Abstract

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.
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 comovement between investment and financial conditions. As shown in Figure 1, nonresidential private fixed investment remained depressed, and gradually reached pre-crisis levels in 2012. 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 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 paper 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.\footnote{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 different from those that drive financial conditions.} I present a search and matching model of customer capital in
Figure 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 2007q4. 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.

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 paper introduces a new transmission mechanism that stems from financial shocks. When coping with a reduction in external financing, firms adjust not 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 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.\footnote{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 B.}

Column (1) in Table 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 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 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

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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.)
Table 2: Sales Employment and Financial Conditions

\[ \Delta S_{it} = \alpha_i + \beta_i X_t + \epsilon_{it} \]

<table>
<thead>
<tr>
<th></th>
<th>(1994q1 - 2015q4)</th>
<th>(1994q1 - 2015q4)</th>
<th>(1989q1 - 2007q2)</th>
<th>(1994q1 - 2012q4)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>(\Delta \text{Employ.})</td>
<td>(\Delta \text{Credit.})</td>
<td>Spreads</td>
<td></td>
</tr>
<tr>
<td>1. Sales-Related Occupations (SRO)</td>
<td>1.025</td>
<td>0.267</td>
<td>0.177</td>
<td>-1.371</td>
</tr>
<tr>
<td></td>
<td>(0.076)</td>
<td>(0.044)</td>
<td>(0.076)</td>
<td>(0.309)</td>
</tr>
<tr>
<td>2. SRO – cashiers and clerks</td>
<td>1.220</td>
<td>0.358</td>
<td>0.274</td>
<td>-1.262</td>
</tr>
<tr>
<td></td>
<td>(0.107)</td>
<td>(0.054)</td>
<td>(0.003)</td>
<td>(0.410)</td>
</tr>
<tr>
<td>3. SRO – cashiers and clerks + marketing</td>
<td>1.238</td>
<td>0.351</td>
<td>0.283</td>
<td>-1.361</td>
</tr>
<tr>
<td></td>
<td>(0.106)</td>
<td>(0.053)</td>
<td>(0.099)</td>
<td>(0.402)</td>
</tr>
<tr>
<td>4. SRO – supervisors, cashiers and clerks + marketing</td>
<td>1.195</td>
<td>0.358</td>
<td>0.468</td>
<td>-1.561</td>
</tr>
<tr>
<td></td>
<td>(0.138)</td>
<td>(0.063)</td>
<td>(0.105)</td>
<td>(0.449)</td>
</tr>
</tbody>
</table>

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).

(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 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 paper 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 papers relies on households’ attempt to increase savings, which results in a contraction in demand and a subsequent

\(^4\)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.

\(^5\)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.
lowering of prices and occupation rates. This brings about lower employment and investment, which reinforces the household’s initial desire to increase savings and reduce consumption, which triggers in the process, a sizeable recession.

Two important distinctions separate my paper 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 my paper 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 paper is closely related to Ottonello (2015); both papers 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 paper 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, the paper 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 paper 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 rates prevented other sectors from offsetting 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.

⁶The 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.
Although not directly related, this paper 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.\footnote{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.}

The rest of the paper 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.

## 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 Compu-stat and the information contained in Dealscan and CapitalIQ. All variable definitions and groups’ construction are described in more detail in Appendix 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 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 2009q3 – 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 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
Table 3: Descriptive Statistics - Capital Expenditures

