ABSTRACT

Title of dissertation: Essays on Macroeconomics and International Finance

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My doctoral research contributes to the fields of macroeconomics and international finance. Within macroeconomics, I have explored the role of financial frictions in shaping macroeconomic outcomes following a recession. I have studied the dissonance between the rapid improvement in financial conditions and the sluggish recovery in investment observed in the aftermath of the Great Recession. In related research I also analyze the fast improvement in financial conditions and analyze the existence of a positive feedback between asset prices and leverage through the lens of liquidity shocks. Within international finance, I have an empirical and theoretical interest in the analysis of capital flows. My research in this area has focused on the role of domestic investors in preventing economies from experiencing the largely-documented pervasive effects of net sudden stops in capital flows, and its determinants.

Chapter 1. The rapid improvement in financial conditions and the sluggish recovery of physical investment in the aftermath of the Great Recession are difficult to

reconcile with the predictions of existing models that link impaired access to credit and investment. I propose a tractable model that solves this puzzle by exploiting the role of customer markets in shaping the persistent effects of financial shocks on investment decisions. In my model, firms react to a negative financial shock by reducing expenditures in sales-related activities and increasing prices to restore internal liquidity, at the expense of customer accumulation. Once financial conditions start reverting to normal levels, the firm postpones investment due to a shortage of customers relative to its existing production capacity and the need to first rebuild its customer base. This mechanism can capture two important features of the data: First, the slow recovery of investment despite improving financial conditions, and second, the positive correlation between financial conditions and investment observed during downturns and the weakening of this correlation observed during upturns.

Chapter 2. I assess how the inclusion of complementary sources of liquidity can have sizeable reinforcing effects during a crisis and in its aftermath. In this paper, I allow for the possibility to finance investment projects either by selling existing capital units or by borrowing using the units not sold as collateral. The main characteristic of this model is that capital is heterogeneous and composed by units of different quality, which are only observed by the owner. The asymmetric information on capital quality makes both, the asset prices at which investors can sell their assets and the loan-to-value (i.e. leverage) ratio at which they can borrow to be endogenously determined. The simultaneity in the determination of asset prices and leverage lead to the existence of liquidity spirals. For instance, a negative exogenous shock that reduces leverage creates a fall in the funds available to finance capital purchases (i.e. a decline in demand). It also increases the supply for assets in the market, since entrepreneurs require selling more units to finance the same amount of investment. These two effects create unambiguously a fall in prices. The fall in prices reinforces the initial fall in loan-to-values since lenders expect the quality of units used as collateral to be lower. This mechanism explains why alternative sources of liquidity fall rapidly during downturns, and why liquidity can recover faster during upturns.

Chapter 3. This paper, which is joint work with Eduardo Cavallo and Alejandro Izquierdo, explores the determinants behind the decision of domestic investor to adjust their asset position in response to a variation in gross capital inflows and avoid episodes of net sudden stops. We present evidence that while sudden stops in gross inflows are associated with global conditions, domestic factors such as the degree of domestic liability dollarization, economic growth and institutional background are important to prevent these episodes in becoming net sudden stops. We also extend the concept of *"Prevented Sudden Stops"* and differentiate *"Delayed"* from *"Purely Prevented"* episodes. A purely prevented episode is one in which there is not a sudden stop in any of the quarters for which there was a sudden stop in gross inflows. A delayed episode is one in which there is at least one quarter in which there was both a sudden stop in gross inflows and a net sudden stop. We want to analyze how this classification can affect the extent to which economic growth and domestic liability dollarization can still account for the offsetting behavior of domestic investors.

Essays on Macroeconomics and International Finance

by

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To Mom, Dad, Alex and Ana

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Chapter 1: Financial Shocks and Investment Recovery in a Model of Customer Markets

1 Introduction

The aftermath of the Great Recession has challenged our understanding of how real investment and financial frictions interact. Existing models of physical investment and impaired access to credit motivated by the 2007-2009 crisis exhibit a tight association between investment and financial conditions. This association allowed these models to characterize the dynamics of real and financial variables observed during the downturn. However, their prediction of a robust recovery fueled by improving financial conditions is at odds with the dynamics displayed by investment throughout the recovery period. In particular, the sharp improvement in financial conditions was accompanied by a sluggish recovery in aggregate investment.

The years that followed the Great Recession witnessed a change in the co-movement between investment and financial conditions. As shown in Figure 1.1, nonresidential private fixed investment remained depressed, and gradually reached pre-crisis levels in 2012. Also, economic activity depicted in the blue dashed line and represented by manufacturing output experienced a slow recovery process. In contrast, the index of credit standards reported by the Federal Reserve Board reveals a drastic tightening in credit conditions by banks during the crisis, but a rapid loosening that had reached pre-crisis credit standards by 2009. Aggregate measures of financial soundness (e.g., the Chicago Financial Index) are also indicative of a prompt recovery of financial conditions during the same period.

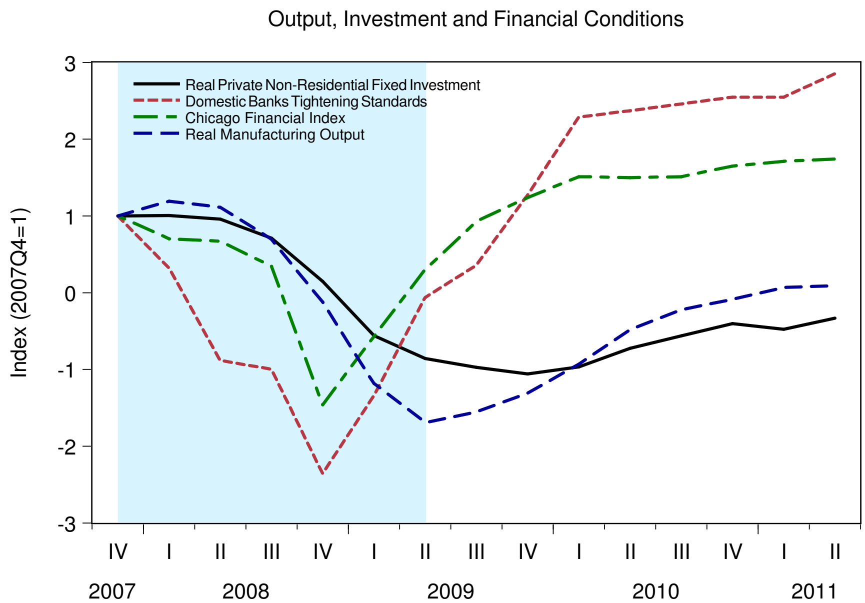
Analysis of the correlations between financial variables and real investment provides additional evidence of the changing dynamics after the Great Recession. Table 1.1 shows how the strong correlation observed prior to the crisis between the cyclical component of private nonresidential fixed investment, credit spreads (taken from Gilchrist and Zakrajsek (2012)) and year-to-year growth in the S&P500 fell after 2009. The correlation between credit spreads and private fixed investment shifted from -0.68 prior to the crisis to 0.09 after the crisis; at the same time, the correlation between the same category of investment and asset prices dropped from 0.93 to 0.32.

If the financial turmoil that hit the world in 2007 made it clear that financial conditions play an important role in shaping macroeconomic outcomes and dynamics, why did investment not fit this pattern in the recovery period? Why did investment fail to react to improving financial conditions?

In this chapter I posit that a firm's reaction to deteriorating financial conditions has consequences for its customer base. These consequences are key to understanding investment decisions after financial conditions have stabilized.[1] I present a

[1] This argument is in line with the views of Krishnamurthy and Muir (2015), who argue that as credit spreads revert to pre-crisis levels more quickly, there is a separate role for financial and real factors in explaining the evolution of macroeconomic variables in the aftermath of a financial crisis. This suggests, according to the authors, that the state variables that drive investment are

Fig. 1.1: Investment and Financial Conditions in the Aftermath of the Great Recession



Source. Author's own calculations based on data from FRED and Federal Reserve Board Surveys. All series are normalized to 1 in the 2007$q4$. The scale of credit tightening standards the and Chicago Financial Index are reverted, so a tightening of conditions is captured by a decline in the series. Blue shadow area corresponds to NBER recession dates.

search and matching model of customer capital in which firms must engage in selling effort. Following a negative financial shock, the firm reacts by cutting expenses in sales-related activities for customer attraction and increasing prices to regain internal liquidity. However, these decisions are not costless; in a model that encompasses the long-lasting nature of customer relationships, they are taken at the expense of future customer accumulation. Once financial conditions start to improve, the firm postpones physical investment decisions due to a shortage of customers relative to existing production capacity and the need to first rebuild its customer base.

This chapter introduces a new transmission mechanism that stems from financial shocks. When coping with a reduction in external financing, firms adjust not

different from those that drive financial conditions.

Tab. 1.1: Correlations between the cyclical components of Real and Financial Variables

	$corr\,(INV, SP500)$	$corr\,(INV, GZSPRD)$	$corr\,(SP500, GZSPRD)$
Pre-crisis	0.636	-0.320	-0.552
Crisis	0.931	-0.676	-0.888
Post-crisis	0.324	0.094	-0.882

Source Author's own calculations based on data from FRED. "Pre-crisis" corresponds to the period 2005q2-2007q3, "Crisis" to the period 2007q4-2009q2, and "Post-crisis" to the period 2009q3-2011q4.

only their pricing decisions but also their selling effort, in a way that saves money in the short-run but reduces future demand. Thus, the introduction of customer markets helps us to better understand the drivers of investment decisions during and after a financial crisis and to better target economic policies to boost economic activity.

Selling Effort and Financial Conditions. The main trigger mechanism presented in the model is the decline in expenses for customer accumulation that follows a financial shock. This idea is supported empirically in the procyclicality of selling effort and its positive comovement with financial conditions. In fact, different measures of selling effort underwent a steep decline during the Great Recession. An important fraction of this selling effort is accounted for by employment in sales-related activities. In fact, CPS data show that employment in sales and related occupations plunged 5.8% from peak to trough during the Great Recession. In addition, the decline in sales employment growth during the 2007 recession was steeper than the decline in total employment growth, as pointed out by Gourio and Rudanko (2014a).

Sales-related employment is characterized by its procyclicality and contemporaneous comovement with financial conditions. Table 1.2 reports the results of simple linear regressions between the year-to-year growth in alternative definitions of sales-related activities and measures of economic activity and financial conditions. The definition of sales-related activities is based on the categories for sales employment described in Gourio and Rudanko (2014a). The first category corresponds to the broad definition of Sales and Related Occupations reported in the 2010 Census Occupation Classification. The second category excludes cashiers and clerks from the first category. The third category consists of the second category plus market researchers, managers in marketing, and purchasing agents. Finally, the fourth category excludes first-line supervisors from the third category.[2]

Column (1) in Table 1.2 presents evidence of a positive comovement between the growth in sales-related activities and the growth in total employment for the period 1994q1-2015q4. This is suggestive of the procyclicality in sales employment activities. The results reported in column (1) are also indicative of the higher responsiveness of sales employment to fluctuations in economic activity compared to total employment. This implies that sales employment exhibits more cyclical variation, and that it is a volatile component of total employment.

Moreover, periods of financial distress coupled with a reduction in credit growth and a higher level of bond spreads are associated with periods of contraction in selling effort. Column (2) highlights positive and significant comovement between the year-to-year growth in total credit to non financial corporations and

[2] This classification accounts for the fact that the definition of sales-related activities includes categories of employment more closely related to customer attention, such as cashiers and clerks, rather than new customer acquisition. And that the current Census classification of sales activities excludes occupations that can play an active role in customer accumulation, such as marketing researchers. A detailed description of the sales-related occupations groups is presented in Appendix 1.B.

the growth in sales employment for the period 1994q1-2015q4. This correlation is higher for categories with more involvement in customer acquisition (third or fourth categories). This positive comovement is not driven by the Great Recession, but rather as column (3) shows excluding this particular period does not eliminate this relationship. However, for some categories of sales employment, the comovement has strengthened during recent years.

The comovement between financial conditions and selling effort is not limited exclusively to credit growth. Column (4) reports a negative and significant correlation between the measure of credit spreads obtained from Gilchrist and Zakrajsek (2012) and the growth in sales-related employment.

An additional category of selling effort includes expenditures on advertising, which accounts for 2-3% of total GDP in the U.S. These expenditures are procyclical and volatile, as pointed out by Hall (2012), based on the McCann advertising series. For example, during the first quarter of 2009, total advertising in the U.S. fell approximately 12% compared with the same quarter in 2008.[3]

Pricing Decisions. The decline in customer investment following a financial shock in my model is coupled with an increase in prices and markups. After a negative shock, firms increase prices (i.e., reduce discounts) as an optimal response to the decline in sales-related expenses and to increase their internal liquidity. In the presence of search and matching frictions in customer attraction, when a firm is forced to cut expenses for sales employment, it is no longer optimal to offer discounts. This

[3] "For many businesses that carry ads the pain is even greater still. Advertisement in magazines is expected to fall by 18.3%. Radio advertisement is predicted to plunge by 21.8% and newspaper advertisement by 26.5%." (*The Economist*, "Nothing to shout about", July 2009.)

is because lower levels of sales employment reduce the probability of creating new customer relationships. With low probabilities of matching, a price reduction only results in lower current profitability and longer queues for potential new customers and not in creating more customer relationships. This mechanism is reinforced in my model by the higher value that current profitability has in periods when external sources of financing are lacking, which also discourages lowering prices.

This feature in price-setting behavior is not novel. Since Phelps and Winter (1970), the idea that firms seek to maintain and retain customers through pricing decisions has been present in the literature, and has been extended to analyze periods of financial turmoil. Greenwald et al. (1984), Gottfries (1991), Klemperer (1995), and Dasgupta and Titman (1998) argue that during a recession and in the presence of credit market imperfections, firms boost current profits to meet liabilities by increasing prices, at the expense of forgoing market share. Opler and Titman (1994) and Chevalier (1995) provide empirical evidence that more financially constrained firms lose market share during economic downturns and have higher prices than their less leveraged rivals.[4]

More recently, Gilchrist et al. (2014a) and Gilchrist et al. (2016) find evidence that during the last recession, firms experiencing a deterioration in their balance sheets were more likely to increase prices to cope with liquidity shortfalls. In particular, they find that average prices at liquidity-constrained firms jumped almost

[4] These ideas are also echoed in Chevalier and Scharfstein (1996), who find that during recessions, financially constrained supermarket chains raise prices relative to less financially constrained chains. Pichler et al. (2008) posit that more indebted firms use higher effective discount rates when valuing investment returns and, as a consequence, are less willing to lower their current prices to invest in market share. Campello (2003) finds that markups are more countercyclical in industries in which firms use more external financing.

Tab. 1.2: Sales Employment and Financial Conditions
$$\Delta S_{it} = \alpha_i + \beta_i X_t + \epsilon_{it}$$

	ΔEmploy.	ΔCredit.		Spreads
	$1994q1-2015q4$	$1994q1-2015q4$	$1989q1-2007q2$	$1994q1-2012q3$
	(1)	(2)	(3)	(4)
1. Sales-Related Occupations (SRO)	1.025 (0.076)	0.267 (0.044)	0.177 (0.076)	-1.371 (0.309)
2. SRO − cashiers and clerks	1.220 (0.107)	0.358 (0.054)	0.274 (0.003)	-1.262 (0.410)
3. SRO − cashiers and clerks + marketing	1.238 (0.106)	0.351 (0.053)	0.283 (0.099)	-1.361 (0.402)
4. SRO − supervisors, cashiers and clerks + marketing	1.195 (0.138)	0.358 (0.063)	0.468 (0.105)	-1.561 (0.449)

Notes: Total employment and series of sales-related occupations are from CPS monthly files obtained from IPUMS. All series are seasonally adjusted using Tramo-Seats. All coefficients in the table are significant at 1%. Credit corresponds to growth of total credit to nonfinancial institutions, adjusted for breaks. Series for spreads are obtained from Gilchrist and Zakrajsek (2012).

30% relative to liquidity-unconstrained firms.

A Complementary Demand Channel. As a result of the reduction in selling effort and increase in prices, the firm finds itself with fewer customers. The mechanism highlighted in this chapter introduces a new demand channel. Previous research on demand factors in the Great Recession have emphasized household wealth and savings following the empirical work of Mian and Sufi (2010, 2012). Using county-level data, the authors show how households' deleveraging process and the subsequent contraction in demand are important in understanding aggregate economic performance.[5] This mechanism has been quantitatively assessed by Caggese and Orive (2015), Huo and Rios-Rull (2012); Rios-Rull and Huo (2016). The demand channel presented in these articles relies on households' attempt to increase savings, which results in a contraction in demand and a subsequent lowering of prices and occupation rates. This brings about lower employment and investment, which reinforces

[5] Similarly, using micro data, Kahle and Stulz (2013) find evidence of a demand channel that affects capital expenditures for firms in the U.S with different credit reliance. For the case of the Eurozone, Barkbu et al. (2015) report that little of the observed declined in investment remains unexplained after accounting for the effect of the decline in output.

the household's initial desire to increase savings and reduce consumption, which triggers in the process, a sizeable recession.

Two important distinctions separate this chapter from this literature. First, the behavior of demand in my model is fully determined by the firm's choices in terms of selling effort and price-setting; if anything, the deleveraging story and the mechanism I propose can be thought of as complementary and provide an additional source of amplification, as discussed more extensively in section 5.2. Second, financial shocks in this chapter are not accompanied by a deflationary process, as in Rios-Rull and Huo (2016); on the contrary, in my model firms lower the discounts charged to new customers and increase markups after being hit by a shock.

Investment Recovery and Financial Shocks. In summary, when firms need to invest in customer accumulation, financial shocks affect the dynamics of investment during and after the shock. During the shock investment expenditures fall as a consequence of the reduction in external sources of funding and the lower value the firm puts into the future. This is also true after the shock, because the shortage of customers relative to its installed capacity limits the profitability of undertaking investment projects. With fewer customers, one unit of capital invested does not necessarily increase marginal revenue in the next period.

As a result, after financial conditions have started to improve, it is therefore not optimal to expand capacity until this base has also begun to recover. This simple mechanism can account, first, for a weak recovery in investment despite a rapid improvement in financial conditions. And second, the mechanism accounts for the positive correlation exhibited between financial conditions and investment during downturns, as well as, the lower or even negative correlation during upturns.

Additional Related Literature. This chapter is closely related to Ottonello (2015); both documents focus on the slow recovery of investment after a recession. However, the direct mechanisms through which financial conditions affect investment differ. In Ottonello's model, financial shocks cause capital unemployment. Consequently, after a shock, the economy devotes more resources to absorbing existing capital than accumulating new capital. In my model, in contrast, financial shocks cause a reduction in the customer base, which confines investment during the recovery phase. When financial conditions begin to improve, firms need to devote more resources to rebuilding their customer base than to accumulating capital.

This chapter builds extensively on the idea of customer markets presented by Gourio and Rudanko (2014b). These authors argue that goods market frictions result in relationships that are long-term in nature, which renders the customer base an important variable in understanding firms' decision making. Models that include customer capital are able to capture investment dynamics that go beyond the predictions of the standard Tobin $q's$ model, since they introduce an additional adjustment cost on firm expansion. I extend this framework to analyze how these frictions also interact with financial conditions to explain investment dynamics during the recovery period after the Great Recession. In this respect, this chapter is also related to Gilchrist et al. (2016), who introduce financial frictions in a model of customer markets to explain the lack of deflation experienced during the 2007-2009 period.

A competing literature has evaluated the role of uncertainty in explaining the weak recovery, with mixed results. On the one hand, Bloom et al. (2012) argue that uncertainty shocks have sizeable effects on GDP and can also account for the weak recovery in real variables. On the other hand, Arellano et al. (2012) introduce a model with financial frictions and point out that uncertainty shocks cannot account for the slow recovery after the Great Recession. Their results differ mostly because of different assumptions on the persistence of uncertainty episodes, rather than on the existence or absence of financial frictions. While in Bloom et al., periods of heightened uncertainty are estimated to be highly persistent, Arellano et al. find low persistence in their measure of uncertainty (the interquartile range of sales growth across firms), which falls relatively quickly after 2009.[6]

Along the same lines, Fajgelbaum et al. (2014) show how a high level of uncertainty about economic fundamentals deters investment when uncertainty evolves endogenously. The authors conclude that the economy can potentially experience a unique rational expectations equilibrium in which low activity and high uncertainty are self-reinforced.

This chapter is also related to Rognlie et al. (2014), who associate the slow recovery in nonresidential investment with a combination of investment overhang in the residential sector and weak aggregate demand. According to the authors, excess housing capital lowered residential investment, since a high stock of housing worked as a substitute for new investment. Additionally, the zero lower bound on interest

[6] The behavior of uncertainty during the recovery has been different depending on the measure considered. While the Policy Uncertainty Index developed by Baker et al. (2015) has displayed great persistence, other measures (realized stock market volatility, idiosyncratic stock market volatility, option-implied volatility on the S&P 100 stock futures index, forecast dispersion, and measure of economic data surprises) recovered rapidly after the crisis. See Caldara et al. (2014) for a comparison.

rates prevented other sectors from offseting the fall in residential investment. In such way, the overall fall in aggregate demand reduced the returns on capital and, as a consequence, nonresidential investment.

Although not directly related, this chapter builds on Jovanovic (2009), who postulates that capital investment requires not only resources (e.g., consumption units or cash) but also an investment option (i.e., a project). Project availability can be rationalized in my model as an opportunity to expand provided by growth in the customer base. This is because the presence of customer markets introduces a wedge between the expected return of a unit of capital tomorrow and Tobin's q; this wedge can be understood as a measure of the availability of profitable investment projects, and it is mainly driven by the state of customer capital. In this way, the return of investment after a collapse in the customer base can be understood as a reduction in project availability that limits investment decisions.[7]

The rest of this chapter is organized as follows. Section 2 describes investment recovery for different groups of firms. Section 3 introduces a model of investment with financial frictions and customer markets. Section 4 discusses the model's implications for investment and pricing decisions. Section 5 presents quantitative results, and Section 6 concludes.

[7] Banerjee et al. (2015) state that the slow growth in capital formation is due to a lack of profitable investment opportunities. However, their argument is based on the premise that uncertainty about future demand prevents firms from committing to irreversible physical investment.

2 *Investment in the Aftermath of the Great Recession*

The aftermath of the Great Recession has been characterized by a generalized slow recovery in capital expenditures. This section reports how after two years of recovery and despite of better financial conditions, average investment rates were below pre-crisis level. In addition, in this section I assess using matching estimators, whether the extent of recovery differs across firms with different degrees of financial reliance, and whether this reliance also has implications for the behavior of investment dynamics during the downturn. I find evidence that firms with low levels of cash and short-term positions experienced a more pronounced decline in investment during the crisis, followed by a relatively weaker recovery, compared to firms with similar characteristics. This result complements the findings of Gilchrist et al. (2014b) that this group of firms was also more prone to increase prices during the Great Recession in order to regain internal liquidity at the expense of customer acquisition.

For this purpose, I collect quarterly data from CRSP/Compustat from the third quarter of 1992 to the fourth quarter of 2013. I classify firms based on information from 2006q2 about their leverage ratios, bank/credit dependance, collateral availability, and their liquidity position, to account for different levels of financial reliance. These categories are obtained by combining data from Compustat and the information contained in Dealscan and CapitalIQ. All variable definitions and groups' construction are described in more detail in Appendix 1.B.

The sample of firms is divided into six interrelated categories. The first category corresponds to firms with bank relationships. This *bank-related* group encompasses firms with two or more loan facilities with the same U.S lead bank in the five years before the crisis, according to Dealscan. Firms are also classified in terms of their *leverage* ratios. Firms with high leverage includes firms in the first quintile of leverage distribution. This group of firms is particularly relevant, as Giroud and Mueller (2016) finds evidence that more highly leveraged firms exhibit a significantly larger decline in employment in response to a drop in consumer demand during the Great Recession.

From this group of highly leveraged firms, I distinguish some additional categories. First, I examine firms with a bank loan or revolver at the end of 2006; this category is introduced as an alternative measure for *bank-related* firms to overcome the fact that information in Dealscan is limited to larger firms. Second, I distinguish firms with high leverage and real estate proprietorship; this group captures the relevance of the collateral channel as an important driver in investment decisions. This channel was extensively discussed by Chaney et al. (2012), and it is stressed by macro models that link impaired access to credit and investment. This group of firms can potentially benefit not only by improvements in financial conditions, but also by the upturn in commercial real estate prices. Third, I distinguish firms with low levels of cash stocks: some highly leveraged firms have access to short-term liquidity positions that reduce their vulnerability to abrupt shifts in financial conditions.

Finally, firms are classified according to their liquidity ratio, the sum of cash and short-term investment over assets. This ratio is a measure of the ability to turn short-term assets into cash to cover debt obligations and fund operation costs. This category corresponds to firms in the two lowest quintiles of the liquidity ratio by 2006q2. According to Gilchrist et al. (2016), firms with low liquidity ratios are more prone to increase prices as an adjustment mechanism to cope with the reduction in external sources of financing.

2.1 Investment: Descriptive Statistics

The weak recovery in investment in the aftermath of the Great Recession was generalized across firms with different ex-ante reliance on financial conditions. Table 1.3 shows quarterly averages of capital expenditures, during and after the Great Recession. Column 1 corresponds to the values obtained for the whole sample. The first empirical observation is that investment, measured as the ratio of capital expenditures over lagged property, plant and equipment, fell sharply during the Great Recession, from a pre-crisis average of 9.51 percent to an average of 5.42 percent in the second year of the crisis, i.e., a decline of 43 %. In the first year following the crisis, capital expenditure recovered by only 0.9 percentage points to an average of 6.37 percent in 2009$q3 - 2010q2$. The recovery in the second year is larger, reaching an average of 8.40 %, though still below pre-crisis levels, as indicated by the significance of the hypothesis test for differences in means. Since then, the average capital expenditures ratio has oscillated around 8 %, which is still below the levels observed before the Great Recession.

In the remaining columns I repeat the exercise for subsamples to describe the evolution of investment on firms facing different financial conditions. Column 2 shows average capital expenditures for firms that had a bank relationship before

Tab. 1.3: Descriptive Statistics - Capital Expenditures

				Leverage Measures				
		Whole Sample	Bank Relation	High Leverage	High Leverage/ Bank depen.	High Leverage/ Real Estate	High Leverage/ Low Cash	Liq. Index
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Pre Crisis	p1. 2006q3-2007q2	0.0951	0.0682	0.0804	0.0632	0.0525	0.0670	0.0611
Crisis	2007q3-2009q2	0.0705	0.0529	0.0609	0.0591	0.0432	0.0508	0.0494
	c1. 2007q3-2008q2	0.1012	0.0622	0.0741	0.0648	0.0526	0.0614	0.0604
	c2. 2008q3-2009q2	0.0542	0.0432	0.0424	0.0449	0.0321	0.0414	0.0409
Recovery	r1. 2009q3-2010q2	0.0637	0.0403	0.0602	0.0439	0.0318	0.0432	0.0493
	r2. 2010q3-2011q2	0.0840	0.0574	0.0556	0.0549	0.0457	0.0462	0.0568
	r3. 2011q3-2012q2	0.0810	0.0544	0.0626	0.0492	0.0417	0.0512	0.0563
Difference	r1. vs p1.	-0.0314***	-0.0279***	-0.0202***	-0.0193**	-0.0207***	-0.0238***	-0.0118***
$H_0 : r_i = p1$	r2. vs p1.	-0.0111***	-0.0108***	-0.0248***	-0.0083	-0.0068	-0.0208***	-0.0043***

Notes: “Bank relation” includes all firms with two or more loan facilities with the same U.S lead bank in the period 2001-2006 according to Dealscan. “High Leverage” are the firms in the first quintile of the leverage distribution. “High Leverage / Bank Dependent” are firms in the first quintile of the leverage distribution that had a loan or revolver by the end of 2006, according to Capital IQ. “High Leverage / Real Estate” stands for firms in the first quintile of the leverage distribution that reported real estate proprietorship in 2001-2006. “High Leverage/Low Cash” comprises firms in the first quintile of leverage and last quintile of cash stocks. Finally, “Liq. Index” corresponds to the firms in the two lowest quintiles of the cash distribution. For the Abadie-Imbens estimator, the control group does not include all the firms in the sample, but just those that best match the treated firms in several dimensions (industry, credit rating, market-to-book ratio, operating cash flow, cash holdings, size, and leverage ratio). *** (**) [*] denotes significance at the 1 (5) [10] % level.

the crisis. These firms display a lower pre-crisis capital expenditure than the whole sample. In the crisis they experienced a fall in investment of the same order of magnitude as the whole sample (35 percent). The recovery following the recession has been slow, particularly in the first two years after the official end of the crisis. The hypothesis test comparing the pre-crisis average in $2006q3 - 2007q2$ against the post-crisis average in $2010q3 - 2011q2$ indicates that their difference is statistically significantly different from zero at the 5 percent level.

Columns 3-6 contain the results corresponding to highly leveraged firms, i.e. firms in the top quintile of the leverage distribution. While they experienced a fall in investment of 47 percent during the crisis, similar to the whole sample, these firms experienced a slightly faster recovery in their investment in the aftermath of the Great Recession than the whole sample, though the differences are not meaningful. Despite this, the recovery in investment was slow and had still not reached pre-crisis levels as of 2012. The only exception are the high leveraged firms that are dependent on bank loans. For these firms investment in the second year following the crisis was not statistically different from pre-crisis levels. This result is explained by a higher dispersion in this sub-sample, since the differences in the means are not different from those observed for other sub-samples. Firms with high leverage and real estate assets (Column 5) experienced a decline of 38% in capital expenditures, one of the largest declines from pre-crisis to the second year in the recession in the sample. For this group, after two years in recovery, capital expenditure still remained 25% below the average in $2006q3 - 2007q2$.

Firms with high leverage and low levels of cash holdings (Column 6) do not behave very differently from the whole sample. Although, this sub-sample display substantially lower pre-crisis levels of capital-expenditures-to-property ratio (1.2 percent), the hypothesis tests of the difference between the average in the year prior to the crisis and the average in the first year after the official end of the crisis indicates that the two magnitudes are not statistically different.

Finally, firms with low liquidity are characterized by average capital expenditure ratios that are not statistically different from the mean of the whole sample. In fact, investment for low liquidity firms is not statistically different from investment of firms with higher leverage. However their investment rate fell by 37% during the crisis and was still 7% below pre-crisis levels two years into the recovery.

In summary, after two years of recovery and despite of better financial conditions, average investment rates across different samples were below pre-crisis level. The slow recovery in investment in the aftermath of the Great Recession was generalized across firms with different ex-ante reliance on financial conditions.

2.2 Matching Estimators

To assess the effect on investment of reliance on external financing during the recovery period, I employ the Abadie and Imbens's matching estimator and compare the average change of capital expenditures between the final year of the crisis (2008q3-2009q2) and the first year of the recovery (2009q3-2010q2) for matched firms within the groups described above. For two reasons I chose these periods. First, it allows me to control for seasonality, because I compare equivalent periods in different years. And second, it reduces the likelihood of a change in the financing composition of firms, which can render the initial classification less reliable.

To construct this estimator, I first consider firms that display more reliance on financial conditions (treated observations). Then, from the remaining firms in the population (non-treated observations), I select control observations that best match the treated ones on several dimensions. The covariates considered to perform the matching are industry, credit rating, size, cash flows, market-to-book value, and when the initial classification does not include them, leverage and cash stocks, as in Almeida et al. (2012) and Kahle and Stulz (2013).

Matches in categorical variables such as industry and credit ratings are exact. Exact matching by industry allows me to control for the different size and role of customer markets in different sectors of the economy, a feature highlighted by Gourio and Rudanko (2014b). Matches in continuous variables (e.g., leverage, size, cash, cash flows, and market-to-book ratio) are not exact. Thus, the results reported include a bias correction to account for inexact matches. I select one match per firm and exclude from the estimation all firms with no close exact match. Matches are created based on the averages of the covariates as of 2006.

Table 1.4 reports the average treatment effect on the treated group for changes in capital expenditures. In the first column, I show results for firms with a bank relationship; for this group, there is no differential pattern in the recovery of investment relative to the otherwise equivalent firms in the control group.

Column (2) reports the estimates for firms with high leverage. The evidence indicates that these firms had a faster recovery than their matches in the control group. However, it should be noted that these firms were not differentially affected

Tab. 1.4: Investment Recovery after the Great Recession

	Bank Relation	Leverage Measures				Liq. Index
		High Leverage	High Leverage/ Bank depen.	High Leverage/ Real Estate	High Leverage Low Cash	
	(1)	(2)	(3)	(4)	(5)	(6)
A. *(2008q3-2009q2) versus (2009q3-2010q2)*						
Abadie-Imbens	0.00207	0.0111*	-0.0013	-0.0041	-0.0116	-0.052*
	(0.0024)	(0.0059)	(0.0088)	(0.00113)	(0.0081)	(0.0028)
B. *(2006q3-2007q2) versus (2008q3-2009q2)*						
Abadie-Imbens	-0.0062*	-0.031	0.0033	0.0199	0.0116	0.011***
	(0.0032)	(0.0085)	(0.0011)	(0.0029)	(0.114)	(0.0038)
Observations	1770	2973	449	254	315	3398

Notes: "Bank relation" includes all firms with two or more loan facilities with the same U.S lead bank in the period 2001-2006 according to Dealscan. "High Leverage" are the firms in the first quintile of the leverage distribution. "High Leverage / Bank Dependent" are firms in the first quintile of the leverage distribution that had a loan or revolver by the end of 2006, according to Capital IQ. "High Leverage / Real Estate" stands for firms in the first quintile of the leverage distribution that reported real estate proprietorship in 2001-2006. "High Leverage/Low Cash" comprises firms in the first quintile of leverage and last quintile of cash stocks. Finally, "Liq. Index" corresponds to the firms in the two lowest quintiles of the cash distribution. For the Abadie-Imbens estimator, the control group does not include all the firms in the sample, but just those that best match the treated firms in several dimensions (industry, credit rating, market-to-book ratio, operating cash flow, cash holdings, size, and leverage ratio). *** (**) [*] denotes significance at the 1 (5) [10] % level.

by the crisis in terms of capital expenditures, as shown in Panel B of Table 1.4. Therefore, there would be no reason to expect that their capital expenditures would recover at a slower pace. These results are in line with Kahle and Stulz (2013).

Within the highly leveraged firms, I consider three subgroups: those with bank dependence, those that own real estate, and those with a low stock of cash. Results for these groups are displayed in Columns (3)-(5). There is no evidence of a faster decline or recovery of investment for these firms relative to their respective control groups.

