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Essays on Financial Crises and Misallocation

A dissertation submitted in partial satisfaction of the requirements for the degree of Doctor of Philosophy in Economics

by

Gabriel Roberto Zaourak

2017
The following essays contribute towards our understanding of financial crises and development dynamics. The dissertation is composed of three chapters.

**Chapter one—Lobbying for Capital Tax Benefits and Misallocation of Resources During Credit Crunches**

Corporations often have strong incentives to exert influence on the tax code and obtain additional tax benefits through lobbying. For the U.S. 2007-2009 financial crisis, I show that lobbying activity intensified, driven by large firms in sectors that depend more on external finance. Using a heterogeneous agent model with financial frictions and endogenous lobbying, I study the aggregate consequences of this rise in lobbying activity. When calibrated to U.S. micro data, the model generates an increase in lobbying that matches both the magnitude and the cross-sector and within-sector variation observed in the data. I find that lobbying for
capital tax benefits, together with financial frictions, can account for 80% of the decline in output and almost all the drop in total factor productivity observed during the crisis for the non-financial corporate sector. Relative to an economy without lobbying, this mechanism increases the dispersion in the marginal product of capital and amplifies the credit shock, leading to a one-third larger decline in output. I also study the long run effects of lobbying. Restricting lobbying implies welfare gains of 0.3% after considering the transitional dynamics to the new steady state.

**Chapter 2—Market Power and Aggregate Efficiency in Financial Crises**

In joint work with Fernando Giuliano, we document that during financial crises in emerging economies, large firms become relatively larger and small firms become relatively smaller. What are the aggregate consequences of the resulting increase in market concentration? We answer this question quantitatively with a model where firms are able to exploit their market power through heterogeneous markups. Financial frictions take the form of a collateral constraint that gets tighter during a financial crisis. We discipline the model using detailed plant-level microdata for Colombia, and analyze the transition dynamics of an economy as it adjust to a credit crunch. We find that when firms are able to adjust their markups in response to a credit shock, the response of aggregate output and productivity is dampened. Variable markups act as a buffer that partially offsets the misallocation triggered by a financial crisis. This follows from adjustments at both the intensive and extensive margins.

**Chapter 3—Innovation Effort in a Model of Financial Frictions: The Case of Reforms**

The last chapter is part of an ongoing project to explore the role of innovation as a key
ingredient to capture development dynamics of the growth miracles in the East of Asia. During the second half of the last century those economies carried out a rapid dismantling of distortions affecting the size of firms that led to a reallocation of resources. This, together with a slow financial liberalization, created the conditions for sustained increase in per capital income, an increase of investment rates and improvements in aggregate productivity. Using an environment with financial frictions and resource misallocation in a pre-reform economy, Buera and Shin (2013) were able to capture the first two facts. However, the model delivers counterfactual dynamics for aggregate productivity due to the assumption of exogenous firm level productivity. Extending their framework to allow firms to improve their productivity through innovation, I explore the implications of the interaction between financial frictions, resource misallocation and endogenous innovation.
The dissertation of Gabriel Roberto Zaourak is approved.

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Pablo David Fajgelbaum

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University of California, Los Angeles

2017
To my wife, Rocio,

for her love, patience, and for always guiding me in the right direction.

To my parents, Adriana and Roberto,

for providing me with the tools to succeed, and for teaching me the value of effort.

To the rest of my family, for always believing in me.
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VITA

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Chapter 1

Lobbying for Capital Tax Benefits and Misallocation of Resources During Credit Crunches
1.1 Introduction

Understanding the factors that contribute to large declines in total factor productivity (TFP) during financial crises is key for designing policies that lead to robust recoveries. A growing consensus among economists views resource allocation among firms as an important driver of TFP over time (Oberfield (2013) and Gopinath et al. (2015)). During periods of financial distress, financial frictions can prevent productive firms from operating at the optimal scale leading to misallocation and lower TFP (Khan and Thomas (2013)). In this paper, I show that financial frictions affect lobbying decisions that aim to extract tax benefits, and that this channel is relevant to explaining the changes in TFP observed during financial crises. I focus on tax benefits associated to capital, since those are the most important ones in the tax code.\(^1\)

I make three contributions. First, I document the increase in lobbying activity intended to affect the tax code that occurred during the U.S. financial crisis in 2007-2009.\(^2\) Second, I contribute to the literature that studies the effects of financial frictions on resource allocation and productivity fluctuations over business cycles by quantifying a new channel —lobbying— that interacts with financial frictions and changes the effects of that source of misallocation. Third, I conduct counterfactual experiments to study the long run implications of lobbying.

\(^1\)The U.S. government provide different types of tax breaks to corporations allowing them to reduce their tax burden. The literature has found that the tax code can be influenced through lobbying. Since lobbying entails substantial fixed costs, then large and capital intensive firms can target those benefits to themselves. Special tax provisions for individual firms have been documented by Siegfried (1974), Barlett and Steele (1988) and McIntyre and Nguyen (2004). See Richter et al. (2009) and Arayavenchkit et al. (2014) for a discussion of different tax benefits associated with capital and the endogeneity of the tax code.

\(^2\)Throughout, I will refer to “lobbying to affect the tax code” and “lobbying for capital tax benefits” simply as “lobbying”. In the lobbying data there are 77 issues that firms can choose to lobby for. The one that firms use to try to influence the tax code is Taxation. This is the most important issue in terms of expenditure, and it is the one used in the empirical analysis.
and fiscal reforms.

The main finding of the paper is that lobbying for capital tax benefits amplifies the misallocation that arises due to financial frictions during a credit crunch. The interaction between lobbying and financial frictions generates two opposing effects, one that increases misallocation and one that alleviates the distortions. In the calibrated economy, the first effect dominates. Compared to an economy without lobbying, I find that the lobbying economy amplifies the distortions arising from financial frictions, leading to a one-third larger decline in output.