<table>
<thead>
<tr>
<th></th>
<th>Whole Sample</th>
<th>Bank Relation</th>
<th>High Leverage</th>
<th>High Leverage/ Bank depen.</th>
<th>High Leverage/ Real Estate</th>
<th>High Leverage/ Low Cash</th>
<th>Liq. Index</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
</tr>
<tr>
<td>Pre Crisis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p1. 2006q3-2007q2</td>
<td>0.0951</td>
<td>0.0682</td>
<td>0.0804</td>
<td>0.0632</td>
<td>0.0525</td>
<td>0.0670</td>
<td>0.0611</td>
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<td>Crisis</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>2007q3-2009q2</td>
<td>0.0705</td>
<td>0.0529</td>
<td>0.0609</td>
<td>0.0591</td>
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<td>0.0622</td>
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<td>0.0432</td>
<td>0.0424</td>
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<td>Recovery</td>
<td></td>
<td></td>
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<td>r1. 2009q3-2010q2</td>
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<td>0.0403</td>
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<td>0.0318</td>
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<td>0.0574</td>
<td>0.0556</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>r1. vs p1.</td>
<td>-0.0314***</td>
<td>-0.0279***</td>
<td>-0.0202***</td>
<td>-0.0193***</td>
<td>-0.0207***</td>
<td>-0.0238***</td>
<td>-0.0118***</td>
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<tr>
<td>r2. vs p1.</td>
<td>-0.0111***</td>
<td>-0.0108***</td>
<td>-0.0248***</td>
<td>-0.0083</td>
<td>-0.0068</td>
<td>-0.0208***</td>
<td>-0.0043***</td>
</tr>
</tbody>
</table>

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.
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
Table 4: Investment Recovery after the Great Recession

<table>
<thead>
<tr>
<th>Bank Relation</th>
<th>Leverage Measures</th>
<th>Abadie-Imbens</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High Leverage</td>
<td>(1)</td>
<td>1770</td>
</tr>
<tr>
<td></td>
<td>High Leverage/</td>
<td>0.00207</td>
<td>2973</td>
</tr>
<tr>
<td></td>
<td>Bank depen.</td>
<td>(0.0024)</td>
<td>449</td>
</tr>
<tr>
<td></td>
<td>High Leverage/</td>
<td>0.0111*</td>
<td>254</td>
</tr>
<tr>
<td></td>
<td>Real Estate</td>
<td>(0.0059)</td>
<td>315</td>
</tr>
<tr>
<td></td>
<td>High Leverage/</td>
<td>-0.0013</td>
<td>3398</td>
</tr>
<tr>
<td></td>
<td>Low Cash</td>
<td>(0.0088)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Liq. Index</td>
<td>-0.0041</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.00113)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-0.0116</td>
<td></td>
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<td></td>
<td></td>
<td>(0.0081)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-0.052*</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0028)</td>
<td></td>
</tr>
</tbody>
</table>

A. (2008q3-2009q2) versus (2009q3-2010q2)

B. (2006q3-2007q2) versus (2008q3-2009q2)

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.

Table 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 by the crisis in terms of capital expenditures, as shown in Panel B of Table 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 paper 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 $\beta$. 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 paper 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 $y^*_t$ 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 $z_t$ 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:

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

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 $1 - \rho^a$ 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 $y^{d}_t = n_t$.

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 vice versa. 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:

\[
n_t = (1 - \rho^n)n_{t-1} + s_t \eta(\theta_t).
\]

**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 \(\varepsilon_t\) 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 \(\pi_t = py_t - s_t \eta(\theta_t) \varepsilon_t\). 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 \(\Phi(x_t, k_t)\), total cost of sales representatives \(\kappa(s_t)\), total wage payments \(l\), dividend payments \(\varphi(d_t)\), and outstanding debt stock \(b_t\). The firm’s dividend payout \(\varphi(d_t)\) 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:

\[
\pi_t - l - \Phi(x_t, k_t) - \kappa(s_t) - \varphi(d_t) + \frac{b_{t+1}}{R} - b_t = 0.
\]

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 \(\varphi_w\) 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 $\zeta_t$ of collateral (capital), plus a multiple $\psi$ of operating revenues $\pi_t$:

$$b_{t+1} + \varphi_w(l_t + \kappa(s_t)) \leq \zeta_t k_{t+1} + \psi \pi_t \quad (4)$$

The variable $\zeta_t$ follows an AR(1) process around its unconditional mean $\zeta$. 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. 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 (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 paper.