Finally, firms with low liquidity levels show a weaker recovery in their capital expenditures relative to the control group. Notice that this group of firms exhibit similar investment rates compared to highly leveraged firms, so the magnitude of this variation is relevant for total investment as discussed in previous section. When I extend the analysis to compare the drop in capital expenditures entailed by the crisis, firms in this category exhibit a significant larger contraction. In summary, capital expenditures from firms with low liquidity levels were relatively more affected by the Great Recession; the recovery is also weaker compared to similar firms, but with higher levels of cash and short-term investment.

This result is important, since Gilchrist et al. (2014b) present additional evidence on the behavior of this group of firms during the Great Recession. More specifically, these firms were more likely to increase prices to cope with the reduction in external financing. But more importantly, if only financial constraint were at play, we expected firms with low liquidity to recover faster than their counterparts. These dynamics of lower investment, higher prices, and weaker recoveries are consistent with the predictions of models with customer markets and financial frictions, which I introduce in the next section.

3 Model

This chapter builds on the industry model of Gourio and Rudanko (2014b), with its framework extended to introduce financial frictions in line with Jermann and Quadrini (2012). Industry production is carried out by a large representative firm that operates in j different submarkets within the same industry. This model embodies the idea that expenses on sales representatives and discounts to attract potential buyers are necessary inputs to create new customer relationships. This simple framework provides analytical tractability and allows me to delineate the mechanisms through which financial shocks impact investment decisions when customer relationships are important.

The model builds on the competitive search framework introduced by Moen (1997), in which firms attract new customers by granting discounts to balance the trade-off between attracting more customers and increasing profitability per customer; customers balance the trade-off between lower discounts and congestion when searching for products. This form of price-setting has serious consequences for financially constrained firms, as it exacerbates the trade-off between higher current profitability and customer base during periods of distress.

3.1 Firm

Consider an economy in which one large firm produces a continuum of goods in the interval $[0, 1]$ and sells them in different submarkets, denoted by j. The firm's objective is to maximize the present discounted value of dividends, subject to a flow-of-funds constraint and a borrowing constraint. The firm discounts the future at a rate β. The economy is characterized by competitive search, so the firm posts prices to attract new clients within each submarket. As in Arseneau and Chugh (2008), the focus of this chapter is the symmetric equilibrium in which the firm chooses the same allocations for each submarket j. Thus I dispense with the use of subindex j.

Production. This firm produces y_t^s units of output using a production technology of the form $f(l_t, k_t, u_t, z_t) = z_t l_t^{\alpha} (u_t k_t)^{1-\alpha}$ where $0 < \alpha \leq 1$. Production makes use of a flexible factor of production (l_t) with a fixed cost that equal to 1, and capital services, which comprise the product of installed capital (k_t) and the utilization rate (u_t). Production is also subject to an aggregate productivity shock z that is governed by an AR(1) process.

Capital Accumulation. Capital accumulation involves a time-to-build technology, with an endogenous rate of depreciation that depends on the degree of utilization. Investment is subject to a physical adjustment cost. In this way, if the firm decides to adjust its capital stock ($x_t > 0$), the total cost of investment would include the purchase price and the physical adjustment cost denoted by $\Phi(x_t, k_t)$.

The capital stock evolves according to:

$$k_{t+1} = (1 - \delta^k(u_t))k_t + x_t \tag{1.1}$$

where x_t denotes investment and $\delta^k(\cdot)$ is a convex and increasing function that determines the depreciation rate based on the level of capital utilization; capital that is used more intensively depreciates faster.

Customer Markets. The firm ends period $t-1$ with a stock n_{t-1} of customers in each submarket. However, only a fraction $1-\rho^n$ survives as a customer in period t. Except for this exogenous separation, customer relationships continue as long as the customer is willing to purchase one unit of product, and as long as the firm is willing to sell the unit.

I assume that each customer demands exactly *one* unit of the good sold in each particular submarket. Therefore, the demand for goods in each submarket is given by $y_t^d = n_t$.

To attract new potential customers, the firm is prompted to hire sales representatives s_t (more broadly, this concept embodies advertising or product positioning). As in Gourio and Rudanko (2014b), I assume that these sales representatives are placed in different locations, starting from the most central to the least central. Therefore, the measure of sales representatives generating s_t effective units of sales is given by an increasing and convex function of the form $\kappa(s_t)$.

Meetings between sales representatives and potential buyers are subject to search frictions. In each period, some locations for submarket j might have more sales representatives than buyers, or viceversa. Similar to the literature of frictional labor markets, I assume a matching function of the form $m(c_t, s_t) = \xi c_t^{\gamma} s_t^{1-\gamma}$. The measure $m(c_t, s_t)$ indicates the number of new customer relationships created when c buyers and s sales representatives meet. The parameter $\xi > 0$ represents the degree of matching efficiency, and $\gamma \in (0, 1)$ the elasticity of new customer relationships with respect to the number of sales representatives. Denote by $\theta = \frac{c}{s}$ the queue length of potential buyers over sales representatives. Then, the probability that a sales representative finds a successful match is $\eta(\theta) = \xi\theta^{\gamma}$, while the probability that a potential buyer finds a successful match is $\mu(\theta) = \xi\theta^{\gamma-1}$.

I use the previous definitions to obtain an expression for the law of motion of the stock of customers, which ultimately represents how the demand for goods evolves over time:

$$n_t = (1 - \rho^n)n_{t-1} + s_t\eta(\theta_t). \tag{1.2}$$

Pricing Decisions. Buyers value differentiated product j at p, which is endogenously determined by total industry output and independent of the specificity of the product in each submarket. To maximize profits, the firm will charge the highest possible price without driving the customer away. It is assumed, for simplicity, that firms cannot commit to future prices, and thus optimally prices each unit at exactly p in submarket j to extract the maximum amount of rent.

However, to attract new customers, firms can influence buyers' decisions by granting a discount ε_t in the first period of the customer relationship. How this discount influences buyers' decisions is described in Section 3.2. Total operating revenues are given by $\pi_t = py_t - s_t\eta\left(\theta_t\right)\varepsilon_t$. These revenues correspond to the value of production net of the discount granted to new customers.

Financing Decisions. Firms use a combination of internal and external funds to finance their total capital expenditures $\Phi\left(x_t, k_t\right)$, total cost of sales representatives $\kappa\left(s_t\right)$, total wage payments l, dividend payments $\varphi\left(d_t\right)$, and outstanding debt stock b_t. The firm's dividend payout $\varphi\left(d_t\right)$ embeds not only dividend distribution, but also a cost of deviating from the optimal target; these costs are given by a convex function that penalizes deviations from the steady-state level of dividends. The aggregate flow-of-funds constraint for the firm is defined as:

$$\pi_t - l - \Phi\left(x_t, k_t\right) - \kappa\left(s_t\right) - \varphi\left(d_t\right) + \frac{b_{t+1}}{R} - b_t = 0. \tag{1.3}$$

Debt b_t is risk free and $R = (1 + r(1 - \tau))$ includes a tax benefit of debt. Firms also raise funds with an intraperiod loan to finance working capital; a fraction φ_w of the wage bill and sales-related expenses must be paid upfront, before production and revenues are realized. This intra-period loan is repaid at the end of the period at zero interest. The ability to borrow intra and intertemporally is bounded by limited enforcement of debt contracts. Lenders require total liabilities to be limited by the liquidation value ζ_t of collateral (capital), plus a multiple ψ of operating revenues π_t:

$$\frac{b_{t+1}}{1+r} + \varphi_w\big(l_t + \kappa(s_t)\big) \leq \zeta_t k_{t+1} + \psi\pi_t \tag{1.4}$$

The variable ζ_t follows an AR(1) process around its unconditional mean ζ.

This shock represents a reduced form for a financial shock in the sense of Jermann and Quadrini (2012), as it limits the capacity to access external sources of financing.[8] This simple constraint allows me to isolate the more direct effects of a reduction in borrowing capacity in the presence of customer markets, as presented in section 5.2.

Constraint (1.4) is similar to the one presented by Hennessy and Whited (2005), which requires the sum of cash flows plus the market limit on borrowing to be at least as large as the amount of debt issued. This feature of the model adds liquidity motives in price-setting decisions. By setting higher prices (i.e., lower discounts), the firm is able to increase not only its internal liquidity, but also its external funding to relax the flow-of-funds constraint. Nevertheless, it is important to point out that the relationship between financial conditions and prices is not limited to this class of models with collateral constraints. In particular, given the structure of the model, the use of revenues in the borrowing constraint is not a necessary condition for firms to lower discounts following a financial shock, as will be discussed in the quantitative section of the chapter.

3.2 Buyers

There is a measure one of identical households, with a measure one of individuals who live in each household. At each period of time there is a fraction c_t (endogenously determined) of members of the household searching for products in sub-market j from which to buy goods. Due to informational frictions, in order to purchase what is

[8] Duchin et al. (2010) argues that the 2007-2009 crisis was characterized by a negative shock to the supply of external finance for nonfinancial firms. Bassett et al. (2014) present evidence that the reduction in the ability to borrow by firms and households was due to the reduction in credit supply lines.

produced in each market, the potential buyer must meet with a sales representative s_t hired by the firm to sell in that specific market.

Each period the household optimally chooses a combination of places to visit based on the discounts offered by the firm, ε_t, and the queue length in that submarket, θ_t. Assume that the opportunity cost of buying is constant and equal to 1. Optimally, the expected payoff for searching for a new product to buy must equal its cost, as shown in equation (1.5):

$$\mu(\theta_t)\varepsilon_t = 1 \tag{1.5}$$

With probability $\mu(\theta)$, the potential buyer successfully meets a sales representative to form a new customer relationship. In that case, she receives a payoff of ε_t during the first period of the relationship. This amounts to the total payoff, since after the first period the firm charges customers a price equal to their exact valuation of the good, which leaves no surplus for buyers to extract from the match in the future.

4 *Pricing and Investment Decisions*

Denote the aggregate state vector as $\mathbf{\Gamma}_t = \{z_t, \zeta_t\}$ which comprises the aggregate productivity and financial state. Consider the problem of a large firm that chooses the scale of production y_t, customer level n_t, sales expenses s_t, capacity utilization u_t, flexible factor use l_t, capital stock k_{t+1}, investment x_t, debt issuance b_{t+1}, price discounts ε_t, and tightness θ_t in order to maximize the discounted stream of future dividends d_t. Letting λ_t^i denote the Lagrange multipliers associated with each specific restriction in problem 1, the firm's optimization problem is given by

Problem 1. *(Firm) The firm solves:*

$$V\left(k_t, n_{t-1}, b_t, \mathbf{\Gamma}_t\right) = \max_{\substack{\{d_t, y_t, n_t, s_t, u_t, l_t, k_{t+1},\\ x_t, b_{t+1}, \varepsilon_t, \theta_t\}}} \quad d_t + \beta \mathbb{E}\ V\left(k_{t+1}, n_t, b_{t+1}, \mathbf{\Gamma}_{t+1}\right) \tag{1.6}$$

subject to

$$(\lambda_t^1) \qquad \pi_t - l_t - \Phi\left(x_t, k_t\right) - \kappa\left(s_t\right) - \varphi\left(d_t\right) + \frac{b_{t+1}}{R} - b_t = 0 \tag{1.7}$$

$$(\lambda_t^2) \qquad y_t = f\left(k_t, l_t, u_t, z_t\right) \tag{1.8}$$

$$(\lambda_t^3) \qquad y_t = n_t \tag{1.9}$$

$$(\lambda_t^4) \qquad n_t = \left(1 - \rho^n\right) n_{t-1} + \eta\left(\theta_t\right) s_t \tag{1.10}$$

$$(\lambda_t^5) \qquad k_{t+1} = \left(1 - \delta\left(u_t\right)\right) k_t + x_t \tag{1.11}$$

$$(\lambda_t^6) \qquad \mu\left(\theta_t\right) \varepsilon_t = 1 \tag{1.12}$$

$$(\lambda_t^7) \qquad \frac{b_{t+1}}{1+r} + \varphi_w\big(l_t + \kappa(s_t)\big) - \psi \pi_t \leq \zeta_t k_{t+1} \tag{1.13}$$

taking the exogenous processes for $\mathbf{\Gamma}_t$ as given. Equation (1.7) corresponds to the flow-of-funds constraint faced by the firm. Equation (1.8) is the aggregate production function of the economy; thus, the multiplier λ_t^2 represents the shadow value of producing one additional unit of output. Equation (1.9) defines aggregate demand and states that production should be equal to the number of units sold to customers; the multiplier λ_t^3 is the shadow value of selling one additional unit of the good. Equation (1.10) depicts the law of motion for customer base accumulation; the multiplier λ_t^4 is the marginal value of attracting an additional customer. Equation (1.11) corresponds to the capital accumulation equation, which is standard except that utilization u_t affects the degree of depreciation of existing units of capital. Equation (1.12) is a "participation" constraint, as described in Section 3.2, that equates the benefits and costs for a customer to search for a good to purchase. Finally, equation (1.13) is a constraint that limits the borrowing capacity of the firm; the multiplier λ_t^7 associated with this constraint corresponds to the shadow value of relaxing the constraint, either by increasing profits or an exogenous change in borrowing capacity ζ_t.

The model is closed by assuming a decreasing demand curve for industry output of the form $p = \bar{y}^{-\frac{1}{\sigma}}$, where $\bar{y}$ stands for total production in steady state.[9] Details on the derivation of the optimality conditions of this model are provided in Appendix 1.A. In what follows, I will present only the main results and their economic intuition for three important variables in the model: investment, pricing, and sales.

Investment. To ease notation, denote $q_t = \lambda_t^5 \varphi'(d_t)$ and $\upsilon_t \equiv \lambda_t^7 \varphi'(d_t)$. q_t stands for the shadow value of one additional unit of capital, and υ_t accounts for the overall shadow value of a tightening in financial conditions. In fact, a tightening in the capacity to access external sources of funding increases the value of υ_t, as the fall in dividends is offset by the increase in the shadow value of the borrowing constraint

[9] Similarly to Gourio and Rudanko (2014b), the value of σ only affects the scale of variables in steady state. The results presented in the quantitative section are not affected by its magnitude.

λ_t^7.

To understand how the interaction between customer markets and financial frictions affects investment decisions, we can use the investment Euler equation derived from the model and presented in equation (1.14):

$$q_t = \beta E_t \Bigg\{ \Xi_{t+1|t} \Bigg[\lambda_{t+1}^2 f_k \left(k_{t+1}, u_{t+1}, z_{t+1}\right) + \left(1 - \delta\left(u_{t+1}\right)\right) q_{t+1} - \\ - \Phi_k \left(x_{t+1}, k_{t+1}\right) \Bigg] \Bigg\} + \lambda_t^7 \zeta_t \tag{1.14}$$

where $\Xi_{t+1|t} \equiv \frac{\varphi'(d_t)}{\varphi'(d_{t+1})}$. This condition equates the shadow value of a unit of capital today to the sum of four different effects: the new unit's marginal contribution to revenue (represented by the first term in the bracket), the depreciated shadow value of capital next period (second term in the bracket), the contribution of the new unit to the marginal decline of future capital installation costs (third term in the bracket), and the liquidity value of one unit of capital, represented in the last term.

Although these elements are standard in investment equations, this Euler condition has several noteworthy non-neoclassical features. First, the firm discounts future cash flows using a stochastic discount factor $\Xi_{t+1|t}$ that is implicitly determined by firms' balance sheet conditions. Notice that after a financial shock, as dividends drop in response, the future value of one unit of capital is discounted more heavily. Second, the marginal value of capital as a source of liquidity to relax the constraint (1.13). These features are characteristic of models of investment with financial frictions, as stated by Gilchrist and Himmelberg (1999).

Third, the contribution of one unit of investment in terms of future revenue is limited by the size of the future customer base; we can see this by expressing the marginal productivity of one unit of capital as $f_k = (1-\alpha)n/k$, which is the ratio between customer evolution driven by equation (1.10) and capital stock evolution driven by equation (1.11). Fourth, the contribution of a new unit of capital in terms of future revenue is discounted by a factor λ_t^2. As stated previously, λ_t^2 is the shadow value of producing one additional unit of output (or the marginal cost of using factors with higher intensity). However, in models where customers are assets for the firm, it is also true that λ_t^2 equals the shadow of a new customer to the firm, as shown below:

$$\lambda_t^2 = \left[(p - \varepsilon_t)(1 + \psi \upsilon_t) - \frac{\kappa'(s_t)}{\eta(\theta_t)} (1 + \varphi_w \nu_t) \right] + \\ + (1 - \rho^n)\beta E_t \left\{ \left[V_n \left(k_{t+1}, n_t, b_{t+1}, \mathbf{\Gamma}_{t+1} \right) \right] \right\} \tag{1.15}$$

λ_t^2 as presented in equation (1.15) includes the current marginal net profit of having one additional customer, which corresponds to the first term in brackets. This value integrates the marginal sales revenues and additional liquidity introduced by this new customer, net of costs from her acquisition. It also includes the future gains from this newly created relationship, represented in the expected future value that a marginal long-term relationship entails for the firm, which corresponds to the second term in brackets. Combining (1.14) and (1.15) we see that the shadow value of a customer tomorrow affects optimal investment today, by affecting how the future marginal product of capital is discounted.

Customers as Investment Shocks. Shocks to the ability to transform consumption into capital goods also introduce a wedge between the marginal productivity of capital and investment. According to Cuba-Borda (2015), this type of shock can quantitatively account for the slow recovery of investment in the aftermath of the Great Recession. The Euler equation for investment in a model with customer markets cannot be fully nested into a model with investment shocks, as the latter introduces additional wedges into the value of capital next period and installation costs. However, the qualitative dynamics of the mechanism presented in this chapter to explain the slow recovery in investment can be understood as one driver of the estimated shock presented by Cuba-Borda (2015) as a driving force for investment behavior after 2009.

Sales Expenses. The firm decides to hire sales representatives up to the point at which the marginal cost associated with an additional customer equals its marginal value:

$$mc_t + \frac{\kappa'(s_t)}{\eta(\theta_t)} (1 + \varphi_w \upsilon_t) = (p - \varepsilon_t)(1 + \psi \upsilon_t) + \\ + (1 - \rho^n)\beta E_t \left\{ \left[V_n(k_{t+1}, n_t, b_{t+1}, \mathbf{\Gamma}_{t+1}) \right] \right\} \tag{1.16}$$

where $mc_t \equiv \frac{1}{\varphi'(d_t) f_l(t)}(1 + \varphi_w \upsilon_t)$. Marginal costs consist of the resources spent on sales representatives and the costs of adjusting production factors. More specifically, the latter cost is captured by mc_t, which reflects the cost of increasing the use of the flexible factor to accommodate changes in customer orders. In terms of benefits, one additional customer increases current profits by the margin $p - \varepsilon_t$, while total external liquidity available to the firm increases by the factor $\psi\upsilon_t$ when the firm is financially constrained and $\upsilon_t > 0$. With probability $(1-\delta^n)$, this new customer remains at the firm tomorrow, yielding her continuation value $V_n(t+1)$ during the next period.

In this model, the working capital constraint increases the marginal cost of hiring one additional sales representative or one additional unit of the flexible production factor by $(1+\varphi_w\upsilon_t)$. These costs are increasing in the size of the friction υ_t. In other words, when the external sources of financing for customer accumulation are restricted, the cost of attracting customers is also higher. This results in a drastic reduction in sales expenses for customer accumulation after a financial shock. The firm can initially lessen the effect of this credit contraction by over-reducing use of the flexible factor. In that way, resources are freed to devote to customer accumulation; however, this decision is at the expense of a more intensive use of capital in production, as will be highlighted in Section (5.2).

Pricing Decisions. The firm sets discounts to balance the trade-off between attracting more potential buyers per sales representative and the cost of reducing the current profit of the firm. Equation (1.17) shows that firms sets its discount to the points at which they equal the value of a new customer, discounted by the matching elasticity.

$$\varepsilon_t = \frac{\gamma}{(1+\psi\upsilon_t)} V_n(k_t, n_{t-1}, b_t, \mathbf{\Gamma}_t) \tag{1.17}$$

The matching elasticity in equation (1.17) accounts for the relative importance of buyers in forming new matches. A higher value of γ implies that more potential buyers per sales representative are required to form a new customer relationship, so discounts must be higher to attract them. The term V_n represents the forward-looking value of an additional customer, as presented in equation (1.18). This value corresponds to the net gain of a customer and the continuation value for the firm.

$$V_n(k_t, n_{t-1}, b_t, \mathbf{\Gamma}_t) = p(1 + \psi \upsilon_t) - mc_t + (1 - \rho^n)\beta E_t \left\{ \left[V_n\left(k_{t+1}, n_t, b_{t+1}, \mathbf{\Gamma}_{t+1}\right) \right] \right\} \tag{1.18}$$

Higher profits allow the firm to attain higher external liquidity, which makes the trade-off between customers and profits more pronounced. When the firm is more financially constrained, the weight on profitability increases by the factor $\psi \upsilon_t$. When the borrowing constraint is not binding (i.e., $\lambda_t^7 = \upsilon_t = 0$), the value of additional external liquidity is not relevant to the pricing decision. However, when the constraint tightens ($\upsilon_t > 0$), profitability becomes more important, and thus the firm is willing to sacrifice customer accumulation by setting lower discounts.

Notice that by combining equations (1.16), (1.17), and (1.18), it is possible to conclude that discounts (ε_t) are directly proportional to the level of sales employments $\kappa(s_t)$. Intuitively, when the firm is constrained and reduces the level of sales employment, the probability of a potential customer matching with a sales representative drops. This means that keeping prices higher to attract more customers will only result in longer queues and lower profitability, and not in new matches created. Thus, financial shocks that limit the number of sales employees are associated with higher discounts and higher markups. This holds even in scenarios in which profits do not generate higher external liquidity (i.e., $\psi = 0$), as discussed in Section (5.2).

5 *Quantitative Analysis*

5.1 *Calibration*

Functional forms: All functional forms used in this chapter are standard in the literature. The investment cost function, which includes the direct cost of investment and a quadratic adjustment cost, is determined by $\Phi(x_t, k_t) = x_t + \frac{\phi_k}{2}\left(\frac{x_t}{k_t} - \delta(u_t)\right)^2 k_t$. Capital depreciation is represented by the functional form $\delta^k(u) = \delta_0 u_{it}^{\varrho}$ with $\delta_0 > 0$ and $\varrho > 0$. The cost of equity issuance is determined by $\varphi(d_t) = d_t + \varphi_d(d_t - d^{ss})^2$ with $\varphi_d > 0$ and d^{ss} equal to dividend in steady state. Sales cost are represented by a quadratic function of the form $\kappa(s) = \frac{\kappa_0}{2}s^2$ with $\kappa_0 > 0$. Productivity shock follows a standard AR(1) process of the the form $\log z_{t+1} = \rho_z \log z_t + \sigma_z \epsilon_{z_{t+1}}$, where $\epsilon_{z_{t+1}} \sim N(0,1)$. The process for the financial shock follows an AR(1) of the form $\log \zeta_{t+1} = (1-\rho_\zeta)\log(\zeta) + \rho_\zeta \log \zeta_t + \sigma_\zeta \epsilon_{\zeta_{t+1}}$.

Parametrization: The frequency of the model is quarterly. Parameters can be grouped in three sets. The first group is calibrated according to standard values obtained from the literature, the second group is quantified directly from the steady state equations, and the third group is used to match autocorrelations and volatility. A summary of the parameters in the baseline model is presented in Table 1.5.

The discount factor β is set to an annualized value of 0.95, and capital depreciation in steady state δ^k_{ss} to an annualized value of 10%. The capital share in production is 0.36. The capital utilization rate in steady state equals 0.8; this is consistent with the historical average rate of utilization according to the Federal

Reserve Board's Industrial Production and Capacity Utilization series. Customer turnover is set to an annualized rate of $\rho^n = 0.14$, as presented in Paciello et al. (2015). This value is in line with the findings of Gourio and Rudanko (2014b), and more conservative than Gilchrist et al. (2016), who suggest an annualized rate of 21%. The parameter linking depreciation to utilization is set to an annualized value of $\varrho = 1.4$. This value can be directly pinned down from optimality conditions in the steady-state. δ_0 equals to 0.13, consistent with the rate of utilization and the annualized rate of capital depreciation. The interest rate is set at an annualized rate of 4%. The tax benefit from debt is set to 0.35, as in Jermann and Quadrini (2012).

The elasticity between discount prices ε and new matches is given by $\frac{1+\gamma}{1-\gamma}$, where γ is the elasticity parameter of the matching function. In Gourio and Rudanko (2014b), γ is set to a value of 0.11, which yields a price elasticity of demand of approximately 1.2. Moreira (2016) sets the price elasticity for a model with customer markets equal to 1.6, based on the findings of Foster et al. (2016). I set the elasticity equal to 1.5 so $\gamma = 0.2$, similar to Moreira (2016), based on the findings of Paciello et al. (2015), who show that an increase in prices of 1% increases yearly turnover by 7 percentage points. The matching productivity is set to $\xi = 0.6$.

I set the mean of the financial shock equal to $\zeta = 0.499$, which implies a steady state debt-to-output ratio of 3.36. To calibrate the volatility and autocorrelation of the financial shock, I normalize the Chicago National Credit Condition index such that its mean corresponds to ζ. Then, I use the series from $1973q1$ to $2016q2$ to estimate $\rho_\zeta = 0.913$ and $\sigma_\zeta = 0.036$.[10] The residual vector from this exercise is used to compute the simulated path of investment to changes in financial conditions. The parameters for the TFP process are set equals to $\rho_z = 0.9$ and $\sigma_z = 0.02$ to match output volatility. The cost of equity issuance φ_d is set to 0.3, as in Cooley and Quadrini (2001) and Gilchrist et al. (2014b). The capital adjustment cost ϕ_k is set to match the quarterly persistence of the hp-filtered nonresidential private fixed investment in chained dollars for the period 1999q1 to 2006q4, which is equal to 0.9.

5.2 Results

Financial shocks. The red solid line in Figure 1.2 represents the response to a one standard deviation shock in financial conditions. The financial shock directly reduces the firm's external resources. Without any restriction on equity issuance, the firm would be able to meet its financial needs by issuing equity. However, equity injections are costly in the model, as in Jermann and Quadrini (2012). Thus, the tightening in borrowing capacity limits the availability of funds to finance firms' expenditures and increases the value of υ_t, as the drop in dividends is offset by an increase in λ_t^7. A higher υ_t implies a higher value for liquidity, but also that hiring sales representatives and labor is more costly due to the working capital constraint.

As a consequence, expenses in sales-related activities $\kappa(s)$ drop. The complementarity between discounts and sales employment and the increase in the value of liquidity cause discounts to fall and markups to increase on impact, as presented in

[10] Similar results are obtained using alternative measures of credit tightening, such as the St. Louis FED financial conditions index or the survey of tightening conditions produced by the Federal Reserve Board, although, the index of tightening in credit conditions exhibits a higher standard deviations compared to alternative measures.

Tab. 1.5: Model Parameters

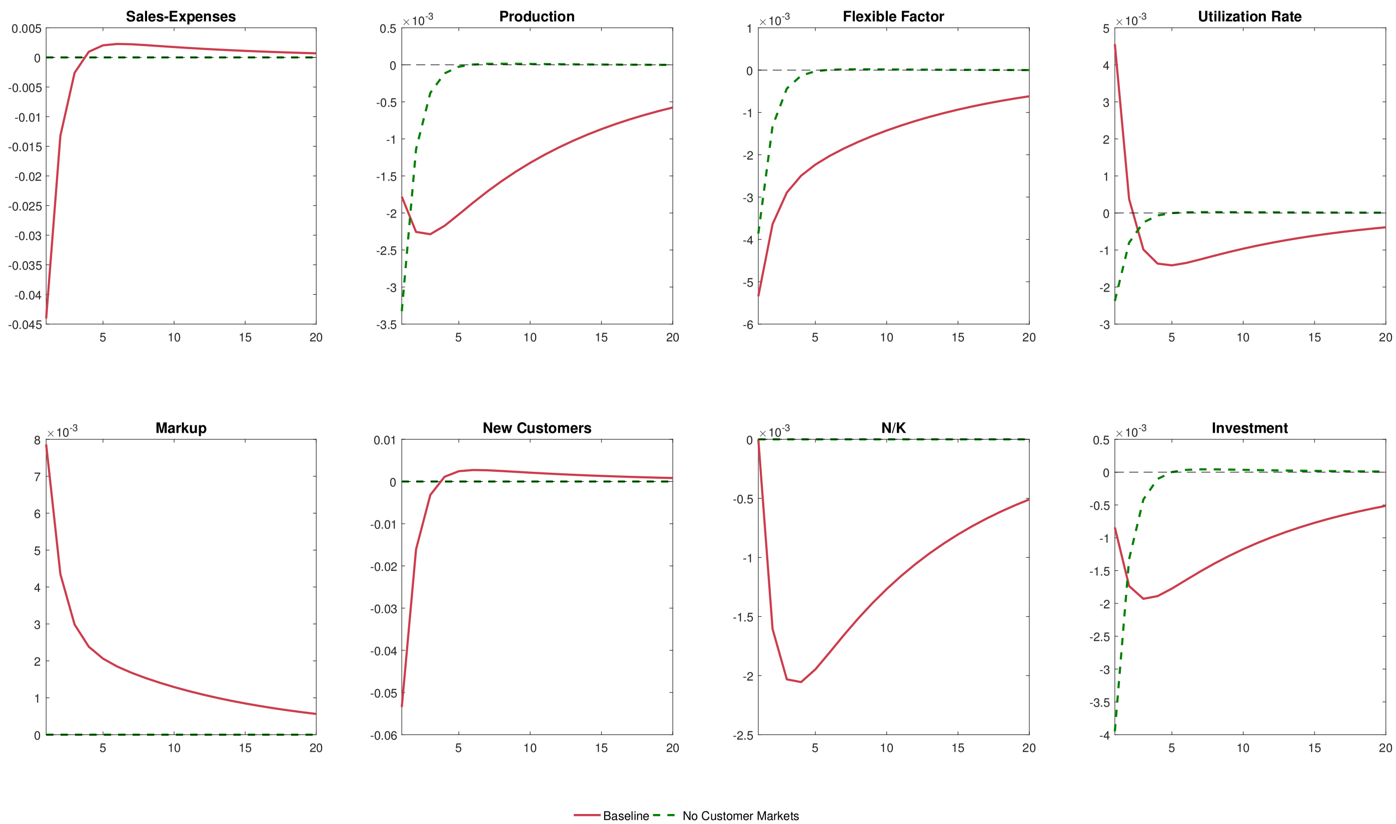
Structural Parameters	Value	Source/Target
Discount Factor	$\beta = 0.95$	Standard DSGE models
Labor Share	$\alpha = 1 - 0.36$	Standard DSGE models
Average Depreciation Rate	$\delta_{ss} = 0.1$	Annualized Rate (NIPA)
Customer Turnover	$\rho^n = 0.14$	Paciello et al. (2015)
Interest Rate	$r = 0.04$	Annualized Rate
Tax Discount	$\tau = 0.35$	Jermann and Quadrini (2012)
Sales Costs	$\kappa_0 = 1$	Normalization
Equity Issuance Cost	$\varphi_d = 0.3$	Cooley and Quadrini (2001)
Matching Productivity	$\xi = 0.6$	Standard Matching Literature
Matching Elasticity	$\gamma = 0.2$	Discount Elasticity=1.5
Constant Depreciation Function	$\delta_0 = 0.13$	Consistent with δ_{ss} and u_{ss}
Rate of Depreciation	$\varrho = 1.4$	Investment Euler Equation
Liquidity Coefficient	$\psi = 0.75$	Taxable Income/Deadweight Loss
Working Capital	$\phi_w = 1$	Jermann and Quadrini (2012)
Mean collateral coefficient	$\zeta = 0.414$	Debt/GDP=3.36
Investment Adjustment Cost	$\phi_k = 38$	AR(1) Investment
Productivity Process	$\rho_z = 0.9$	Gilchrist et al. (2014b)
	$\sigma_z^2 = 0.020$	Match Output Volatility
Financial Process	$\rho_\zeta = 0.9135$	Chicago FED Index
	$\sigma_\zeta^2 = 0.04$	Chicago FED Index

panel 5 of Figure 1.2. Markups are countercyclical in the model. The reduction in sales activity and discounts limits the number of new customers, so that the firm is not able to match the losses associated with turnover. With fewer customers, production falls as shown in panel 2. This suggests that financial shocks create a drop in economic activity based exclusively on how firms cope with changes in economic conditions.

The lower demand is accommodated for by a reduction in the use of factors of production, more specifically, firms reduce the use flexible factor, while capital utilization experiences an initial spike, followed by a drop. Intuitively, the firm reacts by over adjusting labor, as it is also subject to the working capital constraint. After a financial shock, the firm finds it optimal to reduce labor to free up resources for customer accumulation, and to accommodate any excess of demand with a more intensive use of capital. Once financial conditions have begun to improve, the lower demand is accommodated with a combination of lower labor and capital utilization levels.

Panel 8 shows that the response of investment to financial conditions exhibits an inverted hump shape. Investment falls on impact as a result of the contraction in resources to finance investment expenditures. But also it falls due to a higher discounting of the future gain of one extra unit of capital tomorrow. The firm finds itself short of customers relative to installed capacity as reported in panel 7. Investment falls less than the number of customers due to the quadratic adjustment costs and lower depreciation compared to customer turnover. This is important since the shock leaves the economy with a shortage of customers relative to capacity

Fig. 1.2: Impulse Responses to a Negative Financial Shock (Baseline Model vs. No Customer Markets)



Notes. Responses are in log deviations from the non stochastic steady state. The first panel corresponds to sales-related expenditures defined in the model as $\kappa(s_t)$. The second panel corresponds to Production, which corresponds in the model to y and n. The third panel corresponds to changes in flexible production input l. The fourth panel corresponds to changes in capacity utilization u. The fifth panel represents the markup, computed as changes in $(py - s\eta(\theta)\epsilon)/y$ over the marginal cost of l. The sixth panel represents the new customers. The seventh panel presents the ratio between customers n and the capital stock k. The eight panel presents variations in investment x.

installed.

This fact has two important consequences: First, as the financial shock reverts to normal, the firm devotes more resources to recovering its customer base. The model exhibits a rapid recovery in expenses for sales employment. However, search frictions in customer markets delay the process of fully regaining customers, so production takes time to return to steady-state levels. Also, the firm postpones investment decisions until it has accumulated new customers. When the firm is limited by the customer base, investing in one unit of capital today does not necessarily translate into higher marginal revenue tomorrow, making investment less responsive to changes in financial conditions during the recovery phase.