Using data from Compustat that I match with firm-level lobbying expenditures from the Center for Responsive Politics (CRP), I document three novel facts on lobbying during a financial crisis. First, aggregate lobbying expenditure increased during the crisis. Between 2007 and 2009, the deviation from a linear trend in aggregate lobbying expenditure increased by 15 percentage points. This captures changes in both the extensive (number of firms) and intensive (average expenditure) margins. Second, sectors that depend more on external finance (Rajan and Zingales (1998)), and therefore are more likely to be affected by the shock, drove the increase in lobbying activity. I show that the share of these sectors in total lobbying expenditure increased from 53% in 2007 to 63% by 2010. Third, I use a triple difference approach that exploits variations in time (before and after the shock), firm size (small and large), and external financial dependence (low and high) to show that large firms increased lobbying expenditure relative to small firms, and that this difference is disproportionately larger in sectors that rely more on external finance. In addition, small firms reduced lobbying, and this reduction was larger in sectors that depend more on external finance. This finding
suggests that the crisis affected the incentives of small firms and large firms differently, negatively affecting smaller firms, and favoring larger firms. Since firms in sectors that rely more on external finance are empirically more capital intensive, this has implications for the allocation of the tax benefits associated with capital.

Motivated by this evidence—and the corresponding increase in resources devoted to the corporate sector by the U.S. government during the crisis—I ask whether lobbying reinforces or alleviates the misallocation created by financial frictions when the economy suffers a credit crunch.\textsuperscript{3} To address this question, I introduce lobbying into a standard general equilibrium model in which financial shocks affect the allocation of capital among producers. Lobbying varies across firms according to their financial position and their productivity. Because the credit shock affects the flow of funds among firms, it also has an effect on the decision to lobby. I use the model to quantify the contribution of the lobbying channel to the behavior of TFP and the macroeconomy after a financial disruption.\textsuperscript{4}

The main analysis focuses on the model’s ability to match the data on TFP and output for the non-financial corporate sector. I feed a credit shock into the model to produce the observed decline in the ratio of external finance to capital for the non-financial corporate sector between the end of 2007 and 2010. The calibrated model captures 80\% of the decline

\textsuperscript{3}Here I list some important examples regarding the increase in resources to corporations. Bill H.R. 6049 approved by the House includes extensions of several temporary tax benefits (commonly referred as “extenders”) as well as new tax cuts to corporations. The renewable energy tax incentives in this bill cost a total of $17 billion and the largest is the 3-year extension of the “section 45 tax credit” for the production of energy from renewable resources. As another example, bill H.R. 4853 extended many of the provisions to corporations that are known as “Bush tax cuts”, and created new ones. For more example, see the Tax Relief Act of 2008, among others.

\textsuperscript{4}The adjustments of the economy to financial shocks have been studied by Khan and Thomas (2013), Buera et al. (2015a), and Shourideh and Zetlin Jones (2016), among others.
in output and almost all of the decline in TFP observed in the data by the end of 2009. The model also captures the change in aggregate lobbying expenditure observed during the crisis both at the intensive and extensive margins, and partially captures the increase in the participation of the sectors that rely more on external finance in total lobbying expenditure. Regarding within sectors variation, the model delivers similar patterns as in the econometric framework.

The model I use for the analysis is a continuous time version of the two sector economy in Buera et al. (2011). I augment this framework by introducing a government that grants tax benefits associated to capital that can be partly influenced by endogenous lobbying. Agents are heterogeneous with respect to their productivity and wealth. Productivity is subject to idiosyncratic stochastic shocks, while wealth is determined by saving decisions. Producers face a collateral constraint on the amount of capital they can rent, preventing them from borrowing more than a fraction of their wealth. Production in each sector is subject to decreasing returns to scale and a per-period sector-specific fixed cost, which generates the differences in financing needs across sectors to map the model and the data. A financial crisis in this framework is modeled as an exogenous, unforeseen tightening of the collateral constraint that slowly reverts over time.

Firms choose lobbying subject to variable and a fixed cost that is calibrated to match the fact that only a fraction of firms engage in lobbying. The tax benefit schedule per unit of capital consists of two components. The first component is exogenous and common to all

\[^5\text{Consider the solar energy-specific tax break, the fossil and renewable energy tax break or the research and experimentation tax break. All of these benefits are associated with capital, and as a result are exploited by capital intensive firms.}\]
firms, while the second is endogenous and increasing in lobbying effort. This implies that
the tax benefits that firms receive are heterogeneous and depend on two factors: (i) firms
that use more capital receive more tax benefits; (ii) conditional on capital, firms that pay the
fixed cost receive tax benefits according to their lobbying effort. An implication of the tax
benefit schedule is that lobbying affects the unconstrained optimal size of firms by changing
the choice of capital. Since lobbying generates additional tax benefits per unit of capital,
then unconstrained lobbying firms have incentives to increase the demand for this factor. As
a result, there is a complementarity between lobbying and capital that increases the optimal
firm size.

The tightening of the collateral constraint increases misallocation and unambiguously
lowers TFP. Firms with low net worth and positive productivity shocks become constrained
and have to downsize, reducing the demand for capital. In general equilibrium, the interest
rate falls, and unproductive firms with high net worth expand. Capital reallocates from
productive and constrained firms to unproductive and unconstrained firms.

The interaction between lobbying and financial frictions during a crisis introduces two
opposing effects. On one hand, lobbying increases the misallocation of capital and lowers
TFP. Since lobbying and capital are complementary, the increase in capital by unconstrained
firms is accompanied by an increase in lobbying that reinforces the incentive to use more
capital, amplifying the misallocation. On the other hand, there is a positive effect of lobbying:
it provides additional cash flows that can be used to increase savings for firms that are
financially constrained and choose to lobby. By being able to lobby, these firms can alleviate
part of the misallocation caused by the financial shock by saving part of those resources to
overcome the financing constraint.