### 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 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, $\varepsilon_t$, and the queue length in that submarket, $\theta_t$. Assume that the

---

8Duchin 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.
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 (5):

$$\mu(\theta_t)\varepsilon_t = 1$$  \hspace{1cm} (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 $$\varepsilon_t$$ 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 $$\Gamma_t = \{z_t, \zeta_t\}$$ 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 $$\varepsilon_t$$, and tightness $$\theta_t$$ in order to maximize the discounted stream of future dividends $$d_t$$. Letting $$\lambda_i^t$$ 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:**

$$V(k_t, n_{t-1}, b_t, \Gamma_t) = \max_{\{d_t, y_t, n_t, s_t, u_t, l_t, k_{t+1}, x_t, b_{t+1}, \varepsilon_t, \theta_t\}} d_t + \beta\mathbb{E} V(k_{t+1}, n_t, b_{t+1}, \Gamma_{t+1})$$  \hspace{1cm} (6)
subject to

\[ \begin{align*}
(\lambda_1^1) & \quad \pi_t - l_t - \Phi(x_t, k_t) - \kappa(s_t) - \varphi(d_t) + \frac{b_{t+1}}{R} - b_t = 0 \\
(\lambda_2^2) & \quad y_t = f(k_t, l_t, u_t, z_t) \\
(\lambda_3^3) & \quad y_t = n_t \\
(\lambda_4^4) & \quad n_t = (1 - \rho^n)n_{t-1} + \eta(\theta_t)s_t \\
(\lambda_5^5) & \quad k_{t+1} = (1 - \delta(u_t))k_t + x_t \\
(\lambda_6^6) & \quad \mu(\theta_t)\varepsilon_t = 1 \\
(\lambda_7^7) & \quad \frac{b_{t+1}}{1 + r} + \varphi_w(l_t + \kappa(s_t)) - \psi\pi_t \leq \zeta_1k_{t+1}
\end{align*} \]

taking the exogenous processes for \( \Gamma_t \) as given. Equation (7) corresponds to the flow-of-funds constraint faced by the firm. Equation (8) is the aggregate production function of the economy; thus, the multiplier \( \lambda_2^2 \) represents the shadow value of producing one additional unit of output. Equation (9) defines aggregate demand and states that production should be equal to the number of units sold to customers; the multiplier \( \lambda_3^3 \) is the shadow value of selling one additional unit of the good. Equation (10) depicts the law of motion for customer base accumulation; the multiplier \( \lambda_4^4 \) is the marginal value of attracting an additional customer. Equation (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 (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 (13) is a constraint that limits the borrowing capacity of the firm; the multiplier \( \lambda_7^7 \) associated with this constraint corresponds to the shadow value of relaxing the constraint, either by increasing profits or an exogenous change in borrowing capacity \( \zeta_t \).

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 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 \( q_t = \lambda_5^5\varphi'(d_t) \) and \( v_t \equiv \lambda_7^7\varphi'(d_t) \). \( q_t \) stands for the shadow value of one additional unit of capital, and \( v_t \) accounts for the overall shadow value of a tightening

\(^9\)Similarly to Gourio and Rudanko (2014b), the value of \( \sigma \) only affects the scale of variables in steady state. The results presented in the quantitative section are not affected by its magnitude.
in financial conditions. In fact, a tightening in the capacity to access external sources of funding increases the value of $\nu_t$, as the fall in dividends is offset by the increase in the shadow value of the borrowing constraint $\lambda_t^7$.

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 (14):

$$q_t = \beta E_t \left\{ \Xi_{t+1|t} \left[ \lambda_t^2 f_k \left( k_{t+1}, u_{t+1}, z_{t+1} \right) + (1 - \delta (u_{t+1})) q_{t+1} - \Phi_k \left( x_{t+1}, k_{t+1} \right) \right] \right\} + \lambda_t^7 \zeta_t \tag{14}$$

where $\Xi_{t+1|t} = \frac{\phi'(d_t)}{\phi'(d_{t+1})}$. 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 (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 (10) and capital stock evolution driven by equation (11). Fourth, the contribution of a new unit of capital in terms of future revenue is discounted by a factor $\lambda_t^2$. As stated previously, $\lambda_t^2$ 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 $\lambda_t^2$ equals the shadow of a new customer to the firm, as shown below:

$$\lambda_t^2 = \left[ (p - \varepsilon_t) (1 + \psi v_t) - \frac{\kappa'(s_t)}{\gamma(\theta_t)} (1 + \varphi w u_t) \right] + (1 - \rho^n) \beta E_t \left\{ V_n \left( k_{t+1}, n_t, b_{t+1}, \Gamma_{t+1} \right) \right\} \tag{15}$$