TFP vs. Financial Shocks. Even though both shocks can have similar impacts on investment and production, they entail contrasting dynamics in the use of production factors. A negative TFP shock limits the amount of internally generated funds, bringing about a decline in investment and sales-related expenses. The fall in investment results in a tightening of the borrowing constraint as available collateral drops. This effect is similar to the one obtained from a negative financial shock. However, a negative TFP shock also reduces production capacity. This decline in capacity is larger than the reduction in customers, due to lower sales-related expenses. Thus, the firm accommodates for a negative TFP shock by increasing labor and the rate of capital utilization. In contrast, as stated previously, a financial shock does not affect production capacity and the firm accommodates for this shock by reducing production factors.

Dampening vs. Long-Lasting Effects. How does the inclusion of customer markets affect investment dynamics, compared to standard models with financial frictions? To assess this question, I shut down customers in the baseline model, such that financial conditions only affect production due to the existence of a working-capital constraint on labor. The dotted green line in Figure 1.2 presents the impulse response to a financial shock in a model with financial frictions but without customer markets.[11]

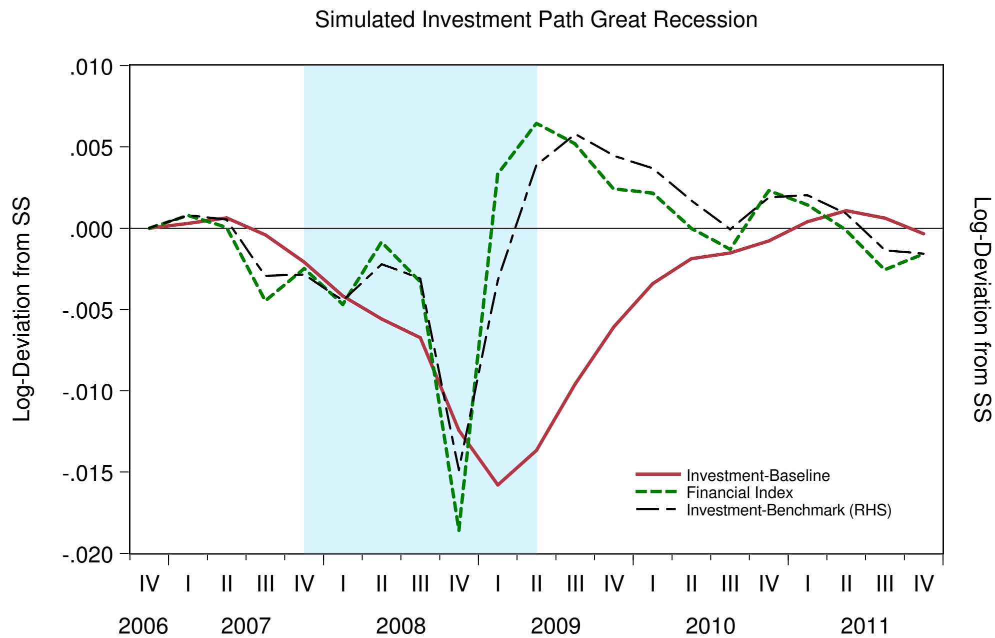
Two important conclusions can be drawn by comparing these two models. First, customer markets dampen the immediate effect on economic activity of financial shocks. The initial responses of investment and production are larger in a model without customer capital. This is because the customer base adds stickiness in the responses, so it works like a cushion for different types of shocks, both real and financial. In other words, the current customer base is a state variable, there is a bound on how much production can fall after a negative shock. Without this limit, output can plunge even more on impact.

Second, the effects of financial shocks are long-lasting compared to a model without customer markets. One of the main predictions of standard models with financial frictions is that economic activity is enhanced by the improvement in financial conditions.[12] The dotted green lines in panels 2 and 8 of Figure 1.2 depict how investment and production rapidly revert to steady state levels in a model with

[11] Models of customer capital exhibit lower absolute volatilities compared to RBC models. Thus, the standard deviation of the financial shock is recalibrated in the model without customer markets to deliver the same absolute volatility of output as the baseline model.

[12] Financial frictions are introduced to existing models as a recurrent phenomenon, which is particularly exacerbated during periods of distress. This specific way of modeling has important implications, since, as pointed out by Hall (2011), it implies that "negative" financial shocks (i.e., improvement in financial conditions) have the ability to stimulate economic activity.

Fig. 1.3: Simulated Investment Path to Changes in Chicago Financial Conditions Index



Notes. Responses are log deviations from the non stochastic steady state. The financial shock series is rescaled such that the value of the index in 2006$q4$ is equal to zero. Blue shaded areas correspond to NBER recessions.

only financial frictions. In contrast, in a model with customer markets, financial shocks entail long-lasting consequences in economic activity and investment.

Investment Recovery and Financial Shocks. The inverted hump shape displayed by investment in response to financial shocks has important implications for the evolution of investment during and after periods of financial distress, such as the Great Recession. It implies that investment plunges with a deterioration in financial conditions, does not respond immediately to improvements in these conditions, and only gradually returns to pre-crisis levels. To asses these points, I feed the model with the actual estimated series of innovations from the Chicago Financial Index for the period 2006$q4$ to 2011$q4$ and simulate the evolution of investment if financial

Tab. 1.6: Correlations between the cyclical components of real and financial variables over different time periods

	Data	Model	
		Customer Markets	No Customer Markets
	(1)	(2)	(3)
2006q4-2008q4	0.5414	0.8340	0.9891
2009q1-2011q4	-0.6943	-0.7924	0.6075

Source Author's own calculations based on data from FRED. "Pre-crisis" corresponds to the period 2006q4-2011q4.

conditions were dictated by the dynamics of this index.[13]

The results of this simulation are displayed in Figure 1.3. The dashed line corresponds to the dynamics of ζ_t, based on innovations from the financial index used as an input in the model. The solid line corresponds to the path of investment. The model preserves the tight relationship between financial conditions and investment during the downturn. The fall in investment is directly linked to the fall in financial conditions, as investment falls prior to 2007q4. However, the model is able to separate the dynamics of financial and real variables during the recovery. Investment only responds to the sudden improvement in financial conditions two quarters later, and returns to steady-state levels only gradually. These results are in deep contrast with the standard predictions of models that link impaired access to credit and investment. Notice that in absence of customer capital the behavior of investment simply mimics the behavior of the financial shock.

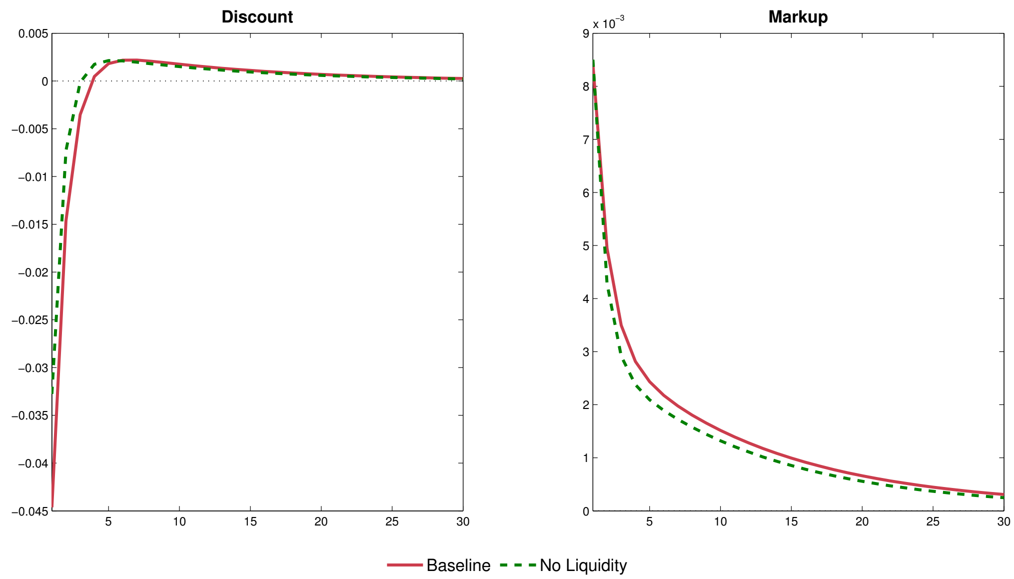
[13] Notice that this sequence of shocks is not perfectly anticipated by the agents, as they forecast the future value of financial conditions based on the autoregressive process in Section 5.1. Although alternative measures of financial conditions, such as the St. Louis Financial Index or Domestic Banks Tightening Standards reported by the Federal Reserve Board might differ quantitatively, they all preserve the same qualitative dynamics as the Chicago Financial Index.

The sluggish recovery in investment and the relationship between financial and real conditions predicted by the model are consistent with data correlations for the period considered in the simulation. Table 1.6 compares the correlation between the cyclical component of real private fixed investment and the Chicago Financial Index before and after the upturn in the latter. Before the improvement in financial conditions observed in 2008q4, the correlation between financial conditions and investment was 0.54 in the data. For the same period, the correlation obtained from the model is 0.83.

After 2008q4, there is a shift in the relationship between financial and real conditions. The data show that the correlation between the Chicago Financial Index and the Real Private Fixed Investment turned negative and equal to -0.69. This is consistent with the results presented in Table (1.1) and discussed previously. A model with customer markets is able to capture weakening in the sensitivity of investment to financial conditions; the correlation from the model is also negative during the same period and equal to -0.79. In contrast, a model without customer capital predicts a lower but still positive correlation during the same period, as shown in Table 1.6 .

Liquidity Effects. One important assumption in the model is the ability of profits to generate not only internal but also external liquidity. This allows me to introduce a liquidity motive to price-setting decisions. However, this assumption is not qualitatively relevant for the model. Figure (1.4) presents the impulse responses of discounts (ϵ_t) and markups after being hit by a financial shock, for two different

Fig. 1.4: Response of Discounts and Markups to Financial Shocks (Different Levels of ψ)



Notes. The responses are in log deviations from the non-stochastic steady state. The left panel correspond to changes in ϵ_t to changes in ψ. The right panel corresponds to changes in $(py - s\eta(\theta)\epsilon)/y$ over the marginal cost of l.

values of $\psi = 0.75$ and $\psi = 0$.

Complementarity between sales and discounts causes firms respond to financial shocks by setting a higher prices for new customers, even in the absence of liquidity motives. The ability to use internal funds as a way to increase external capacity, as in Hennessy and Whited (2005), has implication for pricing decisions, but it is not the main driver of the results presented in this model. The reduction in discounts and the increase in markups are mainly accounted for by the reduction in sales-related expenses.[14]

Demand Shocks. The demand mechanism stressed in this chapter relies on firms' inability to capture new customers after a financial shock. Although I did not explicitly model the behavior of existing customers, it is possible that the deleveraging

[14] This is evident by analyzing equation (1.51) in appendix 1.A.

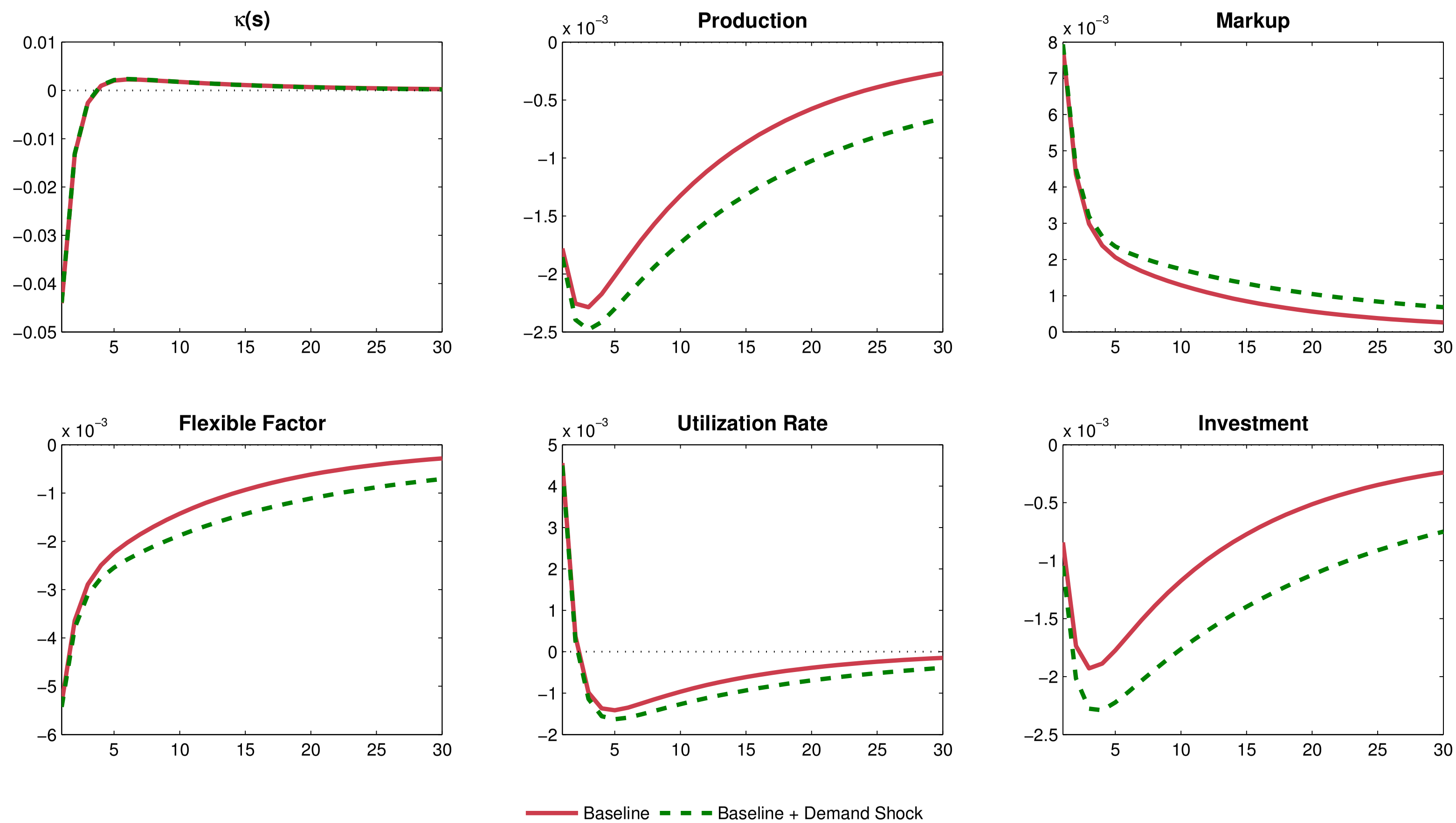
process pointed out in Mian and Sufi (2010) has exerted an additional and generalized effect on the customer base of more and less financially constrained firms. This idea finds support in Nevo and Wong (2015), who document that during the Great Recession households purchased more on sale and at discount stores. To evaluate the possibility that a demand shock not driven by the firm's decisions might create persistent investment dynamics during a financial crisis, I introduce a shock in the separation rate of customers. For simplicity, I set the persistence and volatility of this demand shock equal to the persistence of a TFP shock.

Figure 1.5 presents the impulse response of a simultaneous negative financial shock and a positive shock in the separation rate of existing customers. This combination produces a more pronounced decline in customers, and thus in production. It also generates a more sizeable and protracted drop in investment, compared to the scenario of a financial shock alone. This highlights the importance of the customer base in the evolution of investment dynamics during and after a financial recession. Notice that there is no differential impact on sales expenses after the shock. This suggests that the firm is devoting all available resources to rebuilding the customer base as an important element of the recovery process.

6 *Final Remarks*

Existing models with financial frictions have had difficulty capturing the observed dissonance between improving financial conditions and a weak investment recovery. This chapter proposes a mechanism to disentangle these dynamics. When firms are

Fig. 1.5: Impulse Responses to a Negative Financial Shock and Positive Separation Shock



Notes. Responses are in log deviations from the non stochastic steady state. The first panel corresponds to sales-related expenditures defined in the model as $\kappa(s_t)$. The second panel corresponds to Production, which corresponds in the model to y and n. The third panel represents the markup, computed as changes in $(py - s\eta(\theta)\epsilon)/y$ over the marginal cost of l. The fourth panel corresponds to changes in flexible production input l. The fifth panel corresponds to changes in capacity utilization u. The sixth panel presents variations in investment x..

hit by a financial shock that limits their capacity to raise external funds, they react by cutting sales-related expenses and increasing their prices to cope with the effects of credit rationing.

However, these decisions are not costless, and involve, a disinvestment in customers, that translates into lower demand. When the firm is short of customers relative to installed capacity, investment does not respond immediately to improving financial conditions. The mechanism underlying my model embeds a positive relationship between financial and real conditions during the downturn, but a more nuanced (negative) response during the upturn. This feature is consistent with the correlation exhibited by the Chicago Financial Index and nonresidential Private Fixed Investment during the period 2006q4-2011q4.

The dynamics of investment in the Great Recession are not the only phenomenon that can be explained by customer markets. Models aimed at explaining the decline of entrepreneurship, the entry and exit of firms, or the slow recovery of unemployment could also benefit from incorporating long-lasting customer relationships.

Although customer relationships help us to understand the slow recovery in investment in response to improving financial conditions, this model needs to be extended to capture the quantitative connotations of the Great Recession. One approach would be explicit modeling of the household's decisions on consumption, labor supply, and savings. The combination of financial shocks at the firm and household level reinforces the decline in demand through households' deleveraging process. General equilibrium effects are one aspect of future extensions of the model.

Appendix

1.A Firm Problem

In this section, I derive the optimality conditions of the model presented in Section 3. In constructing the equilibrium, I will restrict attention to an equilibrium that is symmetric across submarkets. Therefore, for ease of notation, I will dispense with the subscript j.

The firm's choices are $\{d_t, y_t, n_j, s_t, u_t, k_{t+1}, x_t, b_{t+1}, \varepsilon_t, \theta_t\}$ to maximize the discounted stream of dividends. The firm's optimization problem is

$$V\left(k_t, n_{t-1}, b_t, \mathbf{\Gamma}_t\right) = \max_{\substack{\{d_t, y_t, n_t, s_t, u_t, k_{t+1}, \\ x_t, b_{t+1}, \varepsilon_t, \theta_t\}}} \quad d_t + \beta \mathbb{E}\ V\left(k_{t+1}, n_t, b_{t+1}, \mathbf{\Gamma}_{t+1}\right) \tag{1.19}$$

s.t

$$(\lambda_t^1): \qquad \pi_t - l_t - \Phi\left(x_t, k_t\right) - \kappa\left(s_t\right) - \varphi\left(d_t\right) + \frac{b_{t+1}}{R} - b_t = 0 \tag{1.20}$$

$$(\lambda_t^2): \qquad y_t = f\left(k_t, l_t, u_t, z_t\right) \tag{1.21}$$

$$(\lambda_t^3): \qquad y_t = n_t \tag{1.22}$$

$$(\lambda_t^4): \qquad n_t = (1-\rho^n)\, n_{t-1} + \eta\,(\theta_t)\, s_t \tag{1.23}$$

$$(\lambda_t^5): \qquad k_{t+1} = (1-\delta\,(u_t))\, k_t + x_t \tag{1.24}$$

$$(\lambda_t^6): \qquad \mu\,(\theta_t)\,\varepsilon_t = 1 \tag{1.25}$$

$$(\lambda_t^7): \qquad \frac{b_{t+1}}{1+r} + \varphi_w\big(l_t + \kappa(s_t)\big) \leq \zeta_t k_{t+1} + \psi\pi_t \tag{1.26}$$

taking the exogenous processes for z_t and ξ_t as given.

It should be noted that, in line with the competitive search literature, the firm's decision also involves posting discounts ε_t and choosing queue length θ_t in each submarket. This requires incorporating, as an additional constraint to the problem, the *participation constraint* from the household's problem of equation (1.5) in the main text.

First-order conditions of the above problem with respect to each of the choice variables are presented below.

$$d_t: \qquad 1 - \lambda_t^1 \varphi'\,(d_t) = 0 \tag{1.27}$$

$$y_t: \qquad \lambda_t^1 p - \lambda_t^2 - \lambda_t^3 + \lambda_t^7 \psi p = 0 \tag{1.28}$$

$$x_t: \qquad -\lambda_t^1 \Phi_x\,(x_t, k_t) + \lambda_t^5 = 0 \tag{1.29}$$

$$l_t: \qquad \lambda_t^2 f_l\,(k_t, u_t, z_t) - \lambda_t^1 - \lambda_t^7 \varphi_w = 0 \tag{1.30}$$

$$u_t: \qquad \lambda_t^2 f_u\,(k_t, u_t, z_t) - \lambda_t^5 \delta'\,(u_t)\, k_t - \lambda_t^1 \Phi_u\,(x_t, k_t) = 0 \tag{1.31}$$

$$s_t: \qquad -\lambda_t^1\left[\eta\left(\theta_t\right)\varepsilon_t+\kappa'\left(s_t\right)\right]+\lambda_t^4\eta\left(\theta_t\right)+\psi\lambda_t^7\eta\left(\theta_t\right)\varepsilon_t=0 \tag{1.32}$$

$$\varepsilon_t: \qquad -\lambda_t^1\eta\left(\theta_t\right)s_t+\lambda_t^6\mu\left(\theta_t\right)-\psi\lambda_t^7\eta\left(\theta_t\right)s_t=0 \tag{1.33}$$

$$\theta_t: \qquad -\lambda_t^1\eta'\left(\theta_t\right)\varepsilon_t s_t+\lambda_t^4\eta'\left(\theta_t\right)s_t+\lambda_t^6\mu'\left(\theta_t\right)\varepsilon_t-\psi\lambda_t^7\eta'\left(\theta_t\right)\varepsilon_t s_t=0 \tag{1.34}$$

$$k_{t+1}: \qquad \beta\mathbb{E}V_k\left(k_{t+1},n_t,b_{t+1},\mathbf{\Gamma}_{t+1}\right)-\lambda_t^5+\lambda_t^7\zeta_t=0 \tag{1.35}$$

$$b_{t+1}: \qquad \beta\mathbb{E}V_b\left(k_{t+1},n_t,b_{t+1},\mathbf{\Gamma}_{t+1}\right)+\frac{1}{R}\lambda_t^1-\frac{1}{1+r}\lambda_t^7=0 \tag{1.36}$$

$$n_t: \qquad \beta\mathbb{E}V_n\left(k_{t+1},n_t,b_{t+1},\mathbf{\Gamma}_{t+1}\right)-\lambda_t^4+\lambda_t^3=0 \tag{1.37}$$

And the corresponding envelope conditions are:

$$V_k\left(k_t,n_{t-1},b_t,\mathbf{\Gamma}_t\right)=-\lambda_t^1\Phi_k(x_t,k_t)+\lambda_t^5\left(1-\delta(u_t)\right)+\lambda_t^2 f_k(k_t,u_t,z_t) \tag{1.38}$$

$$V_b\left(k_t,n_{t-1},b_t,\mathbf{\Gamma}_t\right)=-\lambda_t^1 \tag{1.39}$$

$$V_n\left(k_t,n_{t-1},b_t,\mathbf{\Gamma}_t\right)=\lambda_t^4(1-\rho^n) \tag{1.40}$$

First, I will proceed to derive expressions for all multipliers in the model. From equation (1.27), I have

$$\lambda_t^1=\frac{1}{\varphi'\left(d_t\right)}. \tag{1.41}$$

Replacing the expression in (1.41) into equations (1.29), (1.36), (1.39), (1.30),(1.32), and (1.33), I obtain

$$\lambda_t^5=\frac{\Phi_x\left(x_t,k_t\right)}{\varphi'\left(d_t\right)} \tag{1.42}$$

$$\lambda_t^6=\frac{1}{\varphi'\left(d_t\right)}\frac{\eta\left(\theta_t\right)}{\mu\left(\theta_t\right)}s_t+\psi\lambda_t^7\frac{\eta\left(\theta_t\right)}{\mu\left(\theta_t\right)}s_t. \tag{1.43}$$

$$\lambda_t^7 = \frac{1+r}{\varphi'(d_t)\,R} - (1+r)\beta E_t \left\{ \frac{1}{\varphi'(d_{t+1})} \right\} \tag{1.44}$$

$$\lambda_t^2 = \frac{1}{f_l(k_t, u_t, l_t)} \left(\frac{1}{\varphi'(d_t)} + \lambda_t^7 \varphi_w \right) \tag{1.45}$$

$$\lambda_t^4 = \frac{1}{\varphi'(d_t)} \left[\varepsilon_t + \frac{\kappa'(s_t)}{\eta(\theta_t)} \right] + \lambda_t^7 \left[\psi \varepsilon_t + \varphi_w \frac{\kappa'(s_t)}{\eta(\theta)} \right] \tag{1.46}$$

Combining the expression for λ_t^5 in (1.42) with the one in (1.45) yields

$$\frac{f_u(k_t, u_t, l_t)}{f_l(k_t, u_t, l_t)} \left[1 + \lambda_t^7 \varphi'(d_t)\, \varphi_w \right] = \Phi_x(x_t, k_t)\delta'(u_t)k_t + \Phi_u(x_t, k_t) \tag{1.47}$$

Similarly, using λ_t^1 and λ_t^2 from equations (1.41) and (1.45), respectively, and replacing them in the first-order condition for y_t in (1.28),results in an expression for λ_t^3:

$$\lambda_t^3 = \frac{1}{\varphi'(d_t)} \left(p - \frac{1}{f_l(k_t, u_t, z_t)} \left(1 + \varphi'(d_t)\varphi_w \lambda_t^7 \right) \right) + \psi \lambda_t^7 p. \tag{1.48}$$

The next step is to derive expressions for the dynamic equations of the model associated with the choices of k and n, as well as the pricing equation, using the multipliers computed previously. First, consider the first-order condition for k in (1.35) and the envelope condition (1.38) combined with the multipliers in (1.41), (1.42) and (1.45). The resulting physical investment equation is given by

$$\begin{aligned} \Phi_x(x_t, k_t) = \lambda_t^7 \zeta_t + \beta E_t \Bigg\{ \frac{\varphi'(d_t)}{\varphi'(d_{t+1})} \Bigg[& (1 - \delta(u_{t+1}))\, \Phi_x(x_{t+1}, k_{t+1}) + \\ & + \frac{\Phi_x(x_{t+1}, k_{t+1})\, \delta'(u_{t+1})\, k_{t+1}}{f_u(k_{t+1}, u_{t+1}, z_{t+1})} f_k(k_{t+1}, u_{t+1}, z_{t+1}) - \Phi_k(x_{t+1}, k_{t+1}) \Bigg] \Bigg\}. \end{aligned} \tag{1.49}$$

Similarly, inserting λ^3 and λ^4 from equations (1.48), and (1.46), respectively, into equation (1.37) and the envelope condition (1.40) results in the dynamic equation that rules the spending to attract additional customers:

$$\frac{1}{\varphi'(d_t)}\left[\varepsilon_t+\frac{\kappa'(s_t)}{\eta(\theta_t)}\right]+\lambda_t^7\left[\psi\varepsilon_t+\frac{\varphi_w\kappa'(s_t)}{\eta(\theta_t)}\right]=$$
$$=\frac{1}{\varphi'(d_t)}\left[p-\frac{1}{f_l(k_t,u_t,z_t)}\left(1+\varphi'(d_t)\varphi_w\lambda_t^7\right)\right]+\psi\lambda_t^7p+$$
$$+\left(1-\delta^n\right)\beta E_t\left\{\frac{1}{\varphi'(d_{t+1})}\left[\varepsilon_{t+1}+\frac{\kappa'(s_{t+1})}{\eta(\theta_{t+1})}\right]+\psi\lambda_{t+1}^7\left[\psi\varepsilon_{t+1}+\frac{\varphi_w\kappa'(s_{t+1})}{\eta(\theta_{t+1})}\right]\right\}. \tag{1.50}$$

Finally, the pricing equation that specifies the discount granted to new customers is obtained by combining equations (1.34), (1.41), (1.46), and (1.43), and rearranging terms. The resulting discount equation is

$$\left(1+\psi\lambda_t^7\varphi'(d_t)\right)\varepsilon_t=\frac{\gamma}{(1-\gamma)}\frac{\kappa'(s_t)}{\eta(\theta_t)}\left(1+\varphi_w\lambda_t^7\varphi'(d_t)\right). \tag{1.51}$$

1.B Data Description

1.B.1 CPS Data

CPS monthly files are obtained from IPUMS for the period 1980m1 to 2015m12. Based on the 2010 Occupation Code List, the first category of sales-related occupations includes the following activities: first-line supervisors of sales workers (4700); cashiers (4720); counter and rental clerks (4740); parts salesperson (4750); retail salesperson (4760); advertising sales agents (4800); insurance sales agents (4810); securities, commodities and financial services sales agents (4820); travel agents (4830); sales representatives services, all other (4840); sales representatives, wholesale and manufacturing (4850); models, demonstrators, and product promoters (4900); real estate brokers and sales agents (4920); sales engineers (4930); telemarketers (4940); door-to-door sales workers, news and street vendors, and related workers (4950); and sales-related workers, all others (4965). The second category excludes cashiers (4720) and counter and rental clerks (4740) from the first category. The third category adds to the second the following activities: managers in marketing, advertising and public relations (30); purchasing managers (150); buyers and purchasing agents, farm products (510); wholesale and retail buyers, except farm products (520); purchasing agents, except wholesale, retail, and farm products (530); and economists and market researchers (1800). Finally, the fourth category excludes from the third category first-line supervisors of sales workers (4700).

All employment series produced from CPS monthly files are seasonally adjusted using Tramo-Seats. Quarterly series are obtained as the average of the corresponding months.

1.B.2 Compustat Data

I use quarterly data collected from CRSP/Compustat and rating files from the third quarter of 1992 to to fourth quarter of 2013. I delete observations with negative total assets (*atq*), negative sales (*salesq*), negative cash and marketable securities (*cheq*), cash and marketable securities greater than total assets, firms that are not incorporated in the U.S, firms in the financial sector (firms with two-digit SIC codes between 60 and 69), firms in the utilities sector (firms with two-digit SIC codes equals to 49) and firms involved in major takeover operations.

Investment is measured as the ratio of quarterly capital expenditure (*capxy*) to the lag property, plant and equipment (*ppentq*). Net debt issuance is computed as long-term debt issuance (*dltisy*) minus long-term retirement (*dltry*) divided by lagged assets.[15] Notice that some of these variables can be affected by industry seasonality. To deal with the seasonal component of the data, sample means are computed by controlling directly with seasonal dummies, and matching regressions are performed using identical quarters in different periods.

Several measures of financial reliance are constructed to evaluate their relevance in investment recovery. The classification for these firms is determined before the crisis; specifically, the second quarter of 2006 is selected as the relevant date for computations. I define a *bank-related* firm as a firm with two or more loan facilities with the same U.S lead bank in the five years before 2006 according to Dealscan as in Kahle and Stulz (2013).[16]

A second group of firms is constructed based on their leverage. The first category in this group consists of firms in the top quintile of leverage at 2006q2. A first subgroup includes firms with high leverage and a bank loan or revolver at the end of 2005 and 2006, according to information obtained from CapitalIQ. This

[15] Capital expenditures, aggregate equity issuance, aggregate equity repurchases, long term debt issuance and long-term retirement are reported on a year-to-date basis. Quarterly values for these variables are obtained by subtracting the lagged value from the current value in all quarters, with exception of the first.

[16] I consider a lead bank as those identified as the lead arranger in Dealscan. In case lead-arranger credit is missing, a lead bank is also identified as the lender whose role in the database has been specified as Admin Agent, Agent, Arranger or Lead Bank.

group can be seen as complementary to firms in the *bank-related* group. Following Chaney et al. (2012), I construct a second subgroup of highly leveraged firms with access to collateral, which is determined by real estate assets proprietorship. Real estate is computed using annual files from Compustat to increase the number of firms represented in the sample. The measure of real estate is the sum of buildings (*fatb*), land and improvement (*fatl*), and construction in progress (*fatp*). I include in this group firms in the first quintile of leverage who report consecutively non-negative real estate assets for the last 5 year prior to 2006.[17] Finally, I construct a subgroup of firms with high leverage and low liquidity based on cash holding. This category consists of firms in the top quintile of leverage at 2006q2 and the lowest two quintiles of cash holdings in each quarter during the 3 years previous to the second quarter of 2006.

The matching estimator is computed based on two categorical variables and five non-categorical variables. Firms are exactly matched on industry and credit-rating categories. Industry categories are given by two-digit SIC codes. Credit ratings (*splticrm*) are defined as investment grade (AAA to BBB-), speculative rating (SD to BB+), and unrated. Matching is also based on the market-to-book ratio, cash flows, size, cash holdings, and leverage. The market-to-book ratio is defined as the ratio of total assets (*atq*) plus market capitalization ($prccq \times cshoq$) minus common equity (*ceqq*) to total assets. Cash flow is defined as the ratio of net income (*ibq*) plus depreciation and amortization (*dpq*) to the lag of total assets.

[17] In order to increase the sample size, when possible real estate was computed by subtracting from the gross value of property, plant and equipment all the other components of this asset category that do not correspond to real estate (e.g. natural resources, machinery and equipment, leases, etc.)

Cash holdings is the ratio of cash and short-term investment (*cheq*) to total assets. Size is the log of total assets. Leverage is computed as the ratio of short-term liabilities (*dlcq*) and long-term liabilities (*dlttq*) to total assets.

1.C Sales and Financial Constraints

The conclusions of the model trigger important implications for economic activity at the firm level. It predicts that the customer base will be negatively affected by a financial shock. Although there are not proper ways to account for the full variation in the customer base from the database used in this chapter, it is possible to asses the variation on real sales as a proxy for changes in economic activity. To analyze how sales from firms with low liquidity have evolved in the post-crisis period the following difference in difference approach is used:

$$sales_{it} = \alpha + \beta_1 Post_t + \beta_2 liquid_i + \beta_3 Post_t \cdot liquid_i + \mathbf{X}'\theta + \varepsilon_{it} \tag{1.52}$$

Where $liquid_i$ corresponds to firms in the liquidity ratio of of cash and short-term investment over assets computed as in appendix1.B. $Post_t$ corresponds to the period encompassing $2009q3 - 2010q2$. And sales correspond to the sales reported by firms (saleq) deflated by consumers CPI. The vector $\mathbf{X}$ contains size, industry and seasonal dummies. The results of the previous equation are reported in Table 1.C.1. Of particular interest is the coefficient β_3 which reflects the behavior of sales for firms with low ex-ante liquidity levels relative to firms with higher levels

Tab. 1.C.1: Sales Regression

Coefficient	Value
β_3	-5.23**
	(2.18)
Observations	2238

Source. Author's calculations.

of liquidity. These firms have experience lower levels of sales relative to firms with higher liquidity. Although, it is not possible to fully disentangle the reasons for such behavior, it can give insights on the long-lasting effects of financial frictions on economic recovery.