In order to understand which of these forces dominates, I study the effect of the increase in distortions coming only from financial frictions. To that end, I analyze the response of a re-calibrated economy without lobbying when it is exposed to the same credit shock. This exercise shows that lobbying amplifies the distortions arising from financial frictions, leading to one-third larger decline in output. Comparing impulse responses across models, the dispersion of the marginal product of capital—a measure of misallocation—increases to 12.6% with lobbying and to 10% without lobbying, all relative to the initial steady state. In addition, the quantitative results show that most of the increase in misallocation as a result of lobbying comes from adjustments at the intensive margin.

The model is also useful for understanding the long run implications of policies that change the structure of the economy. In the first experiment, I study the effects of banning lobbying. Since the tax benefit acts as a subsidy on capital and lobbying changes how much these firms can claim, eliminating this component reduces the incentives to save. Compared to pre-crisis economy, the new steady state output and capital decrease 1.2% and 4%, and TFP increases by 0.8%. What are the welfare implications of this policy? Restricting lobbying implies welfare gains of 0.3% after accounting for the full transition between steady states. Finally, I also consider the implications of a fiscal reform. The experiment implies a removal of all capital tax breaks while at the same time keeping the revenue neutral by reducing the corporate tax rate.

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6The credit shock is re-calibrated in this model in order to match the observed decline in the ratio of external finance to capital for the non-financial corporate sector.

7The capital stock includes the capital used for production plus the fixed costs in this economy.
The rest of the paper is structured as follows. Section (1.2) discusses the related literature. Section (1.3) presents the empirical evidence on corporate lobbying for taxation during U.S. great recession. Section (1.4) lays out the model with financial frictions on the producer side and endogenous lobbying to obtain capital tax breaks. Section (1.5) presents the calibration strategy, both for the steady state and for the shock. Section (1.6) has three parts. First, I study the main quantitative exercises. Then I evaluate the ability of the model to generate the empirical facts shown in section (1.3). Lastly, I discuss the long run implications of lobbying and some policy reforms, with special attention to the effects on TFP and on welfare. Section (1.7) concludes with some final remarks and policy implications.

1.2 Literature Review

This paper fits into a large body of papers that studies the role of financial market imperfections explaining business cycle fluctuations, following Bernanke and Gertler (1989), Kiyotaki et al. (1997), Jermann and Quadrini (2012) and Brunnermeier and Sannikov (2014). I share with papers like Khan and Thomas (2013), Buera et al. (2015a) and Shourideh and Zetlin Jones (2016) the focus on the effects of financial frictions on the allocation of capital at the firm level, especially during a credit crunch. I differentiate my paper by introducing a firm level endogenous mechanism (lobbying) that interacts with the financial frictions, especially during a financial crisis. In addition, the model generates new testable implications at the firm level during those episodes, which closely match the patterns seen in the data.

The paper is also related to the important literature that stresses the role of misallocation
of resources. Restuccia and Rogerson (2008) and Hsieh and Klenow (2009) focused on abstract distortions that affect the allocation of capital and labor across firms to explain the variability in the returns to those factors across countries. They show that the dispersion of marginal products caused by those micro-level distortions are the main drivers of the cross-country differences in TFP observed between the U.S. and developing countries. A derived implication of these studies is that an increase in a factor’s return could be the result of increasing levels of distortions that affect the efficient allocation of resources, which negatively affect TFP. Continuing this line of research, a growing and active literature started to use quantitative general equilibrium models to quantify the amount of misallocation particular frictions can produce and their effects on long run output.\textsuperscript{8}

As in Oberfield (2013) and Sandleris and Wright (2014), this paper focuses on the dynamics of misallocation overt time. Following an approach similar to Hsieh and Klenow (2009), they show that the misallocation of resources across firms accounts for a large portion of TFP losses during a financial crises. Kehrig (2015) documents that the dispersion in revenue productivity in U.S manufacturing increases during recessions, and especially during the last financial crisis.\textsuperscript{9} I relate to this line of research by studying two mechanisms contributing to the increase in the dispersion of the marginal product of capital and revenue productivity: financial frictions and lobbying for capital tax breaks.

\textsuperscript{8}Hopenhayn and Rogerson (1993) studies the effects on misallocation of having firing costs. Peters (2012) studies the implications of variable markups for misallocation and for firm level innovation. An important amount of attention has been devoted to financial frictions, which affects the allocation of capital. Prominent examples are Jeong and Townsend (2007), Amaral and Quintin (2010), Buera et al. (2011), Midrigan and Xu (2014) and Moll (2014).

\textsuperscript{9}Complementary to this finding, Chen and Song (2013) find that the dispersion in the marginal product of capital for Compustat firms is also countercyclical. Since revenue productivity is a weighted average of the marginal product of capital and the marginal product of labor, these findings are mutually consistent.
A closely related paper is Arayavenchkit et al. (2014). They show that lobbying for capital tax benefits is another mechanism that generates dispersion in the allocation of capital using a partial equilibrium model with complete markets. This paper integrates financial market imperfections with lobbying in order to understand whether lobbying amplifies or mitigates the misallocation coming from the credit market imperfection, both in the long-run and during a credit crunch.

The paper is also related to the empirical literature that looks at the cross-section implications of lobbying. This paper confirms most of the cross-section facts and extends our understanding by providing new evidence on lobbying for taxation along the business cycle.\footnote{See Richter et al. (2009), Kerr et al. (2014), Igan et al. (2011), Arayavenchkit et al. (2014), and references therein.} Finally, the paper relates to the theoretical literature on rent-seeking. My contribution is twofold. First, I provide a quantitative model of one type of rent-seeking stressed in that literature (Murphy et al. (1993)), and I evaluate the long run implications. Second, after calibrating the model I quantify the welfare cost of this rent-seeking activity. To my knowledge, this is the first attempt.