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\( \lambda^2 \) as presented in equation (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 (14) and (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 paper 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:

\[
mc_t + \frac{k'(s_t)}{\eta(\theta_t)}(1 + \varphi_w v_t) = (p - \varepsilon_t)(1 + \psi v_t) + (1 - \rho^n)\beta E_t \left\{ V_n (k_{t+1}, n_t, b_{t+1}, \Gamma_{t+1}) \right\} \tag{16}
\]

where \( mc_t \equiv \frac{1}{\varphi(d_t)f_i(t)}(1 + \varphi_w v_t) \). 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 \( \psi v_t \) when the firm is financially constrained and \( v_t > 0 \). 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 \( (1 + \varphi_w v_t) \). These
costs are increasing in the size of the friction $v_t$. 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 (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.

\[
\varepsilon_t = \frac{\gamma}{(1 + \psi v_t)} V_n(k_t, n_{t-1}, b_t, \Gamma_t)
\]  \tag{17}

The matching elasticity in equation (17) accounts for the relative importance of buyers in forming new matches. A higher value of $\gamma$ 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 (18). This value corresponds to the net gain of a customer and the continuation value for the firm.

\[
V_n(k_t, n_{t-1}, b_t, \Gamma_t) = p(1 + \psi v_t) - mc_t + (1 - \rho^n)\beta E_t \left\{ V_n(k_{t+1}, n_t, b_{t+1}, \Gamma_{t+1}) \right\}
\]  \tag{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 $\psi v_t$. When the borrowing constraint is not binding (i.e., $\lambda_t = v_t = 0$), the value of additional external liquidity is not relevant to the pricing decision. However, when the constraint tightens ($v_t > 0$), profitability becomes more important, and thus the firm is willing to sacrifice customer accumulation by setting lower discounts.

Notice that by combining equations (16), (17), and (18), it is possible to conclude that discounts ($\varepsilon_t$) 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.

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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 paper are standard in the literature. The investment cost function is determined by \(\Phi(x_t, k_t) = x_t + \frac{\phi_k}{2} \left( \frac{x_t}{k_t} - \delta(u_t) \right)^2 k_t\), which includes the direct cost of investment and a quadratic adjustment cost. Capital depreciation is represented by the functional form \(\delta_k(u_t) = \delta_0 u_t^\rho\) with \(\delta_0 > 0\) and \(\rho > 0\). The cost of equity issuance is determined by \(\varphi(d_t) = d_t \phi_d (d_t - d^{ss})^2\) with \(\varphi_d > 0\) and \(d^{ss}\) equal to dividend in steady state. Sales cost are represented by a quadratic function of the form \(\kappa(s) = \kappa_0 s^2\) with \(\kappa_0 > 0\). Productivity shock follows a standard AR(1) process of 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 5.

The discount factor \(\beta\) is set to an annualized value of 0.95, and capital depreciation in steady state \(\delta_{k^{ss}}\) 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 \(\varphi = 1.4\). This value can be directly pinned down from optimality conditions in the steady-state. \(\delta_0\) 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 $\varepsilon$ and new matches is given by $\frac{1+\gamma}{1-\gamma}$, where $\gamma$ is the elasticity parameter of the matching function. In Gourio and Rudanko (2014b), $\gamma$ 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 $\zeta$. Then, I use the series from 1973q1 to 2016q2 to estimate $\rho_\zeta = 0.913$ and $\sigma_\zeta = 0.036$.\footnote{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.} 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 equal to $\rho_z = 0.9$ and $\sigma_z = 0.02$ to match output volatility. The cost of equity issuance $\varphi_d$ is set to 0.3, as in Cooley and Quadrini (2001) and Gilchrist et al. (2014b). The capital adjustment cost $\phi_k$ 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. Figure 2 presents responses 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 $\nu_t$, as the drop in dividends is offset by an increase in $\lambda^T_t$. A higher $\nu_t$ 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 panel 3 of Figure 2. Markups are countercyclical
### Table 5: Model Parameters