Chapter 2: Liquidity Spirals, Leverage and Asset Prices

1 *Introduction*

The Great Recession was characterized by a sharp deterioration in the borrowing capacity of entrepreneurs due to a generalized drop in assets liquidity. This drop in liquidity surges not only as a consequence of a plunge in asset prices but also the contraction in loan-to-value ratios. However, our understanding on the channels through which changes in loan-to-value ratios affect economic activity are still limited. This chapter aims to fill this gap by providing a theoretical framework to analyze how loan-to-value ratios are an equilibrium outcome in the economy, which is jointly determined with asset prices. This joint determination of asset prices and loan-to-value are key to understand how liquidity shocks are amplified in the economy.

As Figure 2.1 depicts, the loan-to-value or leverage (I will use these two terms interchangeably all along this chapter) is procyclical.[1] This suggests that during bad times liquidity can drop due to the reduction in the amount of resources attainable by unit of collateral pledged. This drop in liquidity can occur even in the absence

[1] The measure of leverage used in this paper correspond to debt to disposable income ratio, which is the measure of leverage discussed in Boz and Mendoza (2014).

of substantial changes in asset prices, and it would suffice to produce a contraction in credit and thus in economic activity. However, as Figure 2.1 also depicts, there exists an important correlation between the evolution of asset prices and leverage. This captures the idea that these two measures of liquidity cannot be considered independently.

This chapter introduces a model in which asymmetric information about the quality of assets shapes the relationship leverage and asset prices. Leverage condenses the ability of agents to raise funds via collateralized lending. The price of assets condenses the ability of agents to raise funds via direct sales of these assets.[2]

On the one hand, leverage is key to determine asset prices in the economy. Leverage sets the opportunity cost of selling assets and, thus, it affects its supply curve. Furthermore, leverage also allows agents to finance capital purchases by either increasing the amount of resources available to fund them or by allowing agents to buy assets on margin, affecting the demand curve. By shaping both supply and demand curves, leverage determines the equilibrium level of asset prices.

On the other hand, asset prices influence the level of leverage in the economy. When capital is heterogeneous in terms of its quality, agents optimally decide the type of asset to sell and the type of assets to keep and pledge as collateral, in exchange for credit. Asset prices implicitly determine the quality of those units kept as collateral by setting the opportunity cost of selling assets. Since shifts in prices affect the composition and quality of collateral units, it determines how much

[2] These concepts are echoed in Brunnermeier et al. (2012)'s notion that capital can be distinguished by two main liquidity properties: its *market liquidity*, when it can be sold off easily with limited price impact. And its *funding liquidity*, when the asset is preserved and pledged as collateral.

financial intermediaries are willing to lend, given their expectations on the quality of assets pledged.

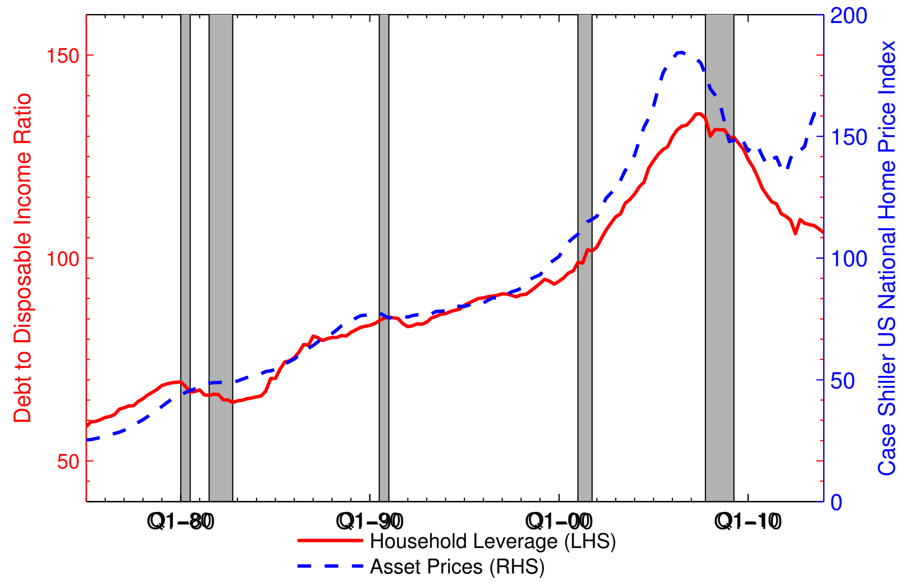
There are two main contributions of this chapter to the existing literature. First, it delivers a model in which leverage is procyclical a feature that is present in the data (Figure 2.1) but absent in macroeconomic models. In my model, during good times, the demand for assets is higher. This implies that more qualities of assets are traded and on average better qualities are pledged as collateral. As the expected quality of the assets used as collateral increases, financial intermediaries are willing to lend more by increasing the loan-to-value ratio of the economy.[3]

Second, my model provides a positive linkage between liquidity shocks and asset prices. In absence of additional shocks or rigidities, this feature is difficult to capture in models encompassing liquidity shocks which are based on Shi (2015). In these model a negative liquidity shock contracts the supply of assets and create a boom in asset prices. On the contrary, in my model a negative liquidity shock reduces leverage and affects the composition of capital trades in the economy. Its effect is twofold: first, it reduces the opportunity cost of selling assets triggering a boost in the supply for assets; second, it reduces the resources available to finance capital purchases leading to a contraction in the demand curve. Both factors impact negatively asset prices. The procyclicality of leverage reinforces this spiral, as loan-to-value ratios fall on impact.[4]

[3] This feature of the model formalizes the ideas developed in Shi (2015). The author stresses that leverage can be increasing in the degree of liquidity in equity, in order to capture the idea that lenders who can sell collateral more easily in the market are more willing to lend a higher amount backed by collateral.

[4] Similar attempts to generate asset prices busts after a liquidity shock are found in Guerron-Quintana and Jinnai (2015), who consider the response of negative shocks in presence of endogenous

Fig. 2.1: Leverage and Asset Prices



Source. Author's calculations based on information from FRED and Standard and Poors.

Leverage vs. Credit Cycles. This chapter introduces endogenous leverage in an otherwise standard model of borrowing constraints. It also explores how liquidity shocks are amplified through the relationship between leverage and asset prices. The literature on financial frictions influenced by the work of Bernanke et al. (1999), Kiyotaki and Moore (1997) and Holmstrom and Tirole (1997) have focused on the amplification generated by the credit cycle. To be more specific, the credit cycle refers to the idea that a drop in asset prices or wealth makes more difficult to borrow, hampers productive processes and triggers a vicious circle of further asset prices and investment deterioration (debt-deflation theory). Instead, the focus of this chapter is on the ratio of loans to asset values and its interaction with the credit

growth.

cycles.

Why is it important to consider loan-to-value ratios? As shown in Figure 2.1, loan-to-value ratios are highly procyclical. For instance, the normal down payment for housing financed by nongovernment mortgages fell from 13% in 2000 to 2.7% in 2006, and then rose to 16% in 2007 (Fostel and Geanakoplos, 2014). Leverage falls in bad times creating an additional deterrent on the ability of entrepreneurs to finance investment projects. More importantly, it is the impact of leverage on asset prices what can bring about a larger deterioration in liquidity; so it is the fall in leverage what drives prices down and it is the combined effect of a fall in leverage and prices what make credit conditions more pervasive during periods of economic distress.

However, the role of leverage has been particularly absent in the literature on borrowing constraints. This literature is characterized by imposing a limit in the ability to borrow, which is determined by a fraction of the market value of the income or assets offered as collateral. In general, these limits are expressed in terms of a collateral constraint of the form $b_{t+1} \leq \kappa \, \mathbf{g}(q_t, y_t, k_{t+1}, k_t, b_t)$, as stated in Mendoza (2006). The collateral function $\mathbf{g}(\cdot)$ could depend on a vector of market prices q, on income y, on asset holding k, or on existing debt b.[5]

In these models κ reflects the loan-to-value or leverage associated with external

[5] Several functional forms have been considered as collateral functions. In Aiyagari and Gertler (1999) it takes the form $\mathbf{g}(\cdot) = p_t \alpha_{t+1} k$ where p_t correspond to the price of equity and α_{t+1} are equity shares. In Bianchi (2011), $\mathbf{g}(\cdot) = y_t^T + p_t^N y_t^N$, where y_t^T and y_t^N corresponds to income from tradables and non-tradables, respectively. More generally, as in Kocherlakota (2000), borrowing constraints take the form $\mathbf{g}(\cdot) = q_t k$ in which k in an inelastic factor. In presence of uncertainty as in Monacelli (2009) or Guerrieri and Iacoviello (2017), borrowing constraints $\mathbf{g}(\cdot) = E_t(q_t k)$ limit the ability to borrow by the expected future value of assets.

borrowing. In models of borrowing constraints, from Kiyotaki and Moore (1997) to Bianchi (2011), Monacelli (2009) or Guerrieri and Iacoviello (2017) this parameter is constant implying that entrepreneurs borrow a constant fraction of the value of assets used as collateral. In models with a focus in regions of the state-space in which the borrowing constraint is not-binding, a constant κ imposes an upper limit on how much leverage is attainable in the economy, but yet, leverage is constant when the borrowing constraint binds. This approach is not only at odds with the evidence on leverage but also undermines potential mechanisms of amplification.

More recently, Bianchi et al. (2012), Bianchi and Mendoza (2013) and Boz and Mendoza (2014) have introduced a stochastic Markov process to capture the dynamics of leverage in normal and bad times. However, the exogeneity of leverage does not allow us to understand how it can be determined in equilibrium, but more importantly, its interaction with asset prices. I depart from this view of exogenously determined leverage to introduce a framework in which leverage is determined in equilibrium. More specifically, I show how leverage is jointly determined in equilibrium with asset prices nesting in the same model leverage and credit driven cycles.

Overview of the Model. This chapter builds on the model of Kurlat (2013). I extend his model by allowing collateralized borrowing and a continuum of capital qualities as in Bigio (2015). Capital in my model is composed of a continuum of heterogenous qualities. Each quality of capital is associated with a different rate of depreciation or Solow neutral productivity shock; low capital qualities depreciate faster than high quality types. At the beginning of the period, entrepreneurs receive an idiosyncratic productivity shock in their ability to transform consumption goods into capital goods. This heterogeneity in the transformation technology allows for segmentation; highly productive entrepreneurs find it optimal to sell more units of capital with higher quality, while less productive entrepreneurs sell only their low quality units and purchase capital in the market at a pooling price.

The economy also contains risk-neutral and competitive financial intermediaries who transfer consumption goods to entrepreneurs. Nevertheless, there exists limited enforceability of debt contracts. The presence of financial intermediaries allows entrepreneurs to finance capital purchases not only with internal but also external funds. The presence of limited enforceability implies an endogenous collateral constraint on debt contracts. This feature of my model is important as collateral is not homogenous but rather is a mixture of different qualities of capital known only by the entrepreneur, creating a new role for low quality assets as a possible device to relax the borrowing constraint.[6]

In this setting the price of assets is not exclusively determined by fundamentals, and in particular higher leverage could create higher asset prices. In other words, asset prices not only reflect the interaction between demand and supply, but also the value of each unit of capital as collateral. When one unit of collateral is able to sustain higher borrowing, entrepreneurs who were initially willing to sell their assets may no longer find this optimal. Instead, they can keep and use those units of capital as collateral reducing the supply of assets and in this way driving up the equilibrium price. In addition, buyers of assets can use this capital to borrow more,

[6] These assumptions are in line with the findings in Ajello (2010), who stresses that entrepreneurs cannot finance new investment opportunities solely by liquidating assets , but also rely on external resources.

increasing the demand for assets, which also drives up the price.

The presence of limited enforceability and heterogenous collateral is a major departure from the existing literature studying financial frictions due to borrowing constraints. Consider for instance the case with no asymmetric information in which capital is homogenous and does not depreciate. Then, when intermediaries seize capital in case of default, one unit of capital seized becomes one unit of resalable capital. Abstracting from possible costs associated with capital foreclosure, intermediaries can lend the exact value of capital pledged (i.e leverage is equal to one).

However, in this model there is a distinction between the ex-ante value of capital pledged by entrepreneurs and the ex-post value of capital available for resale. Since capital quality is heterogenous and since borrowers are privately informed about the value of collateral, intermediaries need to form expectations about how many units of resalable capital will emerge from one unit of capital pledged. This expectation is important in determining the endogenous degree of leverage of the economy.

Related Literature. Kurlat (2013) and Bigio (2015) show that information asymmetries about asset quality can determine endogenously the degree of market liquidity in the economy, that is, the price at which assets can be traded.[7] This chapter extends this framework to analyze how these asymmetries are also associated with the liquidity obtained from collateralized borrowing in the presence of

[7] Authors show that under given circumstances markets can totally collapse and market liquidity dries out as the closing price for assets is equal to zero.

collateral constraints. In my model investment opportunities can be financed not only through direct selling of capital but also by issuing debt from financial intermediaries. However, limited enforcement require the presence of collateral to guarantee debt contracts. Thus, entrepreneurs face a decision on the limits of capital sales as they are at the same time giving up capital to be used as collateral.

Nevertheless, there is a deep contrast between this literature [GF, hereafter] and this chapter. First, unlike GF segmentation in this chapter arises through idiosyncratic productivity shocks instead of heterogenous beliefs. It is the ability to transform assets in consumption the key to determine buyers and sellers in the economy. In GF is the perception about the returns of assets the one that determines buyers and sellers. So the economy is composed of a set of optimists agents (buyers) and a set of pessimists agents (sellers).

Second, this chapter presents leverage as the maximum amount of borrowing per unit of collateral pledged. Leverage is determined by the expectations about the quality of assets pledged as collateral. In GF, every agent delivers the same capital as collateral; lenders need only to worry about collateral and not about the identity of borrowers. Leverage in GF is determined by a Value at Risk (VaR) condition on debt contracts; agents can trade different sets of contracts specifying the amount of the loan, the collateral and the interest rate. GF proves that in equilibrium only the contract that guarantees that the VaR is zero can be traded, and in this way leverage is pinned down.

This chapter is similar to Parlatore (2017), who focus on the decision of traders to sell or keep financial assets to use them as collateral. Informational asymmetries are also present in her model, but I consider the ability of productive asset instead of financial ones to deliver liquidity.

This chapter builds on the model of Kurlat (2013) and Bigio (2015). I take from these documents the idea that entrepreneurs finance investment projects by selling capital of different qualities under asymmetric information at a pooling price. I extend Kurlat's framework by introducing financial intermediaries and limited enforceability of debt contracts. Unlike his model, this chapter separates liquidity in terms of capital sales and collateralized borrowing. Liquidity obtained through capital sales involves the loose of capital proprietorship since sales entail the transfer of assets from one entrepreneur to another. Collateralized borrowing Entrepreneurs can finance investment projects by using capital unsold as collateral. This extension allows me to analyze some novel features in the literature: the surge of endogenous leverage as a result of asymmetric information in the quality of collateral, the existing simultaneous determinacy between asset prices and leverage in equilibrium, the procyclicality of leverage and the effect on asset prices of changes of financial innovation.

This chapter also builds on the idea that deleveraging shocks create disruptive real effects in economies subject to borrowing constraints during periods of financial distress, as suggested in Boz and Mendoza (2010), Perri and Quadrini (2014), Sudipto et al. (2011) and Eggertsson and Krugman (2012). However, this model departs from this literature, which treats leverage as an exogenously determined variable or endogenously determined by changes in expected liquidation prices.

The remainder of the chapter is organized as follows. Section 2 presents the baseline model and imposes the necessary conditions for the existence of equilibrium. Section 3 describes the conditions for leverage procyclicality and the existence of liquidity spirals. Section 4 concludes.

2 Baseline Model

This section presents the baseline model and illustrates the solutions and main mechanisms behind the relationship between leverage and asset prices. In this section, I abstract from labor and saving decisions to capture analytically the interaction between different sources of liquidity. The model is formulated in discrete time with an infinite horizon in which endogenous liquidity arises from a problem of adverse selection in line with Kurlat (2013).

The economy is composed of a unit mass of entrepreneurs indexed by i, risk neutral and competitive financial intermediaries and a competitive producer of consumption goods. Entrepreneurs in this model are the owners of capital and undertake physical investment by transforming consumption goods into capital. Each capital unit is formed by a continuum of heterogeneous pieces, which differ in their degree of depreciation. A competitive firm rents capital from entrepreneurs to produce consumption goods.

2.1 Environment, Technology and Financing Conditions

Production Technology. Consumption goods are produced by a competitive firm with aggregate capital $K_t = \displaystyle\int k_t(i)di$ as the sole input in a standard constant returns to scale production function of the form $y_t = A_t K_t$. This production function is subject to an aggregate shock $A_t \in \mathbb{A}$ on productivity. I assume aggregate productivity follows a Markov process in the neighborhood of its constant unconditional mean A.

Capital Structure. Capital is heterogeneous. Each capital unit k_t owned by entrepreneurs is composed of a continuum of pieces identified by their quality $\varepsilon \in [0, \infty]$. The distribution of qualities is determined by a common p.d.f $f(\varepsilon)$ which follows an exponential distribution invariant across entrepreneurs and time. The quality of a capital unit ε is a shock broadly interpreted as the combination of depreciation and a idiosyncratic Solow-neutral productivity shock. This quality is obtained from a bijective, increasing and differentiable function $\delta(\varepsilon) : [0, \infty] \rightarrow [0, \infty]$, with unconditional mean $\bar{\delta}$. At each period, each quality is randomly assigned to a different degree of shocks. This quality remains private information and can only be learnt by others after depreciation takes place.

Capital is fully separable and entrepreneurs can decide either to sell or keep specific qualities. The existing units of capital at the beginning of each period for any entrepreneur can be denoted as $k \int f(\varepsilon) d\varepsilon$, and the efficiency units remaining after scaled for different shock realizations as $k \int \delta(\varepsilon) f(\varepsilon) d\varepsilon$.

Entrepreneurs and Investment Technology. There is a continuum of entrepreneurs i with unitary mass, who undertake capital investment. At each period entrepreneurs can transform one unit of consumption into θ units of capital. Where θ is an *i.i.d* random variable across entrepreneurs and time. This investment technology is drawn from a distribution with cumulative density function dG with support in $[\theta_0, \theta_1]$. The realization of investment technology is private information as it is only observed by the specific entrepreneur.

Entrepreneurs can finance investment opportunities by either selling their existing capital holdings in exchange for consumption goods or by collateralized borrowing from financial intermediaries. In such way, entrepreneurs can fraction their capital units such that the decision on which capital units to sell k_t^s entails the choice of specific qualities that the entrepreneur will trade in the market. Denoting $\iota(\varepsilon) : [0, 1] \to \{0, 1\}$ as the indicator function representing the qualities from the existing capital stock that entrepreneurs choose to sale, capital sales can be expressed as $k_t^s = k \int \iota_t(\varepsilon) f(\varepsilon) d\varepsilon$.

Capital trades occur under asymmetric information as the realization of productivity θ and the quality ε of capital units offered are private information at the moment of sale. This requires all capital units to be traded at a pooling price p_t.[8]

Alternatively, entrepreneurs can finance their investment opportunities by means of collateralized debt. They can borrow b_{t+1} units of consumption goods from financial intermediaries at a constant interest rate R. However, limited enforcement on debt contracts requires the presence of collateral as a mean to enforce repayment. The debt market opens before the spot market for capital, so only capital units not offered by entrepreneurs $k \int (1 - \iota_t(\varepsilon)) f(\varepsilon) d\varepsilon$ serve the role of collateral. Asymmetric information on productivity prevents entrepreneurs to pledge new capital created; this is because in a case of capital foreclosure, entrepreneurs

[8] When the quality of capital units is publicly known, capital trades occur at differentiated price function that depends on the degree of depreciation. In general, each quality ε would be traded at a price $p(\varepsilon)$ with $p_\varepsilon > 0$.

can divert part of this new capital by claiming lower productivity realizations.

Loan-to-value ratio. In case of default, intermediaries seize the capital used as collateral and sell it to non-defaulting entrepreneurs through a bargaining process. Given information asymmetries, intermediaries ignore the exact quality of the capital that was used as collateral and the units available to resale after depreciation. This feature creates a wedge between the ex-ante value of capital pledged and the ex-post value of capital available to resale, which determines the endogenous degree of leverage in the economy.[9]

As intermediaries are not able to sell all the units originally pledged as collateral, they are not willing to lend more than a fraction κ_t (i.e. the loan-to-value ratio or leverage) of the value of capital pledged as collateral. This fraction accounts for the depreciation of the collateral and is subject to an exogenous financial shock (ζ_t) which follows an AR(1) process. This shock comes as a reduced form of more structural shocks which result in changes in the liquidation value of capital ("liquidity shock"). I assume debt is default-free so no entrepreneur defaults in equilibrium.

Aggregate State. The aggregate state in the economy is given by the aggregate stock of capital $K_t \in \mathbb{K}$, the aggregate level of debt $B_t \in \mathbb{B}$, the aggregate productivity shock $A_t \in \mathbb{A}$ and the financial (liquidity) shock $\zeta_t \in \mathbb{X}$. This aggregate state is summarized by the vector $\Gamma_t = \{A_t, \zeta_t, K_t, B_t\}$ and $\Gamma_t \in \mathbb{A} \times \mathbb{X} \times \mathbb{K} \times \mathbb{B}$.

Timing of Events. A period is divided into four stages: entrepreneurs' decisions, production, investment and consumption. At the beginning of the period ag-

[9] An alternative interpretation also consistent with the existence of a wedge between the ex-ante units of capital used as collateral and the ex-post units available to resale is the following: Intermediaries seize capital before depreciation occurs but are only able to resell these units when depreciations shocks have been realized.

gregate shocks (A, ξ) are realized and overall depreciation takes place; entrepreneurs get a draw in their investment technology θ. Based on the aggregate and individual state realizations, during the first stage entrepreneurs decide whether to undertake investment or instead increase their capital stock by buying assets. Additionally, they decide on the fraction of capital offered in the spot market and the fraction kept to use as collateral.

During the production stage, a representative firm rents all the capital stock from entrepreneurs to produce consumption goods. Simultaneously, debt market opens and entrepreneurs repay their obligations and issue new debt. In case of default (off-equilibrium path), financial intermediaries seize the collateral of defaulting entrepreneurs and sell it to non-defaulting ones through a bargaining process. At this stage the valuation of capital is determined by its marginal productivity and not by asymmetric information about its quality. During the investment stage, entrepreneurs seek to complete the financing of their investment opportunities or simply increase their capital stock by purchasing assets. Investors sell part of their assets not used previously as collateral in exchange for consumption goods. In the final stage entrepreneurs consume their remaining consumption units.

2.2 Entrepreneurs

Entrepreneurs receive a productivity shock θ (hereafter, $\theta-$entrepreneur) in their ability to transform consumption goods into capital.[10] Entrepreneurs maximize their consumption level (c_t) by choosing the level of investment (x_t) to undertake,

[10] More precisely, a $\theta-$entrepreneur is an entrepreneur i who is mapped to a productivity realization θ on her ability to transform consumption into capital goods.

the amount of capital to purchase (k_t^p), the units of capital to sell (k_t^s), the amount to borrow from financial intermediaries (b_{t+1}) and the level of capital accumulation (k_{t+1}) for a given exogenous state $\{\Gamma_t, \theta\}$. The problem of a given entrepreneur is as follows:

Problem 2. *(Entrepreneur) The entrepreneur solves:*

$$\max_{\left\{c_t, k_{t+1}, b_{t+1}, x_t, k_t^p, k_t^s\right\}} \mathbb{E}_t \sum_{s=0}^{\infty} \beta^{t+s} u(c_{t+s}) \tag{2.1}$$

subject to

$$c_t + x_t + p_t k_t^p - b_{t+1} = r_t k_t - R b_t + p_t k_t^s \tag{2.2}$$

$$k_{t+1} = k_t \int \delta(\varepsilon)\big(1 - \iota_t(\varepsilon)\big) f(\varepsilon) d\varepsilon + \delta_t^b k_t^p + \theta x_t \tag{2.3}$$

$$R b_{t+1} \leq \kappa_t q_{t+1} k_t \int \big(1 - \iota_t(\varepsilon)\big) f(\varepsilon) d\varepsilon \tag{2.4}$$

where $u(c) = \log(c)$. Constraint (2.2) is the budget constraint in terms of consumption goods. The right hand side corresponds to the initial resources available for entrepreneurs coming from: capital rents ($r_t k_t$) net of previous debt repayments (b_t) at a constant interest rate R and capital sales (k_t^s). These resources are used for direct consumption (c_t), investment (x_t) or capital purchases (k_t^p). I abstract from intermediation costs, thus capital sales and capital purchases are completed at a unique pooling price p_t.

Capital accumulation is presented in equation (2.3). The first term consists of the remaining capital units owned by a $\theta-$entrepreneur scaled by their depreciation;

these units are formed by their original capital stock k_t net of sales k_t^s of specific varieties ε. The second term stands for capital purchases; the quality of the units acquired is unknown given the problem of asymmetric information. These capital purchases are adjusted by entrepreneur's beliefs about its market depreciation $\delta^b \in [0, 1]$. In equilibrium these beliefs are equal to the realized market depreciation rate and consistent with depreciation at the aggregate level. The last term in equation (2.3) represents the proceeds from investment carried out in the previous period.

Entrepreneurs are subject to a borrowing constraint of the form (2.4). This constraint states that an entrepreneur cannot borrow more than fraction κ_t of the discounted re-sale value of the assets pledged as collateral.[11] Only existing capital at the contracting stage can be used as collateral; that is the initial state of capital proprietorship (k_t) net of the asset sales (k_t^s) during the period. We focus on the solution in which constraint (2.4) is always binding. This assumption is consistent with the solution around a small neighborhood of the steady state, where entrepreneurial returns on savings are greater than the interest rate.[12]

The solution for the entrepreneur's problem consists of breaking up the maximization problem into two stages: in a first stage, entrepreneurs decide the optimal level for capital purchases and capital sales in order to maximize the liquidity available for a given state $\{\Gamma_t, \theta\}$. In a second stage, given the maximum level of

[11] It is important to emphasize the existing distinction between the spot price of capital and its resale price. On the one hand, the price at which capital is traded p_t in equation (2.3) corresponds to the pooling price of capital exchange under asymmetric information among entrepreneurs (buyers and sellers). On the other hand, resale occurs between intermediaries and non-defaulting entrepreneurs, and the final price is obtained via bargaining. As depreciation has already occurred, the resale price (q_{t+1}) in equation (2.4) reflects the valuation of each entrepreneur in terms of the marginal rate of transformation of capital into consumption goods.

[12] Additional discussion on this subject is presented along the lines of section (**??**)

liquidity attainable entrepreneurs decide on the optimal levels of consumption and savings. To ease the notation, define the discounted re-sale price as $\tilde{q}_{t+1} = q_{t+1}/R$ and $\nu_t \equiv (p_t - \kappa_t \tilde{q}_{t+1})^{-1}$ as the inverse of net capital downpayments. The decision on capital sales and purchases are summarized in lemma (1).

Lemma 1. *(Composition and Capital Sales). Optimality conditions for a $\theta-$ entrepreneur are characterized by: a) a productivity threshold $\theta^b := \frac{\delta^b}{p_t}$ such that for any realization of $\theta < \theta^b$ the entrepreneur becomes a buyer of capital and does not invest. b) a threshold quality $\varepsilon^b := \delta^{-1}\left(\frac{\theta}{\nu_t}\right)$ such that for any given realization of productivity θ all qualities below ε^b are sold.*

Proof. See appendix (2.A).

Lemma (1) states the importance of productivity realizations θ to segmenting entrepreneurs into buyers and investors. In particular, θ^b reflects the market return (in terms of capital) of one unit of consumption used to purchase assets. Intuitively, the return for an entrepreneur with a low productivity draw ($\theta < \theta^b$) is higher by purchasing capital units than directly investing. These type of entrepreneurs rebuild their capital stock acquiring capital from more productive entrepreneurs in exchange for consumption goods. On the contrary, for the most productive entrepreneurs ($\theta > \theta^b$) as the return from investment is higher, it is optimal to rebuild their capital stock with the returns from direct investments.

As the distribution of capital qualities is continuous, entrepreneurs find it optimal to sell at least a fraction of their existing capital units as stated in part (b) of Lemma 1. This fraction is increasing in productivity θ and the current price level

p_t; this implies that more productive entrepreneurs finance their investment with a higher share of capital sales over collateralized borrowing. In addition, the fraction of capital units to sell are negatively related to the loan-to-value ratio κ_t. Notice that the loan-to-value margin sets the opportunity cost of selling one unit of capital in terms of the foregone units available to be pledged as collateral. In other words, a higher leverage level reduces the supply of capital units offered by entrepreneurs in the market.

Lemma 2. *(Capital Purchases). For a given $\theta-$entrepreneur such that $\theta < \theta^b$ the amount of capital purchases is determined by:*

$$\delta^b k_t^p = \max\left\{k_{t+1} - k_t \int_{\varepsilon^b}^{\infty} \delta(\varepsilon) f(\varepsilon) d\varepsilon, 0\right\} \tag{2.5}$$

Proof. This proposition comes from combining part (a) in lemma (1) with the capital accumulation equation in (2.3) in the case in which investment is zero ($i = 0$).

Lemma (2) states the total amount of capital that is affordable for capital purchasers. Based on the results from lemma (1) and lemma(2) we can define the optimal amount of liquid resources that one unit of capital provides as l_t in equation (2.6). This amount combines the benefit from capital liquidation at a price p_t, which is referred to as *market liquidity*. And the benefit obtained by pledging capital as collateral at a loan-to-value ratio κ_t, which is referred to as *funding liquidity*.

Definition 1. ***(Liquidity)***. *Total liquidity is determined both by the value of capital* *liquidation and the value of capital as collateral.*

$$l_t = \underbrace{p_t \int_0^{\varepsilon^b} f(\varepsilon)d\varepsilon}_{\textit{Market Liquidity}} + \underbrace{\kappa_t \tilde{q}_{t+1} \int_{\varepsilon^b}^{\infty} f(\varepsilon)d\varepsilon}_{\textit{Funding Liquidity}} \tag{2.6}$$

Taking the optimal liquidity conditions in equation (2.6) and the amount available for capital purchases in equation (2.5), we can denote a $\theta-$entrepreneurs's net worth $\mathbf{n}_t$ as the returns from renting capital, the market and funding liquidity and the replacement cost of capital for either investors or non-investors. All these resources net of debt repayments. Entrepreneurs by choosing their optimal financing decisions implicitly define the optimal level of net worth.

$$\mathbf{n}_t := k_t \left[r_t + l_t + \int_{\varepsilon^b}^{\infty} \frac{\delta(\varepsilon)}{\max\{\theta, \theta^b\}} f(\varepsilon)d\varepsilon \right] - Rb_t \tag{2.7}$$

The entrepreneurs' problem can be restated as a standard consumption-saving decision in terms of the net worth as follows:

Problem 3. *(Saving-Consumption) The $\theta-$entrepreneur solves:*

$$\max_{\{c_t, k_{t+1}\}} \mathbb{E}_t \sum_{s=0}^{\infty} \beta^{t+s} \log(c_{t+s}) \tag{2.8}$$

$$s.t \quad k_{t+1} = \max\left\{\theta, \theta^b\right\}(\mathbf{n}_t - c_t) \tag{2.9}$$

Given logarithmic preferences, entrepreneurs consume a constant fraction of their net worth, thus $c_t = (1-\beta)\mathbf{n}_t$ and $k_{t+1} = \beta \max\left\{\theta, \theta^b\right\}\mathbf{n}_t$. Since policy functions are linear in net worth, the model can be easily aggregated. Next subsection presents the conditions on the determination of the equilibrium price for capital trades.

Asset Prices

The price for capital trades is determined by the intersection between supply and demand coming from entrepreneurs. The supply of assets is obtained by integrating all different qualities offered in the economy by all different entrepreneurs. Based in the conditions stated in lemma (1), the aggregate supply of asset in the economy corresponds to:

$$\mathbf{S}_t(p,\kappa) = K_t \left[\int_{\theta_0}^{\theta_1} F_\varepsilon \left(\varepsilon^b \left(\theta, p, \kappa \right) \right) \; dG(\theta) \right] \tag{2.10}$$

where K_t represents aggregate capital and $F_\varepsilon(\cdot)$ the cumulative density function of qualities. The equilibrium is also characterized by the market depreciation beliefs. These beliefs corresponds in equilibrium to the depreciation market rate of the units supplied.

Proposition 1. *The supply of assets is monotonically increasing in prices* (p) *and monotonically decreasing in leverage* (κ).

Proof. See appendix (2.A).

The formal proof is presented in the appendix, here I sketch a more intuitive line of argument. Supply conditions are uniquely determined by the quality of units offered by each entrepreneur. Notice that the quality of units sold by a $\theta-$entrepreneur (ε^b) is increasing in the value of the asset p and decreasing in leverage κ. On the one hand, an increase in asset prices boosts the amount of liquid funds available from direct sales, making capital sales more attractive, and thus increasing the overall supply of assets. On the other hand, leverage reflects the opportunity cost of selling assets in terms of the renounced units of capital. A higher leverage makes capital sales less attractive since the necessary units to be sold in order to reach a given level of liquidity are lower, thus reducing the overall supply of assets.

It is implicitly assumed that entrepreneurs purchase a diversified portfolio of capital, so the market depreciation holds also at the individual level. Based on equation (2.10) market depreciation beliefs are presented in lemma (3):

Lemma 3. *(Depreciation Beliefs) The belief on market depreciation from capital units traded is a time-varying multiple of average capital depreciation* $\delta^b(p,\kappa) = \bar{\delta}\Lambda_t$ *where:*

$$\Lambda_t := \left(\int_\theta F_\varepsilon \left(\varepsilon^b \left(\theta, p, \kappa \right) \right) \ dG(\theta) \right)^{-1} \left(1 - \frac{1}{\bar{\delta}} \int_{\theta_0}^{\theta_1} \int_{\varepsilon^b}^{\infty} \delta(\varepsilon) f(\varepsilon) d\varepsilon \ dG(\theta) \right) \quad (2.11)$$

Proof. See Appendix (2.A).

Where $\bar{\delta}$ correspond to the average depreciation of aggregate capital. This implies that the equilibrium rate of market depreciation corresponds to a fraction of the overall depreciation rate $\bar{\delta}$. This fraction reflects the average rate of depreciation from the units offered in the market.

The demand for assets is obtained by integrating capital purchases for all non-investors entrepreneurs. The mass of non-investors is determined along the lines of lemma (1), and their demand is derived by combining lemma (2) with the saving-consumption optimal decision of entrepreneurs. The aggregate demand for capital is represented in equation (2.12):

$$\mathbf{D}_t(p,\kappa) = K_t\left[\int_{\theta_0}^{\theta^b}\left(\beta\frac{(r_t+l_t)}{p_t} - \frac{(1-\beta)}{\bar{\delta}\Lambda_t}\int_0^{\varepsilon^b}\delta(\varepsilon)f(\varepsilon)d\varepsilon\right)dG(\theta)\right] - \\ -B_t\left[\int_{\theta_0}^{\theta^b}\beta\frac{R}{p_t}\,dG(\theta)\right] \qquad (2.12)$$

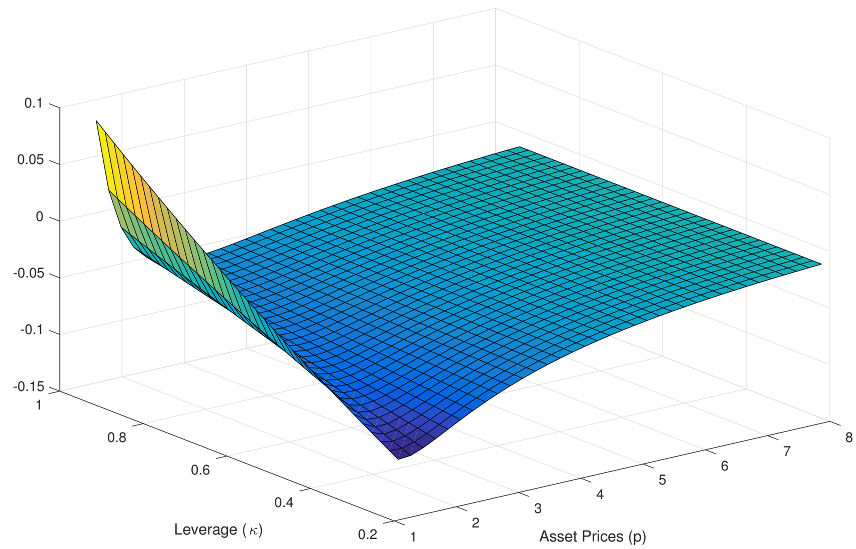
The equilibrium price is implicitly determined by equation (2.13). The level of leverage κ in the economy will determine the final price at which capital is traded by shaping the supply and demand for assets.

$$e(p,\kappa,A) = \mathbf{S}_t(p,\kappa) - \mathbf{D}_t(p,\kappa,A) \quad \text{with } e(p,\kappa,A) = 0 \text{ if } p_t > 0 \qquad (2.13)$$

Since the supply of assets is unambiguously increasing in prices, as pointed out in proposition 1, $\mathbf{D}_p < 0$ is a sufficient condition for the existence of p^* such that $e(p^*,\kappa,A) = 0$ for any $\{\kappa, A\}$. Notice that the behavior of demand is driven by changes in the capital purchasers cutoff θ^b. While it is difficult to impose general conditions for θ^b to be decreasing in p, it is possible to show that for a reasonable calibrations, the assumption $\theta^b_p < 0$ holds in more than 98% of the state space as presented in Figure 2.1.

Next section presents how resale prices and leverage are determined in the economy, and imposes conditions for the existence and uniqueness of such solution.

Fig. 2.1: Entrepreneurs Cutoff θ_p^b



Notes.The simulation corresponds to parameters presented in section **??**. The distribution of capital units is assumed exponential and the distribution of entrepreneurs technology is assumed to be log-normal.

2.3 Financial Intermediaries

Financial intermediaries are risk neutral and operate in a competitive environment. They transfer resources in terms of consumption goods to entrepreneurs. The association with entrepreneurs is characterized by a problem of limited enforceability of debt contracts.[13] As in Kiyotaki and Moore (1997) limited enforcement of repayments implies that any exchange or resources between entrepreneurs and intermediaries must be limited by a collateral constraint as an enforcement device.

[13] As stated in Hart and Moore (1994) this limited enforceability relies on the fact that restrictions on the freedom of entrepreneurs to walk away cannot be imposed.

Capital Resale Prices

As stated previously, when entrepreneurs default, financial intermediaries seize the capital pledged as collateral and sell it to non-defaulting entrepreneurs. These resales occur during production stage in which entrepreneurs are homogenous: first, since the heterogeneity in their ability to transform consumption into capital goods is only relevant during the investment stage; and second, since there is no distinction about the quality of the units rented to the competitive firm as all units have been already scaled by their corresponding depreciation.

Intermediaries and entrepreneurs bargain over the price of these assets. Entrepreneur's valuation is determined by the marginal rate of return of capital. As the production function is linear in capital, the distribution entrepreneurs valuation is determined by the process followed by aggregate productivity $A_t \in \mathbb{A}$. We consider the case in which intermediaries make a sequence of offers until agreement is reached and take the limit as the time between offers goes to zero.[14]

Assumption 1. *For any realization of $A_t \in \mathbb{A}$ intermediaries' valuation is always lower than entrepreneur's.*

Assumption (1) guarantees that is more efficient for intermediaries to sell capital rather than keeping it. It is possible to show that there exists a unique perfect

[14] This feature of the model is consistent with the fact that after foreclosures, assets are sold at discount values. Shleifer and Vishny (1992) posit that asset resales entail additional costs, which limit the potential gains for the seller. When capital is industry specific, potential buyers with the highest valuation are often those in the same industry who generally also experience financial distress. For instance, Ramey and Shapiro (2001) estimate the wedge between purchase price and resale price for machine tools at aerospace plants to be about 69% and the wedge for structural equipment to be 95%.

Bayesian equilibrium in which in the first round intermediaries offers $q_{t+1} = A(1)$, which corresponds to the marginal productivity of capital at the lowest possible realization of $A_t \in \mathbb{A}$, and this offer is accepted by entrepreneurs.[15]

Notice that intermediaries can predict the resale price q_{t+1} at period period t. This is as result that the resale price does not depend on the current realization of productivity, but on the lower limit of its support. Nevertheless, the uncertainty about the quality of assets is still present. So this model is able to separate changes in borrowing capacity coming from anticipated variations in the resale price of assets from the ones coming from a change in the expectations about the quality of assets used as collateral.

Leverage

Consider the case in which a $\theta-$entrepreneur defaults. In that scenario, financial intermediaries seize the capital pledged as collateral. The left hand side of equation (2.14) represents the amount borrowed by a $\theta-$entrepreneur based on the collateral available at period t, in concordance to (2.4). The right hand side corresponds to the value (discounted) of capital resales available for intermediaries. As previously stated, capital resales are subject to liquidity shocks of the form ζ_t, which implies that intermediaries can only sell a fraction of the capital seized after depreciation

[15] For a formal proof, See Gul et al. (1986)

at a price $\tilde{q}_{t+1}$.

$$b_{t+1} = \underbrace{\kappa_t \tilde{q}_{t+1} k_t \int_{\varepsilon^b}^{\infty} f_\varepsilon(\varepsilon) d\varepsilon}_{\text{Amount borrowed at } t} \leq \zeta_t \underbrace{\tilde{q}_{t+1} k_t \int_{\varepsilon^b}^{\infty} \delta(\varepsilon) f_\varepsilon(\varepsilon) d\varepsilon}_{\text{Amount available to resell at } t+1} \tag{2.14}$$

Thus, the model is characterized the existence of an endogenous wedge between the ex-ante (before depreciation) capital pledged, and the ex-post value of capital, which corresponds to the effective units (after non-homogenous depreciation) of capital that intermediaries can re-sell after foreclosure.

Definition 2. *(**Leverage**) Leverage corresponds to the maximum loan-to-value ratio that guarantees a non-negative payoff for financial intermediaries after default.*

Based on the previous definition, we can solve for κ_t in equation (2.14) and integrate over the probability of facing a $\theta-$entrepreneur, so the optimal leverage can be expressed as $\kappa_t = \zeta_t E_\theta \left(\delta(\varepsilon) \mid \varepsilon > \varepsilon^b \right)$. Intuitively, intermediaries adjust loan-to-value ratios based on the expected quality of the units kept and used as collateral by borrowers.

Leverage is endogenous and arises due to asymmetric information in the quality of assets and not for variations in the valuation that intermediaries place to the price of capital resales (see. Section (2.3). This separates this chapter from the existing literature which considers leverage to be endogenous as a result of expected (or unexpected) variations in the resale prices of capital foreclosed.[16]

Proposition 2. *(Leverage) Leverage corresponds to the expected quality of units*

[16] For instance in Perri and Quadrini (2014) leverage is endogenous as a consequence of the different valuations that potential buyers have about capital and that result in different liquidation values.

used as collateral for all entrepreneurs as defined in equation (2.15).

$$l(p,\kappa,\zeta) = \kappa - \zeta_t \left((p - q\kappa)\bar{\theta} + \int_{\theta_0}^{\theta_1} \int_{\varepsilon^b}^{\infty} \frac{\tilde{F}_{\varepsilon}(\varepsilon)}{\tilde{F}_{\varepsilon}\left(\varepsilon^b(\kappa)\right)} \delta'(\varepsilon)\, dG(\theta) \right) \tag{2.15}$$

Proof. See appendix (2.A).

Where $\tilde{F}$ is the survival function, $\tilde{F} = 1 - F$, and $\bar{\theta}$ is the unconditional quality of entrepreneurs $\bar{\theta} = \int_{\theta_0}^{\theta_1} \theta dG(\theta)$. As pointed out in Jones (1990) for $\delta(\varepsilon) > 0$ and $E\left(\delta(\varepsilon)\right) < \infty$, the right-hand side of equation (2.15) exists and is finite. Also, for $f(\cdot)$ log-concave and $\kappa \in (0,1)$, this expression is bounded and thus admits for any given $\{p\}$, the existence of a $\{\kappa^*\}$ which is a fixed-point solution to equation (2.15). However, without further conditions on functional forms, the left-hand side of equation (2.15) may not be necessarily monotonic in κ, thus, $\{\kappa^*\}$ may not be unique.

Lemma 4. *For a linear depreciation function $\delta(\varepsilon)$ and the distributions of qualities ε following an exponential distributions with mean $\bar{\delta}$, for any given $\{p\}$, there exists a unique κ^* which is a fixed-point solution for $l(p,\kappa^*,\zeta) = 0$ and satisfies:*

$$\kappa^* = \zeta_t \left(E_{\theta}\left(\varepsilon^b\left(\theta, p, \kappa^*\right)\right) + E(\varepsilon) \right) \tag{2.16}$$

Proof. See appendix (2.A).

For the case of exponential distributions, For a given θ, the mean of the conditional distribution, given $\varepsilon > \varepsilon^b$, exceeds the mean of the unconditional distribution by the quantity ε^b for all ε^b. This property of exponential distributions has been extensively discussed in Shanbhag (1970), Hamdan (1972), and Kotlarski (1972); it provides higher analytical tractability to the leverage problem, allowing for a unique value solving equation (2.15).

3 Leverage Procyclicality and Liquidity Spirals

The model presented in previous section shows how asset prices and leverage are determined endogenously in equilibrium. This section explores the interaction of these two variables when the economy face a productivity shock $A_t \in \mathbb{A}$ and a liquidity shock ζ_t. A detailed description of the functional forms and parameters used in the simulation is presented in Appendix 2.B.

Assumption 2. *The condition* $\mathbf{D}_\kappa(p^*, \kappa^*) l_p < (\mathbf{S}_p(p^*, \kappa^*) - \mathbf{S}_\kappa(p^*, \kappa^*) l_p) + |\mathbf{D}_p(p^*, \kappa^*)|$ *holds in the neighborhood of the equilibrium* $\{p^*, \kappa^*\}$.

Assumption 2 guarantees the Jacobian for equations (2.13) and (2.15) to be positive and is critical for the following propositions. A sufficient condition requires the demand to be increasing in leverage $\mathbf{D}_\kappa > 0$. This in turn requires that changes in liquidity offset the potential decline in the mass of capital purchasers. More specifically, changes in leverage affect the supply of assets and thus market depreciation δ^b. If fewer units of capital are traded, the expected quality of these units decline in equilibrium. In such way, θ^b drops as a response to positive changes in economic leverage. Since the demand curve can exhibit a non-monotonic behavior as pointed out in Kurlat (2013), I focus in equilibrium outcomes from the state-space that satisfy $\mathbf{D}_p < 0$ and $\mathbf{D}_\kappa > 0$.

Proposition 3. *Prices and Leverage are procyclical.*

Proof. See appendix (2.A).

The formal proof is presented in the appendix. Here, I present a more intuitive narrative on how asset prices and leverage are procyclical. Assume that the economy is in equilibrium characterized by $\{p_0^*, \kappa_0^*, A_0, \bar{\zeta}\}$ and the economy transitions from the state A_0 to the state A_1, with $A_1 > A_2$. The increase in productivity has a direct effect in the return from capital rents r_t. As r_t increases, the resources available to finance capital purchases augment as shown in equation (2.12).

The demand for assets shifts to the right as presented in the first panel of figure (2.1). On impact, asset prices increase and shift from point A to point B in figure (2.4). As stated in lemma 4, the properties of exponential distributions allow me to express leverage as a lineal function of asset prices. Thus, the higher level of asset prices boosts the level of leverage in the economy, as it is reflected in the second graph of figure (2.1).

This variation in leverage triggers and additional round of movements in the supply and demand curves. In response, the demand for assets shifts to the right, as the liquidity provided by assets pledged as collateral increase. On the contrary, the supply curve shifts to the left as the opportunity cost of selling assets augments. Thus, the combination of these two effects pushes the economy to a new equilibrium in point C in figure (2.4). This new equilibrium is characterized by $\{p_1^*, \kappa_1^*, A_1, \bar{\zeta}\}$ with $p_1 > p_0$, $\kappa_1 > \kappa_0$ and as previously stated $A_1 > A_0$; in other words, the economy now exhibit higher levels of leverage and asset prices.

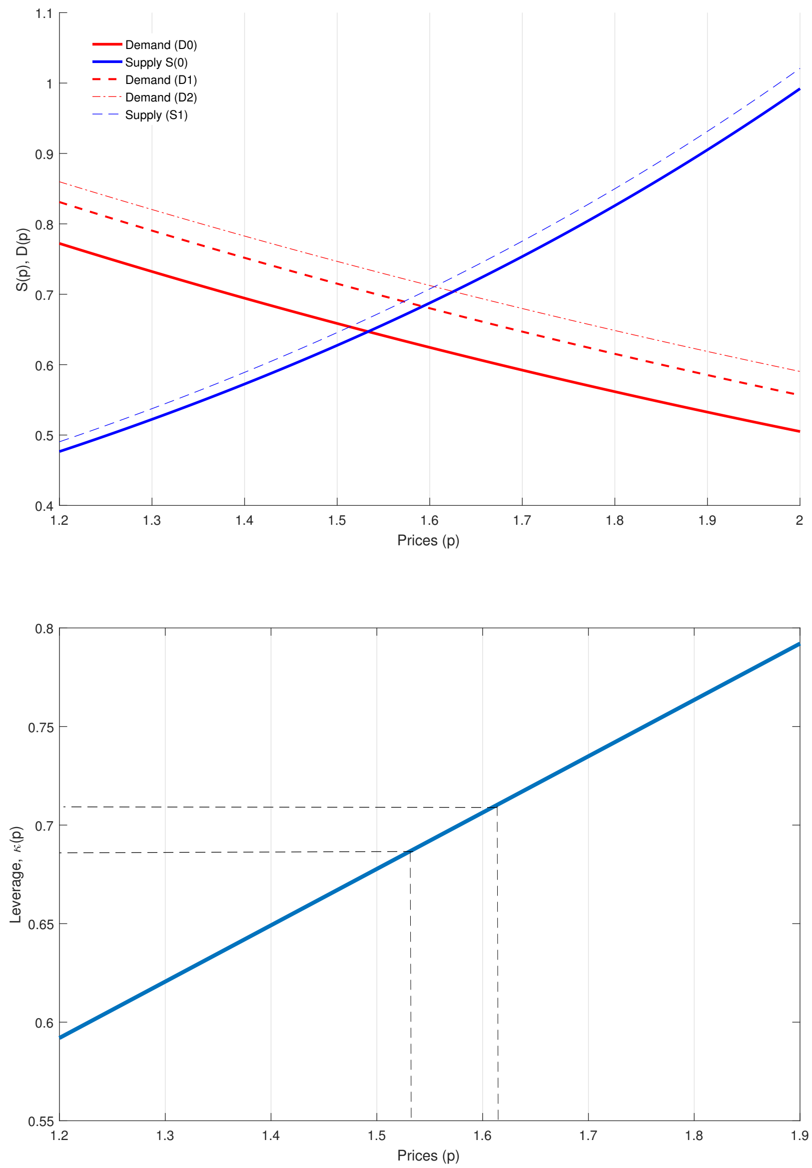
This feature of the model overcomes the important limitations of models with borrowing constraints. In general, leverage deteriorates in bad times as it has been highlighted in the literature of leverage cycles coined by Geanakoplos (2009). Notice that in models with borrowing constraints, leverage is either a fixed parameter (Monacelli, 2009) or the product of exogenous stochastic shocks (Bianchi and Mendoza, 2013). In both cases, these models deliver counterfactual predictions on the behavior of loan-to-value ratios, as they are assumed to be either acyclical or driven by exogenous conditions not necessarily tied to the economic cycle.

Proposition 4. *(Liquidity Spiral) A negative liquidity shock ζ_t leads to lower leverage and lower asset prices.*

As in the previous case, assume that the economy is in equilibrium characterized by $\left\{p_0^*, \kappa_0^*, \bar{A}, \zeta_0\right\}$ and the economy transitions from the state ζ_0 to the state ζ_1, with $\zeta_0 > \zeta_1$, a negative liquidity shock. As a consequence of the shock, the leverage function shifts down, and for each given p, the leverage is lower in the economy as depicted in figure (2.3). The drop in leverage reduces the opportunity costs of selling assets and increase the liquidity requirements of entrepreneurs shifting up the supply for assets; this, as entrepreneur attempt to compensate the decline in funding liquidity with market liquidity. On the contrary, as the funding liquidity drops, the recourses to finance capital purchases are lower. This leads to a decline in the demand for assets stemming from capital purchasers as presented in the first graph of figure (2.3).

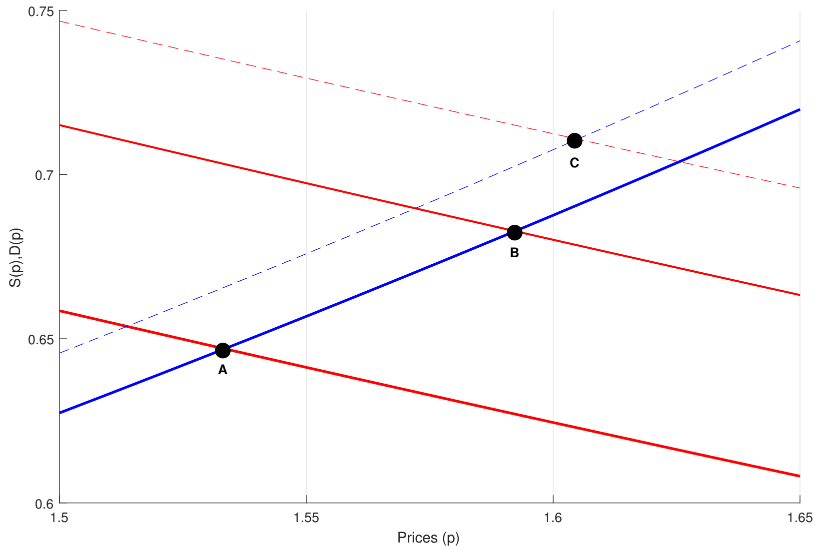
Both, the expansion of supply and the contraction in demand for assets imply

Fig. 2.1: Leverage and Asset Prices Procyclicality



Notes.. The distribution of capital units is assumed exponential and the distribution of entrepreneurs technology is assumed to be log-normal.

Fig. 2.2: Leverage and Asset Prices Procyclicality (Detailed)

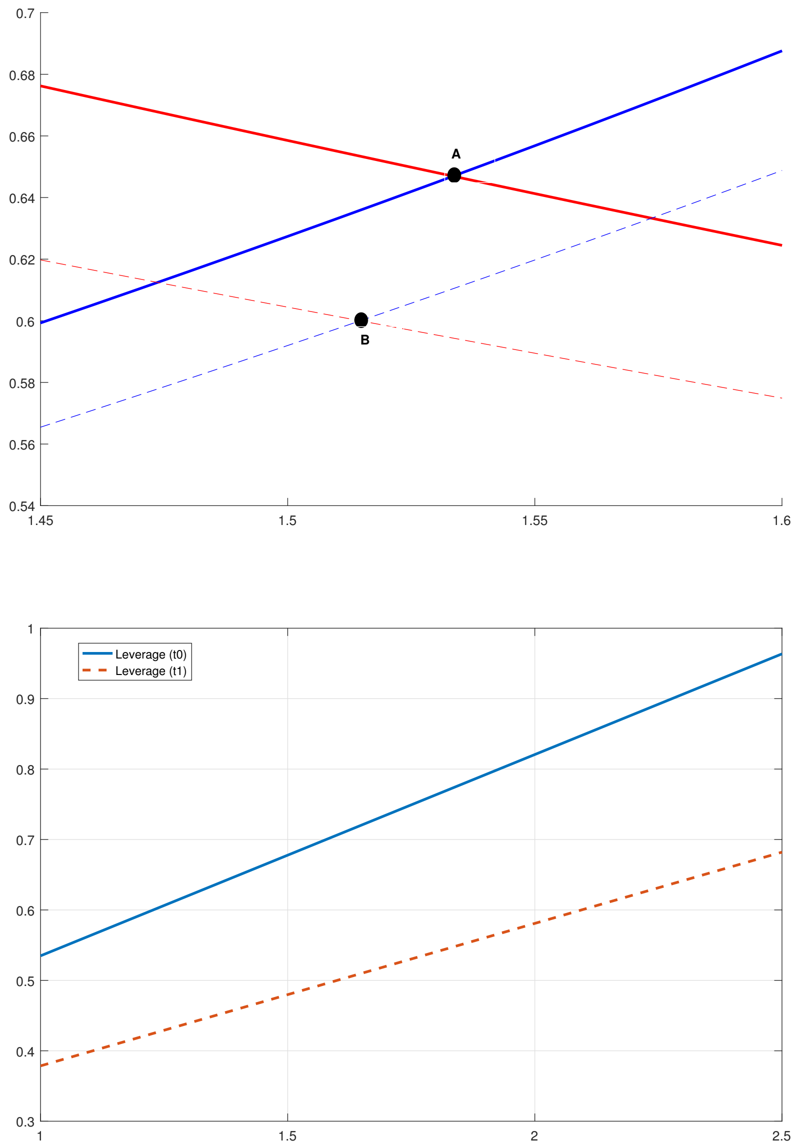


Notes.. The distribution of capital units is assumed exponential and the distribution of entrepreneurs technology is assumed to be log-normal.

that asset prices plummet. As prices drop, the initial decline in leverage is reinforced and triggera a new round of demand and supply shifts. Thus, the economy transitions from point A in figure (2.4) to point B in the same graph. The new equilibrium $\left\{p_1^*, \kappa_1^*, \bar{A}, \zeta_1\right\}$ is characterized by $p_1 < p_0$, $\kappa_1 < \kappa_0$ and $\zeta_1 < \zeta_0$. In conclusion, a negative liquidity shock brings about a drop in asset prices, which reinforces the initial drop in leverage creating a liquidity spiral.

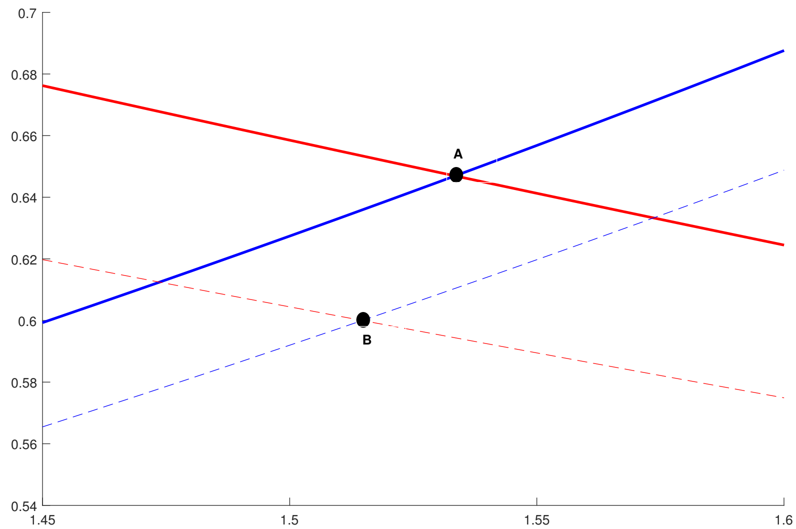
This feature of the model overcomes the counterfactual prediction stemming from models with liquidity shocks as Kiyotaki and Moore (1997) and Shi (2015). These models predict a stock market boom following an adverse liquidity shock to the underlying asset. My model is able to overcome this feature by focusing in shocks to the opportunity cost of selling assets, instead of focusing on implicit restrictions on the amount of asset which can be supplied in the economy.

Fig. 2.3: Liquidity Shocks



Notes.. The distribution of capital units is assumed exponential and the distribution of entrepreneurs technology is assumed to be log-normal.

Fig. 2.4: Liquidity Shocks (Detailed)



Notes.. The distribution of capital units is assumed exponential and the distribution of entrepreneurs technology is assumed to be log-normal.

In summary, this simple model is able to capture two salient features of the data which have been difficult to reconcile with existing models: the procyclicality of leverage and asset prices, and the decline of assets prices after a negative liquidity shock.

4 *Final Remarks*

This chapter explores the effects of asymmetric information about asset quality when agents cannot only trade assets to finance investment projects but also use these assets as collateral. Informational asymmetries creates an endogenous wedge between the ex-ante value of capital pledged by entrepreneurs and the ex-post value of capital available for resale by intermediaries in case of default. This wedge constitutes the leverage of the economy. This leverage is endogenous, as asset prices shape the quality of capital used in the market as collateral. In addition, asset prices are not longer determined exclusively by fundamentals but also for the value of the asset as a liquidity provider. In this context, asset prices and leverage are procyclical and negatively affected by liquidity shocks.

This chapter can be benefited by incorporating general equilibrium effects. In particular the effects of interest rates and how the endogenous response of interest rates to negative liquidity shocks can dampen or amplify the initial response presented in this paper. This is left for future research.

Appendix

2.A Proofs

Lemma 1. *Optimality conditions for a $\theta-$ entrepreneur are characterized by: a) a productivity threshold $\theta^b := \frac{\delta^b}{p_t}$ such that for any realization of $\theta < \theta^b$ the entrepreneur becomes a buyer of capital and does not invest. b) a threshold quality $\varepsilon^b := \delta^{-1}\left(\frac{\theta}{\nu_t}\right)$ such that for any given realization of productivity θ all qualities below ε^b are sold.*

Proof. Combining equations (2.2), (2.3) and (2.4), we can redefine the constraint for any given entrepreneur as equation (A.1).

$$c_t + \frac{k_{t+1}}{\theta} = k_t\left[r_t + p_t\int \iota_t(\varepsilon)f_\varepsilon(\varepsilon)d\varepsilon + \int\left(\frac{\delta(\varepsilon)}{\theta} + \kappa_t\tilde{q}_{t+1}\right)(1-\iota_t(\varepsilon))f_\varepsilon(\varepsilon)d\varepsilon\right] - \\ - Rb_t + k_t^p\left[\frac{\delta_t^b}{\theta} - p_t\right] \tag{A.1}$$

From equation (A.1), decisions for k_t^p and $\iota(\varepsilon)$ only affect the right hand side of the individual resource constraint. Therefore, taking as given the solution for c_t and k_{t+1}, it is possible to solve for capital purchases and qualities of capital sold. Part (a) from lemma (1) is a direct implication of linearity in k_t^p. Denote the first order condition of (A.1) with respect to k_t^p as $\psi(\theta)$:

$$\psi(\theta) = \frac{\delta_t^b}{\theta} - p_t \gtrless 0 \tag{A.2}$$

Productivity levels $\theta < \frac{\delta_t^b}{p_t} = \theta^b$ imply $\psi(\theta) > 0$, so capital purchases are positive ($k_t^p \neq 0$) and its level is determined by equation (2.5). For $\theta > \frac{\delta_t^b}{p_t} = \theta^b$ the value $\psi(\theta) < 0$ and entrepreneurs do not purchase capital ($k_t^p = 0$). This last conditions is analogous to the investment condition. More specifically for $\theta > \frac{\delta_t^b}{p_t} = \theta^b$ implies positive investment ($x_t \neq 0$). Thus, when entrepreneurs are capital buyers they decide not to invest.

The problem of units sold in part (b) requires the function $f(\cdot)$ to be continuous and differentiable. As the function is homogenous in k we can solve for the case where $k = 1$.

$$\varepsilon^b = \underset{\varepsilon^*}{\text{argmax}} \quad p_t \int_0^{\varepsilon^*} f_\varepsilon(\varepsilon) d\varepsilon + \int_{\varepsilon^*}^{\infty} \left(\frac{\delta(\varepsilon)}{\theta} + \kappa_t \tilde{q}_{t+1} \right) f_\varepsilon(\varepsilon) d\varepsilon \tag{A.3}$$

Taking the first order conditions with respect to ε^*:

$$p_t f_\varepsilon(\varepsilon^*) - \left[\kappa_t \tilde{q}_{t+1} + \frac{\delta(\varepsilon^*)}{\theta} \right] f_\varepsilon(\varepsilon^*) \geq 0 \tag{A.4}$$

In any interior solution (A.4) holds with equality. So, by ruling out saddle points in the solution of this problem we can redefine the solution as:

$$\varepsilon^b \leq \delta^{-1} \left(\boldsymbol{\theta} \left(p_t - \kappa_t \tilde{q}_{t+1} \right) \right) = \delta^{-1} \left(\boldsymbol{\theta} / \nu_t \right) \tag{A.5}$$

where $\delta^{-1}(\cdot)$ is the inverse of the depreciation function, which exists for all $\delta(\cdot)$ bijective functions. □

Proposition 1. *The supply of assets is monotonically increasing in prices (p) and monotonically decreasing in leverage (κ).*

Proof. As $\delta(\cdot)$ is a bijective function, it admits the existence of an inverse function $\delta^{-1}(\cdot)$, such that for $\delta(\cdot)$ strictly increasing, its inverse function is also strictly increasing $d\delta^{-1}(\cdot) > 0$. Notice that for $\varepsilon^b = \delta^{-1}(\theta/\nu_t)$, the qualities offered are monotonically increasing in the price level, $\frac{\partial \varepsilon^b}{\partial p} = d\delta^{-1}(\cdot)\theta > 0$, and monotonically decreasing in the level of leverage $\frac{\partial \varepsilon^b}{\partial \kappa} = -d\delta^{-1}(\cdot)\theta q < 0$, Thus:

$$\frac{\partial \mathbf{S}(p,\kappa)}{\partial p} = K_t \int_{\theta_0}^{\theta_1} \frac{\partial}{\partial p}\left(\int_0^{\varepsilon^b} f(\varepsilon)d\varepsilon\right) dG(\theta) = K_t \int_{\theta_0}^{\theta_1} \left(\frac{\partial \varepsilon^b}{\partial p} f(\varepsilon^b)\right) dG(\theta) > 0$$

Notice $\frac{\partial \varepsilon^b}{\partial p} > 0$ a positive function as shown previously. By the properties of a well-defined probability density function, $f(\cdot)$ is non-negative. Thus, the product $\frac{\partial \varepsilon^b}{\partial p} f(\varepsilon^b)$ is non-negative. Define a closed interval $W \subset [\theta_0, \theta_1]$ such that the aforementioned product is a positive function. As the Riemann integral of a strictly positive function is positive, then we have $\int_{\theta_0}^{\theta_1} \frac{\partial \varepsilon^b}{\partial p} f(\varepsilon^b) dG\theta \geq \int_W \frac{\partial \varepsilon^b}{\partial p} f(\varepsilon^b) dG(\theta) > 0$.

$$\frac{\partial \mathbf{S}(p,\kappa)}{\partial \kappa} = K_t \int_{\theta_0}^{\theta_1} \frac{\partial}{\partial \kappa}\left(\int_0^{\varepsilon^b} f(\varepsilon)d\varepsilon\right) dG(\theta) = K_t \int_{\theta_0}^{\theta_1} \left(\frac{\partial \varepsilon^b}{\partial \kappa} f(\varepsilon^b)\right) dG(\theta) < 0$$

The function $\frac{\partial \varepsilon^b}{\partial \kappa} f(\varepsilon^b)$ is non-positive. We can construct a closed interval $W \subset [\theta_0, \theta_1]$ such that the function is negative over this interval. Thus, as the Riemman integral of a stricly negative function is negative, we have $\int_{\theta_0}^{\theta_1} \frac{\partial \varepsilon^b}{\partial \kappa} f(\varepsilon^b) dG(\theta) \leq \int_W \int_{\theta_0}^{\theta_1} \frac{\partial \varepsilon^b}{\partial \kappa} f(\varepsilon^b) dG(\theta) < 0$. □

Lemma 3. *The belief on market depreciation from capital units traded is a time-varying multiple of average capital depreciation* $\delta^b(p, \kappa) = \bar{\delta}\Lambda_t$ *where:*

$$\Lambda_t := \left(\int_\theta F_\varepsilon \left(\varepsilon^b \left(\theta, p, \kappa \right) \right) \, dG(\theta) \right)^{-1} \left(1 - \frac{1}{\bar{\delta}} \int_{\theta_0}^{\theta_1} \int_{\varepsilon^b}^{\infty} \delta(\varepsilon) f(\varepsilon) d\varepsilon \; dG(\theta) \right)$$

. *Proof.* This proof is done by guess and verify. In particular, it requires depreciation beliefs in equation (2.11) to be consistent with the aggregate motion of capital that follows $K_{t+1} = \bar{\delta}K_t + X_t$. First, lets replace the guess on market beliefs in equation (2.3):

$$k_{t+1} = k_t \int_{\varepsilon^b}^{\infty} \delta(\varepsilon) f(\varepsilon) d\varepsilon + \bar{\delta}\Lambda_t k_t^p + \theta x_t \tag{A.6}$$

Then, we obtain aggregate conditions by integrating equation (A.6) over all entrepreneurs:

$$K_{t+1} = K_t \int_{\theta_0}^{\theta_1} \int_{\varepsilon^b}^{\infty} \delta(\varepsilon) f(\varepsilon) d\varepsilon dG(\theta) + \bar{\delta}\Lambda_t \int_{\theta_0}^{\theta_1} k_t^p dG(\theta) + X_t \tag{A.7}$$

where $X_t = \int_{\theta_0}^{\theta_1} \theta x_t dG(\theta)$ stands for total aggregate investment. Notice that for any $p_t > 0$, equilibrium conditions in the capital market require that aggregate capital purchased must be equal to aggregate capital supplied. Thus, by imposing these conditions, we can redefine capital sales in terms of units offered in the market as:

$\int_{\theta_0}^{\theta_1} k_t^p dG(\theta) = K_t \int_{\theta_0}^{\theta_1} \int_0^{\varepsilon^p} f(\varepsilon) dG(\theta)$. Replacing in equation (A.7):

$$K_{t+1} = K_t \int_{\theta_0}^{\theta_1} \int_{\varepsilon^b}^{\infty} \delta(\varepsilon) f(\varepsilon) d\varepsilon dG(\theta) + \bar{\delta} \Lambda_t K_t \int_{\theta_0}^{\theta_1} \int_0^{\varepsilon^b} f(\varepsilon) dG(\theta) + X_t \qquad \text{(A.8)}$$

Notice that by using the definition of Λ_t presented in equation (2.11) we simplify the the following expression $\Lambda_t \int_{\theta_0}^{\theta_1} \int_0^{\varepsilon^b} f(\varepsilon) dG(\theta) = \left(1 - \frac{1}{\bar{\delta}} \int_{\theta_0}^{\theta_1} \int_{\varepsilon^b}^{\infty} \delta(\varepsilon) f(\varepsilon) d\varepsilon \; dG(\theta)\right)$. Plugging this result yields:

$$\begin{aligned} K_{t+1} = K_t \int_{\theta_0}^{\theta_1} \int_{\varepsilon^b}^{\infty} \delta(\varepsilon) f(\varepsilon) d\varepsilon dG(\theta) \quad &+ \quad \bar{\delta} K_t \left(1 - \frac{1}{\bar{\delta}} \int_{\theta_0}^{\theta_1} \int_{\varepsilon^b}^{\infty} \delta(\varepsilon) f(\varepsilon) d\varepsilon \; dG(\theta)\right) + X_t \\ K_{t+1} \quad &= \quad \bar{\delta} K_t + X_t \quad \square \end{aligned}$$

Proposition 1. *(Leverage) Leverage corresponds to the expected quality of units used as collateral for all entrepreneurs as defined in equation (2.15).*

$$l(p, \kappa, \zeta) = \kappa - \zeta_t \left((p - q\kappa)\bar{\theta} + \int_{\theta_0}^{\theta_1} \int_{\varepsilon^b}^{\infty} \frac{\tilde{F}_{\varepsilon}(\varepsilon)}{\tilde{F}_{\varepsilon}\left(\varepsilon^b(\kappa)\right)} \delta'(\varepsilon) \; dG(\theta) \right)$$

Proof. Denote the distribution of capital qualities as $f^t(\varepsilon)$ the truncated distribution defined over $\varepsilon \in (\varepsilon^b, \infty)$ and using the leverage definition:

$$E(\delta(\varepsilon) | \varepsilon > \varepsilon^b) = \int_{\theta} \int_{\varepsilon^b}^{\infty} \delta(\varepsilon) f^t(\varepsilon) d\varepsilon \; dG(\theta)$$

Where $dG(\theta)$ corresponds to probability density function of entrepreneurs' quality.