### 1.3 Empirical Motivation

This section provides evidence on firm level lobbying activity for taxation issues during a financial crisis. I document four related facts based on the case event provided by the U.S. credit crunch in 2007-2009. In addition to contributing to the understanding of political participation during credit crunches, these facts also provide a guidance to construct the
First, during the crisis, lobbying activity increased substantially along both intensive and extensive margins. Second, effective tax rates (ETR) for both lobbying and non-lobbying firms declined significantly. Consistent with the fact that lobbying firms have lower ETR, the decline after the crisis was more drastic for lobbying firms. Third, the increase in lobbying activity for taxation was driven mostly by industries that depend more heavily on external finance (Rajan and Zingales, 1998). In particular, I show that these industries account for more than 50% of total lobbying expenditure, and that this participation increases during the credit crunch. Finally, I provide evidence of heterogeneity in lobbying behavior within sectors of external finance as large firms increased their lobbying expenditure relative to small firms during the crisis. Furthermore, this relative difference was once again stronger in sectors that depend more on external finance. In fact, small firms in externally financed sectors reduce their lobbying expenditure for taxation issues which is consistent with the idea that small firms should be more affected with the credit shock.

1.3.1 Data and Summary Statistics

In order to follow firms over time for the empirical part of the paper, I name-match lobbying expenditure data with firm level characteristics. In this section, I describe the main features of each dataset and the matching procedure.

Firm level lobbying data is based on more that 1,100,000 lobbying reports that became

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11 According to these authors, these sectors are larger in scale and more capital intensive. As discussed in the introduction, a firm’s capital level is important because most of the tax benefits granted by the government are tied to capital.
available under the lobbying Disclosure Act of 1995. This act, together with the Honest Leadership and Open Government Act (2007) established a set of provisions to be followed by anyone lobbying the federal government at congress. Firms, organizations, or individuals that want to lobby have to file a semi-annual report to the Secretary of the Senate’s Office of Public records (SOPR) including the following information: (i) the name of the client, address and general business description; (ii) the total amount of income or expenditure in the lobbying activity, depending whether it is an in-house or an external lobbyist; (iii) all of the general issues for which they are lobbying.

Firms that are trying to influence the government to modify the tax code and obtain tax benefits targeted to themselves have to declare that they are doing lobbying for taxation, allowing me to focus only on those firms. Finally, since any non-profit organization, individual, or firm can engage in lobbying activity, I clean the original dataset to keep only those observations that correspond to firms. To do this, I scrape the data with text-parsing methods to look for keywords that allow me to eliminate entries that do not correspond to firms. After that, I manually check the remaining observations to eliminate non-profits or

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12 The information is provided by the Center of Responsive Politics (CRP), which collected the data from the Senate Office of Public Records. Data is available upon request at [www.opensecrets.org/lobby/](http://www.opensecrets.org/lobby/).

13 A lobbyist is any individual who is employed or under a contract to lobby on behalf of a client. An In-House Lobbyist is an employee hired by an organization to lobby for them. An External Lobbyist is typically an organization or person that works under a contract for the lobbying organization. Organizations could be one of 3 types: non-profit associations, firms, or groups of individuals. The Lobbying Disclosure Act defines “lobbying activity” as lobbying contacts and efforts in support of such contacts, including preparation and planning activities, research and other background work that is intended, at the time it is performed, for use in contacts, and coordination with the lobbying activities of others”.

14 There are 77 issues such as trade, taxes, agriculture, etc. A list of all the issues can be found here: [www.opensecrets.org/lobby/alphabetical_issue.php](http://www.opensecrets.org/lobby/alphabetical_issue.php). In appendix 1.9 I include an example of a form filed by a lobbying firm.
individuals. The final dataset contains information from 2000 to 2014. However, for most of the analysis I restrict my attention to the period 2004-2014.

Financial data by parent firm is primarily taken from Compustat North America. This dataset contains information on publicly traded companies in the United States, including sales, employment, industry classification, assets, and useful information to compute effective tax rates, which I describe below. The balance sheet presentation in Compustat is consolidated at the parent level. This is a problem, because a single organization could have more than one entry. To deal with this issue, I aggregate the information at the ultimate owner using parent-subsidiary identifiers from the NBER patent data project to assign each entry from Compustat to one unique parent. In addition, I also use the dataset ORBIS compiled by the Bureau van Dijk Electronic Publishing (BvD) to check Parent-subsidiary relationships. After obtaining these relationships, I name-match the lobbying data with Compustat using “open refine”, which provides a reconciliation service that uses a probabilistic matching algorithm to pair entries between the two datasets. Data on external financial dependence of 63 2-digit SIC sectors is computed with data from Compustat. To construct this measure (proposed by Rajan and Zingales (1998)), I follow the methodology described in Cetorelli and Strahan (2006). External financial dependence is defined as the fraction of capital expenditure that is not financed with internal cash flows from operations. A positive value implies that a firm must use external sources of funds to finance investment, while a negative value indicates that firms have enough cash flows to fund investments. Appendix (1.9.4) contains

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15 See the Data appendix for a description of the procedure, including the keywords used to eliminate observations.

16 Open refine is available at www.openrefine.org. See Appendix 1.9.2 for additional details of the procedure.
the method used to construct the index and the measure of external financial dependence for each sector.

According to Rajan and Zingales (1998), the external finance measure varies across industries due to technological factors affecting initial project scale, gestation period, the cash harvest period, and the requirement for continuing investment. Consequently, these technological factors determine the demand for external financing and as a result, industries like metal mining or oil and gas extraction—heavily dependent on external finance—should be more affected by a credit shock than industries like leather. For the remainder of the paper, I exclude the financial sector and the agricultural sector.

Later in the paper, I will classify firms into two broad sectors: those producing in sectors that rely more on external finance and those producing in sectors that depend less on external finance. The former includes all the 2-digits SIC sectors with a measure of external financing need below 0. The rest of the sectors will be categorized as sectors that rely more on external finance.