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

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 6 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. Investment falls less than the number of customers due to the quadratic
Figure 2: Impulse Responses to a Negative Financial 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 $\kappa(s)$. 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 $(py - s\eta(\theta)e)/y$ 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 $x$. 
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 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. Figure 3 presents the impulse response to a financial shock in the baseline model (discussed in the previous section) and the model with financial frictions but without customer markets.\footnote{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.}

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
Figure 3: 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 represents the markup, computed as changes in $(py - \eta(\theta)e)/y$ 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 $x$. 
Figure 4: 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 2006q4 is equal to zero. Blue shaded areas correspond to NBER recessions.

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.\textsuperscript{12} Figure 3 depicts how investment and production rapidly revert to steady state levels in a model with 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

\textsuperscript{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.
Table 6: Correlations between the cyclical components of real and financial variables over different time periods

<table>
<thead>
<tr>
<th></th>
<th>Data</th>
<th>Customer Markets</th>
<th>No Customer Markets</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006q4-2008q4</td>
<td>0.5414</td>
<td>0.8340</td>
<td>0.9891</td>
</tr>
<tr>
<td>2009q1-2011q4</td>
<td>-0.6943</td>
<td>-0.7924</td>
<td>0.6075</td>
</tr>
</tbody>
</table>

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

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 2006q4 to 2011q4 and simulate the evolution of investment if financial conditions were dictated by the dynamics of this index.\footnote{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 results of this simulation are displayed in Figure 4. The dashed line corresponds to the dynamics of $\zeta_t$, 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.

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 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) 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 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 (5) presents the impulse responses of discounts ($\epsilon_t$) and markups after being hit by a financial shock, for two different 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 paper 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 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 6 presents the impulse response of a simultaneous negative financial shock and a positive

\(^{14}\)This is evident by analyzing equation (52) in appendix A.
Figure 5: Response of Discounts and Markups to Financial Shocks (Different Levels of $\psi$)

Notes. The responses are in log deviations from the non-stochastic steady state. The left panel corresponds to changes in $\epsilon_t$ to changes in $\psi$. The right panel corresponds to changes in $$(py - s\eta(0)\epsilon)/y$$ over the marginal cost of $l$.

... 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 Concluding Remarks

Existing models with financial frictions have had difficulty capturing the observed dissonance between improving financial conditions and a weak investment recovery. This paper proposes a mechanism to disentangle these dynamics. When firms are 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, invest-
Figure 6: 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 $\kappa(s)$. 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 $(py - \eta(\theta)e)/y$ 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 $x$.
ment 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.
References


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 \( \{d_t, y_t, n_t, s_t, u_t, k_{t+1}, x_t, b_{t+1}, \varepsilon_t, \theta_t\} \) to maximize the discounted stream of dividends. The firm’s optimization problem is

\[
V (k_t, n_{t-1}, b_t, \Gamma_t) = \max_{\{d_t, y_t, n_t, s_t, u_t, k_{t+1}, x_t, b_{t+1}, \varepsilon_t, \theta_t\}} \quad d_t + \beta \mathbb{E} \left[ V (k_{t+1}, n_t, b_{t+1}, \Gamma_{t+1}) \right]
\]

s.t

\[
(\lambda_1^t) : \quad \pi_t - l_t - \Phi (x_t, k_t) - \kappa (s_t) - \varphi (d_t) + \frac{b_{t+1}}{R} - b_t = 0
\]

\[
(\lambda_2^t) : \quad y_t = f (k_t, l_t, u_t, z_t)
\]

\[
(\lambda_3^t) : \quad y_t = n_t
\]

\[
(\lambda_4^t) : \quad n_t = (1 - \rho^n) n_{t-1} + \eta (\theta_t) s_t
\]

\[
(\lambda_5^t) : \quad k_{t+1} = (1 - \delta (u_t)) k_t + x_t
\]

\[
(\lambda_6^t) : \quad \mu (\theta_t) \varepsilon_t = 1
\]

\[
(\lambda_7^t) : \quad \frac{b_{t+1}}{1 + r} + \varphi_w (l_t + \kappa(s_t)) \leq \xi_t k_{t+1} + \psi \pi_t
\]

taking the exogenous processes for \( z_t \) and \( \xi_t \) as given.