Let $\delta(\cdot)$ be a real function continuous and differentiable. Solving the inner integral:

$$\int_{\varepsilon^b}^{\infty} \delta(\varepsilon) f^t(\varepsilon) d\varepsilon = \frac{1}{\tilde{F}_\varepsilon(\varepsilon^b)} \left[-\delta(x)\tilde{F}_\varepsilon(x)\Big|_{\varepsilon^b}^{\infty} + \int_{\varepsilon^b}^{\infty} \tilde{F}_\varepsilon(\varepsilon)\delta'(\varepsilon) \right] = \delta(\varepsilon^b) + \int_{\varepsilon^b}^{\infty} \frac{\tilde{F}_\varepsilon(\varepsilon)}{\tilde{F}_\varepsilon(\varepsilon^b)} \delta'(\varepsilon)$$

Notice $\delta(\varepsilon^b) = \theta/\nu = \theta(p - q\kappa)$. We can replace this expression in the original one to get:

$$\int_\theta \int_{\varepsilon^b}^{\infty} \delta(\varepsilon) f^t(\varepsilon) d\theta d\varepsilon = (p - q\kappa) \int_{\theta_0}^{\theta_1} \theta dG(\theta) + \int_{\theta_0}^{\theta_1} \int_{\varepsilon^b}^{\infty} \frac{\tilde{F}_\varepsilon(\varepsilon)}{\tilde{F}_\varepsilon(\varepsilon^b)} \delta'(\varepsilon) dG(\theta)$$

$$\int_\theta \int_{\varepsilon^b}^{\infty} \delta(\varepsilon) f^t(\varepsilon) d\theta d\varepsilon = (p - q\kappa)\bar{\theta} + \int_{\theta_0}^{\theta_1} \int_{\varepsilon^b}^{\infty} \frac{\tilde{F}_\varepsilon(\varepsilon)}{\tilde{F}_\varepsilon(\varepsilon^b)} \delta'(\varepsilon) dG(\theta)$$

□

Lemma 4. *For a linear depreciation function $\delta(\varepsilon)$ and the distributions of qualities ε following an exponential distributions with mean $\bar{\delta}$, for any given $\{p\}$, there exists a unique κ^* which is a fixed-point solution for equation (2.15) and satisfies:*

$$\kappa^* = \zeta_t \left(E_\theta \left(\varepsilon^b (\theta, p, \kappa^*) \right) + E(\varepsilon) \right)$$

Proof. From equation (2.15) it is straightforward to notice that $E_\theta \left(\varepsilon^b (\theta, p, \kappa^*) \right) = (p - q\kappa)\bar{\theta}$. In addition for a linear $\delta(\cdot)$ function, we have $d\delta(\cdot)$ is constant and w.l.g equals to 1. Thus $\int_{\theta_0}^{\theta_1} \int_{\varepsilon^b}^{\infty} \frac{\tilde{F}_\varepsilon(\varepsilon)}{\tilde{F}_\varepsilon(\varepsilon^b)} \delta'(\varepsilon) dG_\theta = \int_{\theta_0}^{\theta_1} \frac{1}{\tilde{F}_\varepsilon(\varepsilon^b)} \int_{\varepsilon^b}^{\infty} \tilde{F}_\varepsilon(\varepsilon) d\varepsilon dG(\theta)$. Which for the case of exponential distribution is equivalent to:

$$\int_{\theta_0}^{\theta_1} \frac{1}{\tilde{F}_\varepsilon(\varepsilon^b)} \int_{\varepsilon^b}^{\infty} \tilde{F}_\varepsilon(\varepsilon) d\varepsilon dG(\theta) = \int_{\theta_0}^{\theta_1} \frac{1}{\exp^{-\lambda\varepsilon^b}} \int_{\varepsilon^b}^{\infty} \exp^{-\lambda\varepsilon} d\varepsilon \, dG(\theta)$$

Solving the integral yields $\frac{1}{\lambda}$ which is equivalent to $\bar{\delta} = E(\varepsilon)$ for the case of exponential distributions. Notice, that this expression is linear in κ, thus it admits a unique solution for any given of $\{\zeta_t, p_t, \tilde{q}_{t+1}\}$ equals to $\kappa_t^* = \zeta_t \left(1 + \bar{\theta}\zeta_t\tilde{q}_{t+1}\right)^{-1} \left(\bar{\theta}p_t + \bar{\delta}\right)$.

□

Proposition 3. *Prices and Leverage are procyclical*

Proof. Define the Excess supply function as e and the implicit leverage function as l.

$$\begin{aligned} e(p, \kappa, A) &= \mathbf{S}(p, \kappa) - \mathbf{D}(p, \kappa, A) \\ l(p, \kappa, \zeta) &= \kappa - g(p, \zeta) \end{aligned}$$

Define the determinant of the Jacobian as:

$$J = \begin{vmatrix} \left(\frac{\partial \mathbf{S}(p,\kappa)}{\partial p} - \frac{\partial \mathbf{D}(p,\kappa,A)}{\partial p}\right) & \left(\frac{\partial \mathbf{S}(p,\kappa)}{\partial \kappa} - \frac{\partial \mathbf{D}(p,\kappa,A)}{\partial \kappa}\right) \\ \frac{\partial l(p,\kappa,\zeta)}{\partial p} & \frac{\partial l(p,\kappa,\zeta)}{\partial \kappa} \end{vmatrix}$$

The determinant of the Jacobian can be expressed as $|J| = \left(\frac{\partial \mathbf{S}}{\partial p} - \frac{\partial \mathbf{D}}{\partial p}\right) - \left(\frac{\partial \mathbf{S}}{\partial \kappa} - \frac{\partial \mathbf{D}}{\partial \kappa}\right)\frac{\partial l}{\partial p}$. Given the conditions presented in Assumption 2, the Jacobian is positive. Now consider the change in asset prices driven by a change in total productivity:

$$\frac{\partial p}{\partial A} = -\frac{\begin{vmatrix} \left(\frac{\partial \mathbf{S}(p,\kappa)}{\partial A} - \frac{\partial \mathbf{D}(p,\kappa,A)}{\partial A}\right) & \left(\frac{\partial \mathbf{S}(p,\kappa)}{\partial \kappa} - \frac{\partial \mathbf{D}(p,\kappa,A)}{\partial \kappa}\right) \\ \frac{\partial l(p,\kappa,\zeta)}{\partial A} & \frac{\partial l(p,\kappa,\zeta)}{\partial \kappa} \end{vmatrix}}{\begin{vmatrix} J \end{vmatrix}} = -\frac{-\frac{\partial \mathbf{D}}{\partial A}\frac{\partial l}{\partial \kappa}}{\begin{vmatrix} J \end{vmatrix}}$$

This expression can be further simplified since: $\frac{\partial l}{\partial A} = 0$, $\frac{\partial \mathbf{S}}{\partial A} = 0$ and $\frac{\partial l}{\partial \kappa} = 1$. Thus under the conditions characterizing the Jacobian of the model, we can conclude that $sign\left(\frac{\partial p}{\partial A}\right) = -sign\left(-\frac{\partial \mathbf{D}}{\partial A}\frac{\partial l}{\partial \kappa}\right)$. Notice that $\frac{\partial \mathbf{D}}{\partial A} > 0$ since $\frac{\partial \mathbf{D}}{\partial r_t} > 0$ and in equilibrium $r_t = A_t$. Also, $\frac{\partial l}{\partial \kappa} = 1$, Thus $\frac{\partial p}{\partial A} > 0$. Now consider the case for leverage κ:

$$\frac{\partial \kappa}{\partial A} = -\frac{\begin{vmatrix} \left(\frac{\partial \mathbf{S}(p,\kappa)}{\partial p} - \frac{\partial \mathbf{D}(p,\kappa,A)}{\partial p}\right) & \left(\frac{\partial \mathbf{S}(p,\kappa)}{\partial A} - \frac{\partial \mathbf{D}(p,\kappa,A)}{\partial A}\right) \\ \frac{\partial l(p,\kappa,\zeta)}{\partial p} & \frac{\partial l(p,\kappa,\zeta)}{\partial A} \end{vmatrix}}{\begin{vmatrix} J \end{vmatrix}} = -\frac{\frac{\partial \mathbf{D}}{\partial A}\frac{\partial l}{\partial p}}{\begin{vmatrix} J \end{vmatrix}}$$

This expression can be further simplified since: $\frac{\partial l}{\partial A} = 0$, $\frac{\partial \mathbf{S}}{\partial A} = 0$ and $\frac{\partial l}{\partial \kappa} = 1$. Thus under the conditions characterizing the Jacobian of the model, we can conclude that $sign\left(\frac{\partial \kappa}{\partial A}\right) = -sign\left(\frac{\partial \mathbf{D}}{\partial A}\frac{\partial l}{\partial p}\right)$. Notice that $\frac{\partial \mathbf{D}}{\partial A} > 0$ since $\frac{\partial \mathbf{D}}{\partial r_t} > 0$ and in equilibrium $r_t = A_t$. Also, $\frac{\partial l}{\partial p} = -g'(p) < 0$, Thus $\frac{\partial \kappa}{\partial A} > 0$. □

Proposition 4. *(Liquidity Spiral) A negative liquidity shock ζ_t leads to lower leverage and lower asset prices.*

Proof. Consider the change in leverage driven by a change in :

$$\frac{\partial \kappa}{\partial \zeta} = -\frac{\begin{vmatrix} \left(\frac{\partial \mathbf{S}(p,\kappa)}{\partial p} - \frac{\partial \mathbf{D}(p,\kappa,A)}{\partial p}\right) & \left(\frac{\partial \mathbf{S}(p,\kappa)}{\partial \zeta} - \frac{\partial \mathbf{D}(p,\kappa,A)}{\partial \zeta}\right) \\ \frac{\partial l(p,\kappa,\zeta)}{\partial p} & \frac{\partial l(p,\kappa,\zeta)}{\partial \zeta} \end{vmatrix}}{\begin{vmatrix} J \end{vmatrix}} = -\frac{\left(\frac{\partial \mathbf{S}}{\partial p} - \frac{\partial \mathbf{D}}{\partial p}\right)\frac{\partial l}{\partial \zeta}}{\begin{vmatrix} J \end{vmatrix}}$$

This expression can be further simplified since: $\frac{\partial \mathbf{S}}{\partial \zeta} = 0$ and $\frac{\partial \mathbf{D}}{\partial \zeta} = 0$. Thus under the conditions characterizing the Jacobian of the model, we can conclude that

$sign\left(\frac{\partial\kappa}{\partial\zeta}\right) = -sign\left(\frac{\partial\mathbf{S}}{\partial p} - \frac{\mathbf{D}}{\partial p}\right)\frac{\partial l}{\partial\zeta}$. Notice that $\frac{\partial\mathbf{S}}{\partial p} > 0$, $\frac{\partial\mathbf{D}}{\partial p} < 0$ and $\frac{\partial l}{\partial\zeta} = -g'(\zeta) < 0$, Thus $\frac{\partial\kappa}{\partial\zeta} > 0$. Now consider the case for asset prices p:

$$\frac{\partial p}{\partial\zeta} = -\frac{\begin{vmatrix} \left(\frac{\partial\mathbf{S}(p,\kappa)}{\partial\zeta} - \frac{\partial\mathbf{D}(p,\kappa,A)}{\partial\zeta}\right) & \left(\frac{\partial\mathbf{S}(p,\kappa)}{\partial\kappa} - \frac{\partial\mathbf{D}(p,\kappa,A)}{\partial\kappa}\right) \\ \frac{\partial l(p,\kappa,\zeta)}{\partial\zeta} & \frac{\partial l(p,\kappa,\zeta)}{\partial\kappa} \end{vmatrix}}{\begin{vmatrix} J \end{vmatrix}} = -\frac{-\left(\frac{\partial\mathbf{S}}{\partial\kappa} - \frac{\partial\mathbf{D}}{\partial\kappa}\right)\frac{\partial l}{\partial\zeta}}{\begin{vmatrix} J \end{vmatrix}}$$

This expression can be further simplified since: $\frac{\partial\mathbf{S}}{\partial\zeta} = 0$ and $\frac{\partial\mathbf{D}}{\partial\zeta} = 0$. Thus under the conditions characterizing the Jacobian of the model, we can conclude that $sign\left(\frac{\partial p}{\partial\zeta}\right) = -sign - \left(\frac{\partial\mathbf{S}}{\partial\kappa} - \frac{\mathbf{D}}{\partial\kappa}\right)\frac{\partial l}{\partial\zeta}$. Notice that $\frac{\partial\mathbf{S}}{\partial\kappa} < 0$, $\frac{\partial\mathbf{D}}{\partial\kappa} > 0$ and $\frac{\partial l}{\partial\zeta} = -g'(\zeta) < 0$, Thus $\frac{\partial p}{\partial\zeta} > 0$. □

2.B Calibration

The model is calibrated at a quarterly frequency. The discount factor for borrowers is set to $\beta = 0.98$ as in Monacelli (2009). The interest rate is set to an annualized value of 4% $R = 1.04$. The function determining the quality of capital is assumed to be lineal and taking the form $\delta(\varepsilon) = \varepsilon$. In such way the probability density function follows an exponential distribution with parameter $\lambda = 1/\bar{\delta}$, where $\bar{\delta} = 0.98$. Following Ajello (2010) the ability of entrepreneurs to transform consumption goods into capital follows a log-normal distribution with mean $\mu_\theta = 0$ and standard deviation $\sigma_\theta = 0.5$. This parameter is chosen in order to satisfy the conditions under Assumption 2. Lower dispersion increases the area in the state-space in which the demand function is non-monotonic and increasing in asset prices. The mean of the liquidity shock $\bar{\zeta}$ is set to 0.36 such that the average loan-to-value ratio is close to 70%. Productivity shocks are discretized using Tauchen with for $\rho_A = 0.95$ and $\sigma_A = 0.004$. Liquidity shocks are discretized by normalizing liquidity series produced by the Federal Reserve Board and computing an AR(1) process, such that $\rho_\zeta = 0.89$ and $\sigma_\zeta = 0.09$.

Chapter 3: Domestic Antidotes to Sudden Stops (with Eduardo Cavallo and Alejandro Izquierdo)

1 Introduction

The genesis of a "*sudden stop*" in capital flows is an abrupt – and oftentimes unexpected – cut-off of international credit to debtor countries; i.e., a sudden stop in capital inflows. When foreign creditors stop lending, borrowers have to adjust. Yet, not everybody in a country that is borrowing from abroad is a debtor vis-à-vis the rest of the world. In every country, there are agents who borrow and others who save. In open economies, a portion of the national savings is allocated to purchasing foreign assets (capital outflows). Therefore there are domestic agents who own foreign assets. Those assets can possibly be repatriated, providing an alternative source of external financing. If repatriation of assets by residents happens when foreigners stop lending, then a sudden stop in net capital flows may be averted, or prevented. This chapter studies under what conditions sudden stops in net capital flows can be prevented.

The notion of "antidotes to Sudden Stops" or "prevention" in this chapter takes a specific meaning. It is not removing the risk that foreign lenders may abruptly and unexpectedly stop lending. This is usually outside the control of any given country. Instead, it refers to the conditions under which a sudden stop in gross capital inflows from foreigners does not become a fully-fledged sudden stop in net capital flows. Net capital flows to a country is the difference between gross inflows (lending provided by foreigners) and gross outflows (domestic savings allocated to purchasing foreign assets). "Prevention" in this chapter is a situation in which, given a reduction in gross capital inflows of certain magnitude – which we denote "sudden stop in gross inflows" –, gross capital outflows behave in such a way that net capital flows remain relatively stable, meaning that net capital flows do not enter into Sudden Stop mode.

The episodes that are the focus of this chapter can be considered as the sequence of two transitions: first, the transition from normal times to periods of sudden stops in gross inflows. And second, after experiencing a sudden stop in gross inflows, the transition or not to a net sudden stop. We study the determinants behind each transition taking into account domestic and external factors. Our empirical results indicate that, while global conditions are important in explaining the incidence of gross sudden stops, favorable domestic conditions are the antidotes that matter to understand why these episodes do not become net sudden stops. As a corollary we find that, in periods of global distress, the ability of a country to show resilience against capital flight relies heavily on the soundness of domestic conditions. Considering a comprehensive set of variables, we conclude that episodes of prevented sudden stops in net capital inflows are positively related to the institutional background, as well as monetary frameworks with flexible exchange rates accompanied by inflation targeting regimes, and negatively related to the country's level of foreign liabilities and inflation.

This chapter belongs to a relatively new strand of the sudden stops literature that considers the distinct roles of gross capital inflows and outflows. Until the mid-1990s the relative weight of gross capital outflows vis-á-vis gross inflows was negligible in emerging markets. Therefore, making the distinction between gross inflows and net capital flows was largely irrelevant. The discussions about capital flows in emerging markets focused exclusively on "net capital flows" and the potentially disruptive effects their volatility might impose on debtors. As domestic investors started playing more sizable roles in emerging markets, the discussions shifted towards differentiating gross capital inflows from outflows.

The distinction between gross and net flows makes it possible to analyze sudden stop episodes from different perspectives. On the one hand, sudden stops in net flows can be the consequence of a decline in gross inflows by foreigners; on the other hand, they can be a consequence of an increase in gross outflows by domestic agents. In this regard, Cavallo et al. (2013) extend the scope of the term "sudden stop" to reflect also abrupt changes in gross capital flows. The authors schematize a taxonomy for sudden stops based on the possibility that a sudden stop in gross inflows does not translate into a sudden stop in net flows.[1] This is possible when

[1] They present seven potential sudden stops: a sudden stop in inflows that does not imply a sudden stop in net flows (SSI); a sudden stop in inflows that translates into a sudden stop in net flows (SSIN); a sudden stop in net flows that is not a sudden stop in inflows or outflows (SSN); a sudden stop in inflows and sudden stop in outflows that is not a sudden stop in net flows (SSIO); a sudden stop in inflows and a sudden surge in outflows that is also a net sudden stop (SSION); a surge in outflows that is not a sudden stop (SSO); and, a sudden surge in outflows that is a sudden stop in net flows (SSON).

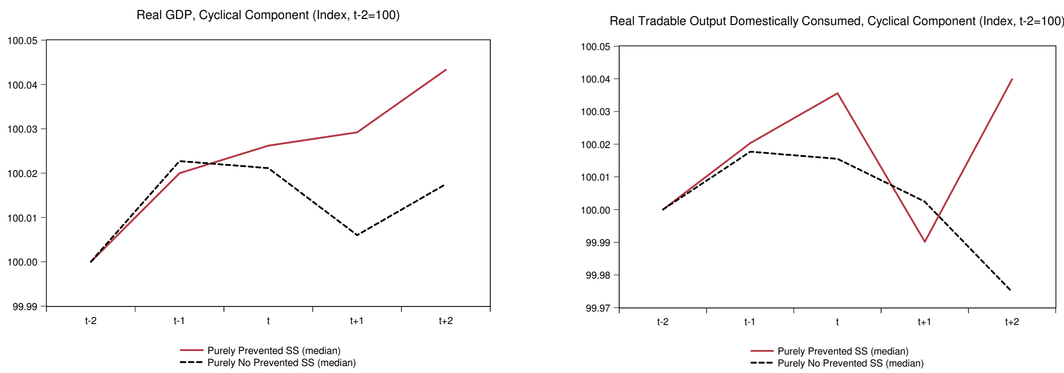
domestic residents adjust their asset positions offseting the decline in inflows from foreigners. They suggest that domestic agents have the ability to prevent episodes of net sudden stops.

In related work, Broner et al. (2013) find that both gross capital inflows and outflows increase during economic expansions and decrease during downturns. The authors also find that in periods of crisis, total gross capital flows collapse due to the retrenchment of outflows from foreign markets everywhere, and that this phenomenon is particularly stronger if the crisis is global. This is what is behind the observation that during the global financial crisis of 2008/09, large capital retrenchments compensated the fall in gross capital inflows (IMF, 2013).

Our view that global conditions are relevant determinants of episodes of decline in gross inflows is consistent with the findings of Forbes and Warnock (2012). They highlight that during the global financial crisis there was an unprecedented number of countries experiencing both stops and retrenchment episodes simultaneously. The authors indicate that global factors, especially global risk through changes in economic uncertainty, as well as changes in risk aversion and global growth, are key drivers of extreme capital flows episodes such as sudden stops in inflows and retrenchment of outflows.

It is important from a policy standpoint to know what are the determinants of prevented sudden stops because sudden stops in net capital flows are significantly costlier in terms of GDP losses to the affected economies than sudden stops in gross inflows (Cavallo et al., 2013). This is so because a sudden stop in net capital flows demands an abrupt adjustment in any outstanding current account deficit, which

Fig. 3.1: GDP and Absorption



Source Author's own calculations based on data from IMF-IFS.

is typically very costly to engineer, particularly in countries with foreign currency liabilities and low shares of tradable output. Instead, a sudden stop in inflows that is offset by resident investors, prevents the external adjustment and therefore, the output costs. Figure 3.1 depicts how the adjustment in output and absorption are larger for economies that are not able to prevent sudden stops.[2] Given that sudden stops in inflows are largely outside the control of local policymakers, having effective antidotes to prevent them from becoming full-fledged sudden stops in net capital flows is welfare enhancing. This chapter sheds light on the role of domestic investors in increasing the likelihood of prevention conditional on a foreigners' sudden stop having materialized and the conditions that characterize this process .

Theoretical Framework. The phenomenon studied in this chapter, i.e., the fact that domestic investors may prevent a net sudden stop from occurring,

[2] To compute Figure 3.1, we have considered only episodes that were fully prevented during all quarters; the same applies for episodes that were not prevented. In addition, we only consider non-overlapping episodes. This clearly reduced the sample size but allows us to get a cleaner picture of the path of GDP and absorption from prevented and not prevented episodes.

can be rationalized in terms of two stories or mechanisms about the behavior of such investors. First, a story of comparative advantage in knowledge. Caballero and Simsek (2016) provides a theoretical framework to understand how domestic investors provide a stabilizing counterforce to the "fickleness" in gross inflows due to their comparative advantage in expertise about local markets. The observed behavior of capital outflows in periods of distress is consistent with the behavior of investors who are specialists and have better information about potential projects in their own country. This assumption aims to capture the attitude of Knightian agents facing unfamiliar (foreign) situations relating to the work in Dow and Werlang (1992) and Caballero and Krishnamurthy (2008).

Second, a story of higher investment incentives due to changes in relative prices. Domestic investors can benefit from changes in exchange rates. Periods of turmoil are accompanied by sharp currency depreciations that affect positively the return of investment in local currency, making it more attractive. This idea is consistent with the findings in Krugman (2000) and Aguiar and Gopinath (2005) who stated that foreign direct investment actually expands during period of crisis. But more closely, to the literature that links currency depreciation and investment incentives such as the theoretical work in Froot and Stein (1991) and Blonigen (1997), and the empirical work of Klein and Rosengren (1994) and Goldberg and Klein (1997).

Related Literature. This chapter is related to Adler et al. (2014). The authors quantify the dynamic impact of global financial shocks on both net and gross capital flows to emerging markets, and analyze the role played by local investors in offsetting the behavior of foreign investors. Making use of a panel vector autoregression and the analysis of the resulting impulse responses, they find that, when facing global uncertainty and shocks to long-term interest rates, local investors can neutralize the decline in inflows from foreign investors. This chapter differs in some relevant dimensions from theirs. First, we consider only periods in which sudden stops occur, i.e. times in which a given country is more vulnerable because of the reduction in external financing. This permits controlling for any bias stemming from nonlinearities in the behavior of domestic agents during normal and crisis times. Second, the methodology we employ exploits the cross-sectional variation (as oppossed to only the time series) in capita flows. Countries display heterogenous patterns in their capital flows dynamics, and the ability of domestic agents to neutralize a sudden stop in gross flows depends on specific characteristics of their home.

This chapter is also related to Cifuentes and Jara (2014). They stress the role of assets held abroad and of exchange rate flexibility in shaping the probability that a retrenchment episode occurs when the economy is facing a sudden stop in gross inflows. Even though their research question is similar, there are important differences between the two documents. First, the set of events under study in both documents do not overlap. This is because, as it will be discussed below, the occurrence of a retrenchment – defined as an extreme event of capital outflows – is neither a necessary nor a sufficient condition to prevent a sudden stop in net flows. Second, our sample includes a broader set of countries and more explanatory variables, e.g. foreign liabilities, institutional quality and contagion effects. This allows for a comprehensive analysis of the role of domestic factors in explaining how prevention can materialize.

Our chapter is part of the literature on the determinants of sudden stops, i.e., Calvo et al. (2004) and Calvo et al. (2008). This literature initially explored the determinants of the abrupt decline in net flows, particularly in emerging economies, because back in the 1990s and early 2000s, they were the most vulnerable to these type of episodes. This chapter is related to the strand of the literature that departs from the net flow approach, and that studies inflows and outflows separately in an effort to understand the role that local and foreign investors have in shaping each of them. This strand of literature includes Calderon and Kubota (2013) and Forbes and Warnock (2012). The focus on gross rather than net capital flows yields some interesting facts. For example, Schmidt and Zwick (2013), using data for the Euro area, conclude that domestic volatility (i.e. uncertainty about the evolution of the economy and the economic policy implemented) played an important role in determining the dynamics of gross flows and the increase in home bias observed in the are during the crisis.

Another examples is Ghosh et al. (2014). The authors postulate that global factors, such as US interest rates and global risk, are important elements associated with capital surges in emerging markets. However, the attractiveness of a country as an investment destination is largely driven by domestic factors. This does not imply that foreign investors do not react to local conditions. On the contrary, foreign investors consider local conditions as much as domestic investors do, but they are more sensitive to changes in global conditions. Fratzscher (2011) finds additional evidence on the role of global factors driving gross flows during the global financial crisis of $2007-2009$ and its aftermath. He finds that the rise in risk was the culprit of the reallocation of flows from many emerging to some advanced economies during the crisis. This is in contrast with the pre- and post-crisis periods, in which external factors had the opposite effect. Domestic factors are instead related to the observed cross-country heterogeneity in the pattern of capital flows.

The existence of a home bias in capital flows has been also part of the literature. In particular, Milesi-Ferretti and Tille (2011) have pointed out a generalized but heterogenous collapse in international capital flows during the financial crisis. Along the same lines, Giannetti and Laeven (2012) show that, during periods of crisis that involve higher uncertainty, investors become more risk averse and revert to domestic investments that can be evaluated at lower costs due to lower asymmetric information. Jochem and Volz (2011) in turn argue that the home bias in the Euro zone is associated to changes in the portfolio structure in favor of domestic assets mainly by financial institutions in an effort to deleverage due to the inherent risk in their balance sheets.

This chapter is structured as follows. Section 2 presents definitions and determinants of sudden stops. Section 3 provides a brief description of the methodology and presents the baseline results. Section 4 summarizes the results from the sensitivity and robustness checks. Section 5 studies the conditions under which a country is able to continue in a path of prevention once it has been able to prevent a sudden stop episode in a given quarter. Section 6 concludes.

2 *Definitions, Measurement and Data*

2.1 *Sudden Stops in Capital Flows*

In the Balance of Payments (BOP) accounting, gross inflows correspond to the total liability transactions in the Financial Account (meaning lending from non-residents). Gross outflows are defined as total asset transactions in the Financial Account (meaning residents' purchases of foreign assets). Using quarterly data on gross capital flows obtained from the Balance of Payment Statistics (BOPS) developed and reported by the International Monetary Fund (IMF), we denote net flows of country j in period t as $N_{jt} = I_{jt} + O_{jt}$, where I_{jt} and O_{jt} represents gross inflows and outflows respectively. See Appendix 3.A for further details on the construction of the capital flows series.

A gross sudden stop in capital *inflows* is defined as an event in which the year-on-year change in gross capital inflows falls below two standard deviations from its historical mean. In terms of measuring its length in time, the sudden stop episode starts from the moment in which the series falls one standard deviation below its historical mean, but conditional on the fact that it will eventually cross the two-standard-deviations threshold. The episode ends when the series goes back to one standard deviation below the historical mean.

A sudden stop in *net* capital flows is defined in an analogous way, using net capital flows, i.e. inflows minus outflows instead of inflows only.

To reduce the effects of seasonality in net and gross capital flow series, we apply a moving average filter. In particular, for quarterly series we define $C^n_{jt} = \sum_{t=0}^{3} N_{jt}$ and $C^i_{jt} = \sum_{t=0}^{3} I_{jt}$ for $t = 4, 5, \ldots, T$. The year-on-year change in net financial flows is defined as $\Delta C^x_{jt} = C_{jt} - C_{j,t-4}$ with $x = \{n, i\}$. Therefore, a sudden stop in net and gross flows can be defined as an episode in which the variable ΔC^x_{jt} falls below two standard deviations from of its historical mean.

A more detailed description of the series used to compute sudden stops is presented in Table 3.C.2 in Appendix 3.C. After all the adjustments, we end with a dataset at quarterly frequency, from 1980 through 2014, which comprises 48 countries (Appendix 3.B).

2.2 Episodes in the Sample

To get a better understanding of the incidence of capital outflows adjustments in preventing sudden stops in gross inflows to become net sudden stops. Figure 3.1 displays the dynamics of the smoothed series of capital inflows and outflows changes for the case of Germany, Thailand and Turkey. The dashed line in the graphs corresponds to the threshold that defines a sudden stops in gross inflows. More specifically, when the solid black line falls below the dashed line we define this as a gross sudden stop.