Lastly, to compute effective tax rates I also use data from Compustat. To compute this measure, I use the definition provided by Gupta and Newberry (1997) and used in Richter et al. (2009) and Arayavenchkit et al. (2014). The effective tax rate for each firm is computed as

\[
ETR = \frac{Income\ Taxes\ Current}{Pre\ Tax\ Income - Equity\ in\ Earnings - Special\ Items + Interest\ Expense}.
\]

The numerator is a measure of how much a firm paid in taxes, while the denominator computes the taxable income coming from balance sheet data. In general, the effective tax
rate will be below the statutory corporate tax rate of 35%.\footnote{Appendix 1.9 contains information related to the computation of this variable and details about other measures from compustat.} In the next section, I discuss this feature in details.

**Cross-Section Facts and Summary Statistics**

In this subsection I briefly describe the data and I provide some summary statistics. The raw data after matching Compustat and the CRP data for corporations gives a total number of 46831 firm-year observations. Between 2004 and 2014, 1544 firms lobbied for some of the 77 issues in at least one year. From those observations, there are 567 firms that lobbied for taxation issues at least one time between 2007 and 2014. The low participation of public firms in lobbying activity has been previously documented by Richter et al. (2009) and others. For this sample, the average fraction of lobbying firms is 8.9%. As shown in table (1.1) lobbying for taxation is the most important issue in terms of expenditure between 2004-2014. In fact, it is the top lobbying issue in each individual year of this sample. This ranking by issues is consistent with evidence provided by Kerr et al. (2014) and Arayavenchkit et al. (2014) for different periods of time, which show that taxation is the most relevant issue for lobbying.

Table (1.2) shows summary statistics for firms lobbying for taxation issues in at least one year in the sample and for firms that did not lobby for taxation issues at all. The table also displays the well documented feature that lobbying firms are larger than non-lobbying firms. For example, the data shows that sales are almost 6 times larger for lobbying firms. This is also true for capital (12 times), assets (1.8 times) and employment (7 times). Another fact consistent with previous work is that lobbying expenditures are relatively small. For
the sample, the average lobbying expenditure in the sample is close to $0.27 million with a standard deviation of 0.7 million. Considering that the returns for lobbying are thought to be quite large, the fact that lobbying firms are so few and that they spend so little money remains a puzzle for political scientists.

Table (1.2) also shows one of the key findings in this literature: lobbying firms pay lower effective tax rates. The tax code in the U.S. allows corporations to claim tax benefits, reducing their tax burden. According to the Government Accountability Office (GAO), in 2011 a third of the corporate tax revenue was lost in tax benefits rebated to corporations. In fact, special tax provisions for individual firms have been documented by Siegfried (1974), Barlett and Steele (1988) and McIntyre and Nguyen (2004). Consistent with this anecdotal evidence, Richter et al. (2009) and Arayavenchkit et al. (2014) have shown that firms that lobby for taxation issues pay lower effective taxes as a result of tax benefits targeted to them. The mechanisms through which firms obtain favorable tax benefits are the existence of narrow research and development credits, tax depreciation schedules tailored to specific types of capital and thorough numerous industry-specific tax breaks related to capital.18

Based on this discussion, I compute the effective tax rates for lobbying and non-lobbying firms for the sample. The average effective tax rate for lobbying firms is 18.8%, while the average effective tax rate for non-lobbying firms is equal to 21.4%.

18 The fairness and implications of a system that grants tax benefits to corporations is a theme of continuous debate in the media and the political arena. See for example CNN Tax breaks. The concern for the existence of lobbying corporations has also been remarked by the president of the United States in the State of the Union speech in 2011.
1.3.2 Evolution of Lobbying Expenditure and Tax Rates

Now I turn my attention to aggregate patterns in the data for lobbying for taxation, focusing on the 2007-2009 credit crunch. I document that during the last U.S. credit crunch there is an unusual increase in lobbying activity for taxation, which holds at both extensive and intensive margins.\textsuperscript{19} Figure (1.1) shows the evolution of aggregate lobbying expenditure for taxation between 2001 and 2014 as percentage deviation from linear trend.\textsuperscript{20} By 2009 lobbying expenditure deviates 15\% from trend suggesting an exacerbation of rent-seeking activity during this time. As mentioned before, this rise is due to the increase in the number of lobbying firms and the increase in the average expenditure that each firm is doing for that purpose. Between 2004 and 2007, on average 7.1\% of firms in Compustat lobby for taxation, while for the period 2008-2011 the average fraction of firms was 10.35\%, indicating an increase in lobbying activity on the extensive margin. The intensive margin follows a similar pattern. For the period 2004-2007, the average lobbying expenditure was $0.26 million, but for the period 2008-2011 it increased to $0.31 million. If we look at deviations from trend, we see a similar pattern. Figure (1.2) displays the evolution of the intensity of lobbying relative to the linear trend, and as expected there is an important increase in the values observed during the period in study. This data raises a natural question: why do we observe such an increase in lobbying activity to influence the tax code?

One possible reason could come from the increase in rents that corporations can extract.

\textsuperscript{19}Unless otherwise noted, I will refer to “lobbying for taxation” as simply lobbying.

\textsuperscript{20}Lobbying variables are deflated by the CPI with 2007 as base year. I use a linear trend since there is not enough data available to apply a Hodrick- Prescott filter. This result is robust to a quadratic trend. Results upon request.
Evidence provided by the Government Accountability Office (GAO, 2013) shows that between 2007 and 2010 the amount of tax benefits that the government granted to corporations increased from 0.6% of the GDP to 1.2%. Even though we cannot argue that the government increased those resources due to the corporate pressure, we can certainly think that the allocation of some of those funds among firms was influenced by corporate lobbying.