It should be noted that, in line with the competitive search literature, the firm’s decision also involves posting discounts \( \varepsilon_t \) and choosing queue length \( \theta_t \) in each submarket. This requires incorporating, as an additional constraint to the problem, the participation constraint from the household’s problem of equation (5) in the main text.

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

\[ d_t : \quad 1 - \lambda_t^1 \varphi'(d_t) = 0 \quad (27) \]
\[ y_t : \quad \lambda_t^1 p - \lambda_t^2 - \lambda_t^3 \psi p = 0 \quad (28) \]
\[ x_t : \quad -\lambda_t^1 \Phi_x(x_t, k_t) + \lambda_t^5 = 0 \quad (29) \]
\[ l_t : \quad \lambda_t^2 f_l(k_t, u_t, z_t) - \lambda_t^1 - \lambda_t^7 \varphi_w = 0 \quad (30) \]
\[ u_t : \quad \lambda_t^2 f_u(k_t, u_t, z_t) - \lambda_t^7 \delta'(u_t) k_t - \lambda_t^1 \Phi_u(x_t, k_t) = 0 \quad (31) \]
\[ s_t : \quad -\lambda_t^1 \left[ \eta(\theta_t) \varepsilon_t + k'(s_t) \right] + \lambda_t^4 \eta(\theta_t) + \psi \lambda_t^7 \eta(\theta_t) \varepsilon_t = 0 \quad (32) \]
\[ \varepsilon_t : \quad -\lambda_t^1 \eta(\theta_t) s_t + \lambda_t^6 \mu(\theta_t) - \psi \lambda_t^7 \eta(\theta_t) s_t = 0 \quad (33) \]
\[ \theta_t : \quad -\lambda_t^1 \eta'(\theta_t) \varepsilon_t s_t + \lambda_t^4 \eta'(\theta_t) s_t + \lambda_t^6 \mu'(\theta_t) \varepsilon_t - \psi \lambda_t^7 \eta'(\theta_t) \varepsilon_t s_t = 0 \quad (34) \]
\[ k_{t+1} : \quad \beta \mathbb{E}V_k(k_{t+1}, n_t, b_{t+1}, \Gamma_{t+1}) - \lambda_t^5 + \lambda_t^7 \zeta_t = 0 \quad (35) \]
\[ b_{t+1} : \quad \beta \mathbb{E}V_b(k_{t+1}, n_t, b_{t+1}, \Gamma_{t+1}) + \frac{1}{R} \lambda_t^1 - \frac{1}{1 + r} \lambda_t^7 = 0 \quad (36) \]
\[ n_t : \quad \beta \mathbb{E}V_n(k_{t+1}, n_t, b_{t+1}, \Gamma_{t+1}) - \lambda_t^4 + \lambda_t^3 = 0 \quad (37) \]

And the corresponding envelope conditions are:

\[ V_k(k_t, n_{t-1}, b_t, \Gamma_t) = -\lambda_t^1 \Phi_k(x_t, k_t) + \lambda_t^5 (1 - \delta(u_t)) + \lambda_t^2 f_k(k_t, u_t, z_t) \quad (38) \]
\[ V_b(k_t, n_{t-1}, b_t, \Gamma_t) = -\lambda_t^4 \quad (39) \]
\[ V_n(k_t, n_{t-1}, b_t, \Gamma_t) = \lambda_t^4 (1 - \rho^o) \quad (40) \]

First, I will proceed to derive expressions for all multipliers in the model. From equation (27), I have

\[ \lambda_t^1 = \frac{1}{\varphi'(d_t)}. \quad (41) \]
Replacing the expression in (41) into equations (29), (36), (39), (30), (32), and (33), I obtain

\[ \lambda_5^t = \frac{\Phi_x(x_t, k_t)}{\varphi'(d_t)} \]

(42)

\[ \lambda_6^t = \frac{1}{\varphi'(d_t)} \eta(\theta_t) s_t + \psi \lambda_7^t \eta(\theta_t) s_t. \]

(43)

\[ \lambda_7^t = \frac{1 + r}{\varphi'(d_t)} R - (1 + r) \beta E_t \left\{ \frac{1}{\varphi'(d_{t+1})} \right\} \]

(44)

\[ \lambda_2^t = \frac{1}{f_l(k_t, u_t, l_t)} \left( \frac{1}{\varphi'(d_t)} + \lambda_7^t \varphi_w \right) \]

(45)

\[ \lambda_3^t = \frac{1}{\varphi'(d_t)} \left[ \varepsilon_t + \frac{\kappa'(s_t)}{\eta(\theta_t)} \right] + \lambda_7^t \left[ \psi \varepsilon_t + \varphi_w \frac{\kappa'(s_t)}{\eta(\theta)} \right] \]

(46)

\[ \lambda_4^t = \frac{1}{\varphi'(d_t)} \left[ \varepsilon_t + \frac{\kappa'(s_t)}{\eta(\theta_t)} \right] + \lambda_7^t \left[ \psi \varepsilon_t + \varphi_w \frac{\kappa'(s_t)}{\eta(\theta)} \right] \]

(47)

Combining the expression for \( \lambda_5^t \) in (42) with the one in (45) yields

\[ \frac{f_u(k_t, u_t, l_t)}{f_l(k_t, u_t, l_t)} \left[ 1 + \lambda_7^t \varphi'(d_t) \varphi_w \right] = \Phi_x(x_t, k_t) \delta'(u_t) k_t + \Phi_u(x_t, k_t) \]

(48)

Similarly, using \( \lambda_1^t \) and \( \lambda_2^t \) from equations (41) and (45), respectively, and replacing them in the first-order condition for \( y_t \) in (28), results in an expression for \( \lambda_3^t \):

\[ \lambda_3^t = \frac{1}{\varphi'(d_t)} \left[ p - \frac{1}{f_l(k_t, u_t, z_t)} (1 + \varphi'(d_t) \varphi_w \lambda_7^t) \right] + \psi \lambda_7^t p. \]

(49)

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 (35) and the envelope condition (38) combined with the multipliers in (41), (42) and (45). The resulting physical investment equation is given by

\[ \Phi_x(x_t, k_t) = \lambda_7^t \zeta_t + \beta E_t \left\{ \varphi'(d_t) \left[ \left[ 1 - \delta(u_{t+1}) \right] \Phi_x(x_{t+1}, k_{t+1}) + \frac{\Phi_x(x_{t+1}, k_{t+1}) \delta'(u_{t+1}) k_{t+1}}{f_u(k_{t+1}, u_{t+1}, z_{t+1})} - \Phi_k(x_{t+1}, k_{t+1}) \right] \right\}. \]

(50)

Similarly, inserting \( \lambda^3 \) and \( \lambda^4 \) from equations (49), and (46), respectively, into equation (37) and the envelope condition (40) results in the dynamic equation that rules the spending to attract
additional customers:

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

Finally, the pricing equation that specifies the discount granted to new customers is obtained by combining equations (34), (41), (46), and (43), and rearranging terms. The resulting discount equation is

\[
(1 + \psi \lambda_t^7 \varphi'(d_t)) \varepsilon_t = \frac{\gamma}{(1 - \gamma) \eta(\theta_t)} \left( 1 + \varphi_w \lambda_t^7 \varphi'(d_t) \right).
\]

**B Data Description**

**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.
B.2 Compustat Data

I use quarterly data collected from CRSP/Compustat and rating files from the third quarter of 1992 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.\footnote{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.}

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).\footnote{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.}

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 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.\footnote{In order to increase the sample size, when possible real estate was computed by subtracting from the gross value
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×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. 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 (dleq) and long-term liabilities (dlttq) to total assets.

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.)