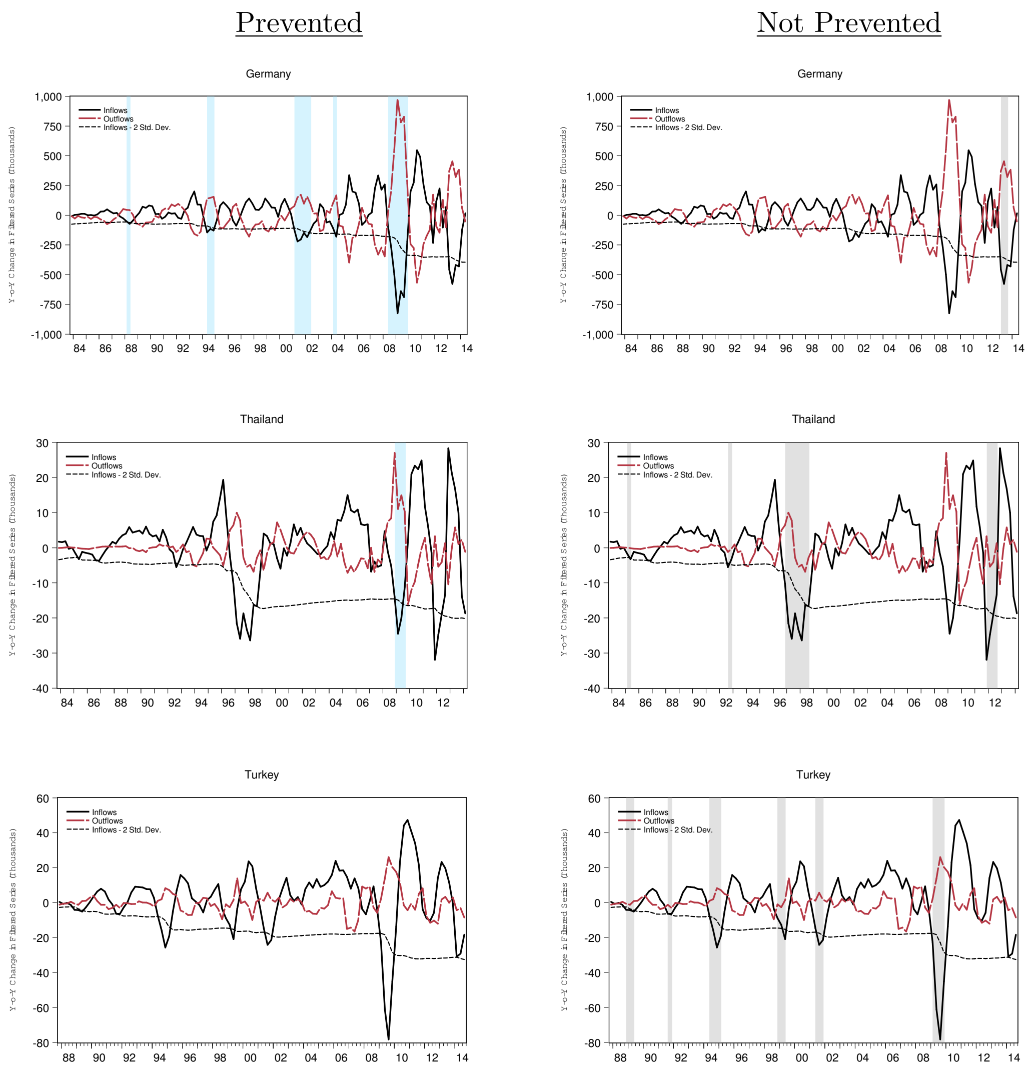
The panels in the first column denominated prevented, present in shaded blue area all episodes of sudden stops in gross inflows that were not a sudden stop in net flows. And the panels in the second column named Not Prevented, present in shaded grey area all episodes of sudden stops in gross inflows that were a sudden stops in net flows.

For the case of Germany presented in the first row of figure 3.1, the changes in capital flows exhibit a "diamond pattern". This implies that periods of large declines in capital inflows have also coincided with the decline in capital outflows of approximately the same magnitude. These offsetting variations have allowed the country to build higher resilience and withstand the changes in foreign investors positions as presented in the blue areas; with the exception of the episode in 2013 (shown in the second column), Germany has been able to prevent the occurrence of a net sudden stop.

The contrasting view is presented in the cases of Thailand and Turkey. Flows in Thailand do not display the "diamond pattern", particularly in the episodes after 1994. Very few episodes in the last 20 years were prevented as shown in the second column; in some cases it was because because the variations in outflows were not enough to compensate the fall in inflows. Turkey presents a radical scenario as all the sudden stops in gross inflows were also sudden stops in net flows. This is evident as the variation in capital inflows displays a relatively higher volatility, when compared to the volatility in capital outflows. In this particular case, the behavior of domestic agents appears to be not enough to compensate the variation in inflows.

Table 3.1 summarizes gross and net sudden stops in terms of the number of episodes, their average duration and the total number of quarters in which countries have experienced these events in the sample. There are a total of 1,274 quarters that we identify as sudden stops in gross inflows – SSI – out of a total of 10,736 quarters in the dataset. This corresponds to 341 unique SSI episodes with an average duration of 3.74 quarters. Out of the 1,274 quarters that qualify as sudden stops in

Fig. 3.1: Inflows, Outflows and Sudden Stops



Source Author's own calculations based on data from IMF-IFS. Grey shaded areas indicate episodes which are catalogued as sudden stops in capital inflows that also are net sudden stops, i.e., not prevented. Blue shaded areas indicate episodes which are catalogued as sudden stops in capital inflows that are not net sudden stops, i.e., prevented.

gross inflows in the sample, 686 quarters are contemporaneously identified as sudden stops in net capital flows, while 588 quarters are not. The latter are "prevented" episodes, while the former are not.

An analysis of the data indicates that not all sudden stops in gross inflows become sudden stops in net flows, suggesting that capital outflows have an important role in preventing the occurrence of net sudden stops. By comparing columns (3) and (8) it is observed that around 46 percent of total potential net sudden stops periods are prevented. This proportion is even bigger if we only consider advanced economies, in which case around 63 percent of total gross sudden stop in inflows periods are not sudden stops in net flows. However, the fraction of prevented periods diminishes if we focus on emerging and frontier economies.[3] In these groups of countries, the fraction of prevented periods decreases considerably, to 32 and 17 percent, respectively.

Importantly, prevented sudden stops are not exclusively related with an extreme decrease in gross capital outflows (or retrenchments).[4] In other words, extreme events of capital outflows are neither necessary nor sufficient to avoid sudden stops in net flows. On the one hand, they are not sufficient: columns (6) and (7) in Table 3.1 show that 17 percent of total net sudden stop periods were accompanied by retrenchments; this percentage is around 22 percent for emerging economies. This suggests that even a very large repatriation of assets may not suffice to prevent a fall in net flows. This is likely to be the case when the underlying decline in gross

[3] For a detailed description on country classification, see Appendix 3.B.

[4] (Forbes and Warnock, 2012) define retrenchments as the mirror image sudden stops, i.e., episodes when there is decline in gross capital outflows that exceed two standard deviations of the sample mean.

inflows is very large, for example three or four standard deviations.

On the other hand, retrenchments are not necessary: columns (8) and (9) in Table 3.1 shows that 22 percent of the total periods of prevented sudden stops were not accompanied by periods of retrenchment in capital outflows. In the case of emerging economies this fraction is around 34 percent, which rises to 38 percent and 53 percent for emerging economies in Latin America and Eastern Europe, respectively.[5] This suggests that even a small repatriation of capital outflows may suffice to prevent a sudden stop in net capital flows.

Another fact is that quarters with prevention and quarters without prevention can coexists within the window of a single sudden stop in gross inflows. Therefore, we distinguish between "purely" and "partially" prevented episodes. "Purely" prevented are episodes when a net sudden stop is avoided during the entire duration of the SSI episode. Meanwhile, "partially" prevented episodes are those when a net sudden stop occurs during at least one quarter of a SSI episode.

Figure 3.2 plots sudden stops in gross capital inflows by duration (in quarters) on the x-axis, against the number of quarters during which prevention was effectively achieved (y-axis). For example, there are 18 sudden stop epsiodes in gross inflows that lasted one quarter, 30 episodes that lasted 2 quarters, 37 episodes that lasted 3 quarters, and so on up to the 3 episodes that lasted 10 consecutive quarters (the longest duration for sudden stops in gross inflows in the database). These add up to the 1,274 quarters that we identify as SSI. For the 18 SSI episodes with

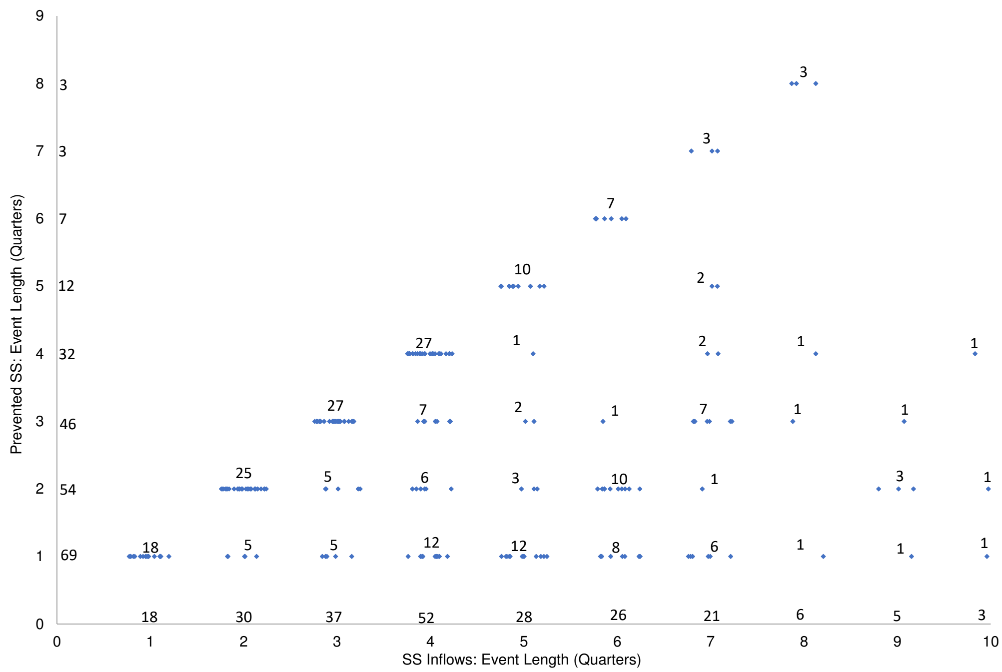
[5] In fact as described in section (4.2) episodes of retrenchment and prevented sudden stops are not necessarily driven by the same domestic conditions either.

Tab. 3.1: Sudden Stop Episodes

	SS Inflows			SS Net				"Prevented" SS		
	# Episodes	Average Duration	# Quarters (Total)	# Episodes	Average Duration	# Quarters (Total)	# Quarters (with Retrench)	# Quarters (Total)	# Quarters (Pure)	# Quarters (No Retrench)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
All countries	341	3.7	1274	347	3.7	1270	219	588	394	130
Advanced	118	4.1	486	116	3.7	426	82	311	207	30
Frontier	63	3.8	237	66	3.5	233	41	91	47	31
Latin America	7	3.7	26	8	3.6	29	3	10	4	5
East Asia and Pacific	1	4.0	4	1	5.0	5	0	0	0	0
Eastern Europe	11	3.9	43	12	3.6	43	8	14	6	6
Emerging	64	3.6	228	67	3.6	239	54	74	52	25
Latin America	14	3.2	45	11	3.5	39	3	21	16	8
East Asia and Pacific	14	3.8	53	15	3.7	56	14	13	10	1
Eastern Europe	13	3.8	49	15	3.5	52	10	26	20	14

Own calculations based on data on capital inflows and outflows from IMF-IFS. Some of these episodes may not be included in the econometric analysis due to lack of data availability for the regressors.

Fig. 3.2: "Purely" and "Partially" Prevented Sudden Stops Episodes



Source Author's own calculations based on data from IMF-IFS. Episodes along the diagonal are "purely prevented" sudden stops, while the rest are "partially prevented" episodes.

duration 1 quarter that were prevented, the prevention is complete; i.e., they are all "purely" prevented. Of the 30 SSI episodes with duration 2 quarters, 25 were "purely" prevented, and 5 were prevented during only 1 quarter. We denote the latter as "partially" prevented. Of the 37 SSI episodes that lasted 3 quarters, 27 were "purely" prevented, 5 were "partially" prevented during 2 quarters, and 5 were "partially" prevented during 1 quarter only. Therefore, the episodes that align over the 45-degree line are the "purely" prevented episodes, while all the episodes below the 45-degree line are "partially" prevented.

The pattern that emerges from the chart is that, as the underlying SSI has longer duration, it is less likely that full prevention will prevail. In fact, none of the

8 SSI episodes in the sample that lasted 9 or 10 quarters were "purely" prevented.

The distinction between "purely" and "partially" prevented episodes is of interest from an analytical standpoint. While focusing on "purely" prevented episodes can help to pin down the factors that can be useful to successfully fend-off sudden stops, the analysis of "partially" prevented episodes is useful to evaluate the factors that determine the length of survival. We apply different methodologies to answer two different questions.

The first question is: what are the factors that determine "prevention"? To answer this question we focus on "purely" prevented episodes only. In order to study the factors that help prevent sudden stops in gross inflows becoming fully-fledged sudden stops in net flows, we use an estimation strategy that exploits the sequential nature of the problem. The problem can be decomposed in two stages. First, the economy either experiences a sudden stop in gross inflows or it does not. If it does, then it can transition either into a prevented sudden stop or into a sudden stop in net flows. Therefore, the transition into a prevented sudden stop can only occur after the economy has experienced a sudden stop in gross inflows, and this should be taken into account at the time of estimation. Given the sequential nature of the problem, we resort to the sequential logit model, which entails the estimation of separate logit regressions for each step of the problem, restricting the sample only to those countries "at risk" of making the transition. In other words, in the first stage, which we denote as "inflows", we estimate a logit using the full sample, while in the second stage, that we call "prevented", we restrict the sample only to those countries that in the previous stage experienced a sudden stop in gross inflows. The identification assumption is that, besides the temporal precedence, the decision in the first stage is independent from the one in the second stage, and this is the reason why it is valid to run separate regressions for each transition.

The second question is: what are the factors that prolong spells of prevention after a sudden stop in inflows has materialized? To answer this question we focus on "partially" prevented episodes, i.e., episodes of sudden stop in inflows that were prevented during some, but not all, the quarters. In this context, we consider two types of "partially" prevented episodes, which involve two types of transitions. Denote a prevented sudden stop in a given quarter as PSS. Denote a net sudden stop in a given quarter, i.e. a sudden stop in inflows that is not prevented, as NSS. Then, a "failed prevention" corresponds to the transition $PSS \to NSS$. Then, by means of duration models, we study the determinants of the hazard rate of transitioning to a NSS, conditional on being in a PSS for a certain period of time.

2.3 Determinants of Sudden Stops

To define the set of determinants of sudden stops (gross and prevented) to be used in the econometric exercise, we have taken into account all the explanatory variables that have been considered in the empirical literature analyzing net sudden stops (Calvo et al., 2008), gross sudden stops (Calderon and Kubota, 2013; Alberola et al., 2012), currency crisis (Frankel and Rose, 1996; Milesi-Ferretti and Razin, 1998), current account reversals (Edwards, 2007) and retrenchments (Forbes and Warnock, 2012). We define a set of baseline explanatory variables to be used in the benchmark regressions, and then we consider additional variables for the sensitivity analysis. In all cases we distinguish between global and domestic determinants. All the data is at the quarterly frequency, unless otherwise stated. A brief description of each variable is provided below; for further details refer to Table 3.C.1 in Appendix 3.C.

Baseline regressors

Regarding the global factors, we consider four variables: global risk, global liquidity growth, global interest rates and global growth. We proxy *global risk* by the US stock market volatility, measured as the VXO – the implied volatility index calculated by the Chicago Board Options Exchange – for the period 1986 – 2014, extended back to 1980 based on Bloom (2009). *Growth in global liquidity* is quantified by the yearly growth rate of global money supply; this measure is computed as the average of the growth rate of M2 in the United States, Eurozone and Japan and the growth rate of M4 for the UK. *Global interest rates* are calculated as the average of the interest rates on long-term government bonds in the United States, core Euro Area and Japan. And finally, *global growth* corresponds to the year-on-year growth rate in the World's real GDP. The source of the last three variables is International Financial Statistics (IFS) from IMF.

We use a more comprehensive set of domestic factors relative to those considered in previous literature. The data series were obtained mostly from IFS – complemented with Datastream and local sources whenever not available –, unless otherwise stated.

Economic performance is measured by the year-on-year growth rate of real GDP. Better economic perfrormance can enhance the resilience of emerging markets to the vulnerabilities associated to sudden stop episodes. A proxy for *soundness of the macroeconomic policy* in the baseline is average CPI inflation. We also include a measure of bank credit to the private sector as percentage of GDP, obtained from Beck et al. (2009).[6] In addition, we introduce a measure of the degree of domestic liability dollarization (which (Calvo et al., 2008) show is a significant determinant of sudden stops), defined as bank foreign borrowing – from IFS and Bank of International Settlements (BIS) – as a share of GDP. As a proxy of *trade openess* which has been shown to be a determinant of sudden stops in Cavallo and Frankel (2008) we use the ratio of real exports plus imports to GDP. Following Calvo et al. (2008), we also include the *current account deficit as a share of the absorption of tradable goods*. The absorption of tradable goods is computed as imports plus tradable output domestically consumed. The latter is calculated as the sum of agricultural and industrial output – obtained from the World Development Indicators (WDI) constructed by the World Bank – minus exports. *Contagion* episodes are accounted for by including a dummy variable that takes the value of 1 if a country reports a sudden stop in gross inflows in t and there is one large trading partner that suffered a sudden stop in $t-1$.

The innovation of this chapter, in terms of the determinants of sudden stops considered, is to include a variable that accounts for each country's *institutional*

[6] Alternative measures considered are: our own measure of private credit to GDP constructed based on IFS data, credit to the private sector by financial institutions as percentage of total deposits in financial institutions also constructed from IFS data, and bank credit to the private sector as a percentage of total deposits in banks obtained from Beck et al. (2009).

background. As a proxy we use of the composite risk rating index produced by the Political Risk Services Group. This index is composed of 12 components: government stability, socio-economic conditions, investment-profile, internal conflict, external conflict, corruption, military and politics, religious tensions, law and order, ethnic tensions, democratic accountability and bureaucracy quality. Since the individual indexes are also reported, we not only consider the overall index but also construct our own sub-index just with the categories that are relevant for this study: rule of law, investment profile, government stability, bureaucracy quality, and corruption. The last measure is the one used in the baseline regression, and the overall index, denoted as 'Political Risk' is considered for the robustness analysis.

We also consider the *exchange rate regime*. Exchange rate flexibility is measured by the fine classification of exchange rate regimes constructed by Reinhart and Rogoff (2004) and updated by Iltzezky et al. (2009); higher values of this indicator is associated to a more flexible exchange rate regime. However the analysis of exchange rate in isolation can be misleading. In fact, the consolidation of macro policies enhancing exchange rate flexibility have been accompanied by inflation targeting as the monetary anchor. To account for this, we add as additional regressors a dummy variable (IT) that takes the value of 1 if the country has adopted inflation targeting and the interaction between the two variables.

A more detailed description of the series used to compute sudden stops and the variables involved in the regressions are presented in Table 3.C.2 in Appendix 3.C.

3 Purely Prevented Sudden Stops

We construct a comprehensive dataset at quarterly frequency, from 1980 through 2014, which comprises in the baseline scenario 48 countries and includes all the variables detailed in the previous section.

3.1 Methodology

In order to study the factors that help to prevent gross sudden stops becoming fully-fledged net sudden stops, we use an estimation strategy that exploits the sequential nature of the problem. The problem addressed in this chapter can be decomposed in two stages. First, the economy either experiences a sudden stop in gross inflows or it does not. If it does, then it can transition towards either a prevented sudden stop or a sudden stop in net flows. Therefore, the transition towards a prevented sudden stop only occurs after the economy has experienced a sudden stop in gross inflows, and this should be taken into account at the time of estimation.

We resort to the *sequential logit model*, initially proposed by Mare (1981) to describe the process of educational attainment and then applied to many other problems in the orbit of empirical microeconomics. The sequential logit model entails the estimation of separate logit regressions for each step, restricting the sample only to those countries "at risk" of making the transition. In other words, in the first stage, that we denote as "inflows", we estimate a logit with the full sample of countries, while in the second state, that we call "purely prevented", we restrict the sample only to those countries that in the previous stage experienced a sudden stop in gross inflows.

As stated previously, we are interested in determining the conditions under which a sudden stop episode is purely prevented; for this purpose, we estimate the following model:

$$Prob(e_{it} = 1) = \mathbf{G}\left(\Phi^{\mathrm{G}}_{t-1}\,\mathbf{B}_{Global} + \Phi^{\mathrm{D}}_{t-1}\,\mathbf{B}_{Domestic}\right) \tag{3.1}$$

where e_{it} is an episode that takes the value of 1 if country i in quarter t is experiencing a sudden stop in gross inflows that is not a net sudden and The assumption made in this model is that, beside the temporal precedence, the decision in the first stage is independent from the one in the second stage, and this is the reason why it is valid to run separate regressions for each transition.

3.2 Baseline Results

Following Forbes and Warnock (2012), all the explanatory variables are lagged one period (quarter), except when stated otherwise. Many of the series are exposed to extreme outliers (observations which are 3 times higher (lower) than the interquantile range at the 75% (25%) percentile). We include interaction terms with dummies that capture extremes values as controls for outliers without to avoid sacrificing the number of observations available.

The main results are presented in Table 3.1. Column (1) presents the results for sudden stops in gross inflows; it shows that global conditions, in particular, global risk and economic growth, are significant predicting the transition of economies towards periods of sudden stop in gross inflows. On the one hand, higher global volatility make countries more prone to experience sudden stops in gross inflows; on the other hand, periods of high economic growth reduce the incidence of such type of episodes.

In addition, the incidence of sudden stops in inflows are also associated with domestic conditions. In particular, higher levels of foreign liabilities and private credit, or the exposure of trading partner to a sudden stop increase countries' vulnerability to stops in gross inflows; while economic growth reduces this vulnerability.

Once the economy has experienced a sudden stop in gross inflows, then it can transition either to a net sudden stop or not. Column (2) in Table 3.1 shows that global conditions do not influence the likelihood of preventing or not a net sudden stop; only domestic characteristics can provide the antidotes for prevention: lower levels of foreign liabilities in the banking system (consistent with the findings in Calvo et al. (2008)) lower levels of inflation and a better institutional background shield the economy to avoid likelihood a purely prevented sudden stop.

In addition, we find that the degree of exchange rate flexibility (FER) is not relevant in explaining neither the transitions to sudden stops in gross or net flows.[7] However, higher flexibility can increase the resilience to a sudden stop in net inflows if it also involves a de-jure commitment to stabilize the price level in the economy.

By shifting the focus to non-advanced economies which have historically more prone to experience these episodes, we find that the results in the baseline scenario

[7] This result is robust to the use of course classification in Iltzezky et al. (2009) or differences with respect to mean as in Cifuentes and Jara (2014) (results not tabulated).

remain unaffected. In addition to global volatility and growth, these economies are more likely to face a sudden stops in gross inflows in periods of high liquidity growth and low global interest rates as reported in column (3). But these conditions do not have any incidence in the ability of non-advanced countries to prevent a sudden stop as shown in column (4). For these economies lower foreign liabilities and a higher flexible exchange rate accompanied by inflation targets reduce the incidence. In addition, the combination of higher economic growth, openness and low levels of private credit by banks are additional antidotes to net sudden stops.

Finally, in Columns (5) and (6) we report the results from excluding outliers present in the sample. There are no substantial differences in the results from a direct modelling approach (Columns (1) and (2)) with respect to the alternative of excluding all extreme observations.

4 *Robustness and Sensitivity Analysis*

We conduct an extensive series of robustness and sensitivity tests including additional control variables, alternative measures of the variables presented in the baseline regression and different definitions of sudden stops.

4.1 *Alternative Measures for Variables in the Baseline Regression*

In columns (1) and (2) of Table 3.2 the lag structure of the domestic variables is set to 4 periods instead of 1. Introducing the fourth lag helps us to reduce the incidence that periods of crisis entail over macroeconomic variables. The results obtained in the baseline remained unaffected, thus, the idea that foreign liabilities, inflation rate, institutions and flexible exchanges rates coined with inflation targeting are not driven by the lag choice of the baseline model.

The rise of private credit is an important deterrent in the ability of prevention in non-advanced economies as presented in previous section. Thus, we assess the relevance over the whole of sample of alternative measures of credit conditions in the economy. In columns (3) and (4) of Table 3.2, we replace our measure of private credit by banks as a percentage of GDP developed by Beck et al. (2009)) by total bank credit as percentage of deposits, without finding important variations with respect to the baseline. Finally, in columns (5) and (6), we introduce a broader measure of credit (total credit as % of GDP), but did not find any differences in the results. Credit in the economy is relevant to understand episodes of sudden stops in gross inflows, but not relevant in the overall sample, to prevent these episode in becoming net sudden stops.

As the measure of institutional quality is relevant in several of our regressions to reduce the probability of a net sudden stops. We evaluate the significance of this variable by introducing the overall index of political risk produced by the Political Risk Services Group, and not just specific subcomponents as in the baseline regression. The results reported in columns (7) and (8) of Table 3.2 are robust to the inclusion of this alternative measure of institutions and are not quantitatively different from our baseline results.

4.2 Alternative Definition of Episodes

Bonanza-Related Episodes

We assess in this section the validity of our results in light of alternative definitions of sudden stops, that account for potential mitigating or reinforcing triggers. We introduce an extension to the standard definition of sudden stops: bonanza-filtered sudden stops. Although this definition may not be totally comparable with the ones used in our baseline regression, it sheds light on the relevance of specific country factors depending on whether the economy is going through periods of distress or not.

Bonanza-filtered sudden stops capture the feature that favorable terms of trade shocks can add sources of financing directly from the current account, without the need of resorting in domestic agents to offset the contraction in capital inflows. We construct bonanza episodes similarly to episodes of extreme flows variations. Thus, a bonanza is defined as a terms of trade window, i.e., a dummy variable that takes de value 1 if the seasonally adjusted terms of trade rise beyond two standard deviations from their historical mean. The length of bonanza episodes is determined from the moment in which the series increases one standard deviation above its historical mean to the moment in which returns to be within the one standard deviation threshold.

An improvement in the terms of trade can reduce the reliance on the compensating behavior in domestic agents after the disruption of capital flows. Thus, we evaluate how sudden stops are more likely to be prevented in absence of a funding mechanism stemming directly from the current account. Columns (1) to (2) in Table 3.3 depict the results when bonanza episodes are excluded. The results are very similar to those presented in the baseline scenario. However, in absence of favorable terms of trade, economic growth surges as an additional important domestic factor to increase the likelihood of prevention.

Preventable Episodes

The ability of a country to prevent a sudden stop can be influenced by the size of its assets available; in other words, if existing assets are enough to offset the change in capital inflows. These assets can be the result of either capital repatriation or simply a reduction in planned outgoing flows; unfortunately given data availability is impossible to disentangle the origin of outflows; in particular, the fraction corresponding to the reduction of investment abroad from domestic investors.

Based on these restriction we can only proxy this capacity to respond in magnitude to a sudden stop in net inflows, making use of the existing stock of assets abroad. We test the baseline results, excluding episodes in which the ratio between the stock of assets (during previous quarter) and the change in capital inflows during a sudden stop is two standard deviations below its historical mean.[8]

Results are presented in columns (3) and (4) in Table 3.3. There is no significant variation compared with our baseline scenario. However, it is important at this point to acknowledge the difficulty in measuring a country's ability to prevent a sudden stop by using their current stock of assets.

[8] This measure accounts for the possibility that not all assets are susceptible to repatriation. The results reported in this section are robust to the period in which assets are measured.

Domestic Private Agents

Hitherto, the analysis has considered both private and public outflows and their role in offsetting changes in capital inflows. In this section we specifically address how private agents can mitigate the incidence of a sudden stop. For that purpose, we construct a series of capital outflows considering only private flows and reconstruct the episodes of net sudden stops based on this newly created series.[9] Column (5) in Table 3.3 presents the results of the second transition when only *private assets* are considered. The results from our baseline framework are also consistent even when we exclude the public sector, although foreign liabilities are not longer an important driver of prevention. Domestic private investors are more responsive to domestic conditions on the verge of a sudden stop in capital inflows, and this responsiveness is tied to lower levels of inflation and credit and better institutional quality and flexible exchange rates accompanied by inflation targeting schemes.

Sudden Stops and Retrenchments

Finally, we study the determinants of episodes of sudden stops in net inflows that are accompanied by retrenchments in net outflows. Notice that as stated previously capital retrenchments are neither necessary nor sufficient to prevent a net sudden stops. In fact, the results reported in column (6) of Table 3.3 suggest that prevented sudden stops and retrenchments are driven to some extent by different domestic conditions. The simultaneity of a sudden stop and a retrenchment appear to be

[9] For a detailed description on how private flows are constructed, please refer to appendix 3.A

more likely to occur when the sudden stops are systemic, in the sense that it also affects a country's trading partners and by the growth in private credit. Since the resilience of a country to a sudden stop builds upon the capacity of domestic agents to offset the fall in foreign inflows, it is necessary to understand the distinction between retrenchment and prevented episodes and the conditions driving each one of these episodes.

5 *Partially Prevented Sudden Stops: Failed Preventions*

As discussed previously, not all quarters during one given episode are prevented. In some cases, the ability of a country to withstand the impact of sudden stop in gross inflows can be limited. In this section we focus on "partially" prevented episodes, in particular on "failed preventions". Denote a prevented sudden stop in a given quarter as PSS, and a net sudden stop in a given quarter as NSS. Then, a "failed prevention" corresponds to the transition $PSS \rightarrow NSS$. In other words, we explore once a country has been able to prevent a net sudden stop, what conditions are necessary for this country to continue in a path of prevention as quarters in a sudden stop in inflows progress.

5.1 Methodology

In order to understand the determinant of "failed preventions", we conduct a duration analysis to estimate the effect of different external and domestic factors on the hazard rate of failed transitions. For a "failed prevention", we consider as *fail-*

ure/death to experiencing a NSS once the country has been in a period of PSS; in other words, we consider the survival of a country as its ability to avoid having a net sudden stops.

Notice that as multiple transitions between PSS and NSS can occur in different quarters of the same episode, we focus exclusively on the information condensed in the first transitions.

The baseline estimation is performed using the Cox regression model, however we consider alternative scenarios including parametric distributions for the baseline hazard. The Cox proportional-hazard model is a semi-parametric method that enables to determine the effect of different variables on the hazard rate. Assuming that there are n episodes of sudden stop in inflows, then the model has the form:

$$\lambda_i\left(t\right) = e^{X_i'\beta} \cdot \lambda_0\left(t\right), \quad i = 1, \ldots, n$$

where X_i is the vector of regressors, β is the vector of regression coefficients, λ_i is the hazard calculated for each episode and λ_0 is the baseline hazard. The baseline hazard function corresponds, in this case, to the probability of transitioning to a different state ($PSS \rightarrow NSS$) when all the explanatory variables are 0. It should be noted that, in a proportional hazard model, the unique effect of a unit increase in a covariate is assumed to be multiplicative with respect to the hazard rate.

Estimates are obtained using clustered standard errors at the country level to account for the fact that for each country there can be multiple unordered failure events of the same type. The Efron's method is used to handle ties.

5.2 *Results*

Table 3.4 reports the results for this exercise. Column (1) presents the baseline results for the Cox Model. Notice that external factors do not affect the probability of experiencing a net sudden stop given that the country has prevented it for a given number of quarters. This result is not surprising since we have already documented that, while important for explaining the transition from a situation with no sudden stop to a sudden stop in inflows, external conditions do not seem to matter to explain the prevention of a net sudden stop. The factors that increase the hazard of transitioning to a net sudden stop given that it was prevented for a while are higher levels of foreign liabilities and the absence of exchange rate flexibility accompanied by price stability.

These results are robust to alternative assumptions on the shape of the baseline hazard. Columns (2)-(4) show the results when we consider parametric functional forms for the baseline hazard: Weibull, Exponential and Gompertz. We do not only find that foreign liabilities and exchange rate flexibility are important but also that lower levels of inflation increase the hazard of surviving. In column (5), we isolate the potential effect of left-censoring in the estimation.[10] We exclude from the database all countries who experience a net sudden stop in the first quarter of a sudden stop in gross inflows. Under this characterization of the dataset, we find that foreign liabilities, inflation and exchange rate flexibility are important to

[10] The left censoring occurs when the observed outcome of a country during a period of sudden stop in inflows is NSS. It can be as result of the inability of a country to prevent a net sudden stop at the origin; or it can be the result of the discrete nature of the data.

understand the differences in the hazard of survival. Finally, in column (6) we report the results after stratifying the baseline hazard for emerging economies; however all main results are unaffected.

6 Final Remarks

The global financial crisis of 2008/09 demonstrated that few countries are exempt from the risk of a foreigners' sudden stop (i.e., a sharp contraction in gross capital inflows). However, it also showed that some countries were more successful preventing that a fall in gross capital inflows turned into a sudden stop in net capital flows. This is important because countries that can avoid sudden stops in net capital flows in the aftermath of a foreigners' sudden stop, can also avoid the large output contractions and the concomitant banking and financial crises that are usually associated with those episodes.

Why are some countries more resilient than others? More specifically, what are the "antidotes" that enable some countries that are affected by foreigners' sudden stops to prevent them from becoming fully-fledged sudden stops in net capital flows? The answer provided in this chapter is that the antidotes are mostly domestic factors. Keeping low levels of liability dollarization, having a strong institutional background, keeping inflation at check, and having flexible exchange rates in the context of credible monetary anchors, are the factors that help to increase the likelihood of preventing a sudden stop in net capital flows during a foreigners' sudden stop.

The methodology employed in this chapter exploits the sequential nature of the sudden stop problem: first countries may or may not experience a foreigners' sudden stop. Second, those that experience a foreigners' sudden stop can prevent it from becoming a sudden stop in net capital flows, or not. This sequencing in turn differentiates this chapter from previous attempts that have focused on the empirical determinants of episodes of sudden stops in gross capital inflows and retrenchments in gross capital outflows. We show that the determinants of prevented sudden stops in our sample are different from the determinants of episodes of sudden stops in inflows that happen simultaneously with retrenchment in capital outflows.

In addition, the methodology employed in this chapter permits disentangling between "purely prevented" sudden stops, and "partially prevented" sudden stops. The former are episodes that are prevented during the entire window of the underlying foreigners' sudden stop, while the latter are prevented only during part of the foreigners' episode. A duration analysis performed using the set of partially prevented episodes suggests that keeping low levels of liability dollarization and having flexible exchange rates combined with an inflationary targeting monetary regime, are the main factors that help to prolong survival (i.e., avoid a sudden stop in net capital flows) during a foreigners' sudden stop.

The main message of this chapter is that while it may not be possible for countries to insulate themselves from the volatility of gross capital inflows, the antidotes to prevent that volatility from forcing potentially costly external adjustments is in their own hands. In doing so, the role of domestic investors is critical. This is so because sudden stops in net capital flows can be prevented when the actions of domestic investors offset a reduction in foreign lending. It is only under favorable domestic conditions that domestic investors may perceive reduced risk in bringing in resources at the time of an external shock, thus insulating the country from the original shock.

Tab. 3.1: Determinants of Prevented Sudden Stops

	Baseline		Non-Advanced		No-Outliers	
	Inflows	Purely Prevented	Inflows	Purely Prevented	Inflows	Purely Prevented
	(1)	(2)	(3)	(4)	(5)	(6)
Global Conditions						
Risk	0.033***	-0.014	0.027**	0.059	0.043***	-0.041
(lagged)	(0.009)	(0.027)	(0.013)	(0.084)	(0.010)	(0.029)
Liquidity Growth	0.005*	0.007	0.013***	-0.025	0.002	0.013
(lagged)	(0.003)	(0.010)	(0.005)	(0.027)	(0.003)	(0.012)
Growth	-0.312***	-0.104	-0.252**	0.106	-0.335***	-0.081
(lagged)	(0.075)	(0.118)	(0.119)	(0.262)	(0.096)	(0.137)
Interest Rates	-0.040	-0.065	-0.313***	0.182	-0.018	-0.188
(lagged)	(0.046)	(0.131)	(0.120)	(1.189)	(0.048)	(0.130)
Domestic Conditions						
Foreign Liabilities	0.029***	-0.067**	0.050***	-0.260**	0.038***	-0.065**
(lagged, % GDP)	(0.008)	(0.031)	(0.014)	(0.115)	(0.010)	(0.031)
CA/TA	-0.004	0.002	-0.003	-0.005	-0.003	-0.004
(lagged)	(0.004)	(0.013)	(0.006)	(0.038)	(0.004)	(0.015)
GDP growth	-0.117***	0.068	-0.126***	0.201*	-0.096***	0.037
(lagged)	(0.026)	(0.055)	(0.040)	(0.108)	(0.033)	(0.062)
Inflation	0.015	-0.252***	0.006	-0.156	-0.019	-0.245**
(lagged)	(0.025)	(0.084)	(0.025)	(0.122)	(0.028)	(0.096)
Openness	-0.001	0.014*	-0.001	0.051***	-0.001	0.012
(lagged)	(0.002)	(0.008)	(0.003)	(0.016)	(0.003)	(0.009)
Private credit by banks	0.006***	-0.005	0.006	-0.056***	0.007***	-0.005
(% of GDP, BDK)	(0.002)	(0.005)	(0.004)	(0.022)	(0.002)	(0.007)
Institutions	-0.000	0.048**	0.002	-0.047	-0.008	0.052**
	(0.008)	(0.020)	(0.012)	(0.080)	(0.009)	(0.021)
Contagion	0.723***	0.415	0.283	-1.102	0.736***	0.490
(lagged, land borders)	(0.166)	(0.436)	(0.191)	(0.802)	(0.181)	(0.479)
Flexible Exchange Rate (FER)	-0.169	-0.151	-0.144	3.092	-0.243	-0.827
	(0.176)	(0.626)	(0.350)	(2.042)	(0.194)	(0.793)
Inflation Targeting (IT)	-0.801*	-2.485*	-0.518	-14.882***	-0.885**	-2.488*
	(0.461)	(1.320)	(0.538)	(1.161)	(0.448)	(1.364)
IT X FER	0.639	4.017***	0.203	17.577***	0.603	4.688***
	(0.455)	(1.499)	(0.596)	(2.471)	(0.443)	(1.562)
Observations	3,636	451	1,614	166	2,927	367

Notes: The dependent variable corresponds to a dummy that takes the value 1 if the country experienced a sudden stop in gross or net capital inflows, and zero otherwise. For details on the definitions of the dependent and independent variables see Table 3.C.1 in appendix 3.C. Estimates are obtained using a logit model and robust standard errors clustered by country, unless otherwise stated. Interaction terms with dummies that capture extreme values for the regressors are included in the regression. An extreme value is defined as one that is three interquartile ranges above the 75th percentile or below the 25th percentile. Standard errors are reported in parenthesis. *** (**) [*] denotes significance at the 1 (5) [10] percent level.

Tab. 3.2: Robustness - Alternative Determinants of Sudden Stops in Gross and Net Capital Inflows

	Lag 4		Credit Conditions				Institutional Quality	
	Inflows	Purely Prevented	Inflows	Purely Prevented	Inflows	Purely Prevented	Inflows	Purely Prevented
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Global Conditions								
Risk	0.034***	-0.005	0.036***	-0.010	0.037***	-0.013	0.033***	-0.011
(lagged)	(0.008)	(0.025)	(0.010)	(0.030)	(0.010)	(0.025)	(0.009)	(0.027)
Liquidity Growth	0.004	0.002	0.006*	0.003	0.006**	0.004	0.005*	0.007
(lagged)	(0.003)	(0.010)	(0.003)	(0.011)	(0.003)	(0.009)	(0.003)	(0.010)
Growth	-0.468***	-0.083	-0.274***	-0.105	-0.286***	-0.066	-0.312***	-0.105
(lagged)	(0.064)	(0.138)	(0.072)	(0.136)	(0.072)	(0.121)	(0.076)	(0.106)
Interest Rates	-0.031	-0.041	-0.051	-0.023	-0.036	-0.081	-0.038	-0.153
(lagged)	(0.047)	(0.127)	(0.045)	(0.140)	(0.044)	(0.128)	(0.046)	(0.139)
Domestic Conditions								
Foreign Liabilities	0.038***	-0.065**	0.027***	-0.090**	0.027***	-0.061**	0.029***	-0.068**
(lagged, % GDP)	(0.009)	(0.029)	(0.009)	(0.035)	(0.008)	(0.030)	(0.008)	(0.031)
CA/TA	0.002	-0.008	-0.002	0.000	-0.000	-0.002	-0.004	0.003
(first lag)	(0.005)	(0.013)	(0.005)	(0.014)	(0.005)	(0.013)	(0.004)	(0.013)
GDP growth	0.017	-0.086	-0.134***	0.091	-0.126***	0.072	-0.117***	0.082
(lagged)	(0.022)	(0.078)	(0.024)	(0.061)	(0.025)	(0.059)	(0.026)	(0.053)
Inflation	-0.023	-0.305***	-0.004	-0.213***	0.005	-0.211***	0.014	-0.251***
(lagged)	(0.029)	(0.115)	(0.026)	(0.078)	(0.025)	(0.075)	(0.027)	(0.084)
Openness	-0.002	0.011*	-0.001	0.018*	-0.002	0.013*	-0.001	0.013*
(lagged)	(0.002)	(0.006)	(0.002)	(0.009)	(0.002)	(0.007)	(0.002)	(0.008)
Private credit by banks	0.007***	-0.008					0.006***	-0.005
(% of GDP, BDK)	(0.002)	(0.006)					(0.002)	(0.005)
Bank credit			0.006***	-0.010				
(% of bank deposits, BDK)			(0.002)	(0.007)				
Credit					0.002***	0.001		
(lagged, % GDP)					(0.000)	(0.002)		
Institutions	-0.005	0.035*	0.004	0.045**	0.001	0.022		
	(0.007)	(0.019)	(0.009)	(0.022)	(0.009)	(0.021)		
Political Risk							-0.001	0.070***
							(0.010)	(0.023)
Contagion	0.737***	0.355	0.631***	0.378	0.617***	0.224	0.723***	0.363
(lagged, trading partners)	(0.159)	(0.423)	(0.164)	(0.510)	(0.161)	(0.430)	(0.166)	(0.427)
Flexible Exchange Rate (FER)	-0.222	-0.087	0.187	-0.559	0.101	-0.047	-0.172	-0.189
	(0.173)	(0.607)	(0.210)	(0.665)	(0.200)	(0.571)	(0.175)	(0.590)
Inflation Targeting (IT)	-1.003**	-1.691	-0.717	-2.628*	-0.706*	-1.952	-0.804*	-2.280*
	(0.449)	(1.308)	(0.445)	(1.399)	(0.408)	(1.259)	(0.461)	(1.364)
IT X FER	0.730*	2.975**	0.219	4.411***	0.329	3.325**	0.644	3.841**
	(0.443)	(1.464)	(0.482)	(1.571)	(0.453)	(1.316)	(0.455)	(1.527)
Observations	3594	480	3609	437	3644	463	3637	458

Notes: The dependent variable corresponds to a dummy that takes the value 1 if the country experienced a sudden stop in gross or net capital inflows, and zero otherwise. For details on the definitions of the dependent and independent variables see Table 3.C.1 in appendix 3.C. Estimates are obtained using a logit model and robust standard errors clustered by country, unless otherwise stated. Interaction terms with dummies that capture extreme values for the regressors are included in the regression. An extreme value is defined as one that is three interquartile ranges above the 75th percentile or below the 25th percentile. Standard errors are reported in parenthesis. *** (**) [*] denotes significance at the 1 (5) [10] percent level.

Tab. 3.3: Robustness - Alternative Episodes of Gross and Prevented Sudden Stops

	Bonanza		Preventable Episodes		Private Episodes	Retrenchment Episodes
	Inflows	Purely Prevented	Inflows	Purely Prevented	Purely Prevented	SS+Retrench
	(1)	(2)	(3)	(4)	(5)	(6)
Global Conditions						
Risk	0.024***	0.002	0.034***	-0.015	-0.012	0.014
(lagged)	(0.009)	(0.029)	(0.010)	(0.027)	(0.025)	(0.025)
Liquidity Growth	-0.002	0.007	0.004	0.005	0.007	0.001
(lagged)	(0.003)	(0.010)	(0.003)	(0.011)	(0.010)	(0.009)
Growth	-0.231***	-0.185	-0.323***	-0.137	-0.065	0.012
(lagged)	(0.072)	(0.153)	(0.070)	(0.124)	(0.117)	(0.114)
Interest Rates	-0.067	0.051	-0.023	-0.055	-0.059	-0.038
(lagged)	(0.055)	(0.131)	(0.042)	(0.133)	(0.125)	(0.088)
Domestic Conditions						
Foreign Liabilities	0.019**	-0.071*	0.027***	-0.062**	-0.042	0.011
(lagged, % GDP)	(0.009)	(0.042)	(0.009)	(0.032)	(0.028)	(0.017)
CA/TA	-0.008	-0.003	-0.004	0.004	0.005	0.012
(lagged)	(0.006)	(0.015)	(0.005)	(0.014)	(0.012)	(0.010)
GDP growth	-0.117***	0.136**	-0.107***	0.087*	0.057	-0.037
(lagged)	(0.024)	(0.065)	(0.025)	(0.052)	(0.050)	(0.038)
Inflation	0.006	-0.261***	0.004	-0.235***	-0.262***	-0.040
(lagged)	(0.026)	(0.092)	(0.025)	(0.083)	(0.078)	(0.036)
Openness	-0.000	0.008	-0.002	0.018***	0.017***	0.004
(lagged)	(0.001)	(0.007)	(0.001)	(0.007)	(0.005)	(0.004)
Private credit by banks	0.004*	-0.005	0.005***	-0.004	-0.008*	0.013***
(% of GDP, BDK)	(0.002)	(0.006)	(0.002)	(0.005)	(0.005)	(0.003)
Institutions	-0.003	0.043*	0.004	0.045**	0.035*	0.016
	(0.009)	(0.022)	(0.009)	(0.023)	(0.020)	(0.013)
Contagion	0.869***	0.281	0.698***	0.504	0.143	0.835***
(lagged, land borders)	(0.175)	(0.405)	(0.172)	(0.457)	(0.412)	(0.304)
Flexible Exchange Rate (FER)	-0.112	-0.305	-0.148	-0.183	0.282	-0.476
	(0.200)	(0.688)	(0.172)	(0.587)	(0.542)	(0.431)
Inflation Targeting (IT)	-0.608	-2.551*	-0.767*	-2.630*	-2.388*	-0.325
	(0.480)	(1.348)	(0.466)	(1.354)	(1.249)	(0.581)
IT X FER	0.270	4.292***	0.587	4.137***	3.640***	1.111
	(0.525)	(1.543)	(0.457)	(1.513)	(1.391)	(0.756)
Observations	3,641	392	3,577	441	438	563

Notes: The dependent variable corresponds to a dummy that takes the value 1 if the country experienced a sudden stop in gross or net capital inflows, and zero otherwise. For details on the definitions of the dependent and independent variables see Table 3.C.1 in Appendix 3.C. Estimates are obtained using a logit model and robust standard errors clustered by country, unless otherwise stated. Interaction terms with dummies that capture extreme values for the regressors are included in the regression. An extreme value is defined as one that is three interquartile ranges above the 75th percentile or below the 25th percentile. Standard errors are reported in parenthesis. *** (**) [*] denotes significance at the 1 (5) [10] percent level.

Tab. 3.4: Duration Analysis of Failed Preventions

	Cox	Parametric Models			Cox	Stratified
	Model	Weibull	Exponetial	Gompterz	Filtered	Emerging
	(1)	(2)	(3)	(4)	(5)	(6)
Global Conditions						
Risk	-0.020	-0.030	-0.026	-0.023	0.019	-0.020
(lagged)	(0.023)	(0.025)	(0.024)	(0.023)	(0.036)	(0.021)
Liquidity Growth	0.013	0.016	0.014	0.013	0.004	0.012
(lagged)	(0.010)	(0.011)	(0.011)	(0.010)	(0.017)	(0.010)
Growth	0.049	0.026	0.035	0.044	0.385*	0.064
(lagged)	(0.085)	(0.098)	(0.093)	(0.088)	(0.198)	(0.089)
Interest Rates	0.018	0.015	0.016	0.016	-0.159	0.026
(lagged)	(0.115)	(0.139)	(0.128)	(0.118)	(0.237)	(0.117)
Domestic Conditions						
Foreign Liabilities	0.036***	0.043***	0.041***	0.038***	0.058***	0.036**
(lagged, % GDP)	(0.014)	(0.014)	(0.014)	(0.013)	(0.021)	(0.014)
CA/TA	0.010	0.011	0.011	0.010	0.004	0.012
(first lag)	(0.010)	(0.011)	(0.010)	(0.010)	(0.015)	(0.011)
GDP growth	-0.008	-0.000	-0.003	-0.005	0.055	-0.040
(lagged)	(0.045)	(0.050)	(0.047)	(0.043)	(0.062)	(0.044)
Inflation	0.062	0.082*	0.076*	0.070*	0.161**	0.052
(lagged)	(0.041)	(0.042)	(0.039)	(0.037)	(0.075)	(0.036)
Openness	-0.006	-0.005	-0.005	-0.006	-0.006	-0.007
(lagged)	(0.005)	(0.006)	(0.005)	(0.005)	(0.014)	(0.004)
Private credit by banks	-0.004	-0.005	-0.004	-0.004	0.006	-0.004
(% of GDP, BDK)	(0.003)	(0.004)	(0.004)	(0.003)	(0.005)	(0.003)
Institutions	-0.012	-0.016	-0.015	-0.014	-0.042	-0.004
	(0.016)	(0.018)	(0.017)	(0.016)	(0.031)	(0.016)
Contagion	-0.291	-0.375	-0.355	-0.327	-0.163	-0.340
(lagged, trading partners)	(0.326)	(0.336)	(0.323)	(0.314)	(0.627)	(0.331)
Flexible Exchange Rate (FER)	-0.112	-0.137	-0.113	-0.100	0.149	-0.134
	(0.428)	(0.520)	(0.479)	(0.444)	(0.917)	(0.422)
Inflation Targeting (IT)	0.614	0.834	0.778	0.707	1.115	0.717*
	(0.480)	(0.514)	(0.495)	(0.462)	(0.898)	(0.422)
IT X FER	-1.610*	-1.927**	-1.844**	-1.743**	-3.169*	-2.213**
	(0.839)	(0.948)	(0.894)	(0.833)	(1.853)	(0.881)
Observations	354	354	354	354	299	354

Notes: Denote a prevented sudden stop in a given quarter as PSS. Denote a net sudden stop in a given quarter, i.e. a sudden stop in inflows that is not prevented, as NSS. Then, "failed prevention" corresponds to the transition $PSS \rightarrow NSS$. For details on the definitions of the regressors see Table 3.C.1 in Appendix 3.C. Interaction terms with dummies that capture extreme values for the regressors are also included in the regression. An extreme value is defined as one that is three interquartile ranges above the 75th percentile or below the 25th percentile. Estimates are obtained using clustered standard errors at the country level to account for the fact that for each country there can be multiple unordered failure events of the same type. The Efron's method is used to handle ties. Standard errors are reported in parenthesis. *** (**) [*] denotes significance at the 1 (5) [10] percent level.

Appendix

3.A Construction of Capital Flows Series

In 2009 there was a methodological change in the construction of the Balance of Payments (BOP) statistics, from BPM5 to BPM6. The calculation of the series of direct investment were the most affected by this change. While BPM5 distinguishes between "Direct Investment Abroad" and "Direct Investment in Reporting Economy", BPM6 computes direct investment distinguishing between assets and liabilities. The IMF reports the BPM5 series up to 2008 and the BPM6 series from 2005.

Due to this methodological change, the subcomponents of the financial account of the BOP (direct investment, portfolio investment and other investment) are not comparable between BPM5 and BPM6, since BPM5 does not follow the asset-liability criterium for the calculation of direct investment. Despite not being able to use the subcomponents of the financial account prior to 2005, the total flows of capital – both inflows and outflows – can still be computed because BPM5 reports the aggregate series of asset and liability transactions.

The series of inflows and outflows are computed using the following series from the BOP statistics reported by the IMF:

- 1980 – 2004 (BPM5)
  - Assets: Total Asset Transactions
  - Assets excluding reserves: Total Asset Transactions - Reserve Assets
  - Liabilities: Total Liability Transactions
- 2005 – 2014 (BPM6)
  - Assets: Direct Investment, Assets + Portfolio Investment, Assets + Financial Derivatives, Assets + Other Investment, Assets + Reserve Assets
  - Assets excluding reserves: Assets - Reserve Assets
  - Liabilities: Direct Investment, Liabilities + Portfolio Investment, Liabilities + Financial Derivatives, Liabilities + Other Investment, Liabilities

The series of BPM5 and BPM6 are combined to generate assets and liabilities series for the full period. Based on them, capital outflows are computed as the negative of the assets excluding reserves, while the inflows correspond to the liabilities.

The series of assets were disaggregated into private and public. Assets of the public sector were computed by adding up all the asset transactions in the portfolio investment, financial derivatives and other investment categories corresponding to the general government and to the monetary authority. Asset transactions of the private sector were computed as the difference between total asset transactions (excluding reserves) and asset transactions of the public sector.

3.B Country Classification

We identify 4 groups of countries: advanced economies, emerging economies, frontier economies and developing economies. The groups of emerging and frontier economies are constructed based on the S&P Dow Jones classification. The group of *Non-Advanced Economies* is defined as the set of countries that are classified either as emerging, frontier or developing economies.

Advanced Economies: Canada, United States, Australia, Hong Kong, Japan, New Zealand, Singapore, Austria, Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, Israel and South Korea.

Emerging Economies: Greece, Turkey, South Africa, Brazil, Chile, Colombia, Mexico, Peru, India, Indonesia, Malaysia, Philippines, Thailand, Russian Federation, Czech Republic, Hungary and Poland.

Frontier Economies: Argentina, Ecuador, Panama, Cyprus, Jordan, Lebanon, Bangladesh, Sri Lanka, Pakistan, Vietnam, Mauritius, Morocco, Namibia, Kazakhstan, Bulgaria, Ukraine, Slovak Republic, Estonia, Latvia, Lithuania, Croatia, Slovenia and Romania.

Developing Economies: Malta, Bolivia, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Paraguay, Uruguay, Venezuela, The Bahamas, Aruba, Belize, Netherlands Antilles, Suriname, Yemen, Myanmar, Cambodia, Laos, Nepal, Cabo Verde, Ethiopia, Lesotho, Mozambique, Seychelles, Sudan, Uganda, Fiji, Vanuatu, Papua New Guinea, Samoa, Tonga, Armenia, Azerbaijan, Belarus, Albania, Georgia, Kyrgyzstan, Moldova, Tajikistan, Macedonia, Bosnia and Herzegovina.

3.C Tables

Tab. 3.C.1: Description of Variables and Sources

Variable	*Definition*	*Source*
Sudden Stops		
Capital Flows	See Appendix 3.A.	BOPS (BPM5 and BPM6), IMF.
Gross Sudden Stop Episode	Dummy that takes de value 1 if the year-on-year change in foreign capital *inflows* falls below two standard deviations from its historical mean. In terms of measuring its length in time, the sudden stop episode starts from the moment in which the series falls one standard deviation below its historical mean, but conditional on the fact that it will eventually cross the two-standard-deviations threshold. The episode ends when the series goes back to one standard deviation below the historical mean.	Constructed by authors.
Net Sudden Stop Episode	Dummy that takes de value 1 if the year-on-year change in foreign capital *net flows* falls below two standard deviations from its historical mean. In terms of measuring its length in time, the sudden stop episode starts from the moment in which the series falls one standard deviation below its historical mean, but conditional on the fact that it will eventually cross the two-standard-deviations threshold. The episode ends when the series goes back to one standard deviation below the historical mean.	Constructed by authors.

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Table 3.C.1 – continued from previous page

Variable	*Definition*	*Source*
Terms of Trade	100*(Price of Exports / Price of Imports). **This variable is used to compute sudden stop episodes associated with bonanzas.**	
Sovereign Bond Spreads	*Emerging Countries*: From 1991, JPM EMBI Composite. Before 1991, effective Fed Funds rate. *Developing Countries*: Average Euro-area government bond spread over German 10-year government bond. *Developed Countries*: From 1995, G7 government bond spread over US Treasury bonds. Before 1995, German 10-year government bond spread over US Treasury bonds. **This measure is used to compute systemic sudden stop episodes.**	EMBI from Bloomberg. Effective Fed Funds rate from FRED. Government bond spreads for Euro area and G7 countries computed from bond yields obtained from Datastream.
Domestic Factors		
GDP Growth	Year-on-year growth rate of real GDP.	IFS.
CPI Inflation	Year-on-year growth rate of CPI.	IFS. When note available, CPI inflation was obtained from local sources and from Datastream.
CAD	Current account deficit.	BOPS (both BPM5 and BPM6), IMF.

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Table 3.C.1 – continued from previous page

Variable	*Definition*	*Source*
Absorption of Tradable Goods	Imports plus tradable output domestically consumed minus exports. Tradable output domestically consumed is constructed as the share of tradable output multiplied by GDP. The share of tradable output is computed as the ratio of agriculture plus industrial output to total GDP. The obtained series are deflated using the implicit GDP deflator.	Imports, exports and GDP in local currency at current prices from IFS (National Accounts). Agriculture and industrial value added as percentage of GDP, at annual frequency, from WDI (World Bank). Implicit GDP deflator from IFS.
Trade Openness	Exports plus imports as percentage of GDP.	Exports, Imports and GDP in local currency at current prices from IFS (National Accounts).
DLD	Domestic Liability Dollarization. *Emerging and Developing countries*: Bank foreign borrowing as a share of GDP. *Developed countries*: Banks' local asset positions in foreign currency (vis-a-vis the non-bank sector) as a share of GDP.	Bank foreign borrowing from IFS (line 26c). Banks' local asset positions in foreign currency from BIS. GDP in US dollars from WEO, IMF.
Private Credit I	Deposit money banks and other financial institutions claims on the private sector as a percentage of GDP.	Claims on the private sector from IFS (lines 22d and 42d). GDP in local currency at current prices from IFS.
Private Credit II	Bank credit to private sector as percentage of GDP.	Beck et al. (2009)

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Table 3.C.1 – continued from previous page

Variable	*Definition*	*Source*
Private Credit III	Deposit money banks and other financial institutions claims on the private sector as a percentage of total deposits. Total deposits correspond to demand, time and saving deposits in deposit money banks and other financial institutions.	Claims on the private sector from IFS (lines 22d and 42d). Financial system deposits from IFS (lines 24, 25, and 45).
Private Credit IV	Bank credit to private sector as percentage of total bank deposits.	Beck et al. (2009)
Regional Contagion	Dummy variable that takes the value of 1 if a country reports a sudden stop in t and there is at least one country with *geographic proximity* with a sudden stop in $t-1$.	Constructed by authors.
Trade Contagion	Dummy variable that takes the value of 1 if a country reports a sudden stop in t and there is at least one *top 10 trading partner* with a sudden stop in $t-1$.	Constructed by authors.
Institutional Quality	Sum of the following components: rule of law, investment profile, government stability, bureaucracy quality, and corruption.	Political Risk Services Group.
Financial Risk-Taking Index	Index that measures a country's ability to finance its official, commercial, and trade debt obligations. Its components are: foreign debt as percentage of GDP, foreign debt service as percentage of exports of goods and services, current account as percentage of exports of goods and services, net international liquidity as months of import cover, exchange rate stability.	Political Risk Services Group.
Depth of Financial System	Stock market capitalization as percentage of GDP. Annual frequency.	Beck et al. (2009)

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Table 3.C.1 – continued from previous page

Variable	*Definition*	*Source*
Financial Openness Index	Index measuring a country's degree of capital account openness.	Chinn and Ito (2006)
Exchange Rate Regime	Monthly fine classification (1-15) of countries according to their Exchange rate regime.	Reinhart and Rogoff (2004), updated by Iltzezky et al. (2009).
Public Debt	Public debt as percentage of GDP. Annual frequency.	Abbas et al. (2010)
International Investment Position	Stock of international assets and liabilities. Annual frequency.	BOPS (BPM5 and BPM6), IMF.
Global Factors		
Global Risk	US stock market volatility.	Bloom (2009). VXO index updated from CBOE website.
Growth Rate of Global Money Supply	Average of the year-on-year growth rate of M2 in the United States, M2 in the Eurozone, M2 in Japan and M4 in the UK.	IFS.
Global Interest Rates	Average rate on long-term government bonds in the United States, Euro area and Japan	IFS.
Global Growth	Year-on-year growth rate of World's real GDP.	IFS.

Tab. 3.C.2: "Prevented" Sudden Stop Episodes

Country	*Start*	*End*	*Country*	*Start*	*End*	*Country*	*Start*	*End*
Advanced Economies			Italy	1995q1	1995q1	United States	1998q2	1998q3
Australia	1990q1	1991q1	Italy	2000q4	2002q3	United States	1999q2	1999q2
Australia	1998q1	1998q1	Italy	2007q3	2009q2	United States	2001q3	2001q3
Australia	2001q4	2002q1	Japan	1990q4	1991q3	United States	2008q3	2009q1
Australia	2005q1	2005q4	Japan	1992q4	1993q1	United States	2012q1	2012q1
Australia	2008q3	2008q3	Japan	1996q3	1996q4	*Frontier, Emerging and Developing Economies*		
Australia	2009q1	2009q3	Japan	1998q3	1999q1	Albania	2012q3	2013q2
Australia	2012q2	2012q3	Japan	2008q3	2009q4	Argentina	1989q1	1989q1
Austria	1993q3	1993q3	Korea	1997q3	1997q3	Argentina	1998q4	1999q2
Austria	2001q1	2002q1	Korea	1998q4	1999q1	Armenia	2001q1	2001q3
Austria	2008q4	2009q4	Korea	2009q3	2009q3	Aruba	2012q4	2012q4
Belgium	2006q1	2006q3	Luxembourg	2008q2	2009q2	Azerbaijan	2009q1	2009q4
Belgium	2008q4	2009q4	Netherlands	1991q1	1991q4	Bahamas	1989q2	1990q1
Canada	2008q4	2009q2	Netherlands	1994q4	1994q4	Bahamas	1995q3	1996q2
Hong Kong	2008q3	2009q3	Netherlands	2002q1	2002q1	Bahamas	2003q2	2004q3
Denmark	1986q4	1987q2	Netherlands	2008q1	2009q3	Belarus	2008q4	2009q1
Denmark	1991q3	1991q3	Netherlands	2010q4	2011q3	Belarus	2013q1	2013q1
Denmark	1992q3	1993q2	New Zealand	2005q3	2005q3	Bolivia	2000q2	2000q2
Denmark	1994q3	1995q1	New Zealand	2008q2	2008q3	Bolivia	2004q4	2005q1
Denmark	2001q2	2002q2	New Zealand	2012q1	2012q3	Bolivia	2006q2	2006q2
Denmark	2008q4	2009q4	Norway	1983q4	1983q4	Bosnia and Herzegovina	2005q1	2005q1
Denmark	2011q3	2011q4	Norway	1988q3	1988q4	Bosnia and Herzegovina	2008q3	2008q4
Finland	1992q1	1992q2	Norway	1991q3	1991q4	Bosnia and Herzegovina	2010q2	2010q3
Finland	2001q1	2001q4	Norway	2002q1	2002q2	Brazil	1995q1	1995q2
Finland	2003q1	2003q3	Norway	2008q1	2008q2	Brazil	2002q3	2003q2
Finland	2005q3	2005q3	Norway	2009q3	2010q1	Brazil	2008q2	2008q3
Finland	2009q2	2009q3	Portugal	1983q4	1984q2	Cabo Verde	2009q3	2009q3
Finland	2012q3	2012q4	Portugal	1992q3	1992q3	Cabo Verde	2013q1	2013q3
France	2002q1	2002q3	Portugal	1996q2	1996q3	Cambodia	1997q4	1998q1
France	2008q2	2008q3	Portugal	2002q4	2003q1	Cambodia	2010q1	2010q1
France	2009q1	2009q1	Portugal	2004q4	2005q2	Chile	2000q2	2001q1
France	2011q4	2012q3	Portugal	2008q2	2009q3	Chile	2008q4	2009q2
Germany	1988q1	1988q2	Portugal	2010q4	2011q1	Chile	2013q4	2014q1
Germany	1994q2	1994q4	Singapore	1998q4	1998q4	Costa Rica	2008q4	2008q4
Germany	2001q1	2002q2	Singapore	2008q3	2009q3	Croatia	2005q1	2005q3
Germany	2004q1	2004q2	Spain	1994q2	1995q1	Croatia	2010q3	2010q3
Germany	2008q2	2009q4	Spain	2001q3	2002q2	Croatia	2011q1	2011q1
Germany	2013q4	2013q4	Spain	2008q2	2008q4	Cyprus	2008q2	2008q2
Iceland	1989q2	1989q4	Sweden	1991q2	1991q2	Cyprus	2010q1	2010q1
Iceland	2002q2	2002q2	Sweden	1996q4	1997q3	Cyprus	2010q4	2011q2
Iceland	2008q2	2009q1	Sweden	2001q1	2002q3	Czech Republic	2006q2	2006q4
Ireland	1991q4	1992q1	Sweden	2008q4	2009q2	Czech Republic	2008q4	2009q4

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Table 3.C.2 – continued from previous page

Country	*Start*	*End*	*Country*	*Start*	*End*	*Country*	*Start*	*End*
Ireland	1994q4	1994q4	Switzerland	2008q1	2009q1	El Salvador	2009q1	2009q1
Ireland	2008q2	2008q4	United Kingdom	1991q4	1992q2	Estonia	2008q2	2008q2
Israel	2001q1	2001q2	United Kingdom	1994q2	1994q4	Ethiopia	2005q3	2005q4
Israel	2002q1	2002q2	United Kingdom	1998q1	1998q4	Fiji	2005q1	2005q1
Israel	2007q3	2009q2	United Kingdom	2001q3	2002q4	Fiji	2012q1	2012q4
Israel	2011q4	2012q1	United Kingdom	2008q2	2009q3	Greece	2006q2	2006q3
Italy	1993q1	1993q3	United States	1990q2	1990q4	Greece	2010q2	2010q3
Greece	2014q1	2014q1	Malaysia	2008q3	2008q3	Russian Federation	1998q3	1999q4
Guatemala	2008q4	2008q4	Malta	2000q1	2000q3	Russian Federation	2009q4	2009q4
Hungary	2002q4	2002q4	Malta	2009q4	2009q4	Russian Federation	2014q1	2014q3
Hungary	2009q1	2009q3	Mauritius	2008q3	2009q2	Samoa	2010q1	2010q1
India	1992q2	1992q4	Mauritius	2012q2	2013q2	Samoa	2013q3	2013q3
India	1998q4	1998q4	Mexico	2008q4	2009q3	Seychelles	1987q3	1988q1
India	2001q4	2002q3	Morocco	2009q1	2009q3	Seychelles	2009q2	2009q2
Indonesia	2006q4	2007q1	Namibia	2002q4	2003q2	Slovak Republic	1998q2	1999q1
Jordan	1992q3	1992q3	Namibia	2008q1	2008q1	Slovak Republic	1999q4	1999q4
Jordan	2007q3	2007q4	Namibia	2010q3	2011q2	Slovak Republic	2010q2	2010q4
Jordan	2008q3	2008q4	Nepal	1986q4	1987q1	Slovak Republic	2012q2	2012q4
Jordan	2011q4	2012q1	Nepal	1990q2	1991q1	Slovenia	1997q3	1997q4
Jordan	2012q3	2012q3	Nepal	1995q4	1996q1	Slovenia	2008q3	2009q1
Kazakhstan	2009q1	2009q1	Nepal	2009q4	2010q1	South Africa	2008q3	2008q3
Kyrgyz Republic	2010q2	2011q1	Netherlands Antilles	2002q4	2003q1	Sri Lanka	1994q2	1994q3
Lao PDR	2008q3	2008q4	Netherlands Antilles	2009q2	2009q2	Sri Lanka	1995q4	1996q1
Lao PDR	2012q1	2012q1	Pakistan	2012q2	2012q4	Sri Lanka	1998q4	1999q1
Lao PDR	2013q2	2013q3	Panama	2002q1	2002q4	Sri Lanka	2013q3	2014q1
Latvia	1998q3	1999q2	Panama	2008q4	2009q1	Tajikistan	2009q3	2009q3
Lesotho	1989q3	1989q4	Papua New Guinea	1992q4	1992q4	Thailand	1996q3	1996q3
Lithuania	2000q4	2001q3	Paraguay	2007q3	2007q4	Thailand	2008q4	2009q3
Lithuania	2008q3	2008q3	Paraguay	2009q4	2009q4	Tonga	2008q3	2009q2
Lithuania	2013q1	2013q1	Philippines	1997q3	1997q3	Ukraine	2008q4	2008q4
Macedonia	2002q1	2002q2	Philippines	2008q2	2009q1	Ukraine	2010q1	2010q1
Macedonia	2002q4	2002q4	Poland	1991q4	1992q2	Vanuatu	2009q2	2010q1
Macedonia	2012q2	2012q2	Poland	2008q4	2008q4	Venezuela	2012q2	2012q4
Macedonia	2013q4	2014q2	Romania	2012q3	2012q3			

Note: A *"prevented"* sudden stop in economy j during period t in an event in which a sudden stop in gross inflows does not translate into a sudden stops in net flows due to the offsetting variation in capital outflows from domestic agents. A prevented sudden stop episode is conceived as one or more consecutive periods (quarters) in which a sudden stop in net flows does not coexist with a sudden stop in gross inflows. This implies that within an episode of sudden stop in gross inflows, there can be more than one prevented sudden stop episodes.

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