If lobbying affects the tax code and benefits certain firms and sectors, we should observe that lobbying firms reduce their effective tax rate as a result of the increase in lobbying activity during the crisis. In order to show this feature in the data, I compute the average effective tax rate for lobbying and non-lobbying firms in my sample. The results between 2007 and 2014 are displayed in Figure (1.3). The figure shows that both groups of firms saw declines in tax rates. However, those that engaged in lobbying obtained a bigger decline, consistent with the increase in lobbying activity.

To test whether the tax rates of lobbying and non-lobbying firms diverged during the crisis, I run the projection of firm level effective tax rates on time dummies $\beta_t$, the interaction of those dummies with and indicator for lobbying for firm $i$ in period $t$, and industry fixed effects $ind_s$,

$$ETR_{it} = \sum_{t=2007}^{2014} \beta_t + \sum_{t=2007}^{2014} \beta_t\text{lobby}_{it} + ind_s + \epsilon_{it}$$

The coefficient for the interaction term of this regression with the confidence bands are plotted in figure (1.4). The figure shows the evolution of the difference between the effective tax rate for non-lobbying firms and lobbying firms. As with figure (1.3), we see that there
is an increase in the difference between the tax rate paid by lobbying firms and the non-lobbying firms during the crisis. This indicates that, in a statistical sense, lobbying firms had a decline in effective tax rates relative to non-lobbying firms.

1.3.3 Sectoral variation

In this section, I provide evidence that the increase in lobbying activity was mostly driven by a particular group of firms. In principal, it is not clear which type of firms should increase their lobbying activity during the financial crises. Previous work by Rajan and Zingales (1998) has shown that there are sectors that are more sensitive to variations in the supply of credit due to the reliance on external finance. It is natural to think that these sectors (and firms) would be more affected during a credit crunch and therefore would try to disproportionately influence the government to obtain tax benefits. To study this hypothesis I look at the lobbying expenditure of all firms in sectors that depend more on external finance as a share of total lobbying expenditure, focusing on taxation. I find that those firms tend to lobby more, both in the cross section and over time. Additionally, these firms increased their lobbying activity the most during the recent crisis. Figure (1.5) illustrates these two facts. The participation in total lobbying expenditure for taxation of the industries that rely more on external finance went from 53% at the bottom of 2007 to 63% at the peak of the time period, and coinciding with the crisis. Consistent with the fact that lobbying reduces the tax obligation, figure (1.6) shows the effective tax rates as a function of the Rajan and Zingales measure of financial dependence. The figure reveals that sectors that are more capital intensive and exert more lobbying tend to have a lower tax rate.
The evidence provided in these graphs, in principle, supports the original hypothesis: sectors and firms that are in more trouble tend to lobby more the government to try to obtain preferential tax treatment. However, it is not clear ex ante whether large or small firms were responsible for the increase in lobbying during the crisis. On one hand, small firms are more likely to be affected by monetary or financial shocks, especially in those sectors that depend more on external finance. Following this argument, we should observe that these firms increased lobbying activity. On the other hand, large firms may have the necessary political connections or resources to spare during a crisis (Faccio (2006) and Faccio et al. (2006)). In the next section, I study this issue more closely.

1.3.4 Within Sector Variation

In the previous section, I established that the increase in lobbying activity observed during the 2007-2009 financial crisis was driven by firms in sectors that depend more on external finance. These sectors are therefore more likely to obtain tax benefits targeted to them.

In order to understand which firms are behind the increase in lobbying activity, I use a triple difference approach to show the differential effect of the credit shock across sectors with different degrees of external dependence, accounting for differences in size. The econometric specification is the following:

\[ \text{specification is the following:} \]

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21 Gertler and Gilchrist (1994) find that the growth in sales, inventories, and bank debt of small manufacturing firms are more affected by monetary shocks. Sharpe (1994) found that small firms have a disproportional response, relative to large firms, to financial shocks. Using CPS data Duygan-Bump et al. (2015) find that the 2007-2009 credit shock increased the probability of going to the unemployment pool for workers in small firms in sectors that depend more on external finance.
\[ \text{lobby}_{sit} = \delta_0 + \delta_1 \text{SME}_{sit-1} + \delta_2 T_t + \delta_3 \text{Fdep}_{si} + \delta_4 (SME_{sit-1} \times Fdep_{si}) + \delta_5 (Fdep_{si} \times T_t) \] 
\[ + \delta_6 (SME_{sit-1} \times T_t) + \delta_7 (SME_{sit-1} \times Fdep_{si} \times T_t) + X'_{sit} \beta + \omega_{st} + \epsilon_{sit}, \]

where \( \text{lobby}_{sit} \) is the log of lobbying for taxation of a firm \( i \) in sector \( s \) at period \( t \) (lobbying intensity).

The variable denoted by \( \omega_{st} \) is a set of industry-state fixed effects that controls for industry-state time invariant observable and unobservable factors affecting the lobbying decision of firms. On the other hand, \( X_{sit} \) is a vector of firm level characteristics measured in \( t - 1 \). This vector includes assets, sales, and capital.

In the proposed regression, the three key variables are \( T_t \), \( SME_{t-1} \) and \( Fdep_{si} \). Following the recommendation of the Trade Commission, I assign the label \( SME \) to those firms with less than 500 employees. According to this definition, I construct the dummy variable \( SME_{it-1} \) that takes a value of 1 if the firm in the previous period was considered a small-medium firm. This variable captures the fact that lobbying intensity is different in the cross section depending on size. The variable \( T_t \) is an indicator that takes a value of 1 in the years 2008-2010 and 0 between 2005-2007. This allows me to focus on a 3 year window around the crisis. Finally, \( Fdep_{si} \) is an indicator variable that takes a value of 1 for firms in sectors that depend more on external finance and 0 otherwise. This variable allows me to account for the differences in lobbying observed across sectors based on financial needs.

To study the effect of the financial crisis on the incentives of corporations to lobby, I
also include all the interaction terms between the main three variables. The coefficient $\delta_6$ captures the effect of the crisis on lobbying for small firms relative to large firms in industries with low external financial dependence (this is the difference-in-difference coefficient). On the other hand, the coefficient $\delta_7$ measures how much small firms relative to large firms are affected in sectors that depend more on external finance on top of the effect found in sectors with low external financial dependence. This estimate uses variations in three margins: time (before and after the crisis), firm size (small vs large), and external financial dependence (low and high).

I estimate equation (1.1) using an ordinary least squares regression on a balanced panel of 3402 parent companies and 20412 firm-year observations. To evaluate the significance of the coefficient, I cluster the standard errors by state and industry to allow for correlations among firms in the same industry and state. The results of the estimation of equation (1.1) are displayed in table (1.3). To simplify the exposition, I show the results based on size and financial dependence along the columns. An important first observation is that large firms in both sectors increased lobbying activity during the crisis, and large firms in sectors with high external dependence had a higher increase. In addition, small firms in industries with high external dependence reduce the amount of lobbying relative to pre-crisis. It follows that the difference between large and small firms in both sectors increased with the crisis, indicating that the observed rise in aggregate lobbying is driven by large firms.\textsuperscript{22}

The second observation to notice is that this increase in lobbying intensity by large firms

\textsuperscript{22}The negative value is due to the dummy $SME$ being an indicator for small and medium firms. A negative value means that small firms are reducing the intensity of lobbying relative to large firms, so large firms are doing relatively more.
relative to small firms is larger in sectors with high external dependence. This is shown in the second row. Finally, the third row of the table is the triple difference (DDD) estimate, or simply $\delta_7$. This estimate indicates that the relative effect of the crisis for large and small firms on lobbying in the second sector (high dependence) is 0.18 percentage points bigger than in the first sector (low dependence). In other words, large firms relative to small firms increased an additional 0.18% over the relative increase of large and small in the first sector.

Similar results are obtained by looking at the probability of starting to lobby during the crisis rather than the intensity. For this specification, I replace $\text{lobby}_{sit}$ by and indicator function that takes value of 1 if the firms $i$ in sector $s$ at period $t$ is lobbying and 0 otherwise. The results of this regression are displayed in table (1.4). The results are similar in sign to the ones obtained in table (1.3).

All of these results are consistent with the idea that large unconstrained firms are wealthier and have more resources to spare during the crisis in order to extract more rent. On the other hand, small firms, especially those in sectors more affected by the shock, have more trouble operating during these episodes and have to reduce their expenditure on lobbying.

The results presented in this section provide a set of useful guidelines for a model that attempts to explain the effect of lobbying on the economy. First, given the fact that only a small fraction of firms are doing lobbying, I propose a model with endogenous lobbying decision subject to a fixed cost required to influence the government. In this way, since lobbying entails fixed costs, larger and wealthier firms will be the ones engaging in this activity. Second, given that I observe that sectors that depend more on external finance tend to lobby more, I will have an economy with two sectors that will have differences in
their scale of production to capture the differences in financing needs. Third, given that I observe a different response to the crisis based on size and the sector of operation of each firm, I will allow for firm level heterogeneity in terms of productivity and wealth, that together with decreasing returns to scale generate the different impulse responses of lobbying. Finally, and related to the previous point, I will introduce financial frictions in the form of a collateral constraint. This assumption will allow me to hit the economy with a credit supply shock that will have different effects on firms of different sizes and producing in different sectors.

1.4 The Model

In this section, I present a model in which the misallocation of capital arises endogenously due to the existence of financial market imperfections and lobbying for capital tax benefits. The aim of the model is to measure to what extent the proposed mechanisms explain the dynamics of total factor productivity and output, as well as understand the implications for economic recovery during a credit crunch. To this end, I propose a variant of the standard span of control framework of establishment size as in Lucas (1978) extended to allow for financial frictions following Kiyotaki and Moore (1997), Albuquerque and Hopenhayn (2004) and Buera et al. (2011). I depart from those papers in the following way: (i) there is a government that collects taxes and grants capital tax benefits to firms, (ii) firms can choose to lobby the government to receive preferential treatment and obtain more tax benefits that reduce the tax burden, and (iii) because lobbying is costly, firms have to decide whether to pay a fixed cost to engage in lobbying activity or just receive the common component of the
tax benefit. In order to capture the observed differences in external financial dependence across sectors, I introduce sector specific fixed costs as in Buera et al. (2011).

1.4.1 Environment

Time is continuous. There are two intermediate goods, which are the only factors of production required to produce a single final good. The economy is populated by a unit mass of infinitely-lived households/agents that have a homogeneous endowment of time to be used either as a worker or in running a firm. I assume that a fixed measure $q$ of the population has the ability to produce in sector 1 (type 1 agent), and a fraction $1 - q$ has the ability to produce in sector 2 (type 2 agent).23

Individual preferences are described by the following expected utility from consumption of the final good $C_{st}$

$$\mathbb{E}_0 \int_0^\infty e^{-\rho t} u(C_{st}),$$

(1.2)

where $\rho \in [0, 1]$ is the impatience rate and $s \in \{1, 2\}$ denotes the type of agent. The instantaneous utility function $u(C_{st})$ is isoelastic with the inverse elasticity of intertemporal substitution equal to $\theta$

$$u(C_{st}) = \frac{C_{st}^{1-\theta}}{1-\theta}.$$

Agents of type $s \in \{1, 2\}$ are heterogeneous with respect to their productivity to produce

23This is an extreme version of Buera et al. (2011). In their paper, agents have a pair of productivities that come from independent draws from the same distribution. Each productivity is used to produce in one sector. Given those draws, they select into one of those sectors based on which productivity generates higher income. To simplify my quantitative part, I assume only one productivity and I separate agents on types.
and with respect to their financial wealth $a_{st}$. The evolution of the ability is determined stochastically. When born, each agent receives an ability coming from an invariant distribution $G_s(z)$, which evolves based on a continuous time analog of a Markov process

$$dz_{st} = \mu(z_{st})dt + \sigma(z_{st})dW_{st},$$

where $W_{st}$ is a Wiener process, $\mu(z_{st})$ and $\sigma(z_{st})$ are the drift and diffusion of the process respectively. Given an initial level of wealth when born, the evolution of this variable is determined in general equilibrium as an outcome of savings decisions. In this economy, savings take the form of risk-free claims on physical capital. As discussed below, savings will serve two purposes: as self-insurance against idiosyncratic shocks, and as a collateral to finance working capital requirements. As in Aiyagari (1994), agents also face a borrowing constraint, which implies that $a_{st} \geq 0$ at each point in time.

At the beginning of the period, an agent of type $s$ chooses his occupation based on his productivity $z_{st}$ and his wealth $a_{st}$. They can work for a competitive market wage $w_t$ or they can operate the technology in sector $s$ for a profit $\tilde{V}_s^p$. To operate in sector $s$, agents have to pay a fixed cost $f_s$ in units of capital every period. This fixed cost is specific to each sector, and I assume that $f_1 < f_2$. This assumption is motivated by the fact that capital intensity is higher in sector 2, and it helps to map the theory with the data in terms of financial dependence. After paying the fixed cost, the technology available in sector $s$ is given by a decreasing return to scale technology in labor and capital, adjusted by productivity or ability.
The production of the final good used for consumption, investment and lobbying is generated by a set of competitive firms that use the two intermediate inputs denoted by $y_{1t}$ and $y_{2t}$. These two inputs are combined using a constant returns to scale technology,

$$Y = \left[ \gamma y_{1t}^{1-\epsilon} + (1 - \gamma) y_{2t}^{1-\epsilon} \right]^{\frac{\epsilon}{1-\epsilon}}, \quad (1.5)$$

where $\gamma \in (0, 1)$ and $\epsilon \in [0, \infty)$. All producers in this sector are homogeneous with respect to productivity, and they are not subject to financial constraints. The problem of these firms can be reduced to the following relationship coming from the first order condition:

$$y_{1t} = \left[ \frac{p_2}{p_1} \frac{\gamma}{1 - \gamma} \right]^{\frac{\epsilon}{\epsilon - 1}} y_{2t}. \quad (1.6)$$

Finally, there is free entry in the sector, and therefore zero profits. If this is the case,

$$P = \left[ p_1^{1-\epsilon} \gamma^{\epsilon} + (1 - \gamma)^{\epsilon} p_2^{1-\epsilon} \right]^{\frac{1}{\epsilon - 1}}. \quad (1.7)$$

From now on, we assume that the final good is the numeraire of the economy.

The economy features two mechanisms affecting the intermediate producers that distort

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24This assumption implies that there is an optimal size for firms, and it is a way of introducing a meaningful firm size distribution. Alternatively, one could choose to work with monopolistic competition and constant returns to scale.
the economy in steady state, and especially during a credit crunch. The first one is related to financial frictions, which restrict how much capital an agent running a firm can borrow. The second one is the existence of capital tax benefits and the possibility to lobby the government to obtain preferential tax treatment. I describe them separately. After that, I describe the problems and constraints involved in the economy in detail.

**Financial Markets**

In this economy, productive capital is the only asset. There is a perfectly competitive financial intermediary that receives deposits and rents capital to firms. The return on the deposits is given by the interest rate $r_t$. The zero profit condition of the financial intermediary implies that the rental rate is equal to the user cost of capital: that is $R_t = \frac{r_t + \delta}{1 - \tau}$ where $\delta$ is the depreciation rate of the economy and $\tau$ is the tax rate that the government charges on operating income.\(^{25}\)

Capital rented $k_{st}$ has to be returned at the end of the period, and due to the existence of limited commitment, the amount of capital that the firm can rent is partly determined by wealth. This assumption implies that agents running the firm are subject to a collateral constraint of the form $k_{st} \leq \lambda_t a_{st}$, where $\lambda_t \geq 1$ summarizes the credit constraints in the economy.\(^{26}\) A low value for $\lambda_t$ is associated with low access to credit. In particular, in the

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\(^{25}\)The structure of the rental market is standard in the financial friction literature. See Buera and Shin (2011), Blaum (2013), Midrigan and Xu (2014) and Moll (2014) among others. Moll (2014) shows that this representation is equivalent to having a firm owning capital in a model with financial frictions and no government. Appendix 1.10.3 shows that this equivalence continues to hold when the government collects taxes and grants capital tax benefits. The proper rental rate emerges from this problem.

\(^{26}\)A way to rationalize the constraint is the following: firms have access to a competitive financial intermediary who receives deposits and rents capital to firms. In this economy, lending directly to firms is not possible. After the production process, the firm could default on its loan with probability $\frac{1}{\lambda}$, and if they do that, they keep the remaining undepreciated capital stock. On the other hand, the financial intermediary
case where $\lambda_t = 1$ firms have to self-finance all their capital rental and therefore there is a strong incentive to save in order to allow production. On the other extreme, when $\lambda_t \to \infty$ there are perfect capital markets. In this case, saving decisions are independent of production decisions and the only motive for saving in this economy is consumption smoothing.

**Lobbying For Capital Tax Benefits**

The second source of distortion comes from the existence of capital tax benefits that can be influenced through lobbying. As a result, corporate lobbying distorts the allocation of this input relative to an economy where the government does not offer these type of tax benefits.

After selling in the market, firms have to pay a tax rate $\tau$ on operating income. However, the government grants tax benefits associated with capital that allow firms to reduce their tax burden. Before production, operating firms in each sector can decide to engage in lobbying activity by paying an upfront cost in units of capital $f_l$. As discussed by Kerr et al. (2014), this cost could include the initial cost of searching for and hiring the right lobbyist, educating these new hires about the details of the firm’s interest, or finding out which legislature should be targeted.\footnote{Paying the upfront cