policy functions. Using a "guess and verify" procedure, it is easy to show that:

$$V(W) = \frac{1}{1-\beta}\log(1-\beta) + \frac{\beta}{(1-\beta)^2}\log\left(\frac{\beta}{\bar{q}}\right) + \frac{1}{1-\beta}\log\left(W + \frac{\bar{q}}{1-\bar{q}}(D_e + w)\right) \tag{1.37}$$

$$\bar{s}^* = \frac{\beta}{\bar{q}}W - \frac{1-\beta}{1-\bar{q}}(D_e + w) \tag{1.38}$$

$$c^* = (1-\beta)W + \frac{\bar{q}(1-\beta)}{1-\bar{q}}(D_e + w) \tag{1.39}$$

$$W'^* = \frac{\beta - \bar{q}}{1-\bar{q}}(D_e + w) + \frac{\beta}{\bar{q}}W \tag{1.40}$$

Clearly, the only values of β and $\bar{q}$ that allow for a steady state with a non-negative constant wealth W are such that $\beta = \bar{q}$. If this is the case, then any amount $W \geq D_e + w$ is a possible steady state with non-negative savings, and the value of total wealth W pins down the optimal steady state levels of savings and consumption. To close the model, I finally need to add a financial intermediary, namely one representative bank, whose program is described in the next section.

1.3.2 Program of the bank

There is a representative bank in the economy. At each period, the bank takes deposits $q_d D$ (at price $q_d = \frac{1}{1+r_d}$) and grants loans qB (at price $q = \frac{1}{1+r}$) to meet firms' demand given the collateral constraint. Like the household, the bank holds a fully diversified portfolio of loans to firms, and knows the average default and reimbursment rates, so that it does not face any aggregate uncertainty on the outcome of its loans. On average, a fraction $\bar{p}$ of the firms default on their loan and reimburse only $\underline{r}$ on average instead of 1, so that the bank obtains an aggregate return equal to $(1 - \bar{p} + \bar{p}\underline{r})B$ on its loans.

The bank faces operating costs in proportion ζ to the total amount of deposits and loans handled $q_d D + qB$. To be solvent, the bank needs to receive more deposits than it grants loans, i.e. $q_d D \geq qB$. The bank's total profit to maximise is then:

$$\max_{D,B} \Pi_b = q_d D - qB - D + (1 - \bar{p} + \bar{p}\underline{r})B - \zeta(qB + q_d D) \tag{1.41}$$

$$\text{s.t.} \qquad q_d D \geq qB \tag{1.42}$$

As mentioned earlier, in the early 2000's in China, interest rates offered by banks are heavily guided by the People's Bank of China. Notably, the deposit and lending rates r_d and r are respectively subject to a ceiling and a floor such that $r_d < r$, which corresponds to $q_d > q$. To account for this situation in the baseline specification of the model, I force the bank to act like a "machine", meaning that it has no free adjustment variable and hence no proper optimisation program to solve. The amount of deposits taken by the bank is hence equal to the aggregate deposits of the households, while the amount of loans granted by the bank is equal to the enterprises' aggregate loan demand. The intermediation margin of the bank is used to cover the operating costs of the bank (accounted for in terms of consumption good). In the baseline calibration, ζ is set to ensure the bank makes zero profits.

Policy experiments liberalizing the interest rates setting are conducted in section 1.5.

1.3.3 Market clearing conditions

There are $4 + N_J$ markets to be cleared: good, labor, deposits and the $1 + N_J$ types of loans (obtained from the bank and alternative sources).[17] There is one single type of good used for consumption, investment and capital for production; it is the numeraire. The wage adjusts to reach the equilibrium on the labor market, while the interest rates adjust to balance the demand and supply of alternative financing. The case of bank loans and deposits is slightly different: usually, the equilibrium is reached by adjusting the deposit and lending rates. However, this project focuses on the case of China during the early 2000's, where both deposit and lending rates are fixed by the People's Bank of China and cannot freely adjust. I detail below how the equilibrium on these markets is dealt with.

Labor market

The inelastic labor supply of the household is fixed, equal to L^S. The demand side on the labor market consists in the aggregate labor demand $L^D(w)$, computed by solving the firms' program, and depends on the wage w. To avoid heavy notations, I summarize the firms' state variables by $m = \{A, k, d; j\}$ and denote the probability distribution of firms across states by $\mu(m)$. The wage has to adjust such that at each period:

$$L^S = L^D(w) = \int l_m^D(w)\mu(m)dm \tag{1.43}$$

Alternative capital market

The alternative capital market is pooled within each type $j \in J$: there is a single separated alternative capital market for each type j, where firms of type j meet the household. The direct

[17]As mentioned earlier, the firms' shares are entirely held by the household and are not transferable.

loan $s_a^j(q_a^j)$ from the household has to be equal to the aggregate demand for alternative funding $a'(q_a^j; j)$ by each type of firms.

$$s_a^j(q_a^j) = \int a'_m(q_a^j)\mu(m)dm = a'(q_a^j; j) \qquad \forall j \in J \tag{1.44}$$

For each $j \in J$, the interest rate q_a^j adjusts to clear the market.

Bank capital markets

In the baseline scenario, the bank cannot refuse the deposits supplied by the household ($q_d s_b$) and the loan demand (qb') it faces, and has basically no room for action. The bank accepts all deposits supplied by the household, and grants all loans demanded by the firms up to the collateral constraint. This implies the following equalities:

$$q_d D = q_d s_b(q_d) \tag{1.45}$$

$$qB = \int q b'_m(q)\mu(m)dm = qb'(q) \tag{1.46}$$

The loan supply from the bank qB should be equal to the aggregate bank loan demand from the firms $qb'(q)$. The aggregate deposits from the household $q_d s_b(q_d)$ should be equal to the deposits in the bank $q_d D$. In section 1.5, I conduct policy experiments where constraints on interest rates setting are relaxed and the bank maximizes its profit as is common in the literature.

Good market

The same good is used for consumption, investment, operating costs of the bank, access costs to alternative financing from the firms' side, and intermediation costs from the household's side. It is the numeraire. On the supply side, we have the aggregate production Y obtained from the firms. On the demand side, there is the consumption of the household C, the aggregate total investment of the firms I (retained earnings, bank loans and alternative loans net of rolled-over debt and of access cost to alternative funding), the aggregate cost of access to alternative financing X paid by the firms, the intermediation costs INT paid by the household, the bank's operating costs and the bank's and household's losses LO due to firms' default. The good is the numeraire, and from Walras' low, if all other markets are in equilibrium, the demand and supply of the good market should also be balanced. The equilibrium on the goods market is reached when:

$$Y = C + I + X + INT + \zeta(qL + q_d D) + LO \tag{1.47}$$

which corresponds to:

$$\int Y_m \mu(m)dm = C + \int inv_m \mu(m)dm + \sum_{j \in J} \int x^j(a'_m)\mu(m)dm + \sum_{j \in J} \chi^j s^j_a \quad (1.48)$$
$$+ \zeta(q_d D + qB) + \int losses_m \mu(m)dm$$

We now have all the elements needed to define an equilibrium in this economy.

1.3.4 Equilibrium definition

In the remainder of this paper, I will solve for and study only stationary equilibria. To define a stationary equilibrium in this environment, I first need to specify the stationary distribution of firms. Equation (1.49) defines the law of motion of the firms' distribution.

$$\mu'(A', k', d'; j) = \int Prob(k' = k'(A, k, d; j), d' = d'(A, k, d; j)|A, k, d; j) T_{AA'} d\mu(A, k, d; j) \quad (1.49)$$

where $T_{AA'}$ is the transition probability from productivity shock A to productivity shock A'.

Given the above law of motion, I can now turn to the definition of the stationary equilibrium in this set-up.

Definition 1.1. *A stationary equilibrium consists in policy functions $a'(A, k, d; j)$, $b'(A, k, d; j)$, $e'(A, k, d; j)$, $c(W)$, $\{s^j_a(W)\}_{j \in J}$, $s_b(W)$, B and D; a probability distribution $\mu(A, k, d; j)$ for firms; and prices $\{w, \{q^j_a\}_{j \in J}, q, q_d\} \in \mathbb{R}^{3+N_J}_+$ such that:*

1. *The policy functions $a'(A, k, d; j)$, $b'(A, k, d; j)$ and $e'(A, k, d; j)$ solve the firms' program as defined in equations (1.8) to (1.19), given prices w, $\{q^j_a\}_{j \in J}$ and q;*
2. *The policy functions $c(W)$, $\{s^j_a(W)\}_{j \in J}$, and $s_b(W)$ solve the household's program as defined in equations (1.30) to (1.33), given prices w, $\{q^j_a\}_{j \in J}$, and q_d;*
3. *The policy functions B and L solve the bank's program as defined in equations (1.41) and (1.42) given q and q_d;*
4. *Markets clear, so that equations (1.43) to (1.48) are satisfied;*
5. *The stationary distribution $\mu(A, k, d; j)$ is the fixed point of equation (1.49).*

1.4 Calibration

The model is calibrated according to the Enterprise Survey data presented in section 1.1, and aggregate moments obtained from the China Statistical Yearbook and World Development Indicators database from the World Bank. The discount rate and the depreciation rate of capital are set in line with the literature, while the interest rates for bank loans and bank deposits are directly obtained from the data. The parameters defining the production function and the technology shock are estimated using the data. The remaining parameters are defined to match aggregate moments from the data.

1.4.1 Parameters derived from the literature and data

As presented in section 1.1.4, the data provide the interest rate charged by the formal banking sector, denoted r. From Table 1.5, the average nominal interest rate for bank loans is equal to 5.29%. After subtracting the inflation rate for investment in fixed assets for the year 2003, the real interest rate in the model is calibrated at $r = 3.09\%$, corresponding to $q = 0.97$. The nominal interest rate on one-year deposits set by the People's Bank of China from February 2002 to October 2004 is equal to 1.98%. Taking into account the rate of inflation for consumer prices in 2003, the real interest rate paid by the bank on deposits is set at $r_d = 0.78\%$, corresponding to an asset price $q_d = 0.9923$. To ensure that the household is indifferent between consuming and saving, I set the value of the discount factor β to 0.9923. The share κ of capital that can be used used by enterprises to reimburse loans in case of default or death is set to 0.25. Regarding the depreciation rate δ, only a few of the studies using depreciation rates for China or other developing countries actually estimate it. According to the results summarized in Table 1.A.14 in Appendix 1.A, it seems reasonable to set δ to 10% for the calibration.

1.4.2 Calibrating the production function

To calibrate the elasticity of output with respect to capital and labor (parameters α and γ respectively), I estimate the production function using data from 2002.[18] There is abundant literature on the estimation of Cobb-Douglas type production functions. As noted, among the first ones, by Marschak and Andrews (1944), a simple OLS regression provides biased coefficients, due to the endogeneity caused by the possible correlation between inputs and unobserved productivity shocks. I follow here the approach suggested by Olley and Pakes (1996) (hereafter OP), that takes this simultaneity into account by using investment as a proxy for the productivity shock. The 2002 data give information on firms' output, capital, labor, investment, materials and energy consumption from 1 to 3 years before the survey, and can therefore be used as panel data.[19]

[18] Missing values for capital in 2003 do not allow me to use that year for the estimation.

[19] Another approach, developed by Levinsohn and Petrin (2003) (hereafter LP), uses intermediate inputs such as energy or materials to proxy the productivity shock. One of the general advantages of this approach is to avoid the issue of missing values due to null investment. However, in my data, there are surprisingly much more missing values for energy than for investment. Hence, I favor investment as proxy variable, and OP's method. Results from LP's approach are available upon request.

In their approach, OP correct both for endogeneity and for sample selection issues due to firms' exit (for instance if they stop their activity during the survey). Since the data from the Enterprise Survey have all been collected at one time, there is no exit, and I do not apply the part of OP's algorithm that corrects for it. Still, it doesn't mean that the selection issue is solved: all firms for which I have data in 1999, 2000 or 2001 are firms that have survived at least until 2002, and I have no information regarding firms that shut down before 2002. My sample is therefore inevitably biased by this selection effect.

Table 1.6: Estimation of the production function coefficients with OP's method

	Olley & Pakes		
	(1)	(2)	(3)
	All	Manufacturing	Services
labor	0.30**	0.28***	0.52***
	(0.0356)	(0.0397)	(0.0925)
capital	0.51***	0.59***	0.43**
	(0.127)	(0.144)	(0.208)
N (first step)	1383	1050	333
N (second step)	778	596	182

Standard errors in parentheses, specification controlling for age
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 1.6 presents the results of the estimation of the production function for OP's method. Results obtained with OLS and fixed effects are shown in Table 1.A.15 in Appendix 1.A for the whole sample, as a reference to compare with more robust approaches. The variable used for output here corresponds to value added (materials have been subtracted). OP's method yields plausible and stable coefficients estimates, with a capital coefficient ranging from 0.43 to 0.59 and a labor coefficient between 0.28 and 0.51. I use these results to calibrate the production function, with calibrated values of parameters α and γ respectively equal to 0.51 and 0.30, as obtained for the whole sample.

OP's procedure also provides estimated series for the productivity of each firm at the available dates. I use these series to estimate the autoregressive coefficient of the productivity process and obtain $\rho = 0.91$. To define the productivity shock process of my model, I use a discrete Markov-Chain process with a transition matrix T such that the theoretical autoregressive coefficient associated to it equal to 0.91. The levels of the productivity shocks, as well as the level of newborn firms' initial capital, are calibrated to match the firms' size distribution (in terms of number of employees) obtained from the data with the size distribution obtained from the model's stationary state. There are 5 shocks and one level of initial capital, hence 6 parameters, that match 8 percentiles of the firm size distribution.[20] I obtain the following values for the shocks matrix A and for the transition matrix T.

$$A = \begin{pmatrix} 0.35 & 0.75 & 1 & 1.6 & 2.7 \end{pmatrix} \tag{1.50}$$

$$T = \begin{pmatrix} 0.8765 & 0.1235 & 0 & 0 & 0 \\ 0.0164 & 0.9146 & 0.0690 & 0 & 0 \\ 0 & 0.0352 & 0.9295 & 0.0352 & 0 \\ 0 & 0 & 0.0690 & 0.9146 & 0.0164 \\ 0 & 0 & 0 & 0.1235 & 0.8765 \end{pmatrix} \tag{1.51}$$

1.4.3 Further Parameters: Matching moments

The remaining parameters are calibrated in order to match the moments highlighted in section 1.1. I allow for two possible types $j \in \{L, H\}$ of firms, which helps matching the patterns of firms' investment financing while keeping low enough the number of parameters to calibrate. Firms of type L have an easy access to lenders in their social circles and do not need to go through intermediaries. They face therefore a low cost of borrowing through alternative finance systems. On the opposite, firms of type H need to go through some intermediaries to get in touch with lenders and hence face a higher cost of borrowing through non-bank systems. This implies that $\eta^H > \eta^L$ and $r_a^H > r_a^L$. Similarly, the household faces a higher intermediation cost when lending to type H firms than when lending to type L firms, so that $\chi^H > \chi^L$. The parameters to be calibrated are then:

- χ^j for $j \in \{L, H\}$: cost of accessing alternative funding for type j households;
- θ: tightness of the collateral constraint to obtain bank loans;
- η^j for $j \in \{L, H\}$: quadratic cost of accessing alternative funding for type j firms;
- ξ: exogenous death probability for all firms;
- p_0: probability for a firm to be of type L.

To achieve this, I first solve for the policy functions of the firms with value function iterations, and for the firms' stationary distribution. I then compute the prices (wage and interest rate for both types of alternative funding) to reach the equilibrium on the labor and alternative funding markets. As mentioned before, the baseline case used to calibrate the model corresponds to the situation of China in 2002, when the bank deposit and loan interest rates are exogenously set by the government, so that the bank does not maximize its profit.

[20] These percentiles are the 1^{st}, 5^{th}, 10^{th}, 25^{th}, 75^{th}, 90^{th}, 95^{th} and 99^{th}, normalized by the median.

Given that the household has to be indifferent between the three possible saving instruments (bank deposits and both types of direct loans to firm), the intermediation costs χ^L and χ^H are tightly related to the prices q_a^L and q_a^H according to the following formula:

$$q_a^j = q_d(1 - \bar{p} + \bar{p}\underline{r}) - \chi^j \qquad \forall j \in \{L, H\} \tag{1.52}$$

Calibrating χ^L and χ^H is therefore quasi equivalent (taking into account the endogenous changes in $\bar{p}$ and $\underline{r}$) to setting the prices q_a^L and q_a^H at values that allow for an equilibrium on the bank capital and alternative financing markets. By determining the prices q_a^L and q_a^H faced by each type of firms on the alternative financing markets, the household's intermediation costs parameters have a crucial impact on the investment financing decisions of enterprises.

The 7 remaining parameters are adjusted to match the firms' investment financing pattern, from which I need at least 7 moments from the data. Table 1.7 presents the moments from the data to be matched. Note that these moments are interdependent, since the shares of financing sources for each firm size have to sum up to 100%[21], so that there are actually 8 independent moments to be matched. I include all three sources in the targeted moments to not underweight deviations from target of one specific source.

Table 1.7: Moments from the data: firms' investment financing

	Small firms	Medium firms	Large firms	Very large
share of retained earnings in investment funding	22%	29%	29%	26%
share of bank loans in investment funding	22%	31%	45%	58%
share of alternative sources in investment funding	56%	41%	26%	16%

The model's moments in terms of financing sources are computed using the firms' stationary distribution and optimal policy functions. Similarly to the data presented in section 1.1, I build four size categories according to the quantity of labor employed by the firms. The size thresholds are set so that the shares of each of the four categories in the firms' stationary distribution across labor are the same as in the data. Namely, if 23% of the enterprises are small in the data, the bottom 23% of the firms in the stationary distribution are classified as small, and so on. Optimal investment decisions and their financing are computed for each firm, and averaged within size categories. Finally, the operating cost parameter ζ is set so that the bank makes zero profit in this baseline calibration. Given that the bank's surplus is very small, ζ's value is also very small, equal to 0.0030.

The calibrated values of the parameters and the corresponding equilibrium prices are presented in Tables 1.8 and 1.9 respectively. These values imply that, depending on firms' type, $q_a^L = 0.9901$

[21]It might not exactly sum up to 100% in Table 1.7 due to rounding.

and $q_a^H = 0.9132$, so that $q_a^H < q < q_a^L$. As a consequence, the results highlighted in point (ii) of Proposition 1.1 and point (i) of Proposition 1.2 always apply for type H firms, meaning that they always marginally prefer to finance investment through bank loans rather than alternative sources. From point (i) of Proposition 1.1, type H firms also marginally prefer to use retained earnings when their use of alternative financing is already relatively high, while it would apply for type L firms only in extreme cases (which are not observed at the stationary equilibrium). Last, if type L firms are using little alternative financing, they marginally prefer to increase it rather than increasing bank loans (case (ii) of Proposition 1.2), whereas the opposite is true if alternative financing is more heavily used (case (i) of Proposition 1.1).

Table 1.8: Calibrated parameter values

q	β	δ	α	γ	χ^L	χ^H
0.97	0.9923	0.10	0.51	0.30	-0.0143	0.0625
θ	η^L	η^H	ξ	κ	p_0	ζ
0.10	0.01	0.0142	0.082	0.25	0.52	0.0030

Table 1.9: Equilibrium prices

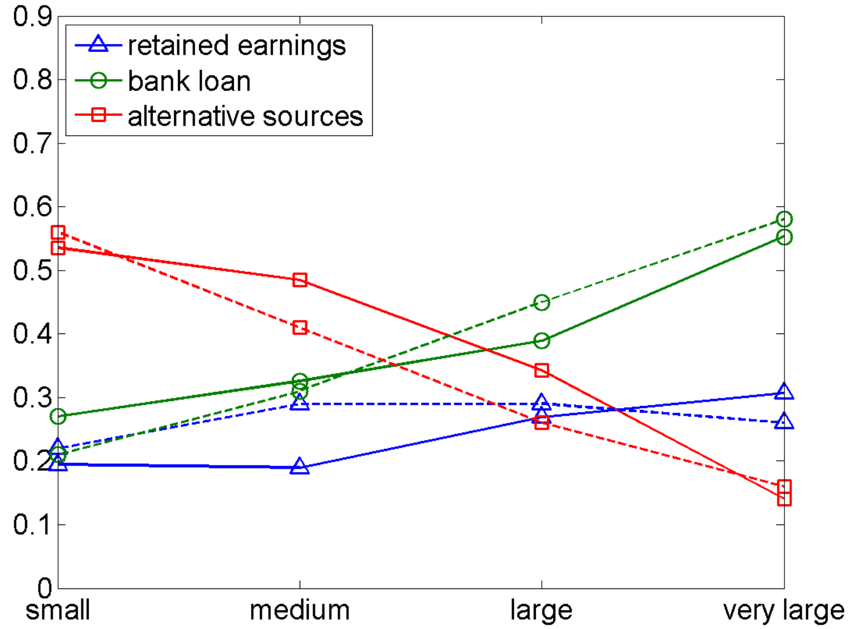
q_a^L	q_a^H	w
0.9901	0.9132	0.80

1.4.4 Baseline fit

Figure 1.4 shows the targeted moments from the data (dashed lines) and their match from the model (solid lines) for the share of investment financed by each of the three sources of funding. The calibration manages to reproduce the data's patterns for small to very large firms: small firms use indeed more alternative sources and less bank loans, while large firms use predominantly bank loans to finance their investment.

To assess the fit of the model, I compare further non-targeted moments to the data. The share of firms *not* using one source of funding and the share of firms *using only* one source of funding, are shown in Figure 1.5. The model is relatively close to some stylized facts from the data, further from some others. For instance, the share of firms not using retained earnings and the share of firms using only bank loans are at levels similar to the data. The share of firms using only alternative sources is decreasing with size as in the data. None of the firms use only retained earnings to finance their investment in the model, due to their high death probability that makes them relatively impatient. Very few enterprises do not use any bank loans to finance their investment. This is related to the debt roll-over mechanism in the model: if a firm is making negative profits, it can roll-over its debt and needs to use some bank loans to finance further access to alternative sources. Hence, every firm rolling over its debt needs to use some bank loans, at least to finance the access cost to alternative sources.

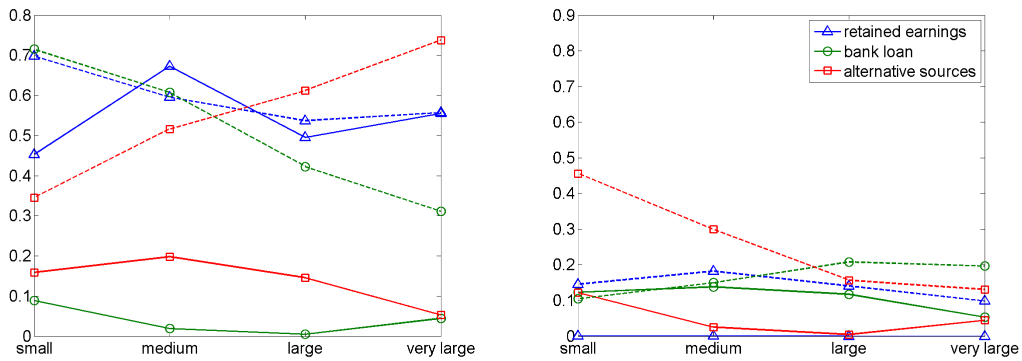
Figure 1.4: Calibrated moments (data in dashed lines, model in solid lines)



In terms of aggregate characteristics of the economy, I obtain a consumption over GDP ratio equal to 57%, which fits quite well the actual consumption rate in China (60% in 2002, 57% in 2003). Similarly, the investment over GDP ratio generated by the model is 44%, while the investment rate in China was equal to 38% in 2002 and 41% in 2003.[22] The share of firms actually investing is equal to 82%, hence slightly higher than the data where respectively 68% and 70% of the firms invested in 2001 and 2002.[23] Finally, the average leverage of enterprises, defined as the ratio of total assets over equity, is equal to 2.10 at the stationary state, which corresponds quite well to the data (average leverage of 2.00, from the Enterprise Survey).

[22]Source: World Bank WDI Database.
[23]Source: Enterprise Survey.

Figure 1.5: Non-targeted moments (data in dashed lines, model in solid lines)



(a) Share of firms not using one source of funding (b) Share of firms using only one source of funding

1.5 Reforming the credit distribution

1.5.1 On-going reforms in China

The regulation of the credit distribution sector is a heated topic in China, and reforms are an on-going process since the mid-2000s. They include liberalizing banks' interest rates by modifying their floors and ceilings, inciting state-owned banks to redirect loans from large state-owned firms towards smaller private enterprises, but also tightening the regulation of the non-bank financial institutions and informal lenders. More details on the regulatory evolution of these three aspects are provided below.

First, while interbank and bond rates were liberalized in 1996, the first significant step towards a liberalization of retail interest rates took place in 2004. From September 1999 until October 2004, lending rates were allowed to move between 0.9 and 1.1 times the benchmark rate for loans to large enterprises, and between 0.9 and 1.3 times the benchmark rate for small and medium enterprises. For deposit rates, banks had to strictly comply with the ceiling and floor rates. On its way towards a credit market liberalization, the Chinese government first suppressed the ceiling rates for bank loans and the floor rates for bank deposits in 2004, allowing banks to increase their intermediation margin by increasing lending rates or decreasing deposit rates. By maintaining the floor and ceiling for loans and deposit rates respectively, the Chinese authorities limit competition across banks to attract borrowers and depositors, and ensure that banks keep a sufficient profit margin. More recently, banks have also been allowed to set deposit rates 10% higher than the benchmark rate in June 2012, and this limit was progressively increased to 50% higher between November 2014 and May 2015. The full liberalization of interest rates is still an open process.

Second, "window guidance" is still an important tool for monetary policy in China. The People's Bank of China (PBC) meets every month with commercial banks and gives written or oral directives in terms of amount of credit distributed as well as loans beneficiaries, depending on their characteristics in terms of industrial sector, size, or even polluting emissions. The PBC started mentioning SME in its quarterly reports (*China Monetary Policy Report*) in 2004, stating its intention to "[promote] financial institutions to increase their support for SMEs and [curb] usury"[24] along with the loosening of the retail interest rates fluctuation bands. However, we have to wait until the spread of the financial crisis and the fourth quarter of 2008 to see some important evolution, with the publication of the *Notice on Perfecting the Management of the Rediscount Business and Increasing Agro-linked Loans and Financing to SMEs*. From 2009 on, the PBC monitors specifically the evolution of the amount lent by commercial banks to SME. Defined by the PBC as an objective for Chinese banks, loans to SME start increasing significantly, and their share across total loans raises despite the general increase in credit in China due to the stimulus package launched in November 2008.[25] From 2012 on, the focus of the PBC narrows towards small and micro-enterprises, to which bank loans are strongly encouraged.

Third, the regulation of financial intermediation has been debated and tightened over the last few years. As mentioned before, the monetary authorities state their intention to "curb usury" in the *China Monetary Policy Report* from 2004. Furthermore, the opportunities for non-bank financial institutions to attract funds from Chinese households are more supervised, as well as the sale to households of more remunerating trust assets through the intermediation of banks. The links between banks and trust companies, for instance, have been clarified either through the repatriation of off-balance-sheet assets into the banks' balance sheets, or through a clearer separation between banks and trust entities. These regulatory changes render access to credit more difficult for enterprises that do not manage to obtain bank loans.

1.5.2 Reforms' counterpart in the model

In this context, my model allows to conduct policy experiments by modifying the functioning of the credit distribution sector. To investigate the impact of various possible policies, I compare the stationary equilibrium of the baseline model calibration to the stationary equilibria reached after various reforms. The following changes can be implemented, simultaneously or separated:

(i) *Interest rates*: I assume perfect competition, meaning that the representative bank can maximize its profit by choosing the amount of deposits it demands and the amount of loans it

[24] *China Monetary Policy Report*, Quarter Three, 2004.

[25] Loans granted to small enterprises increased by 41% in 2009, 29% in 2010, 26% in 2011 and 17% in 2012 according to the PBC monetary reports. Their growth was respectively 16, 14 and 8 percentage points faster than loans to large enterprises in 2010, 2011 and 2012.

supplies, taking the deposit and lending rates as given. Bank's interest rates are then fully liberalized. Instead of being exogenously set by the government, they adjust to reach the equilibrium on the bank deposits and loans markets, given the household's deposit supply and the firms' loan demand. This reflects the on-going liberalization of interest rates in the banking sector.

(ii) *Window guidance*: to take into account the change in incentives given to commercial banks, I relax the collateral constraint faced by enterprises. Thus, banks are able to channel more funds to small enterprises. The extent to which this constraint is relaxed is determined to match the change in the bank lending rate between 2004 and the end of 2007.

(iii) *Non-bank financial intermediation*: I consider experiments where the alternative financing sector is shut down, which is an extreme case of tighter regulation. Since the alternative sources of funds in my model correspond both to family and friends ("cheap" alternative financing, accessible to type L firms) and to external investors ("expensive" alternative financing, accessible to type H firms), I also consider shutting down only "expensive" alternative finance. Indeed, the regulator may not wish to ban contributions to investment financing from family and friends, but only to prevent moneylenders and further intermediaries to take advantage of cash-starved enterprises.

Reforms scenarios

Given these reforms possibilities, four different scenarios are considered, as detailed below. Since the bank's operating cost parameter ζ is set to ensure that bank's profits are zero, the baseline scenario is already at equilibrium and simply liberalizing the interest rates would not induce any change. I therefore always consider a global liberalization of the banking sector, that includes both a loosening of the collateral constraint[26] and a liberalization of the interest rates.

a. For comparison, I study the impact of interest rate liberalization and collateral constraint loosening in the case where alternative financing does not exist neither before nor after the reform;

b. Starting from the baseline case where alternative finance is fully accessible, the banking sector is liberalized, while the regulation of alternative sector remains stable, so that the alternative financing sector remains fully accessible;

c. The third scenario examines the effect of a liberalization the banking sector, when the entire alternative sector is simultaneously shut down, so that enterprises can use alternative financing before the reform but not any more after the reform.

[26] Given the calibration obtained in section 2.4, the parameter θ is increased from 0.1 to 0.292. This increase is designed to reproduce the change in bank lending real rates in China between 2003 and the end of 2007, up from 3.09% to 3.58%.

d. In this last scenario, the banking sector is liberalized, while only the expensive alternative sector is shut down. This means that type L firms maintain their access to alternative financing sources throughout the policy experiment, while type H firms loose the possibility to use alternative financing after the reform. This scenario corresponds most closely to the aim of the Chinese government to curb usury.

Bank's profit maximization

As presented in section 2.3, the program of the bank is linear in the amount of deposits $q_d D$ taken and loans qB granted, and the bank faces the solvency constraint $qB \leq q_d D$. Hence, maximizing this program yields some equality relationships between interest rates and further parameters, equalities that need to be verified in order to avoid a corner solutions (in terms of loans supply or deposits demand). There are two possible solutions to the bank's program:

(i) If both deposits and loans are costless for the bank, meaning that $q_d = \frac{1}{1-\zeta}$ and $q = \frac{1-\bar{p}+\bar{p}\underline{r}}{1+\zeta}$. In this case, the bank is indifferent regarding the amount of deposits and loans it has, and the solvency constraint is not binding. Since $q_d \in (0, 1)$, this can never be the case unless $\zeta = 0$ and $q_d = 1$. The calibrated value of ζ being 0.0030, this case does not occur here.

(ii) Since $\zeta > 0$, holding deposits is always costly for the bank, and the solvency constraint will always bind, so that $qB = q_d D$. In this case, profit maximization brings the following relationship between q and q_d:

$$q = \frac{(1 - \bar{p} + \bar{p}\underline{r})q_d}{1 + 2\zeta q_d} \tag{1.53}$$

This equality is necessary to rule out corner solutions and implies that the bank makes zero profit at each period.

The solution that is relevant here is case (ii). Given that the bank's profits are zero, any amount of deposits and loans such that $q_d D = qB$ is a solution to the bank's program, and loans and deposits are determined by the firms' and household's programs respectively. From the household's program, the deposits price q_d has to be equal to the discount rate β to ensure the existence of a non-zero steady state wealth level. This means that the loan price q has to adjust according to equation (1.53), given the average default rate and reimbursement of enterprises, to ensure that the bank's profit is zero.

1.5.3 Results

After solving for the stationary equilibrium in scenarios *a.* to *d.*, I analyze the impact of the reforms in each case by comparing the aggregate economy, equilibrium prices and the average development path of an individual newborn firm before and after the reform. I also examine the development of newborn firms by simulating the path of a newborn firm with little capital and various initial productivity levels for a very large number of firms[27]. The average path for production, capital and investment is then obtained by averaging across firms.

Presence of alternative finance

Before studying in details the impact of the reforms, it is useful to have in mind the impact of the presence of alternative finance. Comparing the baseline case (where interest rates are not liberalized and the collateral constraint for bank loans is tight) to a similar situation without alternative finance yields the following results. The presence of alternative finance, by relaxing the credit constraints faced by the enterprises, increases the aggregate production, consumption and capital by 6.6%, 6.2% and 8.0% respectively. At the level of individual enterprises, alternative financing opportunities fasten the growth of small newborn enterprises' capital by respectively 11 to 129 percentage points. Similarly, the growth of newborn enterprises' production is 10 to 41 percentage points faster, depending on their initial productivity. Alternative finance has therefore a non-negligible impact on both aggregate variables and enterprise dynamics, and strongly contributes to alleviate credit constraints.

Impact on the aggregate economy

Turning to the impact of credit sector reforms, results for the various scenarios considered are presented in Table 1.10. At the bottom of Table 1.10, the numbers presented correspond to the difference in terms of the average growth paths of newborn firms for production and capital, during the first 6 periods of their life.

Except when alternative finance is fully or partially shut down (scenarios *c.* and *d.*), the banking sector liberalization has a clear positive effect. Overall, the impact of liberalization is influenced by (i) the presence of alternative finance; (ii) general equilibrium effects: prices increase in most scenarios.

Importance of alternative finance. Aggregate production, consumption, and capital increase in all scenarios except scenario *c.*. As shown in scenario *a.*, a naive view of the Chinese economy, not taking into account the presence of alternative financing sources, would overstate the positive impact of the liberalization in terms of consumption. When estimating the potential impact of liberalization reforms, it is therefore useful, as in scenario *b.*, to account for alternative financing

[27] The simulations presented here are done for 20000 firms for each possible initial productivity level. A sequence of productivity shocks is drawn for each simulated firm; the optimal investment decisions and resulting production and capital accumulation are then computed given these shocks, for each firm.

Table 1.10: Impact of banking sector liberalization, for different scenarios

	Initial level	Change, with Alternative Financing Sector: Never allowed *scenario a.*	Always allowed *scenario b.*	Shut down *scenario c.*	Partially shut down *scenario d.*
Aggregates					
Production	8.58	5.34 %	5.47 %	-0.75 %	5.61 %
Capital	20.37	9.54 %	9.91 %	2.43 %	11.11%
Consumption	4.90	4.02 %	3.10 %	-1.08 %	3.05 %
Prices					
Bank lending rate	3.09	+0.19	+0.50	-1.54	+0.06
Low alternative rate	1.00	-	+0.50	-	+0.06
High alternative rate	9.50	-	+0.57	-	-
Wage	0.80	5.48 %	5.41 %	-0.6 %	5.62 %
Firms' path					
New-born average production growth	-	0.5 to 4.6 % pts	-1.6 to 6.9 % pts	-36.8 to -9.8 % pts	-13.6 to 1.3 % pts
New-born average capital growth	-	0.7 to 8.6 % pts	-0.7 to 13.3 % pts	-120.1 to -10.1 % pts	-22.9 to 2.4 % pts

sources, which allow firms to bypass credit constraints and make the impact of liberalization less stringent. A liberalization of the banking sector increases aggregate production by 5.34% in the absence of alternative finance, which is similar to the production increase of 5.47% when alternative finance is taken into account. The aggregate capital increase resulting from the liberalization is also similar whether alternative finance is included or not in the model. However, and most importantly for a policy maker, the change in consumption decreases from 4.02% to 3.10%, strongly reducing the welfare implications for households. Furthermore, the development implications for small young firms are more heterogeneous when alternative finance is available.

Scenario *c.*'s results may seem surprising: while aggregate capital increases, production decreases slightly. This is due to two effects: first, the strong drop in the bank loan rate and the relaxation of the collateral constraint favors a higher level of capital – though far from the increase seen n scenario *b.*. However, financial constraints are still present in this scenario, and alternative financial sources cannot be used any more to alleviate them. Hence, aggregate capital is higher, but its allocation is worse, as is shown by the increase in the dispersion of the marginal productivity of capital across firms, from 0.142 to 0.157. As a consequence, the aggregate production decreases, and so does aggregate consumption. This scenario confirms the importance of alternative finance in alleviating resource misallocations and improving aggregate welfare.

General equilibrium effects. The impact of banking sector reforms is about half smaller than in a partial equilibrium situation where all prices were fixed. In scenario *b.*, aggregate production increases by 5.5% instead of 14.8%, while aggregate capital increases by 9.9% instead of 20.7%. This is due to a general increase in all prices following the reforms, for which I explain the intuition below. There are two mechanisms impacting directly the bank lending rate. First, due to the relaxed collateral constraint, firms' demand for bank loans increases, driving up the prices. Second, in terms of loan riskiness, the liberalization slightly decreases the average default probability of enterprises since firms may more easily roll-over small amounts of debt. However, since they may also borrow higher amounts, the share of debt they are able to reimburse in case of default decreases, so that the expected loan return slightly decreases. To compensate for these two changes, the interest rate of bank loans increases. This second mechanism is also valid for alternative sources, and drives up both alternative interest rates too. Last, given their higher capital level, enterprises also demand more labor, causing a rise in the wage since the labor supply is fixed. This results in an increase in all prices, in particular the type H alternative financing (when available), that raises by 0.57 percentage points.

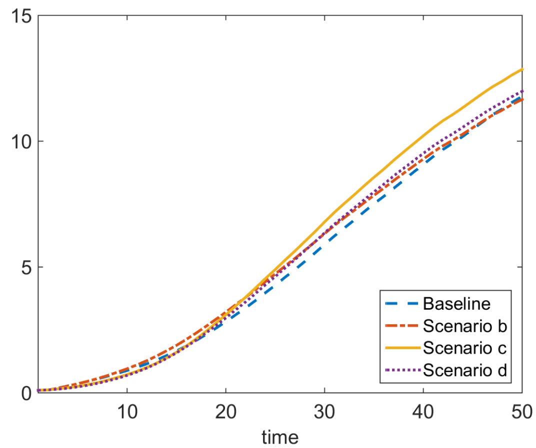
Impact on the demand for bank loans

Having a closer look at the change in firm borrowing behavior in terms of bank loans helps us understand the mechanisms behind reforms' impact. Focusing on scenario *b.*, the liberalization, through the loosening of the collateral constraint, causes a strong increase in the total amount of bank loans distributed (multiplied by 2.2). In terms of extensive margin, the quantitative impact on bank borrowing is relatively small and, if anything, tends to decrease the total amount borrowed from banks. Only 5.5% of the firms that were not using bank loans before start using it after the reforms – most of them being small and medium-sized firms – and they account for only a negligible part of total bank borrowing. A similarly low impact is due to enterprises that would have defaulted without the liberalization, and are now able to roll over their debt: they account for less than 1% of total bank borrowing after the reform, most of it coming from medium or larger enterprises. Finally, due to the increase in the bank lending rate, some firms actually stop borrowing from banks, relying only on retained earnings and alternative finance. These firms were responsible for more than 2% of borrowing before the liberalization. The large majority of the increase in bank borrowing is at the intensive margin. Indeed, firms that were already borrowing before and keep on borrowing account for 99% of total borrowing after the reform. Many of them were constrained by the collateral requirement and increase the size of their bank loan despite the interest rate rise. This intensive margin effect strongly overcomes the extensive margin slight decrease.

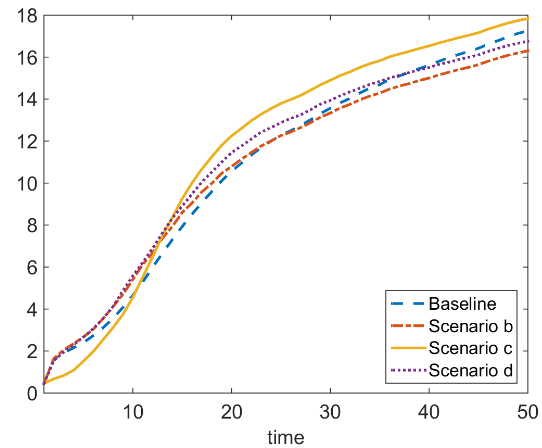
Impact on small, new-born enterprises

In scenarios *a.* and *b.*, newborn firms with a low level of capital and a high enough productivity are strongly benefitting from liberalization. Indeed, it increases their average production growth over the first 6 years by up to 7 percentage points in scenario *b.*. By alleviating the credit constraints before the liberalization, alternative financing reduces the reforms' impact on production for less

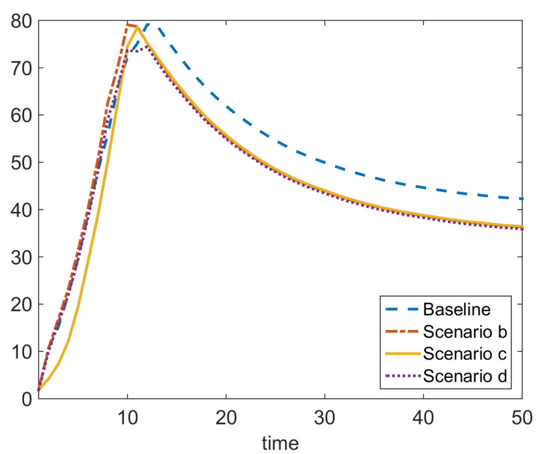
Figure 1.6: Average production path of a new-born firm starting with low capital



(a) Low initial productivity



(b) Medium initial productivity



(c) High initial productivity

productive firms. For more productive firms, the availability of alternative finance combines with the liberalization to produce a stronger impact.

The importance of alternative finance for small firms is also emphasized in scenarios *c.* and *d.*: liberalizing the banking sector cannot compensate for a tight regulation of the alternative financing sector, and newborn enterprises grow much slower, both in terms of production and capital, when their access to alternative finance is shut down. The speed of development of newborn firms decreases by up to 37% and 120% for production and capital respectively in scenario *c.*. This is also true for aggregate production and consumption. This result implies that the regulation of the non-bank financial sector should be accompanied by making the banking sector function on a more competitive basis, but should also be mild enough not to penalize small firms too strongly.

In scenario *d.*, only type H enterprises do not have access to alternative finance. Depending on their initial productivity, newborn firms are differently affected by the reform: enterprises with a high initial productivity level are more penalized by the tighter regulation of alternative finance, because they optimally would want to invest more. On the opposite, enterprises with a low initial productivity gain from the reform of scenario *d.*, since they are able to invest enough using bank loans.

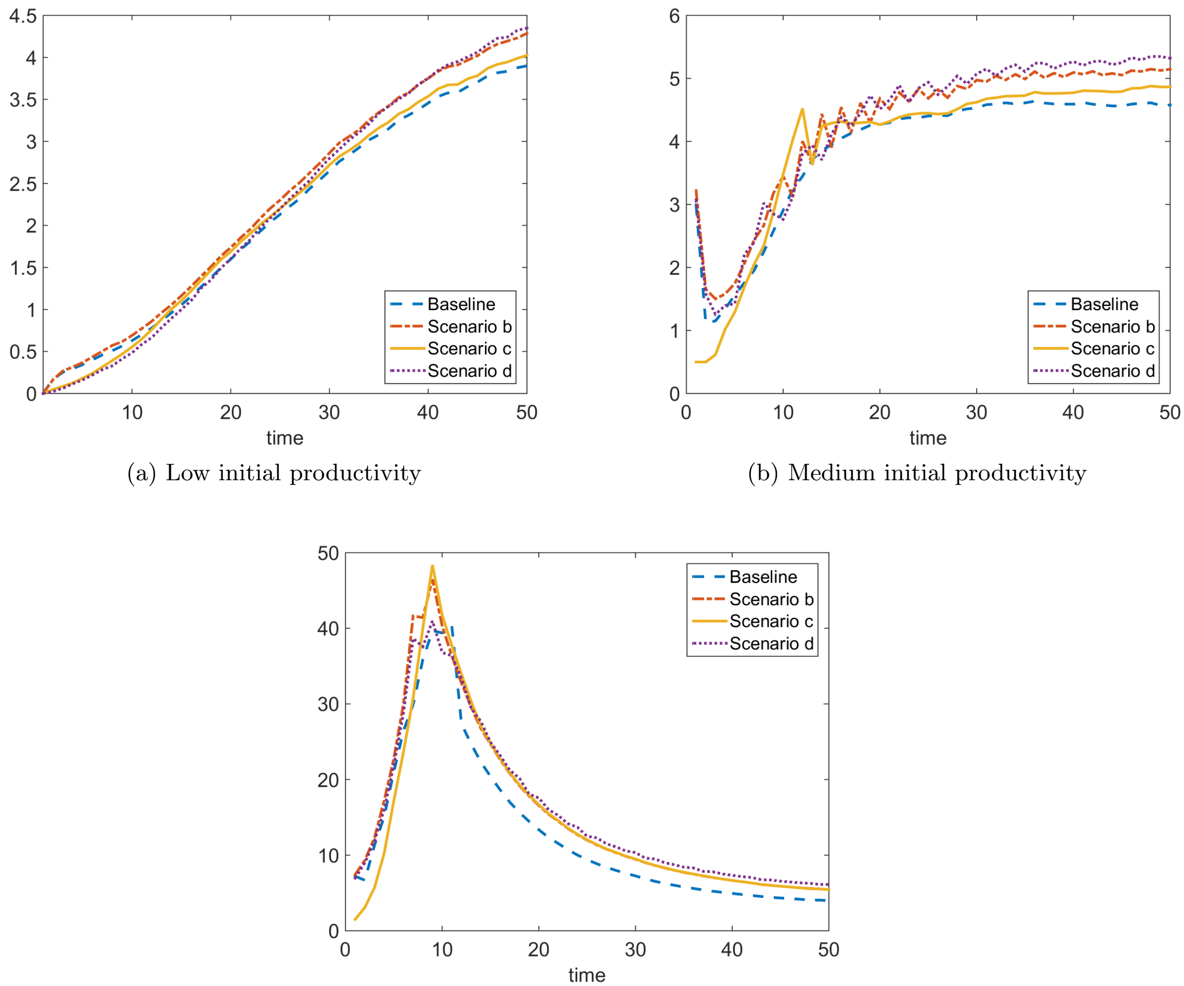
This analysis is further illustrated by Figures 1.6 and 1.7. The blue dashed lines in both figures show, in the baseline calibration, the average production and investment of newborn firms starting with various initial levels of productivity. The red dashed-dotted line corresponds to scenario *b.* (liberalization of the banking sector, no change in alternative finance), while the yellow solid line represents scenario *c.* (liberalization of the banking sector and closing of the alternative sector) and the purple dotted line shows scenario *d.* (liberalization of the banking sector and closing on the expensive alternative sector only). The overshooting of production observed in Figure 1.7c is related to the very high initial productivity level of enterprises: their initially high production decreases after about 10 years, when their productivity shock goes back to its steady state average level. In scenarios *b.* and *d.*, the liberalization allows newborn firms' production to grow somewhat faster towards their steady state level, especially for firms starting with a medium productivity. Similarly, firms starting with a high productivity reach both their peak of production and their long-term average production level earlier in scenario *b.*.

A ban of the alternative financing sector is more detrimental to firms with a high initial productivity, since their suboptimal level of investment implies a larger loss in terms of production during the first 10 periods. (see Figure 1.7c). In scenario *c.*, firms clearly have a lower level of production for the first periods. We can notice that allowing access to L type alternative finance (scenario *d.*) almost restaures the production curve to the level of scenario *b.* (with all alternative sources allowed), meaning that most of the impact of alternative financing is coming from the "cheap" alternative.

As shown in Figure 1.7, for firms with a low or medium initial productivity, investment is lower in the baseline calibration and in scenario *c.* compared to scenario *b.*. This is the case both in the very first years, and later on, when the steady state is reached. Similarly to production, investment in scenario *d.* is almost equal to scenario *b.*, confirming the importance of cheap alternative financing options, even if only half of enterprises have access to it given the calibration.[28] We can also

[28]The share of L type firms is 0.52, see Table 1.8.

Figure 1.7: Average investment path of a new-born firm starting with low capital



(a) Low initial productivity

(b) Medium initial productivity

(c) High initial productivity

observe that high productivity firms delay their investment in scenario *c.* because of financial constraints, thus having a lower level of investment over the first 10 periods. After around 15 to 20 periods periods, all liberalization scenarios show a higher level of investment, which is consistent with their higher level of aggregate capital. We can also observe on Figure 1.8c that the peak of investment is delayed by about one year in the baseline scenario: the firms have to comply with the bank's collateral constraint and to pay alternative finance's access cost, which forces them to delay investment. However, given that the productivity progressively decreases back to its steady state level, delayed investment does not fully take place later on. Therefore the level of the investment peak in the baseline case is lower, as firms' investment plans adjust to their new productivity shock.

Impact on capital allocation

Despite the increase in capital, production and consumption, the average value of firms slightly decreases in scenario b.. Indeed, the discounted stream of dividends is lowered by the increase in all prices. It is less so for type H enterprises and smaller-sized enterprises as they benefit more from the reform in terms of access to finance, and see a smaller decrease in their value. The changes in marginal productivity of capital (MPK) can help evaluating the evolution of capital misallocations. All enterprises see their MPK decrease, which is logical since they invest more. The changes in MPK are fairly similar across firm size, whereas H type firms tend to see their MPK decrease relatively more than L type firms. This confirms that type H enterprises benefit more from banking sector reforms. In terms of dispersion, the standard error of MPK slightly decreases with the reforms, from 0.1420 to 0.1369, which shows once again that capital is better allocated after the reforms.

Conclusion

This paper studies the access to investment funding for Small and Medium Enterprises and the importance of alternative financing sources – namely non-bank, non-retained earnings sources – in a context of banking sector liberalization. These alternative sources include family and friends, non-listed equity and various types of informal lending institutions. The model set-up focuses on the choice of investment financing by heterogeneous enterprises facing a collateral constraint, idiosyncratic productivity shocks and different costs of access to alternative sources of funding. Embedding the firm's side into a general equilibrium model, I quantify the impact of a reform of the credit distribution sector in China, including the liberalization of bank interest rates, the modification of banks' incentives to lend and the regulation of alternative finance.

The model is more specifically tailored to the situation in China at the start of the 21^{st} century where, as shown by firm-level surveys, smaller firms are facing tighter credit constraints than large ones and resort to retained earnings or further alternative sources to finance their investment. I solve for the stationary equilibrium and calibrate the parameters so as to reproduce stylized facts from Chinese data. Using this calibrated model as a benchmark, I show that a liberalization of the banking sector towards more competition among banks for loans and deposits is beneficial to the economy. It indeed increases both the aggregate production and consumption, and improves the development speed of newborn enterprises. By alleviating the credit constraints faced by enterprises, alternative finance also reduces the impact of the liberalizing reforms compared to a "naive" view where alternative finance would not be accounted for. A liberalization of the banking sector increases aggregate production and consumption respectively by 5.5% and 3.1%. It also speeds up the growth of newborn enterprises by up to 7 percentage points in terms of production and 13 percentage points in terms of capital accumulation.

Simultaneously tightening the regulation of alternative finance, on the opposite, would diminish —but not cancel —the benefits of the liberalization in terms of aggregate consumption. It would however be strongly detrimental to younger, smaller firms, reducing their access to credit and their investment, and slowing down their growth by up to 14 and 23 percentage points in terms of production and capital respectively.

From this exercise, we can conclude that the availability of alternative funding allowed Chinese firms to partially bypass credit constraints, and to develop faster in terms of capital size and production, hence favoring a higher long-run aggregate level of capital and production. A liberalization of the banking sector, by easing access to credit and favoring investment, would beneficiate to all enterprises, especially small, high productive ones. Results also show that non-banking credit institutions should be regulated carefully. If not conducted in parallel to a reform of the Chinese banking system, tightening the regulation of alternative funding institutions could undermine the dynamism of younger firms unable to obtain formal bank loans. China has been progressively liberalizing retail bank interest rates since 2004, and the final steps of this liberalization process are still an open debate. This paper shows that such a liberalization is beneficial and necessary before regulating too tightly the alternative financing sector.

Appendix

1.A Tables

Table 1.A.1: Descriptive statistics comparing the composition of 2002 and 2003's samples of the Enterprise Survey - China

Statistics	2002	2003
Number of observations	1548	2400
Year starting operations in China (average)	1987	1987
Year starting operations in China (median)	1993	1993
Publicly listed companies (% of firms)	1.74	2.48
Private held, limited companies (% of firms)	23.43	30.95
Cooperative (% of firms)	15.73	17.77
Other (% of firms)	59.10	48.81
SOE (% of firms)	22.91	23.30
Manufacturing sector (% of firms)	65.89	67.04
Services sector (% of firms)	34.11	32.96
Number of workers one year ago (average)	541	542
Number of workers two years ago (average)	639	504
Number of workers three years ago (average)	511	NA
Total sales one year ago (thousand RMB)	207309	202616
Total sales two years ago (thousand RMB)	175525	189135
Total sales three years ago (thousand RMB)	148582	147502
Capital one year ago (thousand RMB)	19800	NA
Capital two years ago (thousand RMB)	17500	NA
Capital three years ago (thousand RMB)	16200	NA
Energy consumption one year ago (thousand RMB)	6167095	NA
Energy consumption two years ago (thousand RMB)	5437916	NA
Energy consumption three years ago (thousand RMB)	3218342	NA

Data issued from the 2002 and 2003 Enterprise Survey conducted by the Workd Bank, available at http://www.enterprisesurveys.org/

Table 1.A.2: Sources of funding for new investment (% of total new investment), by firm ownership status

		foreign	private	collective	soe
Internal/retained earnings		31.52	24.21	33.67	19.83
Banks	Local banks	22.64	28.83	41.85	52.89
	Foreign-owned banks	0.34	0.23	0.00	0.00
	Special development financing	2.41	0.51	0.00	2.19
Alternative	Family, friends	3.62	11.69	6.67	1.19
	Equity, sale of stock to employees	5.17	5.65	0.00	1.27
	Equity, sale of stock to legal-persons	17.98	13.41	15.70	8.17
	Informal sources	2.59	3.02	0.00	3.41
	Trade credit	5.74	1.66	0.00	0.04
Equity, public issue of marketable share to outside investors		1.72	2.12	0.00	1.91
Others		6.26	8.66	2.11	9.11
Observations		58	630	27	124

The firm size categories across annual total sales are defined as follows:

- Very Small: annual total sales in 2002 below 2500 000 Yuan
- Small: annual total sales in 2002 between 2500 000 and 10 000 000 Yuan
- Medium: annual total sales in 2002 between 10 000 000 and 50 000 000 Yuan
- Large: annual total sales in 2002 above 50 000 000 Yuan

Table 1.A.3: Sources of funding for new investment (% of total new investment), by firm sales , across private firms

		Very Small	Small	Medium	Large
Internal/retained earnings		19.23	21.31	28.77	26.34
Bank	Local banks	19.38	25.35	30.15	39.25
	Foreign-owned banks	0.06	0.00	0.76	0.00
	Special development financing	0.79	0.62	0.56	0.11
Alternative	Family, friends	22.43	15.34	9.01	1.34
	Equity, sale of stock to employees	6.88	8.66	4.43	3.57
	Equity, sale of stock to legal-persons	17.49	12.88	12.95	10.29
	Informal sources	4.26	2.20	3.98	1.38
	Trade credit	1.33	2.23	0.39	2.92
Equity, public issue of marketable share to outside investors		0.18	0.83	1.40	5.74
Others		7.96	10.59	7.60	9.08
Observations		164	121	178	167

Table 1.A.4: Sources of funding for new investment for Germany in 2005, by firm size (in terms of employment)

		All	Small	Medium	Large	Very large
Internal/retained earnings		50.73	53.81	43.52	35.01	24.55
Banks	Local banks	21.13	19.01	25.08	32.72	42.73
	Foreign-owned banks	1.51	0.98	2.87	4.04	6.36
	Investment funds	0.50	0.43	0.33	1.38	0.00
Alternative	Family, friends	0.83	0.99	0.16	0.32	0.00
	Informal sources	0.00	0.00	0.00	0.00	0.00
	Trade credit	4.17	4.25	5.53	2.39	0.00
	Credit card	0.89	0.96	0.90	0.37	0.00
Equity, sale of stock		9.33	9.01	8.98	11.29	20.91
Leasing		10.85	10.49	12.62	12.50	5.45
Others		0.05	0.06	0.00	0.00	0.00
Observations		1177	935	122	109	11

Table 1.A.5: Sources of funding for new investment for India in 2005, by firm size (in terms of employment)

		All	Small	Medium	Large	Very large
Internal/retained earnings		52.30	51.73	56.89	48.89	38.87
Bank	Local banks	31.46	27.49	36.86	39.46	55.04
	Foreign-owned banks	0.87	0.75	0.92	1.69	3.75
Alternative	Family, friends	6.97	9.17	2.33	2.89	0.00
	Informal sources	0.60	0.75	0.09	0.28	0.00
	Trade credit	4.53	6.35	1.16	2.57	1.67
	Credit card	0.87	1.30	0.11	0.32	0.00
Equity, sale of stock		1.10	1.00	1.13	2.36	0.67
Leasing		0.93	1.19	0.48	0.18	0.00
Others		0.36	0.26	0.03	1.38	0.00
Observations		1468	918	320	109	24

Table 1.A.6: Sources of funding for new investment for Colombia in 2006, by firm size (in terms of employment)

		All	Small	Medium	Large	Very large
Internal/retained earnings		33.01	31.52	39.96	74.85	52.67
Bank	Private banks	35.93	35.87	40.32	11.14	47.33
	State-owned banks	7.15	7.77	2.41	0.42	0.00
Alternative	Family, friends	9.88	11.09	0.11	0.00	0.00
	Debt	0.19	0.13	0.48	1.76	0.00
	Informal sources	0.63	0.64	0.49	0.84	0.00
	Trade credit	9.78	10.67	3.10	0.08	0.00
	Non-bank financial institutions	1.38	0.72	6.16	10.92	0.00
Equity, sale of stock		0.36	0.03	3.58	0.00	0.00
Others		1.70	1.56	3.37	0.00	0.00
Observations		559	404	122	25	8

Table 1.A.7: Sources of financing: share (%) of enterprises declaring not using one financing source, or using only one finance source, by ownership status

		All	Foreign	Private	Collective	SOE
not using (0%)	internal/retained earnings	61.61	56.14	60.26	59.26	71.54
	bank loans	52.47	63.16	55.93	48.15	30.89
	alternative	56.80	57.89	51.44	70.37	80.49
using only (100%)	internal/retained earnings	20.10	33.33	19.23	25.93	17.07
	bank loans	27.56	19.30	22.76	37.04	53.66
	alternative	26.35	28.07	29.17	18.52	13.01
	observations 831	57	624	27	123	

Table 1.A.8: Sources of financing: share (%) of private enterprises declaring not using one finance source, or using only one finance source, by sales

		Very Small	Small	Medium	Large
not using (0%)	internal/retained earnings	73.17	64.17	51.70	53.66
	bank loans	71.95	62.50	52.27	39.02
	alternative	34.15	43.33	56.82	68.90
using only (100%)	internal/retained earnings	16.46	19.17	21.02	20.12
	bank loans	15.24	21.67	23.30	30.49
	alternative	48.17	32.50	21.59	15.85
	observations	164	120	176	164

Table 1.A.9: Bank loans requirements and applications, by ownership status (% of firms)

		Foreign	Private	Collective	SOE
if having a loan, was collateral needed?	Yes	53.10	58.55	64.41	61.89
if did not apply for a loan, is it because of collateral requirements?	Yes	23.91	27.57	15.09	22.42
if application rejected, was it because of lack of collateral?	Yes	66.67	71.71	56.25	66.67

Table 1.A.10: Bank loans requirements and applications, by sales (% of private firms)

		Very Small	Small	Medium	Large
if having a loan, was collateral needed?	Yes	43.72	49.28	63.84	74.27
if did not apply for a loan, is it because of collateral requirements?	Yes	25.86	32.43	26.80	24.72
if application rejected, was it because of lack of collateral?	Yes	71.15	71.70	77.42	62.50

Table 1.A.11: Average interest rate and collateral required for bank loans, by firm's status

	Foreign	Private	Collective	SOE
	mean	mean	mean	mean
interest rate	5.01	5.29	5.65	5.58
collateral (% of loan)	80.03	84.58	71.30	85.38
Observations	49	456	30	129

Table 1.A.12: Average interest rate charged on bank loans, by sales

	Very Small	Small	Medium	Large
	mean	mean	mean	mean
interest rate	5.74	5.42	5.14	5.17
collateral (% of loan)	96.30	79.20	84.85	82.04
Observations	70	86	144	156

Table 1.A.13: Average interest rate and collateral required for bank loans, by amount invested (in thousand yuan)

	0-100	100-1000	1000-10000	>10000
	mean	mean	mean	mean
interest rate	5.35	5.50	5.13	5.18
collateral (% of loan)	90.72	88.18	83.65	77.61
Observations	59	122	115	60

Table 1.A.14: Depreciation rates estimated or assumed by various studies

Source	Depreciation rate	Country
Bai et al. (2006)	8% for structures 24% for machinery avg 10.52% for 1997-2003	China
Raychaudhuri (1996)	6.7%	India, industry
OECD (2000)	4%	China
Wang and Yao (2003)	5%	China
Hsieh and Klenow (2009)	5%	China and India
Schündeln (2012)	from 8% to 14%	Indonesia
Sun and Ren (2008)	17% for equipment 8% for structure 26% for auto	China
Wu (2009)	from 3.6% to 17% avg 5.2 % for manufacturing avg 4.0 % for services total avg 4.6%	China

Although a depreciation rate close to 5% is often used (for instance by Hsieh and Klenow, 2009), many studies that estimate the depreciation rate in China find higher results (see Table 1.A.14 in Appendix 1.A). Bai et al. (2006) obtain an average depreciation rate of about 10% for the period ranging from 1997 to 2003, Sun and Ren (2008)'s rates range between 8% and 26%, while Wu (2009) obtains estimates between 3.6% and 17%. Furthermore, Udry and Anagol (2006) show theoretically that financially constrained firms tend to hold assets that depreciate faster, which is confirmed empirically by Schündeln (2012). The latter also shows that younger firms have a higher depreciation rate. Given that my study is mainly focused on young firms that may suffer from financial constraints, it seems reasonable to set δ to 10% for the calibration.

Table 1.A.15: Estimation of the production function coefficients with OLS and fixed effects

	Least squares		Fixed effects	
	(1)	(2)	(3)	(4)
	All	All	All	All
labor	0.33***	0.36***	0.33***	0.35***
	(0.0323)	(0.0320)	(0.0563)	(0.0567)
capital	0.52***	0.53***	0.39***	0.37***
	(0.0183)	(0.0181)	(0.0406)	(0.0424)
age		-0.019***		0.031**
		(0.00221)		(0.0151)
Constant	5.99***	5.83***	7.90***	7.80***
	(0.199)	(0.197)	(0.662)	(0.664)
N	1888	1885	1888	1885

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

1.B Proofs

1.B.1 Proof of Proposition 1.1

Proof. First, I demonstrate the Lemma 1 below, as it will be useful for the proof.

Lemma 1. *The value function $V(A, k, d; j)$ is increasing with capital k and decreasing with debt d: $\frac{\partial V(A,k,d;j)}{\partial k} \geq 0$ and $\frac{\partial V(A,k,d;j)}{\partial d} \leq 0$.*

Proof of the Lemma. Using the envelop theorem, tt is easy to derive the partial derivatives of the value function is the following three cases:

- Positive dividends:

$$\frac{\partial V^{ND}}{\partial k} = (1+\mu)\alpha A k^{\alpha-1} l^{\gamma} + \lambda\theta > 0 \tag{1.54}$$

$$\frac{\partial V^{ND}}{\partial d} = -1 - \mu < 0 \tag{1.55}$$

- Positive profits, zero dividends:

$$\frac{\partial V^{ND}}{\partial k} = \nu\alpha A k^{\alpha-1} l^{\gamma} + \lambda\theta \geq 0 \tag{1.56}$$

$$\frac{\partial V^{ND}}{\partial d} = -\nu \leq 0 \tag{1.57}$$

- Negative profits:

$$\frac{\partial V^{ND}}{\partial k} = \zeta \alpha A k^{\alpha-1} l^{\gamma} + \lambda \theta \geq 0 \tag{1.58}$$
$$\frac{\partial V^{ND}}{\partial d} = -\zeta \leq 0 \tag{1.59}$$

Given that the value function in case of default is always equal to zero, this implies the result of Lemma 1.

Let us now turn to the proof of Proposition 1.1. From equations (1.24) and (1.25), I define the marginal benefit of investing (the same for all sources of funding) as:

$$B_m(b') = B_m(a') = B_m(e') = \frac{\partial EV}{\partial k'} \tag{1.60}$$

Focusing on the case where the firm distributes positive dividends, I then examine the marginal cost of investment depending on the financing source:

$$C_m(e') = \frac{1+\mu}{\beta(1-\xi)} \tag{1.61}$$
$$C_m(b') = \frac{\lambda}{\beta(1-\xi)} - \frac{1}{q}\frac{\partial EV}{\partial d'} \tag{1.62}$$
$$C_m(a') = \frac{x^{j\prime}(a')(1+\mu)}{q_a^j \beta(1-\xi)} - \frac{1}{q_a^j}\frac{\partial EV}{\partial d'} \tag{1.63}$$

(i) *Comparing retained earnings and alternative financing.*

$$C_m(a') - C_m(e') = \underbrace{\frac{1+\mu}{\beta(1-\xi)}}_{\geq 0} \left(\frac{x^{j\prime}(a')}{q_a^j} - 1 \right) - \frac{1}{q_a^j} \underbrace{\frac{\partial EV}{\partial d'}}_{\leq 0} \tag{1.64}$$

$q_a^j - x^{j\prime}(a') < 0$ implies that $C_m(a') \geq C_m(b')$, which gives us the result that retained earnings are marginally preferred to alternative financing.

(ii) *Comparing bank loans and alternative financing.*

$$C_m(a') - C_m(b') = \underbrace{\frac{x^{j\prime}(a')(1+\mu)}{q_a^j \beta(1-\xi)}}_{\geq 0} - \frac{\lambda}{\beta(1-\xi)} + \left(\frac{1}{q} - \frac{1}{q_a^j} \right) \underbrace{\frac{\partial EV}{\partial d'}}_{\leq 0} \tag{1.65}$$

When the collateral constraint does not bind ($\lambda = 0$) and $q \geq q_a^j$, we clearly have $C_m(a') \geq C_m(b')$.

These results shows both points (i) and (ii) of Proposition 1.1. □

1.B.2 Proof of Proposition 1.2

Proof. Similarly to the proof of Proposition 1.1, I define the respective marginal cost and benefits of investment financed by various sources. Note that when the firm distributes zero dividends, it does not want to marginally increase its retained earnings, since it has already used all its profits (if any) to invest through retained earnings or alternative sources. Hence I only compare the marginal costs and benefits of bank loans and alternative financing. The marginal benefit of investing is the same for both sources:

$$B_m(b') = B_m(a') = \frac{\partial EV}{\partial k'} \tag{1.66}$$

To study the marginal costs, I separate across two cases depending on the sign of the firm's profits.

(i) *Case of positive profit and zero dividends.* The marginal costs of bank loans and alternative financing are respectively:

$$C_m(b') = \frac{\lambda - \nu}{\beta(1-\xi)} - \frac{1}{q}\frac{\partial EV}{\partial d'} \tag{1.67}$$

$$C_m(a') = \frac{x^{j\prime}(a')}{\beta(1-\xi)(q_a^j - x^{j\prime}(a'))} - \frac{1}{q_a^j - x^{j\prime}(a')}\frac{\partial EV}{\partial d'} \tag{1.68}$$

$$C_m(a') - C_m(b') = \underbrace{\frac{x^{j\prime}(a')}{\beta(1-\xi)(q_a^j - x^{j\prime}(a'))}}_{\geq 0} + \frac{\nu - \lambda}{\beta(1-\xi)} + \left(\frac{1}{q} - \frac{1}{q_a^j - x^{j\prime}(a')}\right)\underbrace{\frac{\partial EV}{\partial d'}}_{\leq 0} \tag{1.69}$$

Here I consider only the case where $q_a^j - x^{j\prime}(a') > 0$. Indeed, remember that tomorrow's capital is given by: $k' = (1-\delta)k + qb' + q_a^j a' + profit - x^j(a')$. If $q_a^j - x^{j\prime}(a') \leq 0$, tomorrow's capital is decreasing with alternative sources, and the firm will never find it optimal to use alternative sources to finance investment. When the collateral constraint does not bind ($\lambda = 0$), having $q \geq q_a^j - x^{j\prime}(a')$ implies that $C_m(a') \geq C_m(b')$. Since the cost function $x^j(.)$ is convex, assuming that $q \geq q_a^j - x^{j\prime}(a')$ is equivalent to assuming that $a' \geq \underline{a}$, where $\underline{a}$ is defined by $x^{j\prime}(\underline{a}) = q_a^j - q$.

(ii) *Case of negative profits.* Here again, we can compute the marginal costs of bank loans and alternative sources.

$$C_m(b') = \frac{\lambda - \nu - \zeta}{\beta(1-\xi)} - \frac{1}{q}\frac{\partial EV}{\partial d'} \tag{1.70}$$

$$C_m(a') = \frac{x^{j\prime}(a')}{\beta(1-\xi)(q_a^j - x^{j\prime}(a'))} - \frac{\zeta}{\beta(1-\xi)} - \frac{1}{q_a^j - x^{j\prime}(a')}\frac{\partial EV}{\partial d'} \tag{1.71}$$

$$C_m(a') - C_m(b') = \underbrace{\frac{x^{j\prime}(a')}{\beta(1-\xi)(q_a^j - x^{j\prime}(a'))}}_{\geq 0} + \frac{\nu - \lambda}{\beta(1-\xi)} + \left(\frac{1}{q} - \frac{1}{q_a^j - x^{j\prime}(a')}\right)\underbrace{\frac{\partial EV}{\partial d'}}_{\leq 0} \quad (1.72)$$

This gives us the same result as for positive profit and zero dividends, and Proposition 1.2 is obtained by combining the two cases.

□

1.C General equilibrium with heterogeneous households

I detail below a version of the general equilibrium model with heterogeneous households instead of a representative one. Using heterogeneous households with a wealth distribution allows to avoid some shortcuts that are necessary in the representative household version, namely:

- Households do not have to be indifferent between saving and consuming, which frees the bank deposit rate for the liberalization experiment;
- Households can hold risky assets, and bear to cost of firms' default if lending directly to them;
- Households do not have to be indifferent between the saving instruments to avoid corner solutions, since the bank loans are risk-free while the direct loan to the firms is risky.

The subsequent changes in the general equilibrium set-up are described in sections 1.C.1 to 1.C.3 of this appendix.

1.C.1 Program of the heterogeneous households

The households are heterogeneous and go through the life cycle as young workers and old pensioners. The young households supply labor inelastically for a gross wage w, and decide how much of their income to consume and save. Their wage is taxed at a rate t to finance the old households' pension scheme by repartition. Old households are retired and earn some pension benefit equal to $\underline{w} < w$. They also optimize their consumption and savings. A young household has a probability ρ to retire, while an old household dies with probability τ^O. Importantly, the households do not face any uncertainty in terms of labor or pension income. They have an incentive to save to smooth consumption because they earn less as pensioners than as workers. To keep the size of the total population constant, every time a household dies, a young household is born and inherits the wealth of the old household. For simplicity, I assume that the households cannot borrow. Given the set-up outlined above, this borrowing constraint is mostly not binding, except for poor, young (working) households. On top of their labor or pension income, the households earn the dividends of the firms. The shares of the firms are equally distributed and the dividends are a per period per household lump-sum transfer (to keep the households' program simple enough, I assume that firms' shares are non-transferable).

Differently from the representative household case, each household can choose between only two (instead of three) saving instruments: bank deposits, and one of the two types of direct loans to firms (corresponding to the two types of alternative financing received by the firms). Indeed, beyond wealth and age differences, I further distinguish between N_J types of households $j \in J$ that pay a different intermediation cost χ^j to find a firm willing to invest. This cost is higher when households search beyond their close social circle, since the search involves more intermediaries to reach a firm needing investment, and this is reflected in the variations in χ^j depending on the household's type j. Granting a direct loan to enterprises is risky, since the firm may default on the loan and not fully reimburse. The households do not have precise enough information on the firm they are lending to to know its specific probability of default, but they know the average probability of default of a firm, and the average reimbursement rate in case of default. Denoting $\bar{p}$ the default probability and $\underline{r}$ the reimbursement rate, an asset priced q_a^j gives a return 1 with probability $1-\bar{p}$ and an return $\underline{r} < 1$ with probability $\bar{p}$.

The households are hence heterogeneous with respect to their total wealth W, their age (young Y or old O), and their type in terms of connection to enterprises. The program of the young and old households is respectively shown in equations (1.73) to (1.80).

when young:

$$V(W;Y,j) = \max_{c,s_b,s_a^j} u(c) + \beta\left((1-\rho)EV(W';Y,j) + \rho EV(W';O,j)\right) \tag{1.73}$$

s.t.

$$W = c + q_d s_b + q_a^j s_a^j + \chi^j s_a^j \tag{1.74}$$

$$W' = \begin{cases} D_e + w(1-t) + s_b + s_a^j & \text{with probability } 1-\bar{p} \text{ if no default} \\ D_e + w(1-t) + s_b + \underline{r} s_a^j & \text{with probability } \bar{p} \text{ if default} \end{cases} \tag{1.75}$$

$$s_a^j, s_b, c \geq 0 \tag{1.76}$$

when old:

$$V(W;O,j) = \max_{c,s_b,s_a^j} u(c) + \beta(1-\tau^O)EV(W';O,j) \tag{1.77}$$

s.t.

$$W = c + q_d s_b + q_a^j s_a^j + \chi^j s_a^j \tag{1.78}$$

$$W' = \begin{cases} D_e + \underline{w} + s_b + s_a^j & \text{with probability } 1 - \bar{p} \text{ if no default} \\ D_e + \underline{w} + s_b + \underline{r} s_a^j & \text{with probability } \bar{p} \text{ if default} \end{cases} \tag{1.79}$$

$$s_a^j, s_b, c \geq 0 \tag{1.80}$$

where W is the current total wealth of the household, c is consumption today, s_b is the amount deposited to the bank, s_a^j is the capital directly supplied to the firm through alternative financing, w is the young households'wage, $\underline{w}$ is the old households'pension income, D_e is the dividends obtained from the firm's profit, j is the type of household, p is the aggregate default probability determined by the firm's program. The resource constraint for the pension scheme further implies that

$$\int_O \underline{w} = \int_Y tw \tag{1.81}$$

The trade-off between the two saving instruments is the following: the bank deposits are risk-free, while the alternative financing is risky and has a higher return (i.e. $q_d > q_a^j \quad \forall j \in J$). Since there is uncertainty on the return of the alternative financing, W' is a random variable. New-born households inherit firms' shares and the left-over wealth of their predecessors (but there is no altruistic motive for bequest).

1.C.2 Program of the bank

The program of the representative bank is similar to the one described in section 1.3.

1.C.3 Market clearing conditions

The new market clearing conditions are similar to the previous ones. The good market clearing condition is modified to take into account the foreign asset returns. To avoid heavy notations, I summarize the firms' state variables by $m = \{A, k, d; j\}$ and the households' state variables by $n = \{W; o, j\}$. The probability distributions of firms and households are respectively denoted by $\mu(m)$ and $\nu(n)$.

Labor market

The inelastic labor supply of each young household is equal to 1, while old households do not work and therefore supply zero labor. The total aggregate labor supply L^S is therefore equal to the share of young households at steady state (exogenously determined by the retirement and death probabilities ρ and τ^O). The wage has to adjust such that at each period:

$$L^S = \int l_n^S \nu(n) dn = \int l_m^D(w) \mu(m) dm = L^D(w) \tag{1.82}$$

Alternative capital market

There is an alternative capital market for each type j, where households and firms of the same type meet. The aggregate alternative savings $S_a(q_a^j; j)$ from each type of household have to be equal to the aggregate demand for alternative funding $a'(q_a^j; j)$ by each type of firms.

$$S_a(q_a^j; j) = \int_{n \in j} s_{a,n}(q_a^j) \nu(n) dn = \int_{m \in j} a'_m(q_a^j) \mu(m) dm = a'(q_a^j; j) \qquad \forall j \in J \tag{1.83}$$

For each j, the interest rate q_a^j adjusts to clear the market.

Bank capital markets

As before, in the baseline specification, the bank has basically no room for action. The bank accepts the totality of the deposits supplied by the households, and grants all loans demanded by the firms up to the collateral constraint. This implies the following equalities:

$$q_d D = \int q_d s_{b,n}(q_d) \nu(n) dn = q_d S_b(q_d) \tag{1.84}$$

$$qB = \int q b'_m(q) \mu(m) dm = q b'(q) \tag{1.85}$$

The loan supply from the bank qB should be equal to the aggregate bank loan demand from the firms $qb'(q)$. The aggregate deposits from the households $q_d S_b(q_d)$ should be equal to the deposits in the bank $q_d D$.

Good market

The equilibrium condition is similar to the representation household case.

1.C.4 Equilibrium definition

To the law of motion of the firms' distribution, I now add the low of motion of the households' distribution:

$$\nu'(W'; o, j) = \int Prob(W' = W'(W; o, j)|W; o, j)\pi_{oo'} d\nu(W; o, j) \tag{1.86}$$

where $\pi_{oo'}$ is the transition probability from age o to age o', with $o, o' \in \{Y, O\}$.

The definition of the stationary equilibrium in this set-up is modified into:

Definition 1.2. *A stationary equilibrium consists in policy functions $a'(A, k, d; j)$, $b'(A, k, d; j)$, $e'(A, k, d; j)$, $s_a(W; o, j)$, $s_b(W; o, j)$, B and D; probability distributions $\mu(A, k, d; j)$ for firms and $\nu(W; o, j)$ for households; and prices $\{w, \{q_a^j\}_{j \in J}, q, q_d\} \in \mathbb{R}_+^{3+N_J}$ such that:*

1. *The policy functions $a'(A, k, d; j)$, $b'(A, k, d; j)$ and $e'(A, k, d; j)$ solve the firm's program as defined in equations* (1.8) *to* (1.19)*, given w, $\{q_a^j\}_{j \in J}$ and q;*
2. *The policy functions $s_a(W; o, j)$, and $s_b(W; o, j)$ solve the household's program as defined in equations* (1.73) *to* (1.80)*, given w, $\{q_a^j\}_{j \in J}$ and q_d;*
3. *The policy functions B and L solve the bank's program as defined in equation* (1.41) *given q and q_d;*
4. *Markets clear*
5. *The stationary distribution $\mu(A, k, d; j)$ is the fixed point of equation* (1.49)*;*
6. *The stationary distribution $\nu(W; o, j)$ is the fixed point of equation* (1.86)*.*

1.C.5 Calibration and results

The calibration approach is the same as the one presented in section 2.4; there are a few additional parameters to be defined. The young and old households' death probabilities and the retirement probability are directly obtained from the data.

The probability of a young household to retire ρ is set to 0.025, which corresponds to an average duration of working life of 40 years. The death probability for old households is set to match the life expectancy of 60-year old persons in China between the years 2005 and 2010, based on the World Population Prospects database published by the United Nations. Hence, the probability of dying when old τ^O is equal to 0.05156, matching the life expectancy of 19.43 years at age 60. The pension income of the households is calibrated to match the quantity of deposits required by banks to be solvent in the baseline specification. I set the ratio $\frac{\underline{w}}{w} = 0.48$.

Finally, the intermediation cost paid by type L households is normalized to $\chi^L = 0.0089$. For H type households, I set $\chi^H = 0.08444$, and both types of households are present in the economy in equal proportions, implying $p_1 = 0.5$.

Results from a previous calibration are qualitatively very similar to the ones obtained in the framework with a representative household.

2 Loan officers and credit distribution

Abstract

This paper studies the impact of a shock in a commercial bank's interest rate or refinancing cost on the way credit is distributed among enterprises. Separating between incumbent borrowers – who have an ongoing relationship with a bank – and newcomers – who have no previous history with any bank, I study the differentiated impact of a credit shock on loan distribution between these two types of borrowers. To do so, I set up a 3-period microeconomic model with a representative bank hiring a loan officer, who is responsible to evaluate and accept or reject loan applications from enterprises. While in the first period, the loan officer only faces one applicant, in the second period he needs to choose whether to renew the loan of the incumbent borrower or to consider a newcomer's application. By inducing the bank to modify the loan officer's compensation scheme, the financial shock may imply a change in the loan officer's renewal strategy in the second period. Since the loan officer has more information on incumbent borrowers than on newcomers, he may choose, as a response to the shock, to prioritize loans to incumbents against loans to newcomers. This model thus builds a theoretical mechanism able to explain the fluctuations in the ability of newcomer enterprises to obtain financial resources for their investment projects and the survival of zombie enterprises.

Introduction

How does a bank change its borrower selection criteria when hit by an external shock? The present study aims at proposing a theoretical framework to answer this question. Focusing on the simple case of a commercial bank employing a loan officer to select projects proposed by entrepreneurs, this paper examines the differential impact of a credit supply shock on enterprises, depending on the quality of their project and on their relationship history with the lending bank. The underlying idea is the following: following an external shock, commercial banks may modify their credit supply by adjusting their decisions in terms of loan approval and renewal. This adjustment may be in favor of incumbent borrowers or newcomers a depending on the optimal loan decisions of the loan officer, inducing differentiated effects on enterprises. This question relates to various strands of literature, both empirical and theoretical.

A first strand of studies tackles the role of loan officers in credit granting, and the impact of their compensation schemes on loan approval decisions. Mostly consisting in empirical papers, there is a growing literature showing a significant impact of the design of loan officers' compensation schemes on lending choices, in terms of amount lent, number of loans approved and riskiness (measured by non-performing loans ratios). Behr et al. (2013) use panel data at the loan officer level to show that a non-linear compensation scheme implies significant adjustment by loan officers: when facing a high non-performing loans ratio in their portfolio (which decreases their remuneration), loan officers spend more time for loan monitoring while decreasing loan origination and selecting more carefully new borrowers. In a similar context, Ben-David and Agarwal (2012) show that a variable compensation causes loan officers to approve more and larger loans, take faster decisions, and that the default rate on those loans increases. On a slightly different note, Berg et al. (2013) show empirically that volume-incentivized loan officers are induced to manipulate hard information in order to get more loans approved by the bank's credit-scoring system. On the theoretical side, Heider and Inderst (2012) theoretically study how the incentive schemes of loan officers and competition across banks relates to the amount of loans approved and their average quality, showing that more competition implies more loans approved, but also a higher default rate.

Another part of the literature focuses on relationship lending and the use of soft versus hard information in the borrower's evaluation process. Bharath et al. (2011) show empirically that enterprises obtain more favorable loan conditions (less collateral required, larger loans) when they have a long-term relationship with their bank. Furthermore, Elsas and Krahnen (1998) find that housebanks, which do more relationship lending, establish longer-term relationships with their borrowers, and are able to provide liquidity insurance if the borrower faces a shock on his credit rating. Studying the impact of the recent financial crisis on Italian firms, D'Aurizio et al. (2014) find that non-family firms suffered a higher credit contraction than family firms, and relate it to the more extended use of soft information in loan approval decisions, which plays in favor of family firms. Bolton et al. (2013) study empirically the ties between enterprises, relationship banks (building a long-term relationship with their customers) and transaction banks (granting one-off loans). They show evidence that relationship banking is more effective in mitigating business cycles, if relationship banks enter crisis times with a sufficient excess capital cushion. To reproduce this empirical finding, the authors construct a theoretical model with firms facing relationship- and transaction-banks, and obtain that relationship banks charge higher interest rates and specialize in riskier firms. Their higher capital buffers allow them to roll-over loans more often and to have a lower non-performing loans ratio.

The model suggested in this paper is related to the evidence obtained by D'Aurizio et al. (2014): it connects the obtention of a loan in times of crisis to the type of lending relationship between the borrower and the bank, and to the type of information collected by the bank, which is represented here by the loan officer. While I am interested in the loan renewal decision, my model includes one single type of bank, and the renewal decision depends not only on the bank, but also on the loan officer's joint effort and renewal strategy decision. The mechanism relies therefore on the loan officer's change in strategy rather than on the presence of different types of banks, hence differing from Bolton et al. (2013). The set-up presented below is closest to Vicente (2011), who studies theoretically the use of soft information and credit scoring and its link to the type of borrowers obtaining loans.

In this study, I set up a small-scale theoretical framework to underline the differentiated transmission of a shock in a bank's financial situation – in terms of interest rate charged on loans, or refinancing cost – on different types of enterprises, via the easiness of access to credit. The loan officer's decision regarding loan renewal is key to the mechanism. As it is a discrete decision (renewing or not), it can transform a marginal change in the bank's lending condition and the loan officer's compensation scheme into a discrete sizable jump in access to credit for enterprises. I show that for some parameter's values, a marginal increase in the interest rate charged by the bank creates such a jump: the loan officer's compensation scheme changes, and consequently his renewal decision too. A one percentage point hike in the interest rate can indeed induce the loan officer to move from a renewal strategy "renew if successful" to a renewal strategy "always renew". While the first strategy leaves some opportunities for newcomer enterprises to obtain a loan if the incumbent defaulted on their previous loan, the second strategy implies that a newcomer enterprise has no chance to see its loan application successful, even if the incumbent borrower did not reimburse. This creates a strong and differentiated modification of access to credit for the two types of enterprises – newcomers and incumbent. At a more general macroeconomic level, such a mechanism can contribute to explain the variations in easiness to credit access across time and enterprises types.

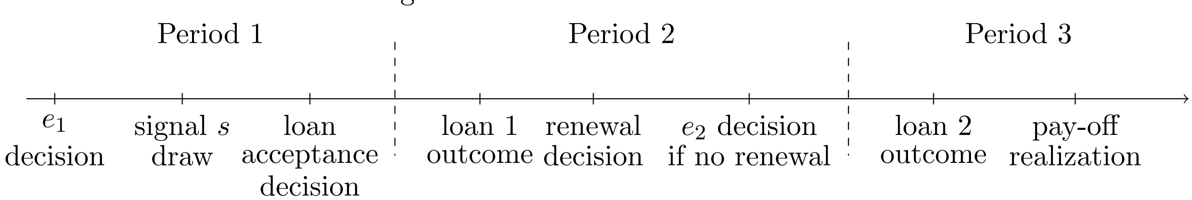
The next section presents the model's general set-up. The model is then solved by backward induction, first detailing the loan officer program in section 2.2, then the bank's program in section 2.3 and showing calibrated examples in section 2.4.

2.1 Set-up

I consider here a set-up with 3 different agents: the entrepreneur (or borrower), the loan officer and the bank. The entrepreneur has a project and a certain success probability, and needs to borrow from the bank to implement this project. Bank loans are granted at a fixed interest rate set exogenously, and the bank is a price-taker on the financial markets. The bank hires the loan officer to study the entrepreneur's loan application and to decide to grant a loan or not. In the model, this implies that the loan officer has to exert some effort in order to obtain a signal regarding the quality of the borrower, according to which he decides whether to grant the loan or not. The bank chooses the compensation scheme of the loan officer in order to maximize its profit, while offering to the loan officer high enough incentives not to shirk. More precisely, the model has 3 periods with the following timing:

- $t = 1$: The loan officer meets a randomly drawn borrower, exerts some effort, obtains a signal regarding the borrower's type and decides to grant a loan or not.
- $t = 2$: The outcome of the first loan (if any) is known and the loan officer decides whether to renew the loan, or to draw a new borrower.
- $t = 3$: The outcome of the second loan is known, the loan officer is paid by the bank according to his compensation scheme and the bank's profits or losses are realized.

Figure 2.1: Time-line of the model



This is illustrated in Figure 2.1. The bank's objective is to maximize its profit, by granting loans only to good-type borrowers. To do so, it hires the loan officer and offers him a compensation scheme that depends on the outcome of the loans granted. The objective of the loan officer is to maximize his expected utility, by deciding optimally how much effort to exert in period 1, whether to renew or not the loan to the incumbent borrower in period 2 and how much effort to exert in period 2 if not renewing.

The refinancing cost of the bank does not appear explicitly. However, it is more broadly contained in the interest rate charged on loans by the bank. Indeed, what matters in the bank's program is the difference between the refinancing cost and the loan interest rate. Normalizing the refinancing cost to zero, a change in the resulting loan interest rate can then be interpreted either as an interest rate shock, or as a shock in the refinancing cost.

In this set-up, I consider a single representative bank, hiring a single loan officer who can grant one loan per period. The bank has all negotiation power to split the surplus between the loan officer and itself, as long as the loan officer faces only limited liability. It will therefore aim at maximizing its profit while giving the lowest possible compensation to the loan officer, provided that he still has incentives to work and exerts optimal effort. Given that a loan officer can only spend a limited amount of time working per day, it does not seem unrealistic to allow him to grant only a limited and fixed number of loans per period – here, I normalized it to one loan per period.

For tractability, I make simplifying assumptions regarding the following elements:

- *the borrower's type*: The borrower's type reflects the quality of his project and entrepreneur skills, and corresponds to his probability of success. It is fixed across time, so that a specific borrower remains of the same type over the three periods. I further assume that the type is discrete, and can take two values: high and low. The project of a high type borrower has a positive net present value (NPV) and is worth being financed, while the project of the low type borrower has a negative NPV and should not be financed.
- *asymmetric information*: The borrower knows his type, but neither the loan officer nor the bank can observe the borrower's type. Hence the necessity for the bank to hire a loan officer, who will exert some (costly) effort to obtain a noisy signal regarding the borrower's type. The bank knows whether the loan officer has granted a loan or not, and can observe the outcome of that loan, but it observes neither the signal received by the loan officer nor the loan officer's renewal decision in period 2.
- *the signal*: the signal obtained by the loan officer is discrete too, and takes 2 values, high or low. The precision of the signal increases when the loan officer exerts more effort.
- *limited liability and the bank's contract*: if the project of a borrower fails, he obtains zero and defaults on his loan. The borrower has no collateral to pledge. Good type projects net present value is positive, so the bank can charge an interest rate high enough to cover the default risk, and still give a positive expected pay-off to the borrower. Bad type projects NPV is negative, so that if the bank charges a high enough interest rate to break even, the expected pay-off of the bad type borrower is negative, and he prefers not to borrow. Bad type projects are not worth being implemented from an aggregate welfare point of view, but given

that the borrower is subject to limited liability only, his expected pay-off is always positive if he borrows through the good type's contract.[1]

- *the discount factor*: the discount factors of all agents are set to 1 for simplicity.

Let me now define some notations. The borrower's type is denoted $\theta \in \{\underline{\theta}, \overline{\theta}\}$, where $0 > \underline{\theta} > \overline{\theta} < 1$, meaning that a $\overline{\theta}$-type borrower has a higher success probability than a $\underline{\theta}$-type borrower. The signal s the loan officer obtains takes its value from $\{\underline{s}, \overline{s}\}$. The effort exerted by the loan officer is e_1 in period 1, and e_2 in period 2.

The distribution of the signal s and its informativeness depend on the effort exerted by the loan officer, and consist in the probability of obtaining either a high or low signal, given the borrower's true type and the effort exerted. Since the signal is discrete and can take only two different values, we only need to specify the probabilities $P(\overline{s}|\overline{\theta}; e)$ and $P(\overline{s}|\underline{\theta}; e)$ to know the complete distribution of s given effort e. Some more assumptions are needed to guarantee that the set-up makes sense. Assumption 2.1 ensures that the signal is informative, while Assumption 2.2 implies that effort is rewarding for the loan officer. Assumption 2.3 is a simplifying assumption implying that low and high signals have the same precision.

Assumption 2.1. *$P(\overline{s}|\overline{\theta}; e) \geq P(\overline{s}|\underline{\theta}; e)$ with a strict inequality when $e > 0$, which is equivalent to $P(\underline{s}|\overline{\theta}; e) \leq P(\underline{s}|\underline{\theta}; e)$ or to $P(\overline{s}|\overline{\theta}; e) \geq 0.5$ and $P(\underline{s}|\underline{\theta}; e) \geq 0.5$.*

Assumption 2.2. *$\frac{\partial P(\overline{s}|\overline{\theta};e)}{\partial e} > 0$ and $\frac{\partial P(\underline{s}|\underline{\theta};e)}{\partial e} > 0$. This implies that if the loan officer exerts more effort, he increases $P(\overline{s}|\overline{\theta}; e)$ and $P(\underline{s}|\underline{\theta}; e)$ and obtains a more precise signal.*

Assumption 2.3. *The signal's distribution conditional on type verifies the following property: $P(\overline{s}|\overline{\theta}; e) = P(\underline{s}|\underline{\theta}; e) = P(e)$, so that a positive and a negative signal have the same informational content if obtained by exerting the same amount of effort, and effort has the same impact on both $P(\underline{s}|\underline{\theta}; e)$ and $P(\overline{s}|\overline{\theta}; e)$.*

The effort exerted by the loan officer is costly, and the cost function is denoted $c(e)$. Assumption 2.4 imposes that the cost function is convex and positive, while Assumption 2.5 makes sure that the utility function is concave.

Assumption 2.4. *The cost function verifies the following properties: $c(e) \geq 0$, $c'(e) \geq 0$ and $c''(e) \geq 0$.*

[1]If there were unlimited liability, or the possibility to pledge collateral, the bank would be able to design a contract mechanism that achieves a separating equilibrium in which only good types want to borrow. With limited liability and no collateral, there is no possibility of a separating equilibrium and the bank has to hire a loan officer to screen applicants.

Assumption 2.5. *The utility function has the following properties:* $u'(c) > 0$, $u''(c) < 0$.

In periods 2 and 3, the loan officer's compensation scheme depends on the following three possible outcomes:

- no loan is granted, the loan officer obtain y;
- a loan is granted but is not successful, the loan officer obtains b;
- a loan is granted and is successfully reimbursed, the loan officer obtains g.

It is easy to show that, for the loan officer incentives to be sensible, the bank optimally sets $b \leq y \leq g$. Limited liability further implies that $b, y, g \geq 0$. Given this general set-up, we can now turn to the loan officer's program.

2.2 The program of the loan officer

The loan officer chooses how much effort to exert (in order to obtain a more or less precise signal of the borrower's type), and whether to grant a loan or not. As mentioned above, he has the following compensation scheme for each loan decision: $\{y, b, g\}$. The loan officer obtains y if he does not grant a loan; when he grants a loan, he obtains b if the borrower defaults and g if the borrower reimburses. Given this compensation scheme, the loan officer has three decisions to make:

- How much effort e_1 to exert in period 1, when considering the loan application of a newcomer;
- Whether to renew the loan to the incumbent or to consider the loan application of a newcomer in period 2, given the result of the first loan granted in period 1;
- How much effort e_2 to exert in period 2, if considering the loan application of a newcomer.

This problem is best written and solved backwards. Subsections 2.2.1 to 2.2.3 describe the loan officer's optimization step by step, before including it into the bank's program.

2.2.1 Effort decision in period 2, when drawing a new borrower

I analyse here the situation of a loan officer who has decided to draw a new borrower in period 2 and needs to determine how much effort e_2 he wants to exert. Considering that the loan officer approves the loan application when obtaining a good signal, and rejects the loan application otherwise, his maximization program is as follows:

$$\max_{e_2} \mathbb{E}(U_N(e_2)) = u(g)P(\overline{s}; e_2)\mathbb{E}(\theta|\overline{s}; e_2) + u(b)P(\overline{s}; e_2)(1 - \mathbb{E}(\theta|\overline{s}; e_2)) + u(y)P(\underline{s}; e_2) - c(e_2)$$

Given the signal received s and effort exerted e, it is easy to compute the probability to face a high type or a low type is using Bayes' rule:

$$P(\overline{\theta}|s;e) = \frac{P(s|\overline{\theta};e)P(\overline{\theta})}{P(s|\overline{\theta};e)P(\overline{\theta}) + P(s|\underline{\theta};e)P(\underline{\theta})}$$

$$P(\underline{\theta}|s;e) = \frac{P(s|\underline{\theta};e)P(\underline{\theta})}{P(s|\overline{\theta};e)P(\overline{\theta}) + P(s|\underline{\theta};e)P(\underline{\theta})}$$

The probability that the loan will be repaid, conditional on the effort exerted e and the signal received s, is then:

$$\begin{aligned} P(\text{loan repaid}|s;e) &= \mathbb{E}_{\theta}(\theta|s;e) \\ &= \overline{\theta}P(\overline{\theta}|s;e) + \underline{\theta}P(\underline{\theta}|s;e) \\ &= \frac{\overline{\theta}P(s|\overline{\theta};e)P(\overline{\theta}) + \underline{\theta}P(s|\underline{\theta};e)P(\underline{\theta})}{P(s|\overline{\theta};e)P(\overline{\theta}) + P(s|\underline{\theta};e)P(\underline{\theta})} \end{aligned}$$

To simplify notations, I further denote:

$$\begin{aligned} P(\overline{s}|\overline{\theta};e) = P(\underline{s}|\underline{\theta};e) &= P(e) \\ \delta &= P(\overline{\theta}) - P(\underline{\theta}) \\ \Delta &= \overline{\theta}P(\overline{\theta}) - \underline{\theta}P(\underline{\theta}) \\ \Delta_2 &= \overline{\theta}^2 P(\overline{\theta}) - \underline{\theta}^2 P(\underline{\theta}) \end{aligned}$$

We can finally note that:

$$\begin{aligned} P(\overline{s};e) &= P(e)(P(\overline{\theta}) - P(\underline{\theta})) + P(\underline{\theta}) \\ &= P(e)\delta + P(\underline{\theta}) \\ P(\overline{s};e)E_{\theta}(\theta|\overline{s};e) &= \overline{\theta}P(\overline{s}|\overline{\theta};e)P(\overline{\theta}) + \underline{\theta}P(\overline{s}|\underline{\theta};e)P(\underline{\theta}) \\ &= P(e)\Delta + \underline{\theta}P(\underline{\theta}) \end{aligned}$$

Using these additional notations, it is possible to rewrite the loan officer's period 2 effort maximization program as:

$$\max_{e_2} \mathbb{E}(U_N(e_2)) = u(g)(P(e_2)\Delta + \underline{\theta}P(\underline{\theta})) + u(b)(P(e_2)\delta + P(\underline{\theta}) - P(e_2)\Delta - \underline{\theta}P(\underline{\theta})) + u(y)(P(\overline{\theta}) - P(e_2)\delta) - c(e_2)$$

The corresponding first order condition with respect to e_2 is then:

$$P'(e_2^*)[\Delta(u(g) - u(b)) + \delta(u(b) - u(y))] = c'(e_2^*) \tag{2.1}$$

where e_2^* is defined as the optimal effort choice. Note that if the loan officer exerts zero effort, the signal is uninformative and it comes down to randomly approving or rejecting the loan application. If the loan officer always grants or never grants the loan independently of the signal obtained, then he has no incentives to make any effort. In these cases, his expected utility becomes:

$$\mathbb{E}(U_N) = \begin{cases} u(y) & \text{if never grants the loan} \\ \mathbb{E}(\theta)u(g) + (1 - \mathbb{E}(\theta))u(b) & \text{if always grants the loan} \\ \frac{1}{2}(u(g)\mathbb{E}(\theta) + u(b)(1 - \mathbb{E}(\theta))) + \frac{1}{2}u(y) & \text{if randomizes} \end{cases}$$

This defines the participation constraints (2.2) to (2.4) that will be part of the bank's optimization program:

$$\mathbb{E}(U_N(e_2^*)) \geq u(y) \tag{2.2}$$

$$\mathbb{E}(U_N(e_2^*)) \geq \mathbb{E}(\theta)u(g) + (1 - \mathbb{E}(\theta))u(b) \tag{2.3}$$

$$\mathbb{E}(U_N(e_2^*)) \geq \frac{1}{2}(u(g)\mathbb{E}(\theta) + u(b)(1 - \mathbb{E}(\theta))) + \frac{1}{2}u(y) \tag{2.4}$$

Note that constraint (2.4) is a combination of constraints (2.2) and (2.3), therefore it is redundant can be dropped.

2.2.2 Loan officer's renewal decision in period 2

At the beginning of period 2, the loan officer decides if he prefers to renew the loan to the incumbent borrower (knowing the outcome of the previous loan) or to consider the loan application of a newcomer. If taking the application of a newcomer, as we just saw in subsection 2.2.1, he obtains a constant expected utility equal to:

$$\mathbb{E}(U_N(e_2^*)) = u(g)(P(e_2^*)\Delta + \underline{\theta}P(\underline{\theta})) + u(b)(P(e_2^*)\delta + P(\underline{\theta}) - P(e_2^*)\Delta - \underline{\theta}P(\underline{\theta})) + u(y)(P(\overline{\theta}) - P(e_2^*)\delta) - c(e_2^*)$$

If renewing the loan to the incumbent, the loan officer does not exert any effort in period 2 and his expected utility depends on the outcome of the first loan. The cases where the loan officer has received a good signal in period 1 are the only cases relevant here, since after receiving a bad signal in period 1 the loan officer does not grant any first period loan, and has no renewal opportunity in period 2. The loan officer's expected utility in case of renewal is:

$$\mathbb{E}(U_I|l1r,\overline{s};e_1) = \mathbb{E}(\theta|l1r,\overline{s};e_1)u(g) + (1-\mathbb{E}(\theta|l1r,\overline{s};e_1))u(b) \qquad \text{if } 1^{st} \text{ loan reimbursed}$$
$$\mathbb{E}(U_I|l1d,\overline{s};e_1) = \mathbb{E}(\theta|l1d,\overline{s};e_1)u(g) + (1-\mathbb{E}(\theta|l1d,\overline{s};e_1))u(b) \qquad \text{if } 1^{st} \text{ loan defaulted}$$

which can be written as:

$$\mathbb{E}(U_I|l1r,\overline{s};e_1) = \frac{P(e_1)\Delta_2 + \underline{\theta}^2 P(\underline{\theta})}{P(e_1)\Delta + \underline{\theta}P(\underline{\theta})}(u(g)-u(b)) + u(b) \tag{2.5}$$
$$\mathbb{E}(U_I|l1d,\overline{s};e_1) = \frac{P(e_1)(\Delta-\Delta_2) + \underline{\theta}(1-\underline{\theta})P(\underline{\theta})}{P(e_1)(\delta-\Delta) + (1-\underline{\theta})P(\underline{\theta})}(u(g)-u(b)) + u(b) \tag{2.6}$$

As mentioned earlier, I assume that the bank can only observe the outcome of the loan, and does not know if the loan is given by the loan officer to a newcomer or an incumbent. Consequently, the compensation scheme $\{y,b,g\}$ is the same in both cases. To make his decision, the loan officer compares his expected utility in both cases.

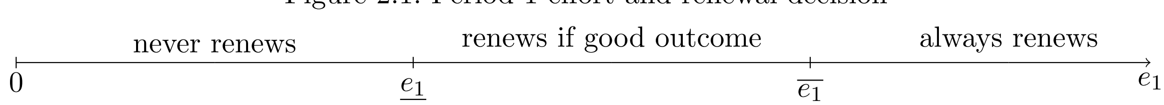
It is not possible to analytically determine which of $\mathbb{E}(U_N(e_2^*))$, $\mathbb{E}(U_I|l1r,\overline{s};e_1)$ and $\mathbb{E}(U_I|l1d,\overline{s};e_1)$ is larger. However, it is possible to characterize the renewal decision of the loan officer, conditioning on his effort level in period 1. As illustrated in Figure 2.1, Proposition 2.1 specifies the loan officer's renewal decision in period 2, given his choice of effort in period 1. It shows the existence of two effort thresholds $\underline{e_1}$ and $\overline{e_1}$ that determine the loan officer's renewal decision, depending on the effort e_1 previously exerted in period 1. Proposition 2.2 defines more specifically the values of these thresholds, depending on the parameters of the model and the compensation schemes.

Proposition 2.1. *There exist two thresholds $(\overline{e_1},\underline{e_1}) \in \mathbb{R}_+^2$ such that:*

- *if $e_1 \leq \underline{e_1}$, the loan officer never renews the loan granted to the incumbent;*
- *if $\underline{e_1} \leq e_1 \leq \overline{e_1}$, the loan officer renews the loan only if the incumbent was successful, and does not renew if the incumbent defaulted;*
- *if $\overline{e_1} \leq e_1$, the loan officer always renews the loan granted to the incumbent.*

Proof. See Appendix 2.A. □

Figure 2.1: Period 1 effort and renewal decision



Depending on the values of the model's parameters and on the compensation scheme, one or the two thresholds $\underline{e_1}, \overline{e_1}$ may be equal to zero or to $+\infty$. In this case, only one or two decision areas in Figure 2.1 may remain feasible. This is stated in Proposition 2.2.

Proposition 2.2. *Depending the parameter values and the loan officer's compensation scheme $\{y, b, g\}$, the thresholds $(\overline{e_1}, \underline{e_1})$ take the following values:*

- *when $\mathbb{E}(U_N(e_2^*)) > \lim_{e_1 \to +\infty} \mathbb{E}(U_I | l1r, \overline{s}; e_1)$, then $\underline{e_1} = \overline{e_1} = +\infty$;*
- *when $\mathbb{E}(U_I | l1r, \overline{s}; e_1 = 0) \leq \mathbb{E}(U_N(e_2^*)) \leq \lim_{e_1 \to +\infty} \mathbb{E}(U_I | l1r, \overline{s}; e_1)$, then $(\underline{e_1}, \overline{e_1}) \in (0, +\infty)^2$. The exact values of both thresholds are defined by:*

$$P(\underline{e_1}) = \underline{\theta} P(\underline{\theta}) \frac{\mathbb{E}(U_N(e_2^*)) - u(b) - \underline{\theta}(u(g) - u(b))}{\Delta_2(u(g) - u(b)) - \Delta(\mathbb{E}(U_N(e_2^*)) - u(b))}$$
$$P(\overline{e_1}) = (1 - \underline{\theta}) P(\underline{\theta}) \frac{\mathbb{E}(U_N(e_2^*)) - u(b) - \underline{\theta}(u(g) - u(b))}{(\Delta - \Delta_2)(u(g) - u(b)) - (\delta - \Delta)(\mathbb{E}(U_N(e_2^*)) - u(b))}$$

- *when $\mathbb{E}(U_I | l1d, \overline{s}; e_1 = 0) < \mathbb{E}(U_N(e_2^*)) < \mathbb{E}(U_I | l1r, \overline{s}; e_1 = 0)$, then $\underline{e_1} = 0$ and $\overline{e_1} \in (0, +\infty)$. The value of the threshold $\overline{e_1}$ is defined by:*

$$P(\overline{e_1}) = (1 - \underline{\theta}) P(\underline{\theta}) \frac{\mathbb{E}(U_N(e_2^*)) - u(b) - \underline{\theta}(u(g) - u(b))}{(\Delta - \Delta_2)(u(g) - u(b)) - (\delta - \Delta)(\mathbb{E}(U_N(e_2^*)) - u(b))}$$

- *when $\mathbb{E}(U_N(e_2^*)) < \mathbb{E}(U_I | l1d, \overline{s}; e_1 = 0)$, then $\overline{e_1} = \underline{e_1} = 0$.*

Proof. See Appendix 2.B. □

Given this characterization of the loan officer's decision in period 2 regarding loan renewal and optimal effort e_2^*, I can go backwards and solve for the loan officer's optimal effort decision e_1^* in period 1.

2.2.3 Loan officer's decision in period 1

Going further backwards, given the optimal decisions e_2^* and the corresponding thresholds $\underline{e_1}$ and $\overline{e_1}$, the total expected utility of the loan officer at the beginning of the first period is:

$$
\begin{aligned}
\mathbb{E}(U(e_1)) =& P(\underline{s}|e_1)\Bigg(u(y) - c(e_1) + \mathbb{E}(U_N(e_2^*))\Bigg) \\
& + P(\overline{s}|e_1)\Bigg(\mathbb{E}(\theta|\overline{s};e_1)\Bigg[u(g) - c(e_1) + \mathbb{1}(e_1 > \underline{e_1})\mathbb{E}(U_I|l1r,\overline{s};e_1) \\
& + \mathbb{1}(e_1 < \underline{e_1})\mathbb{E}(U_N(e_2^*))\Bigg] \\
& + (1-\mathbb{E}(\theta|\overline{s};e_1))\Bigg[u(b) - c(e_1) + \mathbb{1}(e_1 > \overline{e_1})\mathbb{E}(U_I|l1d,\overline{s};e_1) \\
& + \mathbb{1}(e_1 < \overline{e_1})\mathbb{E}(U_N(e_2^*))\Bigg]\Bigg)
\end{aligned}
$$

where $\mathbb{1}(.)$ is a dummy variable. The loan officer's objective is to maximize this expected utility function with respect to effort e_1, given his compensation scheme and the model's parameters. It is useful to note that the optimal effort e_2^* only depends on the compensation scheme $\{y, b, g\}$, the success probabilities $\underline{\theta}$ and $\overline{\theta}$, their distribution and the signal's distribution. The same is true for the thresholds $\underline{e_1}$ and $\overline{e_1}$. As a consequence, e_2^*, $\underline{e_1}$ and $\overline{e_1}$ are constants with respect to e_1, which simplifies the optimization computation.

Because of the presence of the dummy variables, the expression for the total utility of the loan officer is generally not differentiable with respect to e_1 at the following points: $e_1 = \underline{e_1}$ and $e_1 = \overline{e_1}$, where the dummy variables jump. We can however differentiate the total utility separately for the three cases (i) $e_1 < \underline{e_1}$, (ii) $\underline{e_1} < e_1 < \overline{e_1}$ and (iii) $e_1 < \overline{e_1}$.

Case where $e_1 < \underline{e_1}$: never renewing the loan to the incumbent

The total expected utility of the loan officer in that case is:

$$
\begin{aligned}
\mathbb{E}(U(e_1)) =& P(\underline{s}|e_1)\Bigg(u(y) - c(e_1) + \mathbb{E}(U_N(e_2^*))\Bigg) \\
& + P(\overline{s}|e_1)\Bigg(\mathbb{E}(\theta|\overline{s};e_1)\Bigg[u(g) - c(e_1) + \mathbb{E}(U_N(e_2^*))\Bigg] \\
& + (1-\mathbb{E}(\theta|\overline{s};e_1))\Bigg[u(b) - c(e_1) + \mathbb{E}(U_N(e_2^*))\Bigg]\Bigg) \\
=& \mathbb{E}(U_N(e_1)) + \mathbb{E}(U_N(e_2^*))
\end{aligned}
$$

The first order condition for e_1 is then the same as for e_2:

$$c'(e_1^{(a)}) = P'(e_1^{(a)})[\Delta(u(g) - u(b)) + \delta(u(b) - u(y))] \tag{2.7}$$

Equation (2.7) defines the optimal choice of period 1 effort $e_1^{(a)}$, conditional on $e_1^{(a)}$ being smaller than $\underline{e_1}$. It is important to note that if $e_1^{(a)}$ as defined by equation (2.7) is larger than $\underline{e_1}$, then it has to be equal to $\underline{e_1}$.

Case where $\underline{e_1} < e_1 < \overline{e_1}$: renewing the loan if the incumbent was successful in period 1

The total expected utility of the loan officer is then :

$$\begin{aligned}
\mathbb{E}(U(e_1)) =& P(\underline{s}|e_1)\Bigg(u(y) - c(e_1) + \mathbb{E}(U_N(e_2^*))\Bigg) \\
&+ P(\overline{s}|e_1)\Bigg(\mathbb{E}(\theta|\overline{s};e_1)\Bigg[u(g) - c(e_1) + \mathbb{E}(U_I|l1r,\overline{s};e_1)\Bigg] \\
&+ (1 - \mathbb{E}(\theta|\overline{s};e_1))\Bigg[u(b) - c(e_1) + \mathbb{E}(U_N(e_2^*))\Bigg]\Bigg)
\end{aligned}$$

And the first order condition with respect to e_1 is:

$$P'(e_1^{(b)})\Big((\Delta + \Delta_2)u(g) + (\delta - \Delta_2)u(b) - \delta u(y) - \Delta\mathbb{E}(U_N(e_2^*))\Big) = c'(e_1^{(b)}) \tag{2.8}$$

Equation (2.8) defines the optimal choice of effort $e_1^{(b)}$ in the case where $e_1^{(b)} \in (\underline{e_1}, \overline{e_1})$. Here again, if $e_1^{(b)}$ is outside the interval $(\underline{e_1}, \overline{e_1})$, it has to be equal the interval's closest bound.

Case where $e_1 > \overline{e_1}$: always renewing the loan to the incumbent

In this case, the total expected utility of the loan officer is:

$$\begin{aligned}\mathbb{E}(U(e_1)) =& P(\underline{s}|e_1)\bigg(u(y) - c(e_1) + \mathbb{E}(U_N(e_2^*))\bigg) \\ &+ P(\overline{s}|e_1)\Bigg(\mathbb{E}(\theta|\overline{s};e_1)\bigg[u(g) - c(e_1) + \mathbb{E}(U_I|l1r,\overline{s};e_1)\bigg] \\ &+ (1-\mathbb{E}(\theta|\overline{s};e_1))\bigg[u(b) - c(e_1) + \mathbb{E}(U_I|l1d,\overline{s};e_1)\bigg]\Bigg)\end{aligned}$$

The first order condition with respect to e_1 is then:

$$P'(e_1^{(c)})\Big(2\Delta u(g) + (2\delta - 2\Delta)u(b) - \delta u(y) - \delta\mathbb{E}(U_N(e_2^*))\Big) = c'(e_1^{(c)})$$

Similarly to the previous cases, if $e_1^{(c)}$ is smaller than $\overline{e_1}$, it has to be equal to $\overline{e_1}$. After computing the optimal values of $e_1^{(a)}$, $e_1^{(b)}$, $e_1^{(c)}$ and the corresponding values $\mathbb{E}(U(e_1^{(a)})$, $\mathbb{E}(U(e_1^{(b)})$ and $\mathbb{E}(U(e_1^{(c)})$ for each of the three above cases, the loan officer will choose the renewing strategy and corresponding effort e_1^* that provides him with the highest expected utility. This defines the optimal effort of period 1 as:

$$e_1^* = argmax_{e_1 \in (e_1^{(a)}, e_1^{(b)}, e_1^{(c)})}\mathbb{E}(U(e_1))$$

This completes the task of solving for the loan officer's program and optimal decisions, given his compensation scheme and the model's parameters. Although it is not possible to obtain an analytical solution, this section allows us to understand better the determinants of the loan officer's effort and renewal decisions. Given this decision, we can now turn to the bank's program.

2.3 The program of the bank

As explained earlier, the objective of this work is to study how a change in the bank's refinancing cost impacts differently the access to credit of incumbent and newcomer enterprises. Having in mind the main elements guiding the loan officer's renewal decision, I can look at the bank's profit maximization, and analyze how a change in the bank's refinancing condition may impact the compensation scheme offered by the bank to the loan officer, and then may imply a change in the renewal decision of the loan officer.

It is useful to first write the bank's expected profit at each period. In the first period, with a newcomer borrower the bank's expected profit is:

$$\begin{aligned}\mathbb{E}(\Pi_{N1}) &= (r-g)(P(e_1)\Delta + \underline{\theta}P(\underline{\theta})) \\ &+ (-1-b)(P(e_1)\delta + P(\underline{\theta}) - P(e_1)\Delta - \underline{\theta}P(\underline{\theta})) \\ &- y(P(\overline{\theta}) - P(e_1)\delta)\end{aligned}$$

In the second period, if the loan officer renews the loan to the incumbent borrower, the bank's expected profit is, conditional on the first loan's outcome:

$$\mathbb{E}(\Pi_2|l1o) = \mathbb{E}(\Pi_I|l1o, \overline{s}; e_1) = (r-g)P(l2r|l1o, \overline{s}; e_1) + (-1-b)P(l2d|l1o, \overline{s}; e_1)$$

where $l1o$ stands for "first loan outcome", $l2r$ for "successful reimbursment of the second loan" and $l2d$ for "default on the second loan". Finally, if the loan officer does not renew the loan in the second period, the bank's expected profit becomes:

$$\begin{aligned}\mathbb{E}(\Pi_2) = \mathbb{E}(\Pi_{N2}) &= (r-g)(P(e_2)\Delta + \underline{\theta}P(\underline{\theta})) \\ &+ (-1-b)(P(e_2)\delta + P(\underline{\theta}) - P(e_2)\Delta - \underline{\theta}P(\underline{\theta})) \\ &- y(P(\overline{\theta}) - P(e_2)\delta)\end{aligned}$$

Combining the above equations, I can write the total profit of the bank, and its maximization program is then:

$$\max_{y,g,b,e_1e_2} \mathbb{E}(\Pi_R) = P(\underline{s}|e_1)\Bigg\{ -y + P(\overline{s}|e_2)(\mathbb{E}(\theta|\overline{s};e_2)(r-g) + (1-\mathbb{E}(\theta|\overline{s};e_2))(-1-b)) + P(\underline{s}|e_2)(-y)\Bigg\}$$

$$+ P(\overline{s}|e_1)\Bigg\{\mathbb{E}(\theta|\overline{s};e_1)\Bigg[(r-g) + \mathbb{1}(e_1 > \underline{e_1})\Big(\mathbb{E}(\theta|l1r,\overline{s};e_1)(r-g)$$

$$+(1-\mathbb{E}(\theta|l1r,\overline{s};e_1))(-1-b)\Big) + \mathbb{1}(e_1 < \underline{e_1})\Big(P(\overline{s}:e_2)\mathbb{E}(\theta|\overline{s};e_2)(r-g)$$

$$+(1-\mathbb{E}(\theta|\overline{s};e_2))(-1-b) + P(\underline{s}|e_2)(-y)\Big)\Bigg] + (1-\mathbb{E}(\theta|\overline{s};e_1))\Bigg[-1-b$$

$$+\mathbb{1}(e_1 > \overline{e_1})\Big(\mathbb{E}(\theta|l1d,\overline{s};e_1)(r-g) + (1-\mathbb{E}(\theta|l1d,\overline{s};e_1))(-1-b)\Big)$$

$$+\mathbb{1}(e_1 < \overline{e_1})\Big(P(\overline{s}|e_2)\mathbb{E}(\theta|\overline{s};e_2)(r-g) + (1-\mathbb{E}(\theta|\overline{s};e_2))(-1-b) + P(\underline{s};e_2)(-y)\Big)\Bigg]\Bigg\}$$

s.t.

$$c'(e_2) = P'(e_2)[\Delta(u(g)-u(b)) + \delta(u(b)-u(y))] \tag{IC1}$$

$$c'(e_1) = P'(e_1)[\Delta(u(g)-u(b)) + \delta(u(b)-u(y))] \tag{IC2a}$$

$$c'(e_1) = P'(e_1)\Big((\Delta+\Delta_2)u(g) + (\delta-\Delta_2)u(b) - \delta u(y) - \Delta\mathbb{E}(U_N(e_2))\Big) \tag{IC2b}$$

$$c'(e_1) = P'(e_1)\Big(2\Delta u(g) + (2\delta-2\Delta)u(b) - \delta u(y) - \delta\mathbb{E}(U_N(e_2))\Big) \tag{IC2c}$$

$$\mathbb{E}(U(e_1)) \geq u(y) + \mathbb{E}(U_N(e_2)) \tag{IC3}$$

$$\mathbb{E}(U_N(e_2)) \geq u(y) \tag{IC4}$$

$$\mathbb{E}(U(e_1)) \geq u(g)\mathbb{E}(\theta) + u(b)(1-\mathbb{E}(\theta)) + \max\{\mathbb{E}(U_I|l1o, e_1=0), \mathbb{E}(U_N(e_2))\} \tag{IC5}$$

$$\mathbb{E}(U_N(e_2)) \geq u(g)\mathbb{E}(\theta) + u(b)(1-\mathbb{E}(\theta)) \tag{IC6}$$

The constraints can be explained as follows. Constraint (IC1) corresponds to the first order condition of the loan officer's program defining the optimal effort e_2^*. Constraints (IC2a), (IC2b), and (IC2c) respectively correspond to the first order conditions of the loan officer's program with respect to e_1. Only one applies at a time, depending on the relative value of e_1 and the thresholds $\overline{e_1}$, $\underline{e_1}$: (IC2a) if $e_1 < \underline{e_1}$, (IC2b) if $\underline{e_1} < e_1 < \overline{e_1}$ and (IC2c) if $e_1 > \overline{e_1}$. Finally, the last four constraints are participation constraints ensuring that the loan officer has an interest in exerting some effort and does not prefer to shirk by never or always granting the loan, or by randomizing the loan acceptance decision. The participation constraints for randomizing in period 1 and in period 2 are redundant and have been dropped.

Proposition 2.3 states that for all utility functions such that $u(0) > -\infty$, b is optimally set to 0 to maximize the profit of the bank, implying that the loan officer receives zero compensation if the loan he granted is not reimbursed. For utility functions such that $u(0) = -\infty$, there is no solution, unless we add to the problem an outside option for the loan officer, with a minimum utility the bank has to guaranty him, which sets a lower bound to the compensation the loan officer receives. I will further assume that $u(0) > -\infty$, which implies $b^* = 0$.

Assumption 2.6. *The loan officer's utility function is such that $u(0) > -\infty$.*

Proposition 2.3. *Under assumption 2.6, the component b of the compensation scheme is optimally set to zero by the bank to maximize its profit.*

Proof. See Appendix 2.C. □

Proposition 2.3 simplifies substantially the bank's problem by reducing its decision variables to the two elements of the loan officer's compensation scheme, y and g. Hence the bank's program can be written in a more parsimonious way as follows:

$$
\begin{aligned}
\max_{y,g} \mathbb{E}(\Pi_R) = {} & P(\underline{s}|e_1^*)\Bigg\{ - y + P(\overline{s}|e_2^*)(\mathbb{E}(\theta|\overline{s}; e_2^*)(r-g) - (1 - \mathbb{E}(\theta|\overline{s}; e_2^*))) - P(\underline{s}|e_2^*)y \Bigg\} \\
& + P(\overline{s}|e_1^*)\Bigg\{ \mathbb{E}(\theta|\overline{s}; e_1^*)\Bigg[(r-g) + \mathbb{1}(e_1^* > \underline{e_1})\Big(\mathbb{E}(\theta|l1r, \overline{s}; e_1^*)(r-g) \\
& -(1 - \mathbb{E}(\theta|l1r, \overline{s}; e_1^*))\Big) + \mathbb{1}(e_1^* < \underline{e_1})\Big(P(\overline{s} : e_2^*)\mathbb{E}(\theta|\overline{s}; e_2^*)(r-g) \\
& -(1 - \mathbb{E}(\theta|\overline{s}; e_2^*)) - P(\underline{s}|e_2^*)y\Big)\Bigg] + (1 - \mathbb{E}(\theta|\overline{s}; e_1^*))\Bigg[-1 \\
& +\mathbb{1}(e_1^* > \overline{e_1})\Big(\mathbb{E}(\theta|l1d, \overline{s}; e_1^*)(r-g) - (1 - \mathbb{E}(\theta|l1d, \overline{s}; e_1^*))\Big) \\
& +\mathbb{1}(e_1^* < \overline{e_1})\Big(P(\overline{s}|e_2^*)\mathbb{E}(\theta|\overline{s}; e_2^*)(r-g) - (1 - \mathbb{E}(\theta|\overline{s}; e_2^*)) - P(\underline{s}; e_2^*)y\Big)\Bigg]\Bigg\}
\end{aligned}
$$

s.t.

e_1^*, e_2^* solve the loan officer's program

$$\mathbb{E}(U(e_1^*)) \geq u(y) + \mathbb{E}(U_N(e_2^*)) \qquad \text{never loan period 1}$$

$$\mathbb{E}(U_N(e_2^*)) \geq u(y) \qquad \text{never loan period 2}$$

$$\mathbb{E}(U(e_1^*)) \geq u(g)\mathbb{E}(\theta) + u(0)(1 - \mathbb{E}(\theta)) + \max\{\mathbb{E}(U_I|l1o, e_1 = 0), \mathbb{E}(U_N(e_2^*))\} \qquad \text{always loan period 1}$$

$$\mathbb{E}(U_N(e_2^*)) \geq u(g)\mathbb{E}(\theta) + u(0)(1 - \mathbb{E}(\theta)) \qquad \text{always loan period 2}$$

This simplified version of the bank's problem remains analytically untractable, and the first order conditions with respect to y and g cannot be easily analytically computed. Obvious reasons for this situation are the length the expression to optimize and the number of constraints. As stated for the loan officer's program, the expression for expected profits is not differentiable at the jumps of the dummy variables, when e_1 equals one of the two decision thresholds $\underline{e_1}$ and $\overline{e_1}$. More specifically, the fact that y and g influence not only e_1^* and e_2^*, but also the thresholds $\underline{e_1}$ and $\overline{e_1}$ renders these jumps difficult to locate, and forbids to divide the bank's program into smaller, differentiable problems. To be able to study this problem further, it is useful to specify more precisely the cost and the probability functions, and to define parameter values. This is done in the next section.

2.4 Parameterization and results

Since the aim of this paper is to illustrate the functioning of a theoretical credit distribution mechanism, the parameterization I suggest here is simply an example of the potential effects of this mechanism, in terms of access to credit for newcomer and incumbent enterprises. The parameter values shown here allow us to study the effect at stake. The lack of data describing not only on successful loan applications, but also on unsuccessful applications, renders a more precise calibration difficult to implement[2].

First, the effort cost function $c(.)$, the loan officer utility function $u(.)$ and the signal distribution given effort e need to be specified. I use the following functional forms:

$$c(e) = \frac{a}{2}e^2$$

$$u(c) = c^{1/8}$$

$$P(e) = -\frac{1}{e+2} + 1$$

[2]Such a calibration could be a path for future research, if precise enough data can be obtained.

It is easy to check that these functions have the required properties. I further define the following parameter values:

$$\overline{\theta} = 0.9$$
$$\underline{\theta} = 0.2$$
$$P(\overline{\theta}) = 0.8$$
$$a = 20^{-7}$$

With these specified functions, for each value of the interest rate r, I can solve for the optimal effort e_2^* using equation (IC1), and for thresholds $\underline{e_1}$, $\overline{e_1}$ as defined in Proposition 2.2 as functions of the compensation scheme $\{y, b, g\}$. I then deduce optimal effort e_1^*, given the compensation scheme. Finally, I solve numerically for the bank's maximization program, thus determining the optimal compensation scheme $\{y^*, b^*, g^*\}$. Going back to the loan officer's decision, this defines the actual effort and renewal strategies he applies.

Given this calibration, a change in the interest rate r that the bank charges on the borrower implies a change in the optimal compensation scheme of the loan officer, and induces a change in the loan officer's best renewal strategy. This is shown in Figure 2.1, which shows the expected utility of the loan officer, given the optimal compensation scheme decided by the bank, if he never renews the loan (dashed line), if he always renews the loan (solid line) and if he renews the loan only after a successful first loan. On the left-hand-side of the graph, the loan officer's preferred strategy is to renew only if the 1^{st} loan was successful, while on the right-hand-side (when $r \geq 12.2\%$), he always renews. Figure 2.2 complements Figure 2.1 by showing the optimal amount of effort e_1^* decided by the loan officer in period 1: given the evolution of the thresholds $\underline{e_1}$ and $\overline{e_1}$, this effort implies either to always renew the loan (when the interest rate is above 12.2%) or to renew only for successful borrowers (when the interest rate is below 12.2%).

There is a clear threshold effect in the optimal strategy of the bank and the loan officer. When the interest rate r charged by the bank is equal to 12%, the bank maximizes its profit by setting the compensation scheme of the loan officer at: $\{g, y\} = \{5.8430 \times 10^{-5}, 1.2856 \times 10^{-5}\}$. This implies that the optimal efforts decided by the loan officer in period 1 and 2 respectively are:

$$e_1^* = 92.5264$$
$$e_2^* = 86.4209$$

Figure 2.1: Expected utility for various renewal strategies, depending on interest rate r

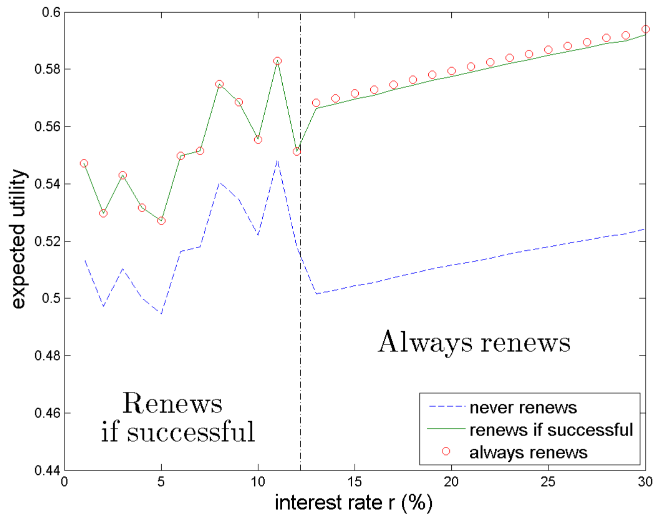
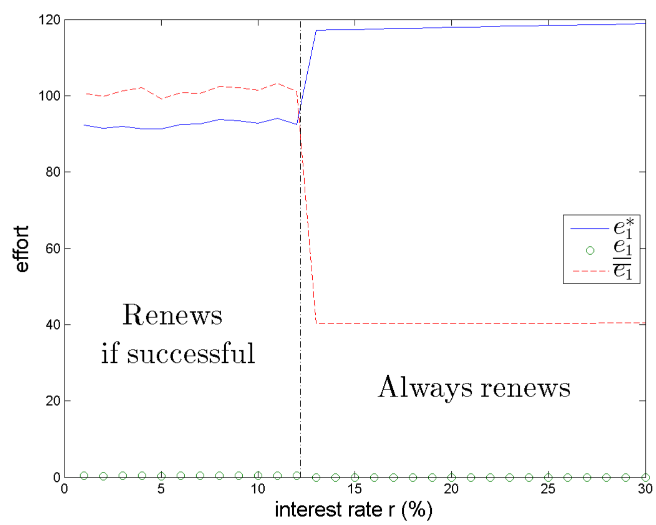


Figure 2.2: Thresholds $\underline{e_1}$ and $\overline{e_1}$, and optimal choice for e_1^* depending on interest rate r



The thresholds for the renewal strategies are in that case:

$$\underline{e_1} = 0.3434$$
$$\overline{e_1} = 101.1005$$

Hence, in period 2, the loan officer optimally chooses to renew only the borrower that successfully reimbursed his first loan. In case of default on the first loan, the loan officer prefers to consider the loan application of a newcomer.

If the interest rate r changes to 13%, keeping all other parameters stable, the compensation scheme chosen by the bank becomes $\{g, y\} = \{9.0778 \times 10^{-5}, 2.6711 \times 10^{-6}\}$. The corresponding levels of effort chosen by the loan officer and the thresholds for the renewal strategies are:

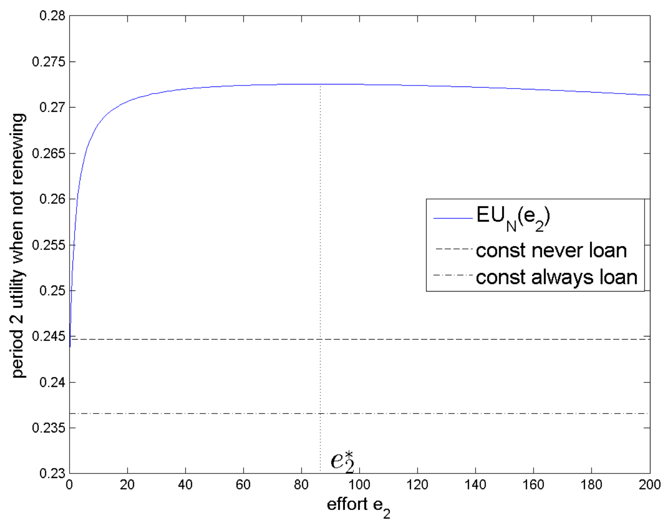
$$e_1^* = 117.1512$$
$$e_2^* = 100.7406$$
$$\underline{e_1} = 0$$
$$\overline{e_1} = 40.3432$$

In that situation, the loan officer optimally chooses to exert much more effort in period 1, learning the borrower's type with less uncertainty, and then to always renew the loan to the incumbent borrower, regardless of the outcome of the first loan. A newcomer in period 2 has therefore no chance to see his loan application accepted, and the entrance possibilities in period 2 are more scarce than they were when the interest rate was set at 12%.

This decision process is illustrated graphically on Figures 2.3 to 2.6. Figure 2.3 represents the choice of effort in period 2 when $r = 12\%$. The blue solid line shows the period 2 expected utility of the loan officer, when not renewing, depending on effort e_2. The black dashed line shows the participation constraint corresponding to the expected utility obtained by the loan officer in period 2 when not exerting effort and never granting the loan (equation (IC4)). Similarly, the black dashed-dotted line represents the level of expected utility when not exerting effort and always granting the loan (equation (IC6)). Clearly, when exerting the optimal level of effort e_2^*, the loan officer maximizes his expected utility and obtains a higher expected utility level than when not exerting any effort.

The optimal choice of effort in period 1, e_1^*, is shown on Figure 2.4. The thick black solid line represents the loan officer's total expected utility for both periods. For effort levels $e_1 \leq \underline{e_1}$, it overlaps with the blue solid curve, which shows expected utility when never renewing the loan in period 2. Since $\underline{e_1}$ is very close to zero, this is not visible on the graph. For effort levels $e_1 \in (\underline{e_1}, \overline{e_1})$,

Figure 2.3: Optimal choice for e_2^* when $r = 12\%$



the total expected utility overlaps with the thin black curve representing expected utility when only renewing successful borrowers. Finally, for effort levels $e_1 \geq \overline{e_1}$, the total expected utility curve corresponds to the solid red line, which is the expected utility when always renewing the loan to the incumbent borrower. Dotted lines represent the additional participation constraints (equations (IC3) and (IC5)). As seen on the graph, the optimal level of effort in period 1 is in the interval $(\underline{e_1}, \overline{e_1})$, and therefore the loan officer optimally applies the following renewal strategy: renew the loan to the incumbent borrower only if period 1's loan has been successful, otherwise consider the application of a newly drawn potential borrower.

Similarly, Figures 2.5 and 2.6 show the optimal choice of effort in both periods when $r = 13\%$. Given this different interest rate, the bank changes the compensation scheme it offers to the loan officer in order to maximize its profit. Given this new compensation scheme, the choice of period 2 effort e_2^* is illustrated in Figure 2.5, and is not too far from the case where $r = 12\%$. However, period 1's optimal effort is higher when the interest rate r is higher, as shown on Figure 2.6. Combined to the strong decrease of both thresholds $\underline{e_1}$ and $\overline{e_1}$, it results in a change in the loan officer's renewal strategy. Indeed, in this situation, the loan officer optimally decides to always renew the loan of the incumbent borrower, regardless of the success of his previous loan.

This example illustrates well how a seemingly marginal change in the bank's borrowing and lending conditions (like an interest rate increase from 12% to 13%) can have an amplified impact on the way credit is distributed across incumbent borrowers and newcomers. With the lower interest rate,

Figure 2.4: Optimal choice for e_1^* when $r = 12\%$

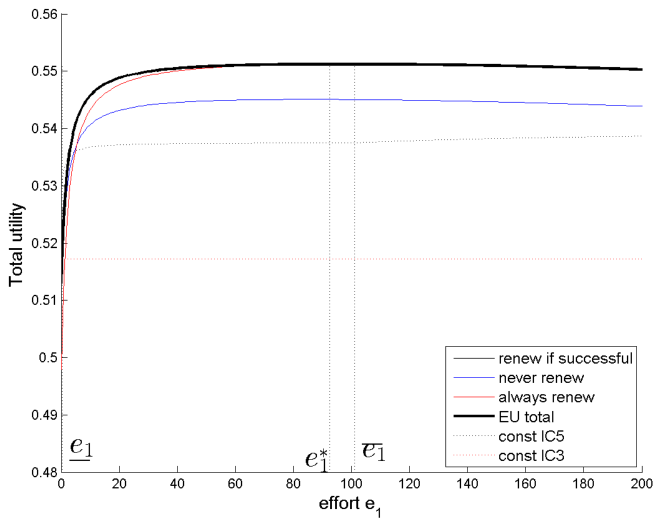


Figure 2.5: Optimal choice for e_2^* when $r = 13\%$

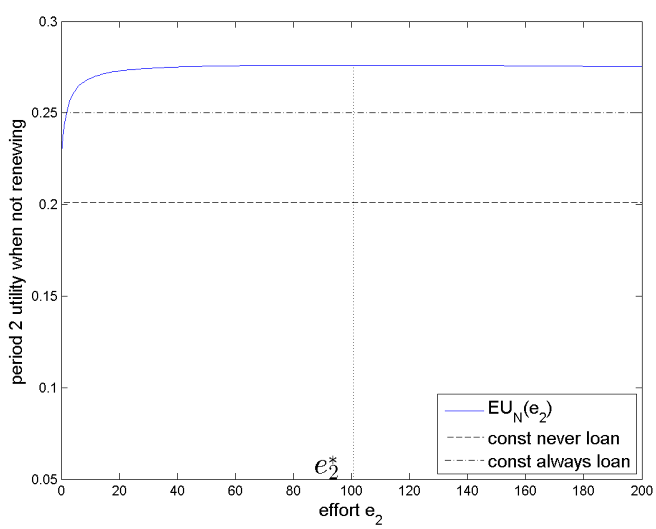
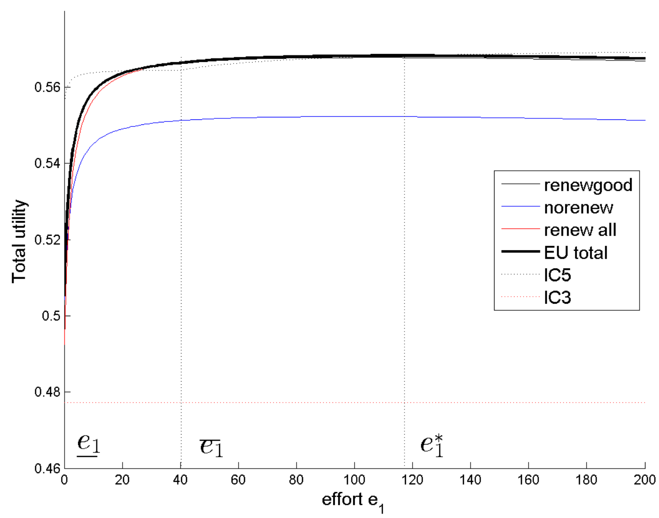


Figure 2.6: Optimal choice for e_1^* when $r = 13\%$



newcomers may obtain a loan in period 2 if the incumbent borrower performed badly, as loan officers prefer no to renew loans to unsuccessful incumbents. On the opposite, with the higher interest rate, newcomers have no chance to see their loan application considered for acceptance, since the loan officer prefers to always renew its loan to the incumbent borrower.

Although this is a very small scale model, the mechanism it contains may have important implications at the aggregate level, by influencing the easiness of creating a new enterprise, and the distribution of enterprises across old and new businesses. The change in the bank's interest rate can be interpreted more broadly: for instance, in a perfect competition set-up, a modification of the refinancing cost the bank faces on the international financial markets could cause such a change in the interest rate, by forcing the bank to charge a higher – or lower – interest rate on loans.

Conclusion

This study suggests a small-scale theoretical set-up underlining the differentiated transmission of a shock in a bank's financial situation – in terms of interest rate charged on loans, or refinancing cost – on different types of enterprises, via the easiness of access to credit. The mechanism at stake goes through the optimal decisions of a loan officer, who is responsible for selecting, accepting or rejecting loan applications. When facing a change in its refinancing cost, the bank adjusts its compensation scheme for the loan officer, who in turn modifies his optimal effort and loan renewal strategy. At the end of the logical chain, incumbent and newcomer enterprises obtain a relaxed or tighter access to credit, even if nothing in their idiosyncratic credit-worthiness has changed.

The model presented here is fairly stylized: a single representative bank, hiring a single loan officer who can decide whether to grant a unique loan per period. However, the effects obtained should be valid considering a loan officer with a fixed number of loans to grant[3].

The implications of the transmission mechanism are broader than its simple microeconomic set-up. It suggests a potential explanation for the accumulation of so-called "zombies", enterprises obtaining cheap loan renewals even if not viable. It can also explain the changes in the easiness to obtain financial resources for newly created enterprises, by contrast with incumbent ones. It thus provides some theoretical foundation for the empirical findings regarding relationship lending and borrowing conditions. Including this set-up within a more general macroeconomic framework would allow to estimate the quantitative implications of this mechanism.

[3] In this set-up, the loan officer has funds to grant only a single loan per period. This could be extended to a fixed number of loans, granted or not to a fixed number of loan applications. This should not modify the qualitative mechanism presented, but would reduce analytical tractability.

Appendix

2.A Proof of Proposition 2.1

Proof. Considering all parameters and the compensation scheme as fixed, $\mathbb{E}(U_I|l1r,\overline{s};e_1)$ and $\mathbb{E}(U_I|l1d,\overline{s};e_1)$ are increasing functions of e_1:

$$\frac{\partial\mathbb{E}(U_I|l1r,\overline{s};e_1)}{\partial e_1} = \frac{P'(e_1)\underline{\theta}\overline{\theta}P(\underline{\theta})P(\overline{\theta})(\overline{\theta}-\underline{\theta})}{(P(e_1)\Delta+\underline{\theta}P(\underline{\theta}))^2}(u(g)-u(b)) > 0$$
$$\frac{\partial\mathbb{E}(U_I|l1d,\overline{s};e_1)}{\partial e_1} = \frac{P'(e_1)(1-\underline{\theta})(1-\overline{\theta})P(\underline{\theta})P(\overline{\theta})(\overline{\theta}-\underline{\theta})}{(P(e_1)(\delta-\Delta)+(1-\underline{\theta})P(\underline{\theta}))^2}(u(g)-u(b)) > 0$$

The minimum of $\mathbb{E}(U_I|l1r,\overline{s};e_1)$ and $\mathbb{E}(U_I|l1d,\overline{s};e_1)$ is reached when $e_1=0$, while their maximum is reached when $e_1=+\infty$, and their values are:

$$\mathbb{E}(U_I|l1r,\overline{s};e_1=0) = \frac{\mathbb{E}(\theta^2)}{\mathbb{E}(\theta)}(u(g)-u(b))+u(b)$$
$$\mathbb{E}(U_I|l1d,\overline{s};e_1=0) = \frac{\mathbb{E}((1-\theta)\theta)}{\mathbb{E}(1-\theta)}(u(g)-u(b))+u(b)$$
$$\lim_{e_1\to+\infty}\mathbb{E}(U_I|l1r,\overline{s};e_1) = \overline{\theta}(u(g)-u(b))+u(b)$$
$$\lim_{e_1\to+\infty}\mathbb{E}(U_I|l1d,\overline{s};e_1) = \overline{\theta}(u(g)-u(b))+u(b)$$

When e_1 tends to infinity, the loan officer knows with certainty the type of the borrower, and his expected utility in case of renewal is the same regardless of the outcome of the first loan. It is easy to show that:

$$\mathbb{E}(U_I|l1d,\overline{s};e_1=0) \leq \mathbb{E}(U_I|l1r,\overline{s};e_1=0) \leq \mathbb{E}(U_I|l1d,\overline{s};e_1\to+\infty) = \mathbb{E}(U_I|l1r,\overline{s};e_1\to+\infty)$$

Given the model's parameters and the compensation scheme $\{y,b,g\}$, $\mathbb{E}(U_N(e_2^*))\in\mathbb{R}_+$ is constant with respect to e_1, known with certainty from period 1 on by the loan officer. Depending on e_1, the ordering between $\mathbb{E}(U_N(e_2^*))$, $\mathbb{E}(U_I|l1r,\overline{s};e_1)$ and $\mathbb{E}(U_I|l1d,\overline{s};e_1)$ changes, and so does the optimal renewal decision of the loan officer. I further define the thresholds $\underline{e_1}$ and $\overline{e_1}$ as the values of e_1 verifying equations (2.9) and (2.10).

$$\mathbb{E}(U_I|l1r,\overline{s};\underline{e_1}) = \mathbb{E}(U_N(e_2^*)) \tag{2.9}$$

$$\mathbb{E}(U_I|l1d,\overline{s};\overline{e_1}) = \mathbb{E}(U_N(e_2^*)) \tag{2.10}$$

Since $\mathbb{E}(U_I|l1r,\overline{s};e_1)$ and $\mathbb{E}(U_I|l1d,\overline{s};e_1)$ are strictly increasing functions of e_1, the thresholds $\underline{e_1}$ and $\overline{e_1}$ are unique. It is intuitive and easy to show that $\mathbb{E}(U_I|l1r,\overline{s};e_1) \geq \mathbb{E}(U_I|l1d,\overline{s};e_1)$, with a strict equality as long as $e_1 < \infty$. This implies that $\underline{e_1} \leq \overline{e_1}$, with a strict equality as long as $\underline{e_1} < \infty$ and $\overline{e_1} < \infty$.

These elements allow us to characterize the optimal renewal decision of the loan officer, depending on his previous effort e_1. When $e_1 < \underline{e_1}$, we always have $\mathbb{E}(U_I|l1d,\overline{s};e_1) < \mathbb{E}(U_I|l1r,\overline{s};e_1) < \mathbb{E}(U_N(e_2^*))$ and the loan officer always decides not to renew the loan to the incumbent borrower, regardless of the outcome of the period 1 loan. When $\underline{e_1} < e_1 < \overline{e_1}$, we always have $\mathbb{E}(U_I|l1d,\overline{s};e_1) < \mathbb{E}(U_N(e_2^*)) < \mathbb{E}(U_I|l1r,\overline{s};e_1)$ and the loan officer decides to renew the loan to the incumbent borrower only if the period 1 loan was successful, and not to renew otherwise. Finally, when $\overline{e_1} < e_1$, this implies that $\mathbb{E}(U_N(e_2^*)) < \mathbb{E}(U_I|l1d,\overline{s};e_1) < \mathbb{E}(U_I|l1r,\overline{s};e_1)$ and the loan officer always renews the loan to the incumbent borrower, regardless of the first loan outcome. □

2.B Proof of Proposition 2.2

Proof. From the expressions of $\mathbb{E}(U_I|l1r,\overline{s};e_1)$ and $\mathbb{E}(U_I|l1d,\overline{s};e_1)$ in equations (2.5) and (2.6), and thresholds definitions shown in equations (2.9) and (2.10), we obtain equations (2.11) and (2.12).

$$P(\underline{e_1}) = \underline{\theta} P(\underline{\theta}) \frac{\mathbb{E}(U_N(e_2^*)) - u(b) - \underline{\theta}(u(g) - u(b))}{\Delta_2(u(g) - u(b)) - \Delta(\mathbb{E}(U_N(e_2^*)) - u(b))} \tag{2.11}$$

$$P(\overline{e_1}) = (1 - \underline{\theta}) P(\underline{\theta}) \frac{\mathbb{E}(U_N(e_2^*)) - u(b) - \underline{\theta}(u(g) - u(b))}{(\Delta - \Delta_2)(u(g) - u(b)) - (\delta - \Delta)(\mathbb{E}(U_N(e_2^*)) - u(b))} \tag{2.12}$$

The left-hand-side of equations (2.11) and (2.12) are probabilities, hence between 0 and 1. The right-hand-side are not and take values in $\mathbb{R}$. For the probabilities and thresholds to be well defined, I need to take care of corner solutions. If the above equations define negative probabilities, then the probability is set to 0, and the corresponding effort threshold is set to 0 too. On the opposite, if the equations define probabilities larger than 1, then the probability is set to 1, and the corresponding effort threshold is set $+\infty$. This gives us the threshold values as specified in proposition 2.2. □

2.C Proof of Proposition 2.3

Proof. Constraints (IC1) and (IC2a) are already written as functions of $u(g)-u(b)$, $u(b)-u(y)$, e_1 and e_2. The same can be done for constraints (IC2b), (IC2c), (IC4) and (IC6), while constraints (IC3) and (IC5) can be rewritten as functions of $u(g)-u(b)$, $u(b)-u(y)$, e_1, e_2 and $u(y)$.

$$\begin{aligned}
c'(e_1) =& P'(e_1)\Big((u(g)-u(b))[\Delta+\Delta_2-\Delta(P(e_2)\Delta+\underline{\theta}P(\underline{\theta}))] \\
&+(u(b)-u(y))[\delta+\Delta-\Delta(P(e_2)\delta+P(\underline{\theta}))]-\Delta c(e_2)\Big) &&\text{(IC2b')}\\
c'(e_1) =& P'(e_1)\Big((u(g)-u(b))[2\Delta-\delta(P(e_2)\Delta+\underline{\theta}P(\underline{\theta}))] \\
&+(u(b)-u(y))[2\delta-\delta(P(e_2)\delta+P(\underline{\theta}))]-\delta c(e_2)\Big) &&\text{(IC2c')}\\
(u(g)-u(b))\times K_1 &+ (u(b)-u(y))\times K_2 - c(e_1) - c(e_2)\times K_3 \geq u(y)P(\overline{s};e_1) &&\text{(IC3')}\\
0 \geq& -(u(g)-u(b))(P(e_2)\Delta+\underline{\theta}P(\underline{\theta}))-(u(b)-u(y))(P(e_2)\delta+P(\underline{\theta}))+c(e_2) &&\text{(IC4')}\\
(u(g)-u(b))\times K_4 &+ (u(b)-u(y))\times K_5 - c(e_1) - c(e_2)\times K_6 \geq u(y)P(\overline{s};e_1)\\
&+\max\{u(b)-u(y)+(u(g)-u(b))\mathbb{E}(\theta|l1o,e_1=0),\\
&(u(b)-(uy))(P(e_2)\delta+P(\underline{\theta}))+(u(g)-u(b))(P(e_2)\Delta+\underline{\theta}P(\underline{\theta}))-c(e_2)\} &&\text{(IC5')}\\
(u(g)-u(b))&(P(e_2)\Delta+\underline{\theta}P(\underline{\theta}))+(u(b)-u(y))(P(e_2)\delta+P(\underline{\theta}))-c(e_2)\\
&\geq (u(g)-u(b))\mathbb{E}(\theta)+u(b)-u(y) &&\text{(IC6')}
\end{aligned}$$

where the values K_1 to K_6 are constant with respect to y, b and g.[4] Assume that $\{e_1, e_2, y, b, g\}$ solve the maximization program of the bank, with $b > 0$. We can set $\tilde{b} = b - \epsilon \in (0, b)$ and then set

[4] The exact values of K_1 to K_6 are:

$$\begin{aligned}
K_1 =& P(e_1)\Delta+\underline{\theta}P(\underline{\theta})+(P(e_2)\Delta+\underline{\theta}P(\underline{\theta}))[-P(e_1)\delta-P(\underline{\theta})+(P(e_1)\Delta+\underline{\theta}P(\underline{\theta}))\mathbb{1}(e_1<\underline{e_1})+(P(e_1)(\delta-\Delta)+(1-\underline{\theta})P(\underline{\theta}))\mathbb{1}(e_1<\overline{e}\\
&+(P(e_1)\Delta_2+\underline{\theta}^2P(\underline{\theta}))\mathbb{1}(e_1>\underline{e_1})+(P(e_1)(\Delta-\Delta_2)+\underline{\theta}(1-\underline{\theta})P(\underline{\theta}))\mathbb{1}(e_1>\overline{e_1})\\
K_2 =& P(e_1)\delta+P(\underline{\theta})+(P(e_2)\delta+P(\underline{\theta}))[-P(e_1)\delta-P(\underline{\theta})+(P(e_1)\Delta+\underline{\theta}P(\underline{\theta}))\mathbb{1}(e_1<\underline{e_1})+(P(e_1)(\delta-\Delta)+(1-\underline{\theta})P(\underline{\theta}))\mathbb{1}(e_1<\overline{e_1})]\\
&+(P(e_1)\Delta+\underline{\theta}P(\underline{\theta}))\mathbb{1}(e_1>\underline{e_1})+(P(e_1)(\delta-\Delta)+(1-\underline{\theta})P(\underline{\theta}))\mathbb{1}(e_1>\overline{e_1})\\
K_3 =& -P(e_1)\delta-P(\underline{\theta})+(P(e_1)\Delta+\underline{\theta}P(\underline{\theta}))\mathbb{1}(e_1<\underline{e_1})+(P(e_1)(\delta-\Delta)+(1-\underline{\theta})P(\underline{\theta}))\mathbb{1}(e_1<\overline{e_1})\\
K_4 =& P(e_1)\Delta+\underline{\theta}P(\underline{\theta})+(P(e_2)\Delta+\underline{\theta}P(\underline{\theta}))[P(\overline{\theta})-P(e_1)\delta+(P(e_1)\Delta+\underline{\theta}P(\underline{\theta}))\mathbb{1}(e_1<\underline{e_1})+(P(e_1)(\delta-\Delta)+(1-\underline{\theta})P(\underline{\theta}))\mathbb{1}(e_1<\overline{e_1})\\
&+(P(e_1)\Delta_2+\underline{\theta}^2P(\underline{\theta}))\mathbb{1}(e_1>\underline{e_1})+(P(e_1)(\Delta-\Delta_2)+\underline{\theta}(1-\underline{\theta})P(\underline{\theta}))\mathbb{1}(e_1>\overline{e_1})-\mathbb{E}(\theta)\\
K_5 =& P(e_1)\delta+P(\underline{\theta})+(P(e_2)\delta+P(\underline{\theta}))[P(\overline{\theta})-P(e_1)\delta+(P(e_1)\Delta+\underline{\theta}P(\underline{\theta}))\mathbb{1}(e_1<\underline{e_1})+(P(e_1)(\delta-\Delta)+(1-\underline{\theta})P(\underline{\theta}))\mathbb{1}(e_1<\overline{e_1})]\\
&+(P(e_1)\Delta+\underline{\theta}P(\underline{\theta}))\mathbb{1}(e_1>\underline{e_1})+(P(e_1)(\delta-\Delta)+(1-\underline{\theta})P(\underline{\theta}))\mathbb{1}(e_1>\overline{e_1})-1\\
K_6 =& P(\overline{\theta})-P(e_1)\delta+(P(e_1)\Delta+\underline{\theta}P(\underline{\theta}))\mathbb{1}(e_1<\underline{e_1})+(P(e_1)(\delta-\Delta)+(1-\underline{\theta})P(\underline{\theta}))\mathbb{1}(e_1<\overline{e_1})
\end{aligned}$$

$\tilde{y} < y$ and $\tilde{g} < g$ such that:

$$u(\tilde{g}) - u(\tilde{b}) = u(g) - u(b)$$
$$u(\tilde{b}) - u(\tilde{y}) = u(b) - u(y)$$

This is possible as long as $u(b) \neq \infty$, which is implied by Assumption 2.6 and the usual utility function assumptions. Keeping e_1 and e_2 stable, this implies that constraints (IC1) to (IC2c), (IC4) and (IC6) are still verified by $\{e_1, e_2, \tilde{y}, \tilde{b}, \tilde{g}\}$. Regarding constraints (IC3') and (IC5'), their left-hand side remains unchanged while their right-hand side decreases with $\tilde{y}$ at a rate equal to $P(\bar{s}; e_1)$. Consequently, constraints (IC3) and (IC5) also remain verified by $\{e_1, e_2, \tilde{y}, \tilde{b}, \tilde{g}\}$. Therefore the allocation $\{e_1, e_2, \tilde{y}, \tilde{b}, \tilde{g}\}$ is feasible. This allocation also provides a higher profit than $\{e_1, e_2, y, b, g\}$ to the bank since it decreases all payments $\{y, b, g\}$ to the loan officer while keeping constant incentives and effort $\{e_1, e_2\}$. Hence $\{e_1, e_2, y, b, g\}$ was not optimal, and at the optimum $b = 0$. □

3 Unveiling the Effects of Foreign Exchange Intervention: A Panel Approach

Joint with Gustavo Adler and Rui Mano (International Monetary Fund)

Abstract

The paper studies the effect of foreign exchange intervention on the exchange rate relying on an instrumental-variables panel approach. We find robust evidence that intervention affects the level of the exchange rate in a meaningful way from a macroeconomic perspective. A purchase of foreign currency of 1 percentage point of GDP causes a depreciation of the nominal and real exchange rates in the ranges of [1.7-2.0] percent and [1.4-1.7] percent, respectively; and the effects are found to be quite persistent. The paper also explores possible asymmetric effects, and whether the effectiveness of foreign exchange intervention depends on the depth of domestic financial markets.

We are grateful to Steven Phillips, Tam Bayoumi, Mitali Das, Jaebin Ahn, Ahuja Ashvin, Emine Boz, Varapat Chensavasdijai, Mai Dao, Takatoshi Ito, Martin Kaufman, Ruy Lama, Nan Li, Lukas Menkhoff, Kenji Moriyama, Hélène Poirson, Belen Sbrancia, Viktor Tsyrennikov, Mauricio Vargas and seminar participants at the 2016 AEA Meetings, the NYU Stern Volatility Institute, and the EUI Macroeconomics Working Group, for their feedback. Remaining errors are ours.

The views expressed in this paper are those of the authors and do not necessarily represent those of their institutions or their institutions' policies.

3.1 Introduction

Volatile capital flows in the context of growing financial integration have posed significant challenges to policy makers across the world in recent years. Emerging market countries, and increasingly advanced market economies, have resorted to a battery of policy tools, including macro-prudential measures, capital controls and foreign exchange intervention (FXI) to cope with the effects of large capital flows. However, the merits of these different tools remain under debate. There is some consensus on how these instruments should impact key macroeconomic variables in theory, but the empirical evidence on their effect and economic relevance remains elusive. The evidence has been particularly hard to find in the case of FXI, reflecting serious endogeneity issues that hamper the identification of its effects, especially on the exchange rate. A number of studies have found evidence on the latter at high (intra-day) frequency but have fallen short of shedding light on the macroeconomic relevance of these effects. In this paper, we take a different approach that allows us to evaluate the merits of FXI as a *macroeconomic* policy instrument.

Large changes in central banks' net foreign asset positions over the last two decades, primarily driven by FXI, give testimony of the importance of FXI as a macroeconomic management tool (Figure 3.1). Whether countries deployed FXI as a way to accumulate reserves for precautionary reasons (e.g., Aizenman and Lee, 2008; Jeanne and Rancière, 2011; Ghosh et al., 2012) or seeking to manage their exchange rates (e.g. Reinhart and Reinhart, 2008; Aizenman and Lee, 2008; Adler and Tovar, 2014; Gagnon, 2012a) was a much discussed subject during the 2000s.[1] But, with the implementation of unconventional monetary policies in advanced economies in recent years, countries facing large capital inflows have been more vocal and open about the primary objectives of carrying out FXI operations, namely dampening the effects of these inflows on their exchange rates. Indeed, a simple indicator of the degree of exchange rate management (Figure 3.2) points to a wide range of de facto exchange rate regimes (even among de jure floaters), suggesting that many countries have relied heavily on (sterilized) FXI to manage their exchange rates.[2] However, the effectiveness of sterilized FXI in terms of its impact on the level of the exchange rate remains debatable.[3]

From a theoretical perspective, the literature has proposed two main channels through which FXI

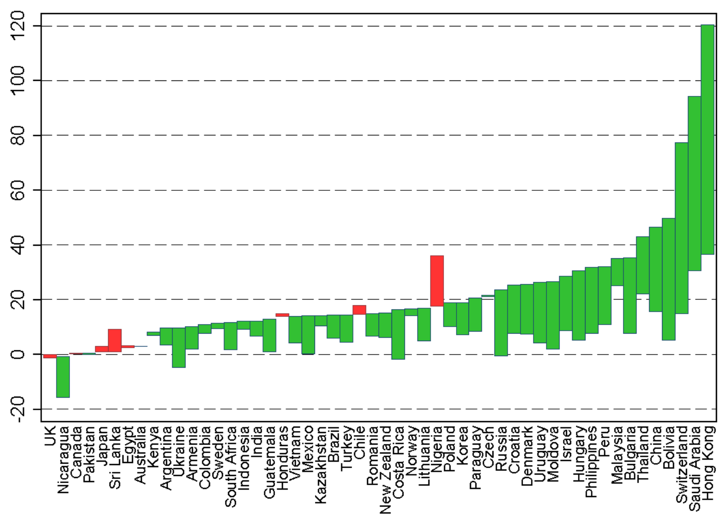
[1]For studies on the motives of FXI, see also Canales-Kriljenko (2003), Moreno (2005), Neely (2008), Stone et al. (2009).

[2]The indicator of exchange rate management is defined as: $\rho_j \equiv \sigma_j^{NFA}/(\sigma_j^{NFA} + \sigma_j^S)$ where σ_j^{NFA} and σ_j^S denote the standard deviations of a proxy of FXI and of the nominal exchange rate, respectively. ρ_j varies between 0 and 1, corresponding to a pure floating and a peg respectively.

[3]A number of studies have explored the effects of FXI on exchange rate volatility and obtained more conclusive results than those focused on exchange rate levels. See for example, Stone et al. (2009), Mandeng (2003), Kamil (2008), Pattanaik and Sahoo (2003), Domaç and Mendoza (2004), Guimarães Filho and Karacadağ (2004), Abenoja (2003). Another related strand of the literature has studied the impact of FXI (and more generally net official flows) on the current account. See for example, Bayoumi et al. (2014), Gagnon (2012b) and Gagnon (2013).

can affect exchange rates: a signaling and a portfolio balance channel. The theory behind the signaling channel posits that sterilized FXI can affect the exchange rate by providing information about the central bank's monetary policy intentions[4]. The portfolio balance theory, pioneered by Henderson and Rogoff (1982), Kouri (1983) and Branson and Henderson (1985), and further studied by Kumhof (2010) and Gabaix and Maggiori (2015) recently, established that in the presence of incomplete markets FXI can affect the exchange rate when domestic and external assets are imperfect substitutes. In this case, sterilized intervention increases the relative supply of domestic assets, driving risk premia up and thereby exerting depreciation pressures on the exchange rate.[5,6]

Figure 3.1: Central Bank Net Foreign Asset Position, 1996-2013



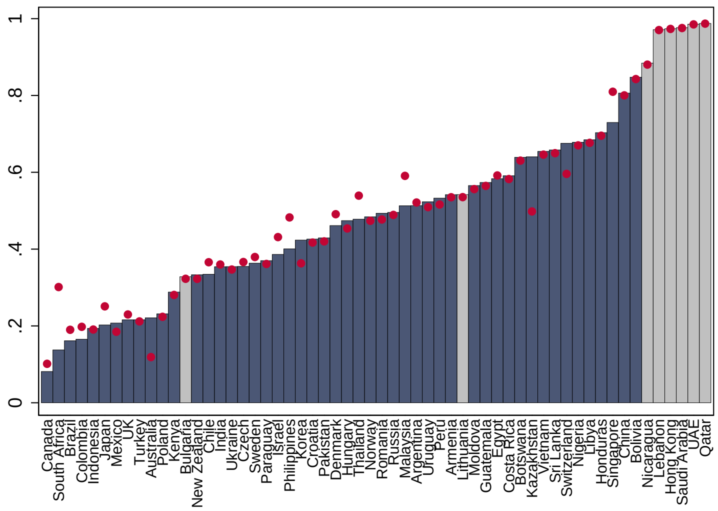
Sources: IMF *International Financial Statistics*; and authors' calculations. Green (red) bars indicate an increase (drop) in the NFA position during the period. The lower end of the bar indicates the initial position, and the upper end the final position, for the cases of NFA increases; and the opposite for NFA decreases.

[4]This channel can be made more effective in the presence of policy coordination as argued by Sarno and Taylor (2001) and Fratzscher (2009).

[5]In the case of the signaling channel, FXI serves as tool to convey information about policy intentions, and thus cannot be thought of as an independent policy instrument. In the case of imperfect asset substitutability (portfolio balance channel), however, FXI is an additional, independent, policy tool.

[6]The literature often also refers to two additional channels: A coordination channel, according to which, frictions at a micro level can affect the extent to which information embedded in central bank operations (assuming an informational advantage) reaches market participants and shapes their expectations–see, for example, Lyons (2006) and Reitz and Taylor (2008)– and a noise-trading channel, whereby the central bank uses FXI to change the trend behavior of the exchange rate in a way that leads so called "noise traders" to begin investing on the premise of this new trend and hence further enhancing the effectiveness of the initial intervention, as in Hung (1997).

Figure 3.2: Degree of Exchange Rate Management, 1996-2013



Sources: IMF *International Financial Statistics*; and authors' calculations. Bars report a measure $\rho_j \equiv \sigma_j^{NFA}/(\sigma_j^{NFA}+\sigma_j^{S})$ where σ_j^{NFA} and σ_j^{S} denote the standard deviations of changes in net foreign assets and of the nominal exchange rate, respectively. Gray bars correspond to countries with de-jure pegs for most of the sample period (1996-2013), and blue bars otherwise. Dots report to a similar measure of exchange rate management but based on a proxy of FXI that includes non-spot interventions (see 3.A).

From an empirical point of view, the literature has seen two distinct waves of work. During the 1980s and part of the 1990s, numerous studies focused on cases of FXI in advanced economies (see, for example, the extensive work by Dominguez, 1990, 1998, Dominquez and Kenen, 1992, Dominguez and Frankel, 1990, 1993b, 1993a; Ghosh, 1992; Kaminsky and Lewis, 1996; Kenen, 1982, and Ito, 2002).[7,8] In general, these studies found limited evidence of effectiveness with regard to the level of the exchange rate, unless interventions were coordinated across major central banks. More recently, in an effort to study developments in emerging markets, there has been a number of studies with more supportive, although often mixed, evidence that intervention affects the exchange rate (see recent reviews of the literature in Menkhoff, 2010 and 2013). Most of these studies, however, are country-specific and thus their results are difficult to generalize. In fact, robust evidence on the effects of FXI has been hard to find beyond some specific cases, possibly reflecting the endogeneity of FXI decisions, which tends to conceal the effect of FXI on exchange rates.[9] Even when authors have

[7] See also other (innovative) approaches undertaken by Kearns and Rigobon (2005), Naranjo and Nimalendran (2000) and Chen et al. (2012).

[8] For comprehensive reviews of the early literature, focused on advanced economies, see Sarno and Taylor (2001) and Neely (2005).

[9] This is illustrated in Appendix Figure 3.C.1, which displays the bivariate relationship between a proxy of FXI

been able to overcome endogeneity issues, the employed empirical strategies have often fallen short of shedding light on the macroeconomic relevance of such effects. Specifically, most of the attempts have relied on high-frequency data (including intra-day) in order to mitigate reverse causality (see, for example, Tapia and Tokman, 2004; Guimarães Filho and Karacadağ, 2004; Domaç and Mendoza, 2004; Humala and Rodriguez, 2010; Kamil, 2008; Rincón and Toro, 2011; Dominguez et al., 2013; etc.). This approach (sometimes combined with some form of instrumentation) helped to break the contemporaneous relationship between exchange rate movements and FXI decisions, by exploiting the fact that FXI decisions are normally taken at a lower frequency than exchange rate movements. In general, the 'high-frequency' approach has been successful in finding evidence of effects of FXI on the exchange rate in the short-run, but doubts remain as to whether these effects are sufficiently persistent (i.e., beyond a few days) to have relevant macroeconomic implications[10].

Because our goal is to understand the relevance of FXI as a macroeconomic policy tool (i.e., beyond intra-day effects), we take a different approach to most of the existing literature, using relatively low frequency (monthly) data and focusing our efforts on the instrumentation–which relies mostly on exogenous variations in FXI related to countries' precautionary motives for accumulating reserves. Also, unlike most of the literature, our approach focuses on panel (as opposed to country time series) data. The reasons for this are twofold: Time-series data for each country is relatively limited, particularly after excluding highly volatile periods in the early 1990s. We hence gain power in our statistical tests at the expense of imposing homogeneity restrictions–which we explore later. More importantly, the (52 country) panel setting allows for an instrumentation strategy that exploits both within country and cross-country variation of the instrumental variables[11].

We find robust evidence that intervention affects the level of the exchange rate in a macroeconomically meaningful way. A positive FXI (FX purchase) of 1 percentage point of GDP leads to, depending on the specification, a depreciation of the nominal and real exchange rate in the range of [1.7-2.0] percent and [1.4-1.5] respectively.[12] Furthermore, we find these effects to be persistent, with estimates of their half-life in the range of [12-23] months, again depending on the specification.

and changes in the nominal exchange on a monthly basis for the period 1996-2013 and a large set of countries. As shown, if anything, there is a positive relationship indicating that positive FXI (reserve accumulation) is accompanied by exchange rate appreciation.

[10] Persistent effects of FXI can be better understood under the portfolio balance approach, whereby interventions change the risk of holding a currency and hence generate predictable exchange rate movements if investors are risk averse. Under risk neutrality, exchange rates are martingales and thus FXI cannot have persistent effects.

[11] Some other papers have also relied on low frequency data, taking an instrumental-variables approach to overcome endogeneity, with mixed results, arguably reflecting different degrees of success in finding good instruments. Examples of this are the work in Phillips et al. (2013) —who explore determinants of exchange rates in a panel setting, although without focusing on FXI —Daude et al. (2014) —who explore the effects of FXI on exchange rates in a panel setting, although relying on an unconventional measure of FX intervention; and Blanchard et al. (2015) —who study the effect of FXI in the context of capital flow shocks.

[12] These magnitudes seem broadly consistent with those implied by the portfolio balance approach model of Gabaix and Maggiori (2015).

The paper explores possible asymmetric effects, and finds no indication of different effects between positive and negative intervention, suggesting that FXI is a useful policy tool both when facing appreciation and depreciation pressures.

The rest of the paper is organized as follows: Section 3.2 presents the econometric methodology, the main results and a number of robustness checks. Section 3.3 discusses extensions of the benchmark specification, exploring dynamic and asymmetric effects. Section 3.3.2 concludes with the key takeaways.

3.2 Econometric Analysis

3.2.1 Approach

The main challenge in evaluating the impact of FXI on exchange rates is the endogeneity of interventions to exchange rate movements. To overcome this difficulty, we use a two-stage least squares approach with instrumental variables that relies on identifying exogenous variations in FXI (i.e. interventions that are unrelated to contemporaneous exchange rate movements). Specifically, we employ the following specification, which is estimated in a panel setting:

$$\log(ER_{it}) = \alpha + \beta \log(ER_{it-1}) + \gamma \widehat{FXI}_{it} + \boldsymbol{\delta}'\mathbf{X}_{it} + \eta_i + \epsilon_{it} \tag{3.1}$$

$$FXI_{it} = a + b \log(ER_{it-1}) + \mathbf{c}'\mathbf{Z}_{it} + \mathbf{d}'\mathbf{X}_{it} + u_i + v_{it} \tag{3.2}$$

Equation (3.1) is the second-stage exchange rate equation linking the exchange rate (ER_{it}) to exogenous (instrumented) FXI as well as to a series of regressors (X_{it}) that are expected to drive exchange rate variations. Equation (3.2) is the first-stage regression relating FXI to a series of driving factors, including those introduced in the second stage and a full set of instruments (Z_{it}). ER_{it} denotes country i's exchange rate at time t (either nominal or real bilateral, in both cases vis-a-vis the U.S. dollar, or real effective, depending on the specification). We follow the convention that an increase represents an appreciation of the domestic currency in all cases;[13] FXI_{it} stands for our proxy of foreign exchange intervention; Z_{it} is the set of instrumental variables; and X_{it} is a set of control variables; all of which are discussed in detail next. u_i and η_i denote country fixed effects for the first and second stage regressions, respectively.

[13] In the rest of the paper, results refer to real bilateral exchange rates vis-a-vis the U.S., unless otherwise indicated. This minimizes issues related to episodes of high inflation (that would affect nominal rate more markedly); and allows for a more parsimonious mapping between the regressors and the dependent variable.

Our interest lies primarily on the parameter γ. A negative value of γ would indicate that a positive intervention (buying foreign currency) depreciates the domestic currency. The benchmark specification assumes homogeneous parameters across countries, although later we relax this assumption to assess the robustness of the results. Next, we discuss how the measure of FXI, and the sets instruments and controls are constructed.

Foreign Exchange Intervention

The definition of FXI is not straightforward, although this is rarely discussed in the literature. From the perspective of the portfolio balance channel, FXI should be understood as any policy- induced financial operation that changes the foreign exchange position of the public sector, as changes in the net FX position would imply changes in the relative supply of domestic assets (money if unsterilized, central bank notes or T-bills if sterilized).[14] In practice, however, measuring FXI is a difficult task, on account of several issues.

First, ideally one would measure FXI as any policy-induced changes in the FX position of the consolidated public sector.[15] However, such data is rarely available, particularly at high frequency. We therefore focus on the central bank's balance sheet, in line with the literature.[16] Second, data on actual purchases and sales of foreign assets are not generally reported. Thus, we conduct our study using several different proxies for FXI, mainly following Dominguez (2012) and Dominguez et al. (2012).[17] The main concern with the use of a proxy relates to possible changes in the central bank net foreign asset position arising from valuation effects rather than actual transactions. As shown in Figure 3.1, however, our main proxy of intervention–the change in the (net) foreign asset position of the central bank–correlates very closely with Net International Reserves flows data from the Balance of Payments statistics, which is flow-based and thus not polluted by valuation effects.

Later we conduct a number of robustness checks, with other proxies, including correcting for valuation effects and off-balance sheet operations (i.e. swaps, forward, etc.). See details in Annex I. We normalize FXI by (HP filtered) trend GDP in U.S. dollars, in order to prevent endogeneity arising from movements in the U.S. dollar value of nominal GDP. This normalization facilitates

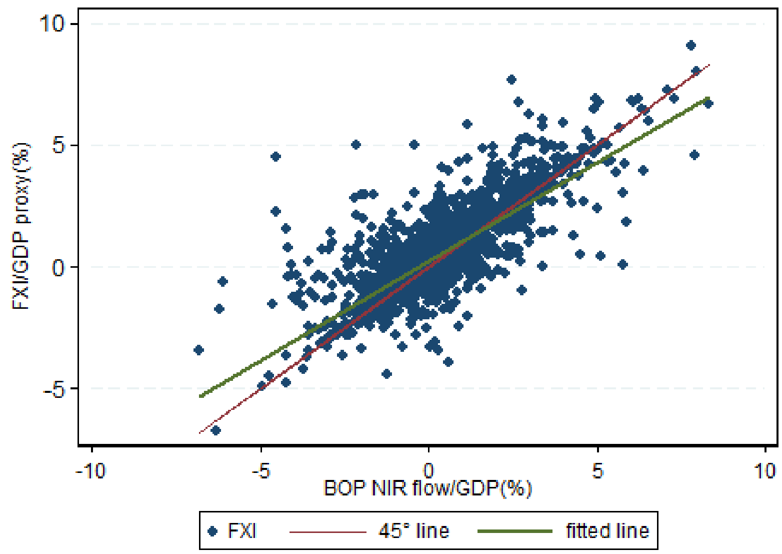
[14] A definition from the perspective of the signaling channel is less straightforward, as one could think of a broader set of policies that would provide information about monetary policy intentions.

[15] Whether public sector agencies other than the central bank intend to affect the exchange rate or not with their FX transactions is irrelevant for the analysis of the effects of FXI on the exchange rate, since the portfolio balance channel would operate in either case. Intent, however, may be relevant for assessing the appropriateness of policies, but such analysis is beyond the scope of this paper.

[16] In most cases, central bank FX transactions appear to be the major source of public sector FX transactions, except in some countries with sizeable sovereign wealth funds.

[17] Alternative measures, like the one proposed by Daude et al. (2014) are also explored.

Figure 3.1: Correlation between BOP data and our proxy for FXI



Sources: IMF International Financial Statistics; Balance of Payments data; and authors' calculations.

the interpretation and comparability of results across countries and time; and helps to prevent unit root problems. In section 3.2.3 we also discuss alternative normalizations. Finally, as our interest is on the effect of *sterilized* interventions, we control for the monetary policy stance by including the domestic (and foreign) interest rate in all specifications, and also check the robustness of the results to including a measure of changes in the monetary base as a control, as discussed below.

Exchange Rate Determinants (Controls)

Guided by the vast literature on exchange rate determinants, a number of controls are included in the specification, which are classified into two groups: a small set of controls, aimed at keeping the specification as parsimonious as possible; and an expanded set of standard exchange rate determinants, the inclusion of which tends to restrict the sample due to data availability.

The small set of control variables is composed of (i) the level of the Chicago Board Options Exchange Market Volatility Index (VIX); (ii) three indices of commodity prices (for energy, metals and agriculture products) with country-specific coefficients; and (iii) the interest rate differential vis-a-vis the U.S., as we focus on the bilateral exchange rate with the US Dollar in most specifications. Commodity prices are included to capture possible terms of trade shocks at high frequency and their differentiated impacts depending on whether countries export or import different commodities. Introducing the interest rate in the model is key for interpreting the results as pertaining to sterilized intervention, since it allows us to control for the effect of simultaneous changes in the interest rate on the exchange rate (which could come from non-sterilized intervention). This approach is superior to trying to exclude observations of unsterilized interventions, since it does not require to define arbitrary thresholds for classifying FXI as sterilized or non-sterilized. Various robustness checks are conducted later, including by introducing the domestic and foreign interest rates separately. When using the nominal bilateral exchange rate, the inflation differential vis-a-vis the US is added in order to control for movements in the exchange rate that reflect persistently high inflation levels.[18]

The expanded set of controls includes other exchange rate determinants following Phillips et al. (2013). These are slow moving series or variables for which less data is available: GDP per capita and expected GDP growth (both relative to the U.S.), lagged trade balance, and trade openness. Finally, we also include in the expanded set of controls an additional variable that captures global financial conditions (in addition to the interest rate and the VIX index) as measured by the net portfolio flows to other countries in the sample, reported by Emerging Portfolio Fund Research (EPFR).

Instruments

Key to our methodology is finding suitable instrumental variables, i.e. variables that are strongly correlated with FXI, but not with the exchange rate. We explore a number of potential instruments, related to various motives for conducting FXI, primarily linked to accumulation of international reserves for precautionary reasons and exchange rate stabilization motives related to balance sheet effects.

In the former case (FXI for precautionary motives), we rely on exogenous variations in FXI explained by the level of international reserves, using standard metrics of reserve coverage, which reflect the adequacy of reserve holdings relative to measures of potential sources of FX liquidity drains.[19] Intuitively, countries with low reserve coverage metrics are expected to intervene more heavily (buying more and selling less reserves) to build up their reserve buffers, and such differences are expected to be uncorrelated with exchange rates. The specific metrics we explore include lagged gross (net) international reserves relative to GDP, imports, external debt or M2. All variables are evaluated in absolute value as well as relative to the average of other countries in the sample, the latter intending to unveil possible ‘keeping up with the Joneses’ effects.[20,21]

[18] By excluding each country at a time, we ensure the measure is exogenous from the perspective of each small open economy. See Blanchard et al. (2015) for a similar approach.

[19] See, for example, Phillips et al. (2013), Daude et al. (2014), IMF (2011) and IMF (2013).

[20] See Cheung and Sengupta (2011), and Cheung and Qian (2009).

[21] The variables are also included in levels —which significance would indicate an objective to build up buffers —and

We also explore a set of new instrumental variables related to exchange rate stabilization motives, not used in previous studies. In particular, we focus on the interaction between a measure of the degree of deposit dollarization in the domestic financial system, and different measures of exogenous financial shocks (VIX, Global EMBI, EPFR flows, etc.) that would tend to exert depreciation pressures on most EMEs. A negative statistical link between this variable and FXI would indicate the use of intervention in response to exogenous shocks with the aim of mitigating balance sheet effects. In this case, while variations of FXI are not fully exogenous to the exchange rate, the variation is largely explained by cross-section differences in the degree of dollarization, which are uncorrelated with contemporaneous exchange rate movements.

Finally, we also examine lagged trade balance as a possible instrument related to a mercantilist motive.

Most of these variables gave intuitive results, with different degrees of significance. However, the instruments finally included in the baseline estimations were chosen according to three specific criteria:

i. Each individual instrumental variable delivers a coefficient sign in the first stage regression consistent with economic theory. This is aimed at ensuring that the variable actually reflects the intervention motive in mind.

ii. The variable helps mitigate endogeneity bias in the second stage regression. That is, the coefficient for fitted values of FXI in the second stage regression should be lower than in the simple OLS version. This condition is imposed because, as discussed before, the direction of the bias is known (central banks tend to react in order to dampen movements in the exchange rate, rather than the opposite, which implies, if any, an upward bias in an OLS regression—where exchange rates are defined as US$/LC).[22]

iii. When instrumenting jointly (using all variables that satisfy the two previous criteria), the specification is required to pass the overidentification and weak instrument tests. The first one (known as Sargan, Hansen or J-test) examines the null hypothesis of joint validity of the instruments, also referred to as a test of over-identifying restrictions.[23] To test for weak instruments, we follow the test developed by Stock and Yogo (2002).[24]

in first differences —which would indicate a desire to maintain a certain level of reserves in proportion to such variables.

[22] This is different from studies that focus on the effect of FXI on the current account, where the direction of the endogeneity bias is ambiguous. See, for example, Bayoumi et al. (2014).

[23] Its statistic follows a χ^2 in the number of overidentifying restrictions. For instruments to pass this test, one should fail to reject the null hypothesis.

[24] The test is built on the F statistic of the first stage regression, but specifically tailored to weak instruments issues, and is therefore preferable to the often used rule of thumb of the first stage F statistic being larger than

Data

The dataset encompasses monthly observations for 52 countries (13 advanced and 39 emerging market economies), during the period January 1996-October 2013 (see Annex Table 3.C.1 for more details). The sample focuses on countries with their own legal tender (i.e., excludes countries that use other countries' currencies as legal tender). Periods during which the de-facto exchange rate regimes (following the classification of Ilzetzki et al., 2010) are classified as freely falling or dual exchange rates are excluded. Some countries did not intervened in the FX market during the period of analysis but are kept in the sample to better identify the role of controls in our specifications. Data come from the IMF's International Financial Statistics, World Economic Outlook and Direction of Trade Statistics. Interest rates are obtained from Datastream, expected GDP growth are from Consensus Forecast. The different measures of the size of the domestic financial sector (discussed below) come from the World Bank's Global Financial Development Database (GFDD). EPFR flows are obtained from Haver Analytics. Deposits dollarization is obtained from the database constructed by Yeyati (2006) and complemented by recent data from IMF country desks. Capital control indices come from Schindler (2009), Chinn and Ito (2006) and Quinn and Toyoda (2008), and are extended in some cases using the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER) data. Details of variables' construction and sources are summarized in Appendix Table 3.C.2.

In the benchmark specification we exclude the 1% top and bottom observations[25] for each variable (except for variables bounded by definition) to avoid undue influence of possible outliers in the results. Table 3.1 presents summary statistics of the main variables; and the distribution of FXI is shown in Appendix Figure 3.C.2.[26]

3.2.2 Main results

Table 3.2 presents the second stage OLS and IV results for the baseline specification, using only the set of instrumental variables that pass the criteria discussed above. In each case, results are reported for the nominal bilateral, real bilateral, and real effective exchange rates, both using the

10. Instruments are considered weak when the maximum size of the IV coefficient's bias relative to the OLS coefficient's bias exceeds a certain threshold. The null hypothesis assumes that instruments are weak, and critical values which depend on the number of instruments used are tabulated in Stock and Yogo (2002). Given the number of instruments included in our benchmark specification, a test statistic above 18 (11) rejects a relative bias above 5% (10%).

[25] The 1^{st} and 99^{th} percentiles are taken over the cross-country distribution for the whole sample. For the exchange rates, we excluded outliers based on the distribution of their month-to-month growth rate.

[26] Variables are tested for stationarity. Both nominal and real bilateral exchange rates are stationary; while real effective exchange rates display non-stationarity in some cases, and under some tests. See further discussion in the robustness section.

Table 3.1: Descriptive statistics

	Obs	Mean	Std Dev	Min	Max
log RER	9149	-3.14	2.57	-10.16	0.69
log NER	9149	-3.03	2.47	-9.96	0.73
log REER	8597	4.53	0.15	3.81	5.08
FXI/GDP	9149	0.19	0.71	-2.70	3.77
FXI/GDP (valuation adj)	9012	0.12	0.69	-2.74	3.45
FXI/GDP (valuation adj + off-BS)	9011	0.12	0.71	-3.04	3.84
FXI/GDP (ΔReserves)	9103	0.18	0.66	-2.40	3.50
FXI/M2	9053	0.53	2.20	-9.09	13.21
FXI/Financial sector size (IFS)	8741	0.39	1.44	-5.57	9.67
FXI/Financial sector size (WB)	8424	0.45	1.85	-9.15	14.13
FXI/Market size	8515	2.27	14.17	-65.66	152.99
VIX	9149	21.53	7.75	10.42	59.89
Interest rate (differential)	9149	0.39	0.51	-0.39	5.12
Inflation rate (differential)	8723	3.09	4.99	-4.71	49.75
Change in M2/GDP	9149	0.49	0.83	-1.90	4.47
Financial dollarization	9149	23.45	23.24	0.00	92.60
Import coverage	9141	0.52	0.49	-0.44	4.31
Low import coverage	9149	0.22	0.42	0.00	1.00
Broad money coverage	9146	0.39	0.40	-1.42	2.16
GDP per capita (differential)	9046	-1.32	0.83	-3.03	0.27
Expected GDP growth (differential)	8571	1.08	2.54	-14.36	11.02
Trade Balance	9039	-0.29	1.01	-3.70	3.57
Trade Openness	9046	5.43	3.04	1.41	27.68
EPFR/GDP	9149	0.01	0.11	-0.59	0.46
EMBI spread	8421	4.78	2.54	1.51	14.19

small and the expanded set of controls. Table 3.3 displays the results of the first stage regression for the same specifications (for the IV specifications alone).

As discussed previously, OLS regressions (Table 3.2, columns 1-6) deliver counter-intuitive results, due to the endogeneity of FXI, even after controlling for usual exchange rate drivers. Our instrumentation strategy (columns 7-12), on the other hand, delivers coefficients for FXI in the second stage that are highly significant and with the expected sign. Moreover, the magnitude of the effects is economically meaningful. A FXI of 1 percentage point of GDP leads to a depreciation in the range of [1.7-1.9] percent of the nominal exchange rate, depending on the specification. The effect is somewhat smaller on the real bilateral exchange rate, in the range of [1.4-1.5] percent, possibly indicating some exchange rate pass-through to inflation; and more so on the real effective exchange rate ([1.2-1.3] percent), suggesting that simultaneous FXI in trading partners tend to offset each other. The results on the real effective exchange rate, however, should be interpreted with caution as regressors are not measured in relative terms to trading partners. Thus, we focus on the first two exchange rate measures, for which the mapping with the regressors is clear. Control variables in the second stage all have expected signs and are statistically significant, except for the interest rate differential. We conduct a series of robustness checks on the latter in the section 3.2.3. The set of variables found to be valid instruments include:

i. Change in M2 normalized by trend nominal GDP, consistent with findings in a number of recent papers (e.g., Phillips et al., 2013; Daude et al., 2014) and the precautionary motives highlighted by Obstfeld et al. (2010).

ii. Broad money coverage: NFA/M2 (lagged)

iii. Imports coverage measured by NFA/imports (lagged), where we also find a non-linear relationship, with a shift for low import coverage levels.

iv. Financial dollarization interacted with VIX.

3.2.3 Main Robustness Checks

We conduct a number of robustness checks on our baseline specification. In this section, we pay special attention to (i) the normalization of FXI (and the link between FXI and domestic financial deepening); (ii) the instrumentation; (iii) the exchange rate regime; (iv) other simultaneous policy responses; and (v) the proxy of FXI.

Different normalizations

While normalizing FXI by GDP seems intuitive and helps interpret the magnitudes involved, there is no obvious economic case for using this particular measure. In fact, the theory of FXI points to other potentially better normalizations. From the perspective of the portfolio balance channel, a relevant measure would be the amount of intervention relative to, for example, the supply of domestic assets or the size of domestic financial markets.[27,28] We explore four alternative norms that go in such direction:

i. broad money (M2);

ii. a (narrow) measure of the size of the domestic financial sector, based on the total amount of domestic assets held by domestic banks (excluding the central bank) as reported in IFS.[29]

iii. an alternative (broader) measure of the size of the domestic financial system based on data from the World Bank Global Financial Development Database (GFDD). This measure encompasses domestic assets of domestic banks, non-bank financial institutions, pension funds, mutual funds, and insurance companies.

[27] The desirable normalization from the perspective of the signaling channel is less obvious, since the effect on the exchange rate could be driven by the mere FXI announcement by the central bank; with actual amounts arguably playing a secondary role.

[28] Other studies have explored measures of FXI relative to the foreign exchange market turnover. However, this is difficult to implement in a panel setting due to limited data on the latter.

[29] Non-depositary financial corporations are also excluded due to missing information for many countries.

Table 3.2: Second stage, baseline results

Dependent variable: exchange rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	OLS						2SLS					
Exchange rate definition:	Nominal	Real	Real effective	Nominal	Real	Real effective	Nominal	Real	Real effective	Nominal	Real	Real effective
FXI/GDP	0.751***	0.740***	0.105**	0.805***	0.781***	0.143***						
	(0.118)	(0.123)	(0.048)	(0.120)	(0.122)	(0.049)						
FXI/GDP (instrumented)							-1.692***	-1.430***	-1.218***	-1.905***	-1.544***	-1.343***
							(0.339)	(0.318)	(0.229)	(0.427)	(0.373)	(0.307)
Dependent variable (lagged)	0.980***	0.975***	0.969***	0.976***	0.960***	0.965***	0.976***	0.966***	0.961***	0.975***	0.953***	0.958***
	(0.005)	(0.004)	(0.004)	(0.006)	(0.006)	(0.005)	(0.002)	(0.003)	(0.004)	(0.003)	(0.004)	(0.004)
VIX	-0.037***	-0.025***	-0.004	-0.040***	-0.031***	-0.007	-0.058***	-0.043***	-0.014***	-0.065***	-0.050***	-0.020***
	(0.006)	(0.006)	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.004)	(0.007)	(0.006)	(0.005)
Interest rate (differential)	0.004	0.212	0.233*	0.064	0.341**	0.339**	-0.324**	0.014	0.088	-0.340**	0.105	0.177
	(0.138)	(0.138)	(0.118)	(0.148)	(0.147)	(0.140)	(0.128)	(0.108)	(0.098)	(0.153)	(0.126)	(0.113)
Inflation rate (differential)	0.027**			0.028**			0.050***			0.056***		
	(0.011)			(0.013)			(0.010)			(0.012)		
GDP per capita (differential)				3.121***	4.869***	1.490*				0.911	3.533***	0.400
				(0.830)	(1.070)	(0.745)				(0.898)	(0.851)	(0.633)
Expected GDP growth (differential)				0.048**	0.053**	0.057***				0.120***	0.113***	0.095***
				(0.021)	(0.021)	(0.015)				(0.026)	(0.023)	(0.017)
Trade Balance (lagged)				-0.108*	-0.255***	0.047				0.175*	-0.032	0.245***
				(0.056)	(0.070)	(0.059)				(0.097)	(0.085)	(0.075)
Trade Openness				0.068	0.136*	-0.056				0.276***	0.303***	0.069
				(0.057)	(0.076)	(0.041)				(0.090)	(0.079)	(0.060)
EPFR/GDP				1.447***	1.680***	0.746**				1.613***	1.859***	0.911***
				(0.289)	(0.327)	(0.312)				(0.308)	(0.299)	(0.210)
Commodity prices	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8755	9149	9017	7950	8312	7871	8755	9149	9017	7950	8312	7871
Countries	55	52	55	51	51	51	55	52	55	51	51	51
R^2	0.99	0.99	0.98	0.99	0.98	0.98	0.98	0.98	0.97	0.98	0.98	0.97
J p-value							0.20	0.29	0.23	0.29	0.35	0.02
Stock & Yogo stat							22.73	24.25	21.38	15.84	18.34	14.56

Standard errors robust to heteroskedasticity in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.3: First stage, baseline results

Dependent variable: foreign exchange intervention (% GDP)

	(1)	(2)	(3)	(4)	(5)	(6)
Exchange rate definition:	Nominal	Real	Real effective	Nominal	Real	Real effective
Exchange rate (lagged)	-0.001	-0.003**	-0.005***	0.000	-0.002	-0.004**
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)
VIX	-0.006**	-0.005**	-0.004*	-0.006**	-0.005**	-0.004*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Interest rate (differential)	-0.130***	-0.095**	-0.116**	-0.148***	-0.108***	-0.113**
	(0.042)	(0.037)	(0.046)	(0.039)	(0.036)	(0.043)
Inflation rate (differential)	0.007**			0.008**		
	(0.003)			(0.003)		
Change in M2/GDP	0.103***	0.104***	0.103***	0.085***	0.089***	0.076***
	(0.023)	(0.022)	(0.025)	(0.019)	(0.019)	(0.019)
Financial dollarization × VIX	-0.009*	-0.011**	-0.010	-0.010*	-0.011*	-0.016**
	(0.005)	(0.005)	(0.007)	(0.006)	(0.005)	(0.007)
Import coverage (lagged)	-0.282**	-0.252*	-0.222	-0.271*	-0.275*	-0.236
	(0.129)	(0.142)	(0.134)	(0.141)	(0.149)	(0.147)
Low import coverage (lagged)	0.049	0.035	0.041	0.003	-0.010	0.020
	(0.044)	(0.042)	(0.042)	(0.040)	(0.038)	(0.040)
Broad money coverage (lagged)	0.018	-0.021	-0.098	-0.051	-0.060	-0.131
	(0.140)	(0.145)	(0.150)	(0.158)	(0.157)	(0.151)
GDP per capita (differential)				-0.672**	-0.482	-0.698*
				(0.289)	(0.333)	(0.367)
Expected GDP growth (differential)				0.025***	0.024***	0.026***
				(0.008)	(0.007)	(0.008)
Trade Balance (lagged)				0.109***	0.100**	0.134***
				(0.039)	(0.038)	(0.043)
Trade Openness				0.076**	0.071*	0.090**
				(0.038)	(0.037)	(0.039)
EPFR/GDP				0.094	0.107	0.140*
				(0.073)	(0.072)	(0.070)
Commodity prices	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8755	9149	9017	7950	8312	7871
Countries	55	52	55	51	51	51
R^2	0.11	0.10	0.10	0.12	0.11	0.10
F stat	7.32	8.18	6.94	6.25	7.14	6.13
F p-value	0.00	0.00	0.00	0.00	0.00	0.00

Standard errors robust to heteroskedasticity in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

iv. a measure of the size of the domestic financial market, also based on GFDD data, encompassing stock market capitalization, and the value of outstanding domestic private and public debt securities.[30]

In general, the correlation across different measures is high, except for the relationship between FXI/M2 and the other metrics (see Appendix Table 3.C.3). As shown in Table 3.4, results with these alternative metrics have the expected sign and are statistically significant in all cases. First stage results are presented in Appendix Table 3.C.4. The magnitude of the coefficient on FXI cannot be directly compared across columns, because of the different scale across FXI measures. However, the marginal effect with respect to FXI/GDP, when using norm J, can be derived as:

$$\frac{\partial \log(ER_{it})}{\partial FXI_{it}^{GDP}} = \gamma \frac{GDP_{it}}{NormJ_{it}} \tag{3.3}$$

Table 3.4: Different normalizations, second stage

Dependent variable: real bilateral exchange rate

	(1)	(2)	(3)	(4)	(5)
FXI/GDP (instrumented)	-1.430***				
	(0.318)				
FXI/M2 (instrumented)		-0.468***			
		(0.096)			
FXI/Financial sector size (IFS, instrumented)			-0.788***		
			(0.165)		
FXI/Financial sector size (WB, instrumented)				-0.586***	
				(0.117)	
FXI/Market size (instrumented)					-0.124***
					(0.037)
Dependent variable (lagged)	0.966***	0.964***	0.965***	0.969***	0.966***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
VIX	-0.043***	-0.044***	-0.041***	-0.047***	-0.045***
	(0.006)	(0.005)	(0.006)	(0.006)	(0.006)
Interest rate (differential)	0.014	0.087	0.006	0.003	0.102
	(0.108)	(0.112)	(0.117)	(0.116)	(0.136)
Commodity prices	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	9149	9053	8741	8424	8515
Countries	52	52	52	48	50
R^2	0.98	0.98	0.98	0.98	0.98
J p-value	0.29	0.41	0.29	0.03	0.08
Stock & Yogo stat	24.25	34.73	27.47	30.16	12.50
Implied effect of FXI/GDP coefficient		-1.40	-1.44	-1.41	-1.61

Standard errors robust to heteroskedasticity in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Evaluated at the mean value of $GDP_{it}/NormJ_{it}$, the marginal effect of FXI^{GDP} is very similar to the baseline estimation (see last row of Table 3.4). Furthermore, equation (3.3) suggests that, as

[30] The latter dataset contains many missing values for some countries. Long-term moving averages are computed to mitigate the limited data.

expected, the effect of FXI^{GDP} on the exchange rate is smaller the larger is the domestic financial market (any of the alternative metrics).

Table 3.5: Testing different normalizations, second stage

Dependent variable: real bilateral exchange rate

	(1)	(2)	(3)	(4)
FXI/GDP (instrumented)	0.226	0.004	-1.851*	-1.131
	(1.063)	(1.519)	(1.008)	(0.857)
FXI/M2 (instrumented)	-0.528*			
	(0.314)			
FXI/Financial sector size (IFS, instrumented)		-0.790		
		(0.764)		
FXI/Financial sector size (WB, instrumented)			0.031	
			(0.360)	
FXI/Market size (instrumented)				-0.058
				(0.063)
Dependent variable (lagged)	0.964***	0.965***	0.967***	0.965***
	(0.004)	(0.003)	(0.003)	(0.004)
VIX	-0.044***	-0.041***	-0.050***	-0.047***
	(0.005)	(0.006)	(0.006)	(0.006)
Interest rate (differential)	0.088	0.006	-0.030	0.052
	(0.112)	(0.117)	(0.114)	(0.126)
Commodity prices	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Observations	9053	8741	8424	8515
Countries	52	52	48	50
R^2	0.98	0.98	0.98	0.98
J p-value	0.27	0.17	0.13	0.21
Stock & Yogo stat	3.71	2.13	5.69	1.65

Standard errors robust to heteroskedasticity in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

To formally test the latter hypothesis, two changes are made to the baseline specification: (i) introduce FXI^{GDP} and FXI^{NormJ} simultaneously in the second stage regression; and (ii) instrument both measures since the particular measure of exogenous FXI might depend on the normalization used.[31] Thus, we run:

$$\log(ER_{it}) = \alpha + \beta \log(ER_{it-1}) + \gamma_1 \widehat{FXI_{it}^{GDP}} + \gamma_2 \widehat{FXI_{it}^{NormJ}} + \boldsymbol{\delta}'\mathbf{X}_{it} + \eta_i + \epsilon_{it} \tag{3.4}$$

$$FXI_{it}^{GDP} = a_1 + b_1 \log(ER_{it-1}) + \mathbf{c}_1'\mathbf{Z}_{it} + \mathbf{d}_1'\mathbf{X}_{it} + u_i + v_{it} \tag{3.5}$$

$$FXI_{it}^{NormJ} = a_2 + b_2 \log(ER_{it-1}) + \mathbf{c}_2'\mathbf{Z}_{it} + \mathbf{d}_2'\mathbf{X}_{it} + w_i + z_{it} \tag{3.6}$$

[31] We use the same instruments regardless of normalization, allowing first stage coefficients (on the instruments and controls) to vary across normalizations. This approach follows from treating each normalization of FXI as a different endogenous variable.

In this setting, the marginal effect of FXI_{it}^{GDP} on the exchange rate is given by:

$$\frac{\partial \log(ER_{it})}{\partial FXI_{it}^{GDP}} = \gamma_1 + \gamma_2 \frac{GDP_{it}}{Norm2_{it}} \tag{3.7}$$

And the coefficients γ_1 and γ_2 test the relevance of the normalizations $\frac{FXI}{GDP}$ and $\frac{FXI}{NormJ}$ respectively. Results (Table 3.5) indicate that the effect of interventions on the exchange rate is not significantly influenced by the depth of the domestic financial system[32] and, as such, do not point to a preferred normalization.

Instrumentation

We conduct two exercises to assess the robustness of our results with respect to the instrumentation strategy. First, we test whether results are driven by any single instrument, by excluding one instrument at a time. Tables 3.6 and 3.7 show that (first and second stage) results are robust to dropping any single instrument. While the strength of the instrumentation comes in part from the change in M2 (as indicated by the weakening of the Stock and Yogo test) the sign and magnitude of the coefficient of FXI in the second stage remains close to the baseline, as well as statistically significant. Results also hold even when both measures related to M2 are excluded from the specification, indicating that the results do not depend on having a measure of broad money in the set of instruments. The coefficient of interest varies between -1.4 and -1.8, which is very close to the baseline specification.

Second, we employ only one instrument at a time (dropping all others). As shown in Table 3.8, the significance of the second stage FXI coefficient falls, to different degrees—and so do the instrumentation tests—but the magnitude of estimated FXI coefficient remains very close to the baseline results. Table 3.9 shows the strength of the relationship between FXI and each of the instruments.

Exchange rate pegs

The baseline estimations include all types of exchange rate regimes (except those classified as de facto free falling or dual exchange rates by Ilzetzki et al. (2010); and countries without their own currency). To confirm that our results are not driven by currencies under pegged regimes, we restrict the sample excluding de-jure regimes with some form of exchange rate targeting, according to three different criteria:

i. excluding de-jure pegs and crawling pegs;

[32] This result is consistent with recent evidence of FXI in countries with large financial systems (e.g. Switzerland, Japan).

Table 3.6: Instrumentation, second stage

Dependent variable: real bilateral exchange rate

	(1)	(2)	(3)	(4)	(5)	(6)
				Dropping from instruments:		
	Baseline	Import coverage	Broad money coverage	Dep. Dollarization × VIX	Change in M2/GDP	Change in M2 & Broad money coverage
FXI/GDP (instrumented)	-1.430***	-1.468***	-1.424***	-1.395***	-1.771***	-1.753***
	(0.318)	(0.339)	(0.318)	(0.321)	(0.678)	(0.677)
Dependent variable (lagged)	0.966***	0.966***	0.966***	0.966***	0.965***	0.965***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)
VIX	-0.043***	-0.043***	-0.042***	-0.042***	-0.045***	-0.045***
	(0.006)	(0.006)	(0.006)	(0.005)	(0.008)	(0.008)
Interest rate (differential)	0.014	0.011	0.015	0.018	-0.017	-0.015
	(0.108)	(0.109)	(0.108)	(0.107)	(0.122)	(0.122)
Commodity prices	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9149	9149	9149	9149	9149	9149
Countries	52	52	52	52	52	52
R^2	0.98	0.98	0.98	0.98	0.98	0.98
J p-value	0.29	0.53	0.29	0.19	0.25	0.21
Stock & Yogo stat	24.25	34.33	30.09	28.08	7.53	9.92

Standard errors robust to heteroskedasticity in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

ii. excluding the latter and ‘narrow crawling band’ regimes (narrower than or equal to +/-2%); and

iii. excluding the latter two and ‘wide crawling band’ï¿½regimes (narrower than or equal to +/-5%).

Results, presented in Appendix Table 3.C.5, are very similar to those of the baseline estimation, with FXI coefficients of somewhat larger absolute magnitude.

The case for excluding de-facto exchange rate targeting regimes is less clear, since these can be thought of as instances where there is clear evidence of effectiveness of FXI. Still, to test the robustness of our results, we restrict the sample in the same way as above, but by excluding cases of de-facto peg exchange rate regimes. Results, also presented in Appendix Table 3.C.5, are broadly similar to the baseline.

Other policy responses

Policy measures other than FXI can also influence or affect the impact of FXI on the exchange rate. Capital control measures and changes in the monetary policy interest rate are most prominent at high frequency. Adequately controlling for these is key to ensure our estimates on FXI are unbiased.

Table 3.7: Instrumentation, first stage

Dependent variable: foreign exchange intervention (% GDP)

	(1)	(2)	(3)	(4)	(5)	(6)
Exchange rate (lagged)	-0.003**	-0.003***	-0.003**	-0.003***	-0.003**	-0.003**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
VIX	-0.005**	-0.005**	-0.005**	-0.007***	-0.005**	-0.005**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Interest rate (differential)	-0.095**	-0.091**	-0.095**	-0.105***	-0.097**	-0.097**
	(0.037)	(0.038)	(0.039)	(0.039)	(0.039)	(0.040)
Change in M2/GDP	0.104***	0.104***	0.104***	0.105***		
	(0.022)	(0.022)	(0.022)	(0.022)		
Financial dollarization × VIX	-0.011**	-0.010**	-0.011**		-0.013**	-0.013**
	(0.005)	(0.005)	(0.005)		(0.005)	(0.005)
Import coverage (lagged)	-0.252*		-0.262**	-0.243*	-0.242*	-0.249**
	(0.142)		(0.113)	(0.140)	(0.144)	(0.116)
Low import coverage (lagged)	0.035		0.037	0.041	0.038	0.039
	(0.042)		(0.045)	(0.041)	(0.044)	(0.047)
Broad money coverage (lagged)	-0.021	-0.219*		-0.042	-0.015	
	(0.145)	(0.130)		(0.140)	(0.143)	
Commodity prices	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9149	9149	9149	9149	9149	9149
Countries	52	52	52	52	52	52
R^2	0.10	0.10	0.10	0.10	0.09	0.09
F stat	8.18	12.22	10.22	8.01	3.84	5.16
F p-value	0.00	0.00	0.00	0.00	0.01	0.00

Standard errors robust to heteroskedasticity in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Capital controls. The presence of capital flow restrictions gives rise to two issues. First, contemporaneous changes in those restrictions could lead to omitted variable bias if not controlled for. Ideally, the estimation should include a measure of changes in such restrictions. However, existing capital control indices are only available (for a large set of countries) at an annual frequency, thus preventing a proper identification of the timing of the measures at monthly frequency. To bypass this obstacle, we exclude from the sample country/year observations for which a change in the Quinn and Toyoda index of capital controls is identified at an annual frequency.[33] The sample is reduced by about 7 percent, and results (Appendix Table 3.C.6, columns 1 and 2) do not change significantly. The coefficient of interest is slightly smaller in absolute value, suggesting that there is some use of capital flow measures contemporaneously to FXI in the baseline sample. Second, differences in capital flow restrictions across countries could give rise to heterogeneous coefficients for the control variables and thereby affect the FXI coefficient. To allow for such heterogeneity

[33]This criterion should suffice to exclude between year variations. There is still the possibility that capital flow measures are taken and reverted within the year, and so would not show in the annual values. However, countries rarely use capital control in such high frequency basis. See, for example, Fernández et al. (2013).

Table 3.8: Using individual instruments, second stage

Dependent variable: real bilateral exchange rate

Instrumenting only with:	(1) Change in M2/GDP	(2) Dep. Dollarization × VIX	(3) Import coverage	(4) Broad money coverage
FXI/GDP	-1.310***	-1.995	-1.614**	-2.454**
	(0.359)	(1.355)	(0.741)	(1.231)
Dependent variable (lagged)	0.967***	0.964***	0.966***	0.962***
	(0.003)	(0.006)	(0.004)	(0.006)
VIX	-0.042***	-0.047***	-0.044***	-0.051***
	(0.006)	(0.012)	(0.008)	(0.011)
Interest rate (differential)	0.025	-0.037	-0.002	-0.079
	(0.108)	(0.166)	(0.123)	(0.158)
Commodity prices	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Observations	9149	9149	9149	9149
Countries	52	52	52	52
R^2	0.98	0.98	0.98	0.97
J p-value			0.08	
Stock & Yogo stat	85.44	9.94	11.28	8.91

Standard errors robust to heteroskedasticity in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

related to capital controls, we modify the baseline specification by including interactions of the key external financial variables (that would normally drive capital flows) with the lagged index of capital controls.[34] We find results similar to the baseline specification (Appendix Table 3.C.6, columns 3 and 4).[35]

Interest rate changes. One somewhat surprising result in the baseline specification relates to the coefficient of the interest rate differential in the second stage, which is quite small and non-significant. Two main issues could affect the result. First, the interest rate may be endogenous to exchange rate movements, if countries in our sample used the interest rate as a tool to 'defend' the exchange rate. Such endogeneity would tend to hide the true effect of interest rate shocks on the exchange rate. To explore this, we estimate an alternative model where we also instrument the interest rate differential by adding an extra equation in the first stage for the interest rate.[36] Second, domestic and foreign interest rates may have asymmetric effects on the exchange rate. To allow for this

[34] As before, we employ the Quinn and Toyoda index, which varies between 0 and 100 (100 being more open).

[35] The possible complementarity of FXI and capital controls is also a relevant aspect, although beyond the scope of this paper. See 3.B for a related discussion.

[36] Whether the set of instruments used for FXI is appropriate for the interest rate is certainly debatable, although the instrumentation tests are passed. Arguably, instrumenting the interest rate properly with the aim of identifying its effect on exchange rates would likely entail searching for exogenous reasons for moving the policy rate, beyond those found for FXI. However, our interest does not lie in the interest rate coefficient. Our goal is simply to ensure that the possible correlation between interest rate changes and FXI does not lead to a bias in the coefficient of the latter. That is, there might be other sources of exogenous interest rate movements, but provided they do not drive exogenous FXI movements our estimation should not suffer from collinearity between interest rates and FXI. This justifies the use of the same set of instruments for both variables.

Table 3.9: Using individual instruments, first stage

Dependent variable: foreign exchange intervention (% GDP)				
	(1)	(2)	(3)	(4)
Exchange rate (lagged)	-0.004***	-0.004***	-0.003**	-0.003***
	(0.001)	(0.001)	(0.001)	(0.001)
VIX	-0.008***	-0.005**	-0.008***	-0.008***
	(0.002)	(0.002)	(0.002)	(0.002)
Interest rate (differential)	-0.087**	-0.080*	-0.107**	-0.104**
	(0.042)	(0.041)	(0.041)	(0.040)
Change in M2/GDP	0.104***			
	(0.022)			
Financial dollarization × VIX		-0.014***		
		(0.005)		
Import coverage (lagged)			-0.251**	
			(0.116)	
Low import coverage (lagged)			0.047	
			(0.046)	
Broad money coverage (lagged)				-0.227*
				(0.125)
Commodity prices	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Observations	9149	9149	9149	9149
Countries	52	52	52	52
R^2	0.10	0.09	0.09	0.09
F stat	22.51	8.38	4.65	3.30
F p-value	0.00	0.01	0.01	0.08

Standard errors robust to heteroskedasticity in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

possibility, we introduce these two interest rates separately in the model. These variations deliver mixed results (Appendix Table 3.C.7) regarding the estimated effect of interest rate changes on the exchange rate, but in all cases the coefficient of FXI in the second stage remains basically unaltered.[37]

Measures of FXI

So far, we have relied on the change in the central bank NFA position as a proxy for FXI. While this is consistent with other studies, this measure is polluted by factors other than FXI that affect

[37] For the instrumentation of the interest rate differential, $Findol \times VIX$ is significant and positive in the first stage, suggesting that indeed, in dollarized economies, the interest rate is used as a tool to stabilize the value of the domestic currency in response to external financial (VIX) shocks.

the NFA position, like valuation effects and income flows generated by assets and liabilities. Thus, we conduct a series of robustness checks on our proxy for FXI:

i. Excluding observations with small absolute values (10% smallest) of FXI, as these may be particularly affected by valuation effects and income flows.

ii. Using a more refined proxy of FXI that adjusts for estimates of valuation effects and income flows. A detailed description of the methodology is available in 3.A.

iii. Including off-balance sheet operations in our proxy of FXI in order to capture the increasing use of non-spot instruments (i.e. FX derivatives). See also 3.A.

iv. Using changes in *gross* international reserves (rather than relaying on a net concept).

We find that results are very stable, reflecting the fact that the different measures of FXI are highly correlated (see Appendix Tables 3.C.8 and 3.C.9).

3.2.4 Other robustness checks

We conduct a number of additional robustness checks (reported in Appendix Table 3.C.10), which include:

i. Changing the treatment of outliers and the sample period. This includes dropping 2% top and bottom outliers; winsorizing the data (1% and 2%); dropping the crisis period (from June 2008 to May 2009); dropping the Asian crisis period; and dropping the largest 5% and 10% FXI/GDP observations.

ii. Exploring alternative measures of exogenous financial shocks, substituting the VIX by the EMBI Global sovereign spread or our measure of EPFR flows to other countries. These alternative variables are used both as controls and as instruments interacted with deposits dollarization. We also simply add the EMBI to the baseline specification as an additional control.

iii. Allowing for country-specific coefficients for VIX, interest rate, and both.

iv. Adding a measure of the real effective exchange rate gap, defined by deviations from an HP filter.

v. Accounting for possible structural breaks related to changes in monetary policy regimes. This includes restricting the sample period to 2003-13 (as most countries consolidated their current regimes in the early 2000s); and restricting the sample only to inflation targeting (IT) countries/periods.

vi. Controlling for the change in the monetary base. The baseline specification controls for the interest rate (differential) to ensure that the estimated effect of FXI does not reflect changes in the monetary policy stance. To further ensure that results are not polluted by the effect of unsterilized interventions, we add the change in the monetary base (in percent of GDP) as a control; and find that results hold.

vii. Finally, estimating a model in first differences out of possible concerns about stationarity. The estimated coefficient for FXI is still negative and statistically significant, although smaller in absolute magnitude. The latter is not surprising since this specification differs from the benchmark in its assumptions about exchange rate dynamics. In the baseline, the introduction of lagged exchange rate level allows for a gradual mean reversion of shocks, while the first differences specification imposes the assumption that shocks have permanent effects. In the next section, we study the persistence of FXI effects more in depth.

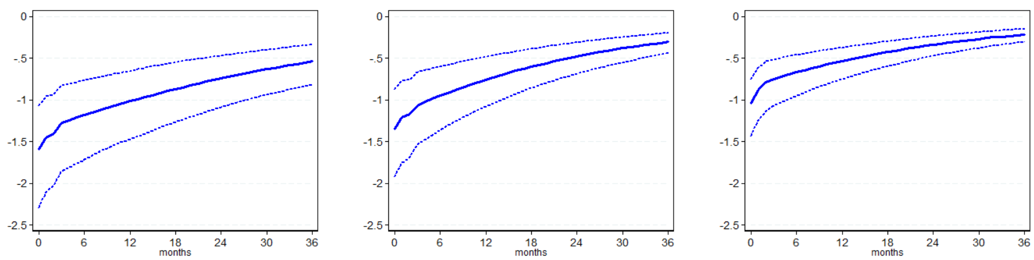
Overall, results display very stable estimates for the effect of FXI on the exchange rate, with magnitudes consistent with those of the baseline specification.

3.3 Extensions

3.3.1 Dynamic Effects

So far, we have focused on the contemporaneous impact of FXI on the exchange rate. And, while the baseline specification allows for some persistent effects through the autoregressive term, different shocks (including FXI) may have different degrees of persistence. In this section we extend our analysis to study this aspect, the understanding of which is paramount to the policy maker. Specifically, lagged values of FXI are added to our benchmark specification. We use up to three lags as coefficients on further lags were not significant. Contemporaneous FXI is instrumented as before, while lags of FXI are included in both the first and second stages as controls as these are exogenous to the current exchange rate. Figure 3.1 displays the implied dynamics of a FXI (FX purchase) of 1 percent of GDP for the different exchange rate measures (corresponding to columns 1-3 in Appendix Table 3.C.11). The immediate impact of FXI on the exchange rate remains similar to our benchmark specification. Effects are relatively persistent, and relatively more so for the nominal than for the real exchange rate. The coefficients of the three FXI lags are positive, meaning that the impact of FXI on the exchange rate decreases over time and that this decay is faster than that of an average shock (captured by the auto-regressive coefficient of the exchange rate). The half-life of FXI shocks (bottom row of Appendix Table 3.C.11) ranges between 12 and 23 months, displaying the highest values for the nominal bilateral exchange rate, and lowest for the real effective exchange rate. This result suggests that FXI may be more effective in affecting nominal than real variables, as one would expect.

Figure 3.1: Impulse response functions of nominal, real and real effective exchange rates



(a) NER (b) RER (c) REER

Dashed lines show bootstrapped confidence intervals.

These half-life estimates remain below those of a general shock to the exchange rate, which lie between 18 and 29 months according to our baseline estimates. The latter are broadly consistent with findings of previous studies, which ranged between 2 and 7 years, depending on the approach.[38] A number of additional robustness checks (see Appendix Table 3.C.12) confirm these results.[39]

3.3.2 Asymmetric effects

Finally, we study whether FXI effects are asymmetric, i.e. whether positive interventions (FX purchases) are more/less effective than negative ones (FX sales). A priori, one can think of two different reasons for possible asymmetric effects, which go in opposite directions:

i. On the one hand, a lower bound on the amount of reserves may constrain the central bank's ability to defend a specific exchange rate level. As agents anticipate this, FX sales may have limited effects on the exchange rate.

ii. On the other hand, while the central bank balance sheet can be expanded unlimitedly through positive FXI (FX purchases), larger FX positions tend to entail a quasi fiscal cost and so FXI may not be sustained indefinitely.[40] Expectations about the latter could, again, render FXI ineffective.

We examine possible asymmetric effects by enriching the specification to allow for a differentiated effect. Specifically:

[38] Frankel and Rose (1996) find a half-life of 4 years for a panel of 150 countries; while Cheung and Lai (2000) obtain a half-life of 2-5 years for advanced countries, and below 3 years for emerging economies. More recently, Chortareas and Kapetanios (2013) suggest a new definition of the half-life, and obtain estimates ranging from 1 to 2 years.

[39] Without the outlier treatment, the effect of FXI is in general stronger, but also less persistent, reflecting a combination of smaller autoregressive coefficients and higher coefficients for the lagged FXI regressors.

[40] See Adler and Mano (2015) for a documentation of the quasi fiscal costs of carrying out FXI.

$$\log(ER_{it}) = \alpha + \beta \log(ER_{it-1}) + \gamma_1 \widehat{FXI}_{it} + \gamma_2 \widehat{FXI_{it}^{POS}} + \boldsymbol{\delta}'\mathbf{X}_{it} + \eta_i + \epsilon_{it} \tag{3.8}$$

$$FXI_{it} = a_1 + b_1 \log(ER_{it-1}) + \mathbf{c}_1'\mathbf{Z}_{it} + \mathbf{e}_1'[\mathbf{Z}_{it} \times \mathbb{I}\left(\widehat{FXI}_{it} > 0\right)] + \mathbf{d}_1'\mathbf{X}_{it} + u_i + v_{it} \tag{3.9}$$

$$\widehat{FXI_{it}^{POS}} \equiv \widehat{FXI}_{it} \times \mathbb{I}\left(\widehat{FXI}_{it} > 0\right) \tag{3.10}$$

Where the innovation relative to the baseline is that positive interventions (FXI_{it}^{POS}) are instrumented separately. Our interest lies in the sign of the coefficient γ_2, which indicates whether positive interventions are more ($\gamma_2 < 0$) or less effective ($\gamma_2 > 0$) than negative ones.

As is shown in Table 3.1, we find no evidence of an asymmetric effect in either direction, suggesting that positive and negative FXI are equally effective.

Conclusions

We study the effect of FXI on the level of the exchange rate, using an instrumental-variables panel setting in a large sample of countries and time. We find robust evidence that intervention affects the level of the exchange rate in a meaningful way. A purchase of foreign currency of 1 percentage point of GDP causes a depreciation of the nominal and real exchange rate in the ranges of [1.7-2.0] percent and [1.4-1.7] percent respectively. Effects are found to be quite persistent, pointing to a half-life in the range of [12-23] months, depending on the specification. Finally, positive and negative interventions appear to be equally effective, suggesting that FXI is a useful policy tool both when facing appreciation and depreciation pressures. Overall, these results indicate that FXI is an effective policy instrument for macroeconomic management.

Table 3.1: Asymmetric effects: Second stage

Dependant variable: exchange rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Including de jure pegs			Excluding de jure pegs			Including de jure pegs			Excluding de jure pegs		
Exchange rate definition:	Nominal	Real	Real effective	Nominal	Real	Real effective	Nominal	Real	Real effective	Nominal	Real	Real effective
FXI/GDP (instrumented)	-1.224	-1.392	-2.523***	-0.914	-1.016	-2.438**	-1.370	-1.398	-1.638*	-0.572	-0.403	-1.182
	(0.783)	(0.905)	(0.772)	(1.085)	(1.246)	(1.232)	(0.953)	(0.909)	(0.925)	(1.128)	(1.116)	(1.264)
Positive FXI/GDP	-0.219	0.180	1.720***	-0.651	-0.528	1.366	-0.287	-0.023	0.439	-1.102	-1.136	0.014
	(0.557)	(0.769)	(0.652)	(0.855)	(1.083)	(1.100)	(0.650)	(0.680)	(0.774)	(0.870)	(0.952)	(1.064)
Dependant variable (lagged)	0.977***	0.968***	0.963***	0.972***	0.962***	0.961***	0.974***	0.953***	0.959***	0.968***	0.946***	0.958***
	(0.005)	(0.005)	(0.005)	(0.004)	(0.005)	(0.007)	(0.006)	(0.007)	(0.006)	(0.005)	(0.006)	(0.007)
VIX	-0.052***	-0.038***	-0.012*	-0.054***	-0.041***	-0.018**	-0.057***	-0.045***	-0.019**	-0.056***	-0.045***	-0.018**
	(0.008)	(0.007)	(0.007)	(0.008)	(0.007)	(0.008)	(0.009)	(0.008)	(0.008)	(0.009)	(0.008)	(0.009)
Interest rate (differential)	-0.179	0.065	0.223	-0.237	0.058	0.212	-0.179	0.175	0.348***	-0.205	0.170	0.316
	(0.184)	(0.171)	(0.165)	(0.220)	(0.195)	(0.192)	(0.198)	(0.179)	(0.198)	(0.243)	(0.194)	(0.225)
Inflation rate (differential)	0.053***			0.062***			0.057***			0.062***		
	(0.013)			(0.016)			(0.016)			(0.018)		
Commodity prices	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Expanded set of controls	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8755	9149	9017	7688	8032	7589	7950	8312	7871	7083	7371	6980
Countries	55	52	55	48	48	48	51	51	51	46	46	46
R^2	0.99	0.99	0.98	0.98	0.98	0.98	0.99	0.98	0.98	0.98	0.98	0.98

Bootstrapped standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix

3.A Proxies for FXI

Adjusting NFA for valuation and income flows

A general problem faced by the literature on foreign exchange intervention (FXI) is the lack of comprehensive data on such operations. Only a handful of countries, mostly advanced economies, publish actual intervention data. In absence of such data, much of the research has been conducted using changes in reserves as a proxy for FXI, although the latter measure is polluted by valuation effects as well as income flows (generated by the return on assets). Here, we follow an alternative approach aiming at adjusting reserves series for such components and thus constructing a more precise proxy for intervention.

This approach is based on Dominguez (2012), except that we focus on a net concept of reserves, as opposed to a gross concept. Define country j's foreign exchange intervention (i.e., purchases) at time t as:

$$FXI_{j,t} \equiv \Delta NFCA_{j,t} - \Delta^{val} NFCA_{j,t} - \Delta^{inc} NFCA_{j,t} \tag{3.11}$$

where $\Delta NFCA_{j,t}$ denotes changes in net foreign currency assets; $\Delta^{val} NFCA_{j,t}$ denotes valuation changes and $\Delta^{inc} NFCA_{j,t}$ stands for income flows on the next foreign currency position. We estimate each of these as:

$$\Delta NFCA_{j,t} = \sum_{s \in S} \Delta H^s_{j,t} \tag{3.12}$$

$$\Delta^{val} NFCA_{j,t} = \sum_{s \in S} (P^s_t - P^s_{t-1}) H^s_{j,t-1} \tag{3.13}$$

$$\Delta^{inc} NFCA_{j,t} = \sum_{s \in S} i^s_{t-1} H^s_{j,t-1} \tag{3.14}$$

where $H^s_{j,t}$ is the net position on a security s at time t; P^s_t denotes the market price of foreign asset s at time t; and i^s_t denotes the monthly interest rate on those securities. The price of a (zero coupon) security maturing n months ahead is estimated by $(1 + i^s_t)^{-n}$.

The break-down of foreign currency assets into different securities is given by the IMF's Data Template on International Reserves and Foreign Currency Liquidity. The currency composition of the different securities (not provided by the template) is assumed to be uniform across the asset class, and broken down into 7 major currencies, as indicated in the Currency Composition of Official Foreign Exchange Reserves (COFER) dataset. These include: US dollar, the Australian dollar, Canadian dollar, British pound, Japanese Yen, Swiss Franc and Euro. Because the Fund's reserve template only focuses on assets, the data is complemented by using the series of central bank foreign liabilities available through IMF's International Financial Statistics. As noted by Dominguez (2012), most central banks claim to hold primarily long-term government bonds. Thus, we follow her in assuming that securities are mostly composed of 10-year bonds. Also along the lines of Dominguez (2012) and Dominguez et al. (2012), 3-month interbank yields are used as proxies for returns on holdings of foreign currency and deposits. Valuation effects are zero for the latter assets. The IMF's reserve position and holdings of SDR are valued at the SDR rate, and generate income according to the SDR interest rate. Gold holdings are valued at market prices. Table 3.A.1 summarizes the information used to make this valuation and income flow adjustments.

Off Balance Sheet FX Interventions

We also construct a measure that, in addition to the adjustment for valuation effects and income flows, accounts for off-balance sheet (non-spot) operations, as:

$$FXI_{j,t} \equiv \Delta NFCA_{j,t} - (\Delta^{val} NFCA_{j,t} + \Delta^{inc} NFCA_{j,t}) + OBS_{i,t} \tag{3.15}$$

where $OBS_{i,t}$ include changes in aggregate short and long positions in forwards and futures in foreign currencies vis-a-vis the domestic currency (including the forward leg of currency swaps), and financial instruments denominated in foreign currency but settled by other means (e.g., in domestic currency), as reported in the *International Reserves and Foreign Currency Liquidity Template*.

Table 3.A.1: Valuation adjustments

Type of asset	Currency Structure	Asset/Maturity Structure	Valuation adjustment	Estimated Income
Official Reserve Assets				
Foreign currency reserves				
Securities	Currency shares from COFER (US$, €, £, ¥, A$, C$, and SFranc)[1]	10-year sovereign bonds[2]	Implicit market value based on 10-year rate[3]	10-year coupon rate

continued

Table 3.A.1: Valuation adjustments

<table>
<tr><th>Type of asset</th><th>Currency Structure</th><th>Asset/Maturity Structure</th><th>Valuation adjustment</th><th>Estimated Income</th></tr>
<tr><td>Official Reserve Assets</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Foreign currency reserves</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Total currency and deposits</td><td></td><td>3-month CD</td><td>None</td><td>3-month interbank rate</td></tr>
<tr><td>IMF reserve position</td><td rowspan="2">SDR basket</td><td rowspan="2">SDR basket</td><td rowspan="2">SDR valuation changes</td><td rowspan="2">SDR rate</td></tr>
<tr><td>SDRs</td></tr>
<tr><td>Gold</td><td>None</td><td>None</td><td>Gold Price variations</td><td>None</td></tr>
<tr><td>Other reserve assets</td><td>Currency shares from COFER (US$, €, £, ¥, A$, C$, and SFranc)</td><td>10-year sovereign bonds</td><td>Implicit market value based on 10-year rate</td><td>10-year coupon rate</td></tr>
</table>

Source: IMF COFER and Data Template on International Reserves /Foreign Currency Liquidity.

[1] Using annual aggregate statistics for the groups of emerging market economies. Weights are adjusted proportionally to add to 1.

[2] As in Dominguez (2012), assumes 10-year maturity holdings.

[3] Computed from the market interest rate.

3.B Capital controls

Other recent studies have pointed to the possible complementarity between FXI and restrictions on capital mobility.[41] While this aspect is somewhat beyond the scope of the paper, we discuss this issue briefly, using our set-up and allowing for an interaction term between FXI and different measures of capital controls. Similarly to previous extensions, the interacted term is instrumented separately, and the set of instrumental variables includes the baseline instruments both alone and interacted with capital controls. Specifically:

$$\log(ER_{it}) = \alpha + \beta \log(ER_{it-1}) + \gamma_3 \widehat{FXI_{it}^{GDP}} + \gamma_4 (\widehat{FXI_{it}^{GDP} \times KC_{it-1}}) + \boldsymbol{\delta}'\mathbf{X}_{it} + \eta_i + \epsilon_{it} \tag{3.16}$$

$$FXI_{it}^{GDP} = a_3 + b_3 \log(ER_{it-1}) + \mathbf{c}_3'\mathbf{Z}_{it} + \mathbf{e}_3'(\mathbf{Z}_{it} \times KC_{it-1}) + \mathbf{d}_3'\mathbf{X}_{it} + u_i + v_{it} \tag{3.17}$$

$$FXI_{it}^{GDP} \times KC_{it-1} = a_4 + b_4 \log(ER_{it-1}) + \mathbf{c}_4'\mathbf{Z}_{it} + \mathbf{e}_4'(\mathbf{Z}_{it} \times KC_{it-1}) + \mathbf{d}_4'\mathbf{X}_{it} + w_i + z_{it} \tag{3.18}$$

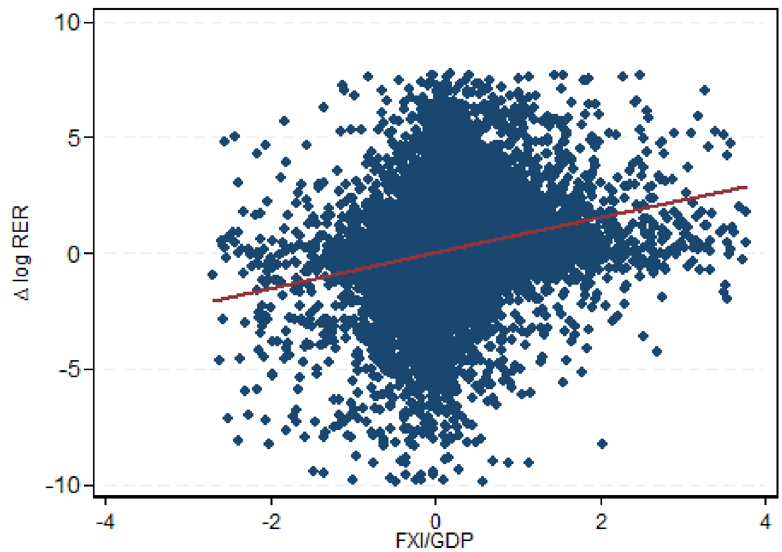
[41] Bayoumi et al. (2014) find that the impact of FXI on the current account is larger for economies with greater restrictions on capital flow mobility.

The innovation relative to the baseline is the interaction with capital controls (KC_{it}), for which we use three different indices: Schindler (2009), Quinn and Toyoda (2008) and Chinn and Ito (2006). Each index is introduced in levels, or as threshold dummies for high capital controls (using different threshold values). We explore both absolute (time-invariant) and time-varying thresholds based on the period cross-country distribution of the index. Lagged values of capital controls are used to mitigate endogeneity concerns, and the level of capital controls is also included as a control variable.

Our results (not reported) do not lend support to the hypothesis of complementarity between capital controls and FXI; and in some cases they are counter-intuitive, suggesting that the effect of FXI on the exchange rate may decrease with higher levels of capital controls. These results point to the complexity of the relationship between FXI and restrictions on capital mobility, policy tools that could be used as complements or as substitutes of each other. For instance, restrictions on capital flows in the form of 'quotas' could increase the effectiveness of FXI, by reducing the substitutability between domestic and foreign assets. But imposing capital controls could also render FXI unnecessary, if it suffices to maintain exchange rate stability. In the latter case, we would simultaneously observe high capital controls and very low levels of intervention. Furthermore, the set of instruments used in the baseline specification may not be appropriate when exploring the interaction between capital controls and FXI, as reserve accumulation and exchange rate stabilization motives are likely to change in the presence of significant restrictions on capital mobility.

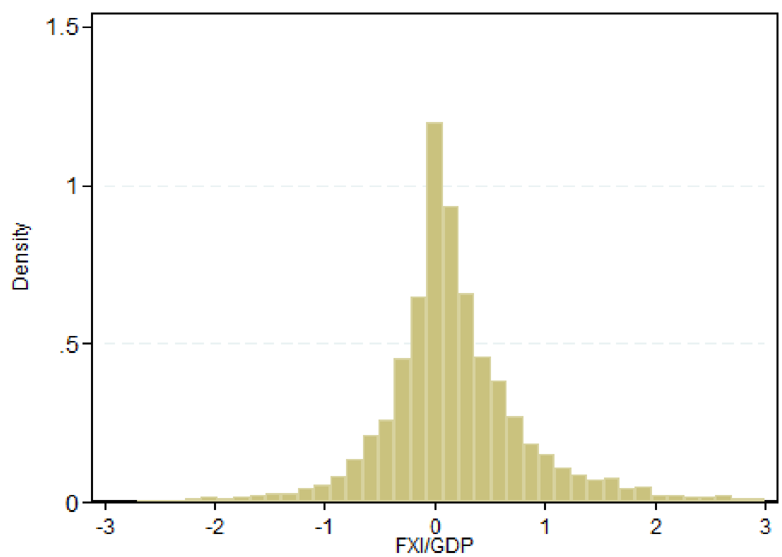
3.C Further results

Figure 3.C.1: Correlation between the change in log(RER) and FXI/GDP



Sources: IMF International Financial Statistics; and authors' calculations

Figure 3.C.2: Distribution of FXI/GDP



Sources: IMF International Financial Statistics; and authors' calculations

Table 3.C.1: Country list

	IFS code	Start date	End date	Obs
Argentina	213	Feb 1996	Dec 2011	173
Armenia	911	Feb 1996	Aug 2013	206
Australia	193	Feb 1996	Sep 2013	203
Bolivia	218	Feb 1996	Aug 2013	208
Brazil	223	Feb 1996	Sep 2013	191
Bulgaria	918	Aug 1997	Sep 2013	184
Canada	156	Feb 1996	Aug 2013	209
Chile	228	Feb 1996	Sep 2013	209
China	924	Jul 1999	Sep 2013	152
Colombia	233	Feb 1996	Oct 2013	210
Costa Rica	238	Feb 1996	Aug 2013	211
Croatia	960	Feb 1996	Jun 2013	206
Czech Republic	935	Feb 1996	Sep 2013	205
Denmark	128	Feb 1996	Sep 2013	201
Egypt	469	Jan 2001	Aug 2013	149
Guatemala	258	Jan 1997	May 2010	160
Honduras	268	Jan 2001	Sep 2013	153
Hong Kong	532	Jan 1997	Aug 2013	122
Hungary	944	Jan 2000	Sep 2013	152
India	534	Jan 1999	Sep 2013	177
Indonesia	536	Feb 1996	Dec 2012	173
Israel	436	Feb 1996	Jan 2010	168
Japan	158	Feb 1996	Aug 2013	135
Kazakhstan	916	Jul 2000	Dec 2012	142
Kenya	664	Mar 2002	Dec 2011	115
Korea	542	Feb 1996	Aug 2013	194
Lithuania	946	Feb 1996	Sep 2013	206
Malaysia	548	Feb 1996	Jul 2013	191
Mexico	273	Apr 1996	Sep 2013	207
Moldova	921	Mar 2000	Oct 2013	159
New Zealand	196	Feb 1996	Jun 2011	177
Nicaragua	278	Jan 2006	Dec 2012	84
Nigeria	694	Jun 2007	Dec 2012	62
Norway	142	Feb 1996	Jan 2008	141
Pakistan	564	Feb 1996	Sep 2013	207
Paraguay	288	Feb 1996	Sep 2013	205
Peru	293	Feb 1996	Sep 2013	212
Philippines	566	Feb 1996	Apr 2013	192
Poland	964	Feb 1996	Sep 2013	201
Romania	968	Apr 2001	Sep 2013	142
Russia	922	Dec 1999	Sep 2013	161
Saudi Arabia	456	Feb 1996	Mar 2013	178
South Africa	199	Jan 1999	Oct 2013	162
Sri Lanka	524	Feb 1996	Jan 2013	202
Sweden	144	Feb 1996	Sep 2013	205
Switzerland	146	Jan 1998	Sep 2013	171
Thailand	578	Feb 1996	Oct 2013	200
Turkey	186	Nov 1999	Sep 2013	130
Ukraine	926	Nov 1998	Sep 2013	166
United Kingdom	112	Feb 1996	Sep 2013	199
Uruguay	298	Feb 1996	Sep 2013	197
Vietnam	582	Feb 1996	Jul 2013	184

Table 3.C.2: Variables list and definition

Variable Name	Definition	Source
NER	Nominal bilateral exchange rate (increase=appreciation)	IFS
RER	Real bilateral exchange rate, computed from NER and CPI, increase=appreciation	CPI: datastream, IFS
REER	Real effective exchange rate (increase=appreciation)	IFS
FXI/GDP	Foreign exchange intervention (FXI) proxy, computed as the change in the central bank's net foreign assets, normalized by annual HP trend US dollar GDP (in percentage points)	IFS
FXI/GDP (net of valuation gains and income flows)	FXI proxy, computed as the change in the central bank's net foreign assets and adjusted for valuation gains and income flows, normalized by annual HP trend US dollar GDP (in percentage points)	Authors' calculations based on IFS; IMF's Data Template on International Reserves and Foreign Currency Liquidity; and IMF's COFER dataset
FXI/GDP (net of valuation and income flows and including off-balance sheet operations)	FXI proxy, computed as the change in the central bank's net foreign assets, adjusted for valuation gains and income flows, and including off-balance sheet operations; normalized by annual HP trend US dollar GDP (in percentage points)	
FXI/GDP (gross)	FXI proxy, computed as the change in the central bank's gross foreign assets, normalized by annual HP trend US dollar GDP (in percentage points)	IFS
FXI/M2	FXI proxy, computed as the change in the central bank's net foreign assets, normalized by annual smoothed broad money (% points)	IFS
FXI/FSS (narrow)	FXI proxy, computed as the change in the central bank's net foreign assets, normalized by annual smoothed financial sector size (IFS data) (% points)	IFS
FXI/FSS (broad)	FXI proxy, computed as the change in the central bank's net foreign assets, normalized by annual smoothed financial sector size (WB data) (% points)	IFS, World Bank GFDD
FXI/MS	Foreign exchange intervention, computed as the change in the central bank's net foreign assets, normalized by annual smoothed market size (% points)	IFS, World Bank GFDD
VIX	Chicago Board Options Exchange Market Volatility Index (VIX)	Haver Analytics
Interest rate differential	log(1+i)-log(1+i*), where i is the domestic interest rate and i* is the US interest rate (% points)	IFS
Change in M2	Change in broad money over the past month, normalized by smoothed GDP (% points)	IFS
Financial dollarization	Share of domestic deposits denominated in foreign currency (% points)	Levy-Yeyati (2006), IMF country desks
Imports coverage	Central bank's net foreign assets over yearly imports (% points)	IFS, DOTS
Low imports coverage	Time-varying dummy equal to 1 if imports coverage are below the cross-country first quartile	IFS, DOTS
Broad money coverage	Central bank's net foreign assets over M2 (% points)	IFS
GDP per capita (differential)	Difference bewteen domestic GDP per capita in country i and the U.S., in logarithm.	WEO
Expected GDP growth (differential)	Current year expected GDP growth, relative to the U.S.	Consensus Forecast
Trade balance	Exports minus imports of the current month (% points)	DOTS
Trade openness	Rratio of yearly imports plus exports over GDP, smoothed by a 3 years moving average (% points)	DOTS, IFS
EPFR/GDP	Sum of yearly flows of funds towards other countries, normalized by GDP of other countries (% points)	EPFR Flow of Funds
EMBI	EMBI global spread (basis points)	Bloomberg
Inflation	Yearly inflation rate over past 12 months, computed from CPI (% points)	IFS, Datastream
Capital controls	Quinn & Toyoda index for capital controls (the higher, the more open)	Quinn & Toyoda, IMF
Commodity prices	Price indexes for food, metal and energy prices	IFS

Table 3.C.3: FXI normalizations correlations

	FXI/GDP	FXI/M2	FXI/FSS (IFS)	FXI/FSS (WB)	FXI/MS
FXI/GDP	1				
FXI/M2	0.819***	1			
FXI/FSS (IFS)	0.848***	0.843***	1		
FXI/FSS (WB)	0.794***	0.804***	0.942***	1	
FXI/MS	0.325***	0.467***	0.413***	0.473***	1

Table 3.C.4: Different normalizations: First stage

Dependent variable: foreign exchange intervention (% GDP)

	(1) FXI/GDP	(2) FXI/M2	(3) FXI/FSS(IFS)	(4) FXI/FSS(WB)	(5) FXI/MS
Exchange rate (lagged)	-0.003**	-0.013***	-0.005**	-0.005	-0.037**
	(0.001)	(0.005)	(0.002)	(0.003)	(0.018)
VIX	-0.005**	-0.007	-0.008**	-0.012**	-0.041
	(0.002)	(0.005)	(0.003)	(0.004)	(0.025)
Interest rate (differential)	-0.095**	-0.256	-0.195**	-0.237**	-0.881
	(0.037)	(0.153)	(0.083)	(0.109)	(0.990)
Change in M2/GDP	0.104***	0.305***	0.202***	0.318***	1.136***
	(0.022)	(0.073)	(0.045)	(0.078)	(0.379)
Financial dollarization × VIX	-0.011**	-0.071***	-0.028***	-0.038***	-0.205**
	(0.005)	(0.023)	(0.010)	(0.013)	(0.099)
Import coverage (lagged)	-0.252*	-0.663	-0.268	-0.118	0.920
	(0.142)	(0.510)	(0.339)	(0.419)	(1.345)
Low import coverage (lagged)	0.035	0.022	0.022	0.088	0.722
	(0.042)	(0.125)	(0.091)	(0.106)	(0.785)
Broad money coverage (lagged)	-0.021	-0.443	-0.242	-0.463	-4.733
	(0.145)	(0.979)	(0.563)	(0.756)	(3.013)
Commodity prices	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	9149	9053	8741	8424	8515
Countries	52	52	52	48	50
R^2	0.10	0.11	0.14	0.11	0.15
F stat	8.18	7.46	7.64	7.11	2.87
F p-value	0.00	0.00	0.00	0.00	0.02

Standard errors robust to heteroskedasticity in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.C.5: Excluding de jure and de facto pegs: Second stage

Dependent variable: real bilateral exchange rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Excluding de jure:						Excluding de facto:					
	Pegs		Crawling bands		Wide bands		Pegs		Crawling bands		Wide bands	
FXI/GDP (instrumented)	-1.714***	-1.747***	-1.650***	-1.695***	-1.678***	-1.765***	-1.685***	-1.580***	-2.103***	-1.478***	-1.936***	-1.259***
	(0.485)	(0.576)	(0.483)	(0.582)	(0.486)	(0.591)	(0.414)	(0.466)	(0.576)	(0.533)	(0.536)	(0.425)
Dependent variable (lagged)	0.961***	0.946***	0.959***	0.946***	0.958***	0.945***	0.966***	0.946***	0.956***	0.936***	0.952***	0.935***
	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)	(0.005)	(0.005)	(0.006)	(0.007)	(0.007)
VIX	-0.046***	-0.052***	-0.045***	-0.053***	-0.045***	-0.053***	-0.052***	-0.062***	-0.059***	-0.066***	-0.057***	-0.061***
	(0.006)	(0.007)	(0.006)	(0.007)	(0.006)	(0.007)	(0.007)	(0.008)	(0.009)	(0.009)	(0.010)	(0.010)
Interest rate (differential)	-0.025	0.065	-0.038	0.065	-0.063	0.029	-0.013	0.036	0.089	0.217	0.615**	0.632**
	(0.126)	(0.147)	(0.129)	(0.149)	(0.131)	(0.152)	(0.134)	(0.154)	(0.184)	(0.173)	(0.240)	(0.256)
GDP per capita (differential)		3.488***		3.439***		3.326***		7.607***		7.224***		4.608**
		(0.985)		(1.000)		(1.008)		(1.373)		(1.582)		(2.312)
Expected GDP growth (differential)		0.118***		0.119***		0.121***		0.104***		0.121***		0.141***
		(0.027)		(0.027)		(0.027)		(0.028)		(0.035)		(0.046)
Trade Balance (lagged)		-0.054		-0.057		-0.066		0.005		0.007		0.156
		(0.096)		(0.096)		(0.097)		(0.123)		(0.139)		(0.161)
Trade Openness		0.425***		0.428***		0.422***		0.330***		0.476***		0.414***
		(0.102)		(0.104)		(0.106)		(0.107)		(0.118)		(0.142)
EPFR/GDP		2.071***		2.098***		2.091***		2.157***		2.319***		2.512***
		(0.325)		(0.323)		(0.325)		(0.362)		(0.399)		(0.469)
Commodity prices	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8032	7371	7841	7214	7798	7171	7030	6392	5548	5253	3862	3629
Countries	48	46	48	46	48	46	45	44	40	39	30	30
R^2	0.98	0.97	0.98	0.98	0.98	0.97	0.98	0.97	0.97	0.97	0.96	0.97
J p-value	0.14	0.29	0.18	0.28	0.13	0.21	0.12	0.12	0.05	0.02	0.33	0.13
Stock & Yogo stat	14.64	10.37	14.51	10.01	14.38	9.92	16.72	12.24	9.79	8.65	9.36	10.62

Standard errors robust to heteroskedasticity in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.C.6: Robustness to capital controls: Second stage

Dependent variable: real bilateral exchange rate

	(1)	(2)	(3)	(4)	(5)	(6)
	Excluding change in capital controls			Full sample		
FXI/GDP (instrumented)	-1.231***	-1.392***	-1.686***	-1.650***	-2.004***	-2.007***
	(0.334)	(0.395)	(0.439)	(0.435)	(0.523)	(0.524)
Dependent variable (lagged)	0.967***	0.954***	0.966***	0.966***	0.951***	0.951***
	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
VIX	-0.039***	-0.046***				
	(0.006)	(0.007)				
VIX × Capital controls			-0.048***	-0.039***	-0.064***	-0.065***
			(0.008)	(0.008)	(0.009)	(0.009)
Interest rate (differential)	0.070	0.167				
	(0.113)	(0.134)				
Interest rate diff. × Capital controls			-0.030	0.016	0.057	0.057
			(0.176)	(0.175)	(0.195)	(0.195)
GDP per capita (differential)		3.512***			4.557***	4.511***
		(0.908)			(1.014)	(1.017)
Expected GDP growth (differential)		0.123***			0.111***	0.110***
		(0.024)			(0.028)	(0.028)
Trade Balance (lagged)		0.009			-0.096	-0.095
		(0.090)			(0.112)	(0.112)
Trade Openness		0.265***			0.500***	0.504***
		(0.083)			(0.117)	(0.117)
EPFR/GDP		1.930***			2.032***	3.229***
		(0.313)			(0.332)	(0.923)
EPFR × Capital controls				2.564***		-1.574
				(0.400)		(1.209)
Commodity prices	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8284	7474	8020	8020	7467	7467
Countries	52	51	50	50	47	47
R^2	0.98	0.98	0.98	0.98	0.97	0.97
J p-value	0.12	0.13	0.22	0.45	0.70	0.69
Stock & Yogo stat	20.54	15.43	15.13	15.21	11.90	11.84

Standard errors robust to heteroskedasticity in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.C.7: Robustness to interest rate policy: Second stage

Dependent variable: real bilateral exchange rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
FXI/GDP (instrumented)	-1.430***	-1.420***	-1.258***	-1.262***	-1.217***	-1.544***	-1.622***	-1.500***	-1.633***	-1.343***
	(0.318)	(0.319)	(0.295)	(0.298)	(0.297)	(0.373)	(0.385)	(0.351)	(0.375)	(0.345)
Dependent variable (lagged)	0.966***	0.967***	0.969***	0.969***	0.969***	0.953***	0.952***	0.954***	0.952***	0.952***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)
VIX	-0.043***	-0.041***	-0.045***	-0.045***	-0.046***	-0.050***	-0.058***	-0.051***	-0.060***	-0.050***
	(0.006)	(0.007)	(0.005)	(0.007)	(0.006)	(0.006)	(0.009)	(0.006)	(0.009)	(0.006)
Interest rate (differential)	0.014					0.105				
	(0.108)					(0.126)				
Interest rate (differential, instrumented)		-0.207					1.140			
		(0.508)					(0.711)			
US interest rate			-0.083***	-0.089*	-0.084***			-0.026	-0.121**	-0.018
			(0.020)	(0.050)	(0.021)			(0.025)	(0.061)	(0.027)
Domestic interest rate			0.007					0.011		
			(0.009)					(0.011)		
Domestic interest rate (instrumented)				0.013					0.115*	
				(0.045)					(0.062)	
GDP per capita (differential)						3.533***	3.380***	3.330***	3.175***	3.926***
						(0.851)	(0.880)	(0.901)	(0.943)	(0.966)
Expected GDP growth (differential)						0.113***	0.132***	0.112***	0.133***	0.106***
						(0.023)	(0.027)	(0.023)	(0.027)	(0.022)
Trade Balance (lagged)						-0.032	0.039	-0.042	0.048	-0.060
						(0.085)	(0.102)	(0.084)	(0.106)	(0.084)
Trade Openness						0.303***	0.361***	0.298***	0.372***	0.274***
						(0.079)	(0.092)	(0.078)	(0.094)	(0.081)
EPFR/GDP						1.859***	1.944***	1.843***	1.970***	1.731***
						(0.299)	(0.308)	(0.306)	(0.321)	(0.301)
Domestic Interest rate	No	No	No	No	Yes	No	No	No	No	Yes
Commodity prices	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9149	9149	9050	9050	9149	8312	8312	8219	8219	8312
Countries	52	52	52	52	52	51	51	51	51	51
R^2	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
J p-value	0.29	0.20	0.26	0.16	0.17	0.35	0.64	0.32	0.80	0.10
Stock & Yogo stat	24.25	24.30	26.51	26.37	25.68	18.34	18.39	20.35	19.24	19.71

Standard errors robust to heteroskedasticity in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.C.8: FXI measure: Second stage

Dependent variable: real bilateral exchange rate

	(1) Valuation	(2) Valuation & off-balance sheet	(3) Gross reserves	(4) Dropping small FXI 10%
FXI/GDP (instrumented)	-1.343***	-1.364***	-1.571***	-1.288***
	(0.296)	(0.303)	(0.355)	(0.318)
Dependent variable (lagged)	0.969***	0.968***	0.968***	0.967***
	(0.003)	(0.003)	(0.003)	(0.003)
VIX	-0.046***	-0.047***	-0.043***	-0.039***
	(0.006)	(0.006)	(0.006)	(0.006)
Interest rate (differential)	0.070	0.046	0.035	-0.037
	(0.101)	(0.105)	(0.107)	(0.109)
Commodity prices	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Observations	9012	9011	9103	8234
Countries	52	52	52	52
R^2	0.98	0.98	0.98	0.98
J p-value	0.16	0.18	0.13	0.17
Stock & Yogo stat	25.06	22.57	22.51	22.42

Standard errors robust to heteroskedasticity in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.C.9: FXI measures correlations

	FXI	FXI (val adj)	FXI (val adj + off-BS)	FXI (ΔReserves)
FXI	1			
FXI (val adj)	0.732***	1		
FXI (val adj + off-BS)	0.722***	0.968***	1	
FXI (ΔReserves)	0.688***	0.493***	0.470***	1

Table 3.C.10: Further robustness checks

Dependent variable: real bilateral exchange rate

	FXI/GDP	Std Dev	Obs	R^2	J p-value	Stock & Yogo stat
Whole sample	-1.674	0.364	9812	0.97	0.27	11.49
Dropping 1% outliers	-1.430	0.318	9149	0.98	0.29	24.25
Dropping 2% outliers	-0.958	0.334	8431	0.99	0.02	20.98
Winsorized data 1%	-2.155	0.405	9812	0.97	0.10	21.90
Winsorized data 2%	-2.367	0.436	9812	0.96	0.08	23.56
No financial crisis	-1.493	0.354	8642	0.98	0.15	19.38
No Asian crisis	-1.381	0.328	7588	0.98	0.27	21.76
Dropping largest FXI 5%	-1.497	0.370	8692	0.98	0.27	19.99
Dropping largest FXI 10%	-1.569	0.415	8235	0.98	0.23	18.65
Substituting VIX by EPFR	-1.055	0.289	9149	0.98	0.01	24.47
Substituting VIX by EMBI	-1.246	0.311	8421	0.98	0.14	22.78
Adding EMBI	-1.384	0.322	8421	0.98	0.00	19.22
Country specific coeffs for VIX	-1.318	0.326	9149	0.98	0.03	21.26
Country specific coeffs for IR	-1.462	0.319	9149	0.98	0.28	24.16
Country specific coeffs for VIX & IR	-1.284	0.318	9149	0.98	0.24	21.91
Adding REER gap	-1.543	0.394	7833	0.98	0.38	16.03
Sample period 2003-2013	-1.241	0.327	5977	0.97	0.11	18.98
Only inflation-targeting countries	-1.744	0.801	3772	0.97	0.00	7.72
Adding Δ(monetary base)/GDP	-2.745	0.725	9028	0.97	0.18	7.87
Δ RER	-0.959	0.284	9149	-0.16	0.02	26.84

Table 3.C.11: Dynamic effects: Second stage

Dependent variable: exchange rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Including de jure pegs			Excluding de jure pegs			Including de jure pegs			Excluding de jure pegs		
Exchange rate definition:	Nominal	Real	Real effective	Nominal	Real	Real effective	Nominal	Real	Real effective	Nominal	Real	Real effective
FXI/GDP	-1.694***	-1.431***	-1.113***	-1.913***	-1.757***	-1.446***	-1.868***	-1.511***	-1.221***	-2.028***	-1.699***	-1.316***
	(0.338)	(0.323)	(0.214)	(0.517)	(0.500)	(0.388)	(0.425)	(0.378)	(0.294)	(0.643)	(0.585)	(0.461)
FXI/GDP (lagged)	0.113**	0.097*	0.132***	0.119*	0.094	0.177***	0.115*	0.102*	0.148***	0.105	0.090	0.170***
	(0.053)	(0.050)	(0.034)	(0.063)	(0.062)	(0.045)	(0.059)	(0.054)	(0.037)	(0.067)	(0.064)	(0.045)
FXI/GDP (2nd lag)	0.005	-0.005	0.071**	-0.026	-0.045	0.081*	-0.012	-0.011	0.080**	-0.049	-0.051	0.068
	(0.055)	(0.052)	(0.031)	(0.065)	(0.063)	(0.041)	(0.061)	(0.056)	(0.036)	(0.070)	(0.065)	(0.042)
FXI/GDP (3rd lag)	0.137***	0.113**	0.025	0.154**	0.121**	0.048	0.127**	0.108**	0.023	0.128*	0.108*	0.022
	(0.051)	(0.048)	(0.032)	(0.063)	(0.061)	(0.045)	(0.057)	(0.052)	(0.036)	(0.068)	(0.063)	(0.045)
Dependent variable (lagged)	0.976***	0.966***	0.964***	0.971***	0.960***	0.961***	0.974***	0.952***	0.960***	0.968***	0.945***	0.958***
	(0.002)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.003)	(0.004)	(0.004)	(0.003)	(0.005)	(0.004)
VIX	-0.058***	-0.042***	-0.012***	-0.061***	-0.045***	-0.018***	-0.063***	-0.048***	-0.017***	-0.065***	-0.050***	-0.019***
	(0.006)	(0.005)	(0.004)	(0.007)	(0.006)	(0.004)	(0.007)	(0.006)	(0.005)	(0.008)	(0.007)	(0.005)
Interest rate (differential)	-0.247**	0.046	0.116	-0.350**	0.007	0.090	-0.239	0.160	0.224**	-0.349**	0.130	0.191
	(0.125)	(0.107)	(0.098)	(0.147)	(0.124)	(0.111)	(0.148)	(0.124)	(0.112)	(0.176)	(0.143)	(0.125)
Inflation rate (differential)	0.049***			0.061***			0.054***			0.067***		
	(0.010)			(0.012)			(0.012)			(0.014)		
GDP per capita (differential)							1.460*	3.998***	0.889	1.220	4.037***	1.087
							(0.865)	(0.845)	(0.603)	(0.987)	(0.953)	(0.686)
Expected GDP growth (differential)							0.115***	0.099***	0.079***	0.122***	0.105***	0.078***
							(0.026)	(0.024)	(0.017)	(0.029)	(0.027)	(0.019)
Trade Balance (lagged)							0.121	-0.057	0.179**	0.130	-0.054	0.168**
							(0.094)	(0.085)	(0.071)	(0.108)	(0.098)	(0.082)
Trade Openness							0.234**	0.285***	0.037	0.304***	0.415***	0.078
							(0.091)	(0.081)	(0.058)	(0.112)	(0.103)	(0.075)
EPFR/GDP							1.602***	1.860***	0.927***	1.677***	1.985***	1.035***
							(0.309)	(0.300)	(0.207)	(0.331)	(0.323)	(0.222)
Commodity prices	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8533	8880	8668	7522	7817	7380	7761	8072	7646	6929	7171	6797
Countries	55	52	55	48	48	48	51	51	51	46	46	46
R^2	0.98	0.98	0.98	0.98	0.98	0.97	0.98	0.98	0.97	0.97	0.98	0.97
J p-value	0.42	0.41	0.08	0.12	0.11	0.02	0.25	0.31	0.01	0.26	0.21	0.00
Stock & Yogo stat	23.25	24.02	24.10	13.50	14.21	11.79	15.97	18.08	15.03	9.26	10.18	8.26
Half-life of FXI/GDP effect (months)	23	17	14	20	16	12	22	12	12	20	12	12

Standard errors robust to heteroskedasticity in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.C.12: Dynamic effects: Second stage, with lagged controls

Dependent variable: exchange rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Including de jure pegs			Excluding de jure pegs			Including de jure pegs			Excluding de jure pegs		
Exchange rate definition:	Nominal	Real	Real effective	Nominal	Real	Real effective	Nominal	Real	Real effective	Nominal	Real	Real effective
FXI/GDP	-1.615***	-1.407***	-1.114***	-1.820***	-1.677***	-1.405***	-2.061***	-1.764***	-1.494***	-2.056***	-1.789***	-1.498***
	(0.328)	(0.312)	(0.210)	(0.492)	(0.473)	(0.371)	(0.467)	(0.415)	(0.326)	(0.642)	(0.590)	(0.473)
FXI/GDP (lagged)	0.128**	0.124**	0.122***	0.132**	0.125**	0.162***	0.141**	0.142**	0.141***	0.119*	0.126**	0.152***
	(0.052)	(0.049)	(0.034)	(0.061)	(0.060)	(0.045)	(0.062)	(0.057)	(0.041)	(0.067)	(0.064)	(0.047)
FXI/GDP (2nd lag)	0.022	0.018	0.076**	-0.007	-0.021	0.092**	0.036	0.032	0.098**	-0.014	-0.017	0.082*
	(0.054)	(0.051)	(0.032)	(0.064)	(0.061)	(0.041)	(0.064)	(0.058)	(0.040)	(0.070)	(0.066)	(0.046)
FXI/GDP (3rd lag)	0.139***	0.125***	0.036	0.159**	0.135**	0.064	0.126**	0.114**	0.057	0.116*	0.107*	0.056
	(0.050)	(0.048)	(0.032)	(0.062)	(0.060)	(0.045)	(0.060)	(0.055)	(0.040)	(0.068)	(0.064)	(0.048)
Dependent variable (lagged)	0.978***	0.966***	0.963***	0.973***	0.961***	0.960***	0.975***	0.954***	0.958***	0.970***	0.948***	0.957***
	(0.003)	(0.003)	(0.004)	(0.003)	(0.004)	(0.004)	(0.003)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)
VIX	-0.138***	-0.134***	-0.019***	-0.145***	-0.145***	-0.028***	-0.140***	-0.134***	-0.029***	-0.143***	-0.140***	-0.029***
	(0.009)	(0.009)	(0.007)	(0.010)	(0.010)	(0.008)	(0.011)	(0.010)	(0.008)	(0.012)	(0.011)	(0.009)
Interest rate (differential)	-0.659***	-0.477**	-0.404*	-0.828***	-0.599***	-0.502*	-0.811***	-0.581**	-0.551*	-0.941***	-0.659**	-0.610*
	(0.221)	(0.193)	(0.220)	(0.260)	(0.228)	(0.257)	(0.272)	(0.243)	(0.287)	(0.311)	(0.283)	(0.332)
Inflation rate (differential)	-0.154***			-0.166***			-0.202***			-0.208***		
	(0.035)			(0.039)			(0.043)			(0.047)		
VIX (lagged)				0.099***	0.113***	-0.010				0.083***	0.092***	-0.019**
				(0.011)	(0.011)	(0.008)				(0.013)	(0.012)	(0.009)
GDP per capita (differential)							0.102	3.040***	0.655	-0.003	3.131***	0.924
							(0.953)	(0.894)	(0.676)	(1.059)	(0.995)	(0.752)
Expected GDP growth (differential)							0.367***	0.362***	0.183***	0.376***	0.382***	0.201***
							(0.065)	(0.062)	(0.049)	(0.071)	(0.069)	(0.055)
Trade Balance (lagged)							0.175	-0.002	0.251***	0.163	-0.028	0.215**
							(0.117)	(0.111)	(0.088)	(0.129)	(0.123)	(0.098)
Trade Openness							0.247**	0.290***	0.081	0.268**	0.373***	0.104
							(0.097)	(0.087)	(0.064)	(0.112)	(0.105)	(0.078)
EPFR/GDP							2.092***	2.400***	1.046***	2.139***	2.450***	1.107***
							(0.345)	(0.340)	(0.240)	(0.359)	(0.355)	(0.251)
Commodity prices	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lagged controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8324	8821	8610	7365	7759	7323	7546	7953	7532	6768	7069	6700
Countries	55	52	55	48	48	48	51	51	51	46	46	46
R^2	0.98	0.98	0.98	0.98	0.98	0.97	0.98	0.98	0.97	0.97	0.98	0.97
J p-value	0.21	0.51	0.13	0.14	0.16	0.02	0.20	0.51	0.14	0.21	0.25	0.02
Stock & Yogo stat	22.65	24.11	24.59	13.43	14.59	12.33	13.63	15.84	13.55	8.56	9.60	8.02
Half-life of FXI/GDP effect (months)	23	15	13	20	15	12	22	12	12	20	12	12

Standard errors robust to heteroskedasticity in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Since GDP per capita and Trade Openness are slow moving variables, coefficients for their additional lags are not well identified and are not included in the regressions.

Bibliography

Abenoja, Z. (2003): "Foreign Exchange Market Intervention: A Short Review of Transmission Channels and Practices," Bangko sentral review, Bangko Sentral ng Pilipinas.

Adler, G. and R. C. Mano (2015): "On the Cost of Foreign Exchange Intervention," mimeo.

Adler, G. and C. E. Tovar (2014): "Foreign Exchange Interventions and their Impact on Exchange Rate Levels," *Monetaria*, 0, 1–48.

Aizenman, J. and J. Lee (2008): "Financial versus Monetary Mercantilism: Long-run View of Large International Reserves Hoarding," *The World Economy*, 31, 593–611.

Allen, F., R. Chakrabarti, S. De, J. Qian, and M. Qian (2010): "Law, Institutions, and Finance in China and India," in *Emerging Giants. China and India in the World Economy*, ed. by O. U. Press, Eichengreen, Barry and Gupta, Poonam and Kumar, Rajiv, 125–184.

Allen, F., J. Qian, and M. Qian (2005): "Law, finance, and economic growth in China," *Journal of Financial Economics*, 77, 57–116.

Allen, F., J. Qian, C. Zhang, and M. Zhao (2012): "China's Financial System: Opportunities and Challenges," in *Capitalizing China*, ed. by U. of Chicago Press, Fan, Joseph P.H. and Morck, Randall.

Arellano, C., Y. Bai, and J. Zhang (2012): "Firm dynamics and financial development," *Journal of Monetary Economics*, 59, 533–549.

Ayyagari, M., A. Demirguç-Kunt, and V. Maksimovic (2010): "Formal versus Informal Finance: Evidence from China," *Review of Financial Studies*, 23, 3048–3097.

Bai, C.-E., C.-T. Hsieh, and Y. Qian (2006): "The Return to Capital in China," *Brookings Papers on Economic Activity*, 37, 61–102.

Bayoumi, T., J. E. Gagnon, and C. Saborowski (2014): "Official Financial Flows, Capital Mobility, and Global Imbalances," IMF Working Papers 14/199, International Monetary Fund.

Behr, P., A. Drexler, R. Gropp, and A. Guettler (2013): "Financial Incentives and Loan Officer Behavior," Working papers.

Ben-David, I. and S. Agarwal (2012): "Do Loan Officers' Incentives Lead to Lax Lending Standards?" Working Paper Series 2012-07, Ohio State University, Charles A. Dice Center for Research in Financial Economics.

Berg, T., M. Puri, and J. Rocholl (2013): "Loan Officer Incentives and the Limits of Hard Information," Working paper, Duke University.

Bharath, S., S. Dahiya, A. Saunders, and A. Srinivasan (2011): "Lending Relationships and Loan Contract Terms," Review of Financial Studies 24(4): 1141-203.

Blanchard, O., G. Adler, and I. Carvalho Filho (2015): "Can Foreign Exchange Intervention Stem Exchange Rate Pressures from Global Capital Flow Shocks?" mimeo.

Bolton, P., X. Freixas, L. Gambacorta, and P. E. Mistrulli (2013): "Relationship and Transaction Lending in a Crisis," BIS Working Papers 417, Bank for International Settlements.

Branson, W. H. and D. W. Henderson (1985): "The specification and influence of asset markets," in *Handbook of International Economics*, ed. by R. W. Jones and P. B. Kenen, Elsevier, vol. 2 of *Handbook of International Economics*, chap. 15, 749–805.

Cabral, L. M. B. and J. Mata (2003): "On the Evolution of the Firm Size Distribution: Facts and Theory," *American Economic Review*, 93, 1075–1090.

Canales-Kriljenko, J. I. (2003): "Foreign Exchange Intervention in Developing and Transition Economies: Results of a Survey," IMF Working Papers 03/95, International Monetary Fund.

Chen, C.-N., T. Watanabe, and T. Yabu (2012): "A New Method for Identifying the Effects of Foreign Exchange Interventions," *Journal of Money, Credit and Banking*, 44, 1507–1533.

Cheung, Y.-W. and K. S. Lai (2000): "On the purchasing power parity puzzle," *Journal of International Economics*, 52, 321–330.

Cheung, Y.-W. and X. Qian (2009): "Hoarding of International Reserves: Mrs Machlup's Wardrobe and the Joneses," *Review of International Economics*, 17, 824–843.

Cheung, Y.-W. and R. Sengupta (2011): "Accumulation of reserves and keeping up with the Joneses: The case of LATAM economies," *International Review of Economics & Finance*, 20, 19–31.

Chinn, M. D. and H. Ito (2006): "What matters for financial development? Capital controls, institutions, and interactions," *Journal of Development Economics*, 81, 163–192.

Chortareas, G. and G. Kapetanios (2013): "How Puzzling Is The Ppp Puzzle? An Alternative HalfLife Measure Of Convergence To Ppp," *Journal of Applied Econometrics*, 28, 435–457.

Cong, W. and J. Ponticelli (2016): "Credit Allocation under Economic Stimulus: Evidence from China," mimeo.

Cooley, T. F. and V. Quadrini (2001): "Financial Markets and Firm Dynamics," *American Economic Review*, 91, 1286–1310.

Daude, C., E. Levy Yeyati, and A. Nagengast (2014): "On the Effectiveness of Exchange Rate Interventions in Emerging Markets," OECD Development Centre Working Papers 324, OECD Publishing.

D'Aurizio, L., T. Oliviero, and L. Romano (2014): "Family Firms, Soft Information and Bank Lending in a Financial Crisis," CSEF Working Papers 357, Centre for Studies in Economics and Finance (CSEF), University of Naples, Italy.

Degryse, H., L. Lu, and S. Ongena (2013): "Informal or formal financing? Or both? First evidence on the co-funding of Chinese firms," BOFIT Discussion Papers 14/2013, Bank of Finland, Institute for Economies in Transition.

Demetriades, P., J. Du, S. Girma, and C. Xu (2008): "Does the Chinese Banking System Promote the Growth of Firms?" WEF Working Papers 0036, ESRC World Economy and Finance Research Programme, Birkbeck, University of London.

Demirguç-Kunt, A. and V. Maksimovic (1998): "Law, Finance, and Firm Growth," *Journal of Finance*, 53, 2107–2137.

Domaç, I. and A. Mendoza (2004): "Is there room for foreign exchange interventions under an inflation targeting framework ? Evidence from Mexico and Turkey," Policy Research Working Paper Series 3288, The World Bank.

Dominguez, K. and J. A. Frankel (1990): *Does Foreign Exchange Intervention Work?*, no. 16 in Peterson Institute Press: All Books, Peterson Institute for International Economics.

Dominguez, K. M. (1990): "Market responses to coordinated central bank intervention," *Carnegie-Rochester Conference Series on Public Policy*, 32, 121–163.

——— (1998): "Central Bank Intervention and Exchange Rate Volatility," *Journal of International Money and Finance*, 17, 161–190.

——— (2012): "Foreign reserve management during the global financial crisis," *Journal of International Money and Finance*, 31, 2017–2037.

Dominguez, K. M., R. Fatum, and P. Vacek (2013): "Do Sales of Foreign Exchange Reserves Lead to Currency Appreciation?" *Journal of Money, Credit and Banking*, 45, 867–890.

Dominguez, K. M. and J. A. Frankel (1993a): "Does Foreign-Exchange Intervention Matter? The Portfolio Effect," *American Economic Review*, 83, 1356–69.

——— (1993b): "Foreign Exchange Intervention: An Empirical Assessment," in *On Exchange Rates*, ed. by J. A. Frankel, Cambridge, MA: MIT Press.

Dominguez, K. M., Y. Hashimoto, and T. Ito (2012): "International reserves and the global financial crisis," *Journal of International Economics*, 88, 388–406.

Dominquez, K. M. and P. B. Kenen (1992): "Intramarginal intervention in the EMS and the target-zone model of exchange-rate behavior," *European Economic Review*, 36, 1523–1532.

Du, J. and S. Girma (2009): "Source of Finance, Growth and Firm Size ? Evidence from China," Working Papers UNU-WIDER Research Paper, World Institute for Development Economic Research (UNU-WIDER).

Elsas, R. and J. P. Krahnen (1998): "Is relationship lending special? Evidence from credit-file data in Germany," CFS Working Paper Series 1998/05, Center for Financial Studies (CFS).

Fernández, A., A. Rebucci, and M. Uribe (2013): "Are Capital Controls Prudential? An Empirical Investigation," NBER Working Papers 19671, National Bureau of Economic Research, Inc.

Frankel, J. A. and A. K. Rose (1996): "A panel project on purchasing power parity: Mean reversion within and between countries," *Journal of International Economics*, 40, 209–224.

Fratzscher, M. (2009): "How successful is the G7 in managing exchange rates?" *Journal of International Economics*, 79, 78–88.

Gabaix, X. and M. Maggiori (2015): "International Liquidity and Exchange Rate Dynamics," *The Quarterly Journal of Economics*, 130, 1369–1420.

Gagnon, J. E. (2012a): "Combating Widespread Currency Manipulation," Policy Briefs PB12-19, Peterson Institute for International Economics.

——— (2012b): "Global Imbalances and Foreign Asset Expansion by Developing Economy Central Banks," Working Paper Series WP12-5, Peterson Institute for International Economics.

——— (2013): "The Elephant Hiding in the Room: Currency Intervention and Trade Imbalances," Working Paper Series WP13-2, Peterson Institute for International Economics.

Ghosh, A. R. (1992): "Is it signalling? Exchange intervention and the dollar-Deutschemark rate," *Journal of International Economics*, 32, 201–220.

Ghosh, A. R., J. D. Ostry, and C. G. Tsangarides (2012): "Shifting Motives: Explaining the Buildup in official Reserves in Emerging Markets Since the 1980's," IMF Working Papers 12/34, International Monetary Fund.

Girma, S., Y. Gong, and H. Gorg (2008): "Foreign Direct Investment, Access to Finance, and Innovation Activity in Chinese Enterprises," Discussion Papers 07/44, University of Nottingham, GEP.

Greenwood, J., J. Sanchez, and C. Wang (2013): "Quantifying the Impact of Financial Development on Economic Development," *Review of Economic Dynamics*, 16, 194–215.

Guimarães Filho, R. F. and C. Karacadağ (2004): "The Empirics of Foreign Exchange Intervention in Emerging Market Countries: the Cases of Mexico and Turkey," IMF Working Papers 04/123, International Monetary Fund.

Heider, F. and R. Inderst (2012): "Loan Prospecting," *Review of Financial Studies*, 25, 2381–2415.

Henderson, D. W. and K. Rogoff (1982): "Negative net foreign asset positions and stability in a world portfolio balance model," *Journal of International Economics*, 13, 85–104.

Héricourt, J. and S. Poncet (2009): "FDI and credit constraints: Firm-level evidence from China," *Economic Systems*, 33, 1–21.

Hsieh, C.-T. and P. J. Klenow (2009): "Misallocation and Manufacturing TFP in China and India," *The Quarterly Journal of Economics*, 124, 1403–1448.

Humala, A. and G. Rodriguez (2010): "Foreign exchange intervention and exchange rate volatility in Peru," *Applied Economics Letters*, 17, 1485–1491.

Hung, J. H. (1997): "Intervention strategies and exchange rate volatility: a noise trading perspective," *Journal of International Money and Finance*, 16, 779–793.

Ilzetzki, E., C. M. Reinhart, and K. S. Rogoff (2010): "Exchange Rate Arrangements Entering the 21st Century: Which Anchor Will Hold?" mimeo.

IMF (2011): "Assessing Reserve Adequacy," Washington, D.C.

——— (2013): "Assessing Reserve Adequacy - Further Considerations," Tech. rep.

Ito, T. (2002): "Is Foreign Exchange Intervention Effective?: The Japanese Experiences in the 1990s," NBER Working Papers 8914, National Bureau of Economic Research, Inc.

Jeanne, O. and R. Rancière (2011): "The Optimal Level of International Reserves For Emerging Market Countries: A New Formula and Some Applications," *Economic Journal*, 121, 905–930.

Kamil, H. (2008): "Is Central Bank Intervention Effective Under Inflation Targeting Regimes? The Case of Colombia," IMF Working Papers 08/88, International Monetary Fund.

Kaminsky, G. L. and K. K. Lewis (1996): "Does foreign exchange intervention signal future monetary policy?" *Journal of Monetary Economics*, 37, 285–312.

Kearns, J. and R. Rigobon (2005): "Identifying the efficacy of central bank interventions: evidence from Australia and Japan," *Journal of International Economics*, 66, 31–48.

Kenen, P. B. (1982): "Effects of Invertention and Sterilization in the Short Run and in the Long Run," in *The International Monetary Sustem Under Flexible Exchange Rates: Global, Regional, and National: Essays in Honor of Robert Triffin*, ed. by R. N. Cooper, P. B. Kenen, J. Braga de Macedo, and J. van Ypersele, Cambridge, MA: Ballinger.

Kouri, P. J. (1983): "Balance of Payments and the Foreign Exchange Market: A Dynamic Partial Equilibrium Model," in *Economic Interndependence and Flexible Exchange Rates*, ed. by J. S. Bhandari and B. H. Putnam, The MIT Press, chap. 5, 116–156.

Kumhof, M. (2010): "On the theory of sterilized foreign exchange intervention," *Journal of Economic Dynamics and Control*, 34, 1403–1420.

Laurens, B. J. and R. Maino (2007): "China: Strengthening Monetary Policy Implementation," IMF Working Papers 07/14, International Monetary Fund.

Levine, R. (1999): "Law, Finance, and Economic Growth," *Journal of Financial Intermediation*, 8, 8–35.

Levinsohn, J. and A. Petrin (2003): "Estimating Production Functions Using Inputs to Control for Unobservables," *Review of Economic Studies*, 70, 317–341.

Liu, A. P. L. (1992): "The "Wenzhou Model" of Development and China's Modernization," *Asian Survey*, 32, pp. 696–711.

Lyons, R. K. (2006): *The Microstructure Approach to Exchange Rates*, vol. 1 of *MIT Press Books*, The MIT Press.

Mandeng, O. (2003): "Central Bank Foerign Exchange Market Intervention and Option Contract Specification: The Case of Colombia," IMF Working Papers 03/135, International Monetary Fund.

Marschak, J. and W. H. Andrews (1944): "Random Simultaneous Equations and the Theory of Production," *Econometrica*, 12, 143–205.

Menkhoff, L. (2010): "High-Frequency Analysis Of Foreign Exchange Interventions: What Do We Learn?" *Journal of Economic Surveys*, 24, 85–112.

——— (2013): "Foreign Exchange Intervention in Emerging Markets: A Survey of Empirical Studies," *The World Economy*, 36, 1187–1208.

Moll, B. (2014): "Productivity Losses from Financial Frictions: Can Self-financing Undo Capital Misallocation?" *American Economic Review*, 104, 3186–3221.

Moreno, R. (2005): "Motives for intervention," in *Foreign exchange market intervention in emerging markets: motives, techniques and implications*, ed. by B. for International Settlements, Bank for International Settlements, vol. 24 of *BIS Papers chapters*, 4–18.

Naranjo, A. and M. Nimalendran (2000): "Government Intervention and Adverse Selection Costs in Foreign Exchange Markets," *Review of Financial Studies*, 13, 453–77.

Neely, C. J. (2005): "An analysis of recent studies of the effect of foreign exchange intervention," *Review*, 685–718.

——— (2008): "Central bank authorities' beliefs about foreign exchange intervention," *Journal of International Money and Finance*, 27, 1–25.

Obstfeld, M., J. C. Shambaugh, and A. M. Taylor (2010): "Financial Stability, the Trilemma, and International Reserves," *American Economic Journal: Macroeconomics*, 2, 57–94.

OECD (2000): "National Accounts for China. Sources and Methods," Organisation for Economic Cooperation and Development, Paris.

Olley, G. S. and A. Pakes (1996): "The Dynamics of Productivity in the Telecommunications Equipment Industry," *Econometrica*, 64, 1263–97.

Pattanaik, S. and S. Sahoo (2003): "The Effectiveness of Intervention in India: An Empirical Assessment," Reserve bank of india occasional papers, Reserve Bank of India.

Phillips, S., L. Catao, L. A. Ricci, R. Bems, M. Das, J. di Giovanni, D. F. Unsal, M. Castillo, J. Lee, J. Rodriguez, and M. Vargas (2013): "The External Balance Assessment (EBA) Methodology," IMF Working Papers 13/272, International Monetary Fund.

Poncet, S., W. Steingress, and H. Vandenbussche (2010): "Financial constraints in China: Firm-level evidence," *China Economic Review*, 21, 411–422.

Quinn, D. P. and A. M. Toyoda (2008): "Does Capital Account Liberalization Lead to Growth?" *Review of Financial Studies*, 21, 1403–1449.

Raychaudhuri, B. (1996): "Measurement of Capital Stock in Indian Industries," *Economic and Political Weekly*, 31, pp. M2–M6.

Reinhart, C. M. and V. R. Reinhart (2008): "Capital Inflows and Reserve Accumulation: The Recent Evidence," NBER Working Papers 13842, National Bureau of Economic Research, Inc.

Reitz, S. and M. P. Taylor (2008): "The coordination channel of foreign exchange intervention: A nonlinear microstructural analysis," *European Economic Review*, 52, 55–76.

Restuccia, D. and R. Rogerson (2008): "Policy Distortions and Aggregate Productivity with Heterogeneous Plants," *Review of Economic Dynamics*, 11, 707–720.

Rincón, H. and J. Toro (2011): "Are Capital Controls and Central Bank Intervention Effective?" Borradores de Economia 625, Banco de la Republica de Colombia.

Sarno, L. and M. P. Taylor (2001): "Official Intervention in the Foreign Exchange Market: Is It Effective and, If So, How Does It Work?" *Journal of Economic Literature*, 39, 839–868.

Schindler, M. (2009): "Measuring Financial Integration: A New Data Set," *IMF Staff Papers*, 56, 222–238.

SCHÜNDELN, M. (2012): "Appreciating Depreciation: Physical Capital Depreciation in a Developing Country," *Empirical Economics*, 4, 1277 – 1290.

SONG, Z., K. STORESLETTEN, AND F. ZILIBOTTI (2011): "Growing Like China," *American Economic Review*, 101, 196–233.

——— (2014): "Growing (with Capital Controls) like China," *IMF Economic Review*, 62, 327–370.

STOCK, J. H. AND M. YOGO (2002): "Testing for Weak Instruments in Linear IV Regression," NBER Technical Working Papers 0284, National Bureau of Economic Research, Inc.

STOCKEY, N. L. AND R. E. LUCAS JR (1989): *Recursive Methods in Economic Dynamics*, Cambridge, Mass., USA: Harvard University Press.

STONE, M. R., W. C. WALKER, AND Y. YASUI (2009): "From Lombard Street to Avenida Paulista: Foreign Exchange Liquidity Easing in Brazil in Response to the Global Shock of 2008-09," IMF Working Papers 09/259, International Monetary Fund.

SUN, L. AND R.-E. REN (2008): "Estimates of China Capital Input Index by Industries," *Frontiers of Economics in China*, 3, 462–481.

TAPIA, M. AND A. TOKMAN (2004): "Effects of Foreign Exchange Intervention under Public Information: The Chilean Case," *Journal of Lacea Economia*, 4:2, 215–256.

UDRY, C. AND S. ANAGOL (2006): "The Return to Capital in Ghana," Working Papers 932, Economic Growth Center, Yale University.

VICENTE, S. (2011): "Credit Scores and Relationship Lending," Working papers, New York University.

WANG, Y. AND Y. YAO (2003): "Sources of China's economic growth 1952-1999: incorporating human capital accumulation," *China Economic Review*, 14, 32–52.

WEI, Y. D., W. LI, AND C. WANG (2007): "Restructuring Industrial Districts, Scaling Up Regional Development: A Study of the Wenzhou Model, China," *Economic Geography*, 83, 421–444.

WU, Y. (2009): "China's Capital Stock Series By Region and Sector," Economics Discussion / Working Papers 09-02, The University of Western Australia, Department of Economics.

YEYATI, E. L. (2006): "Financial dollarization: evaluating the consequences," *Economic Policy*, 21, 61–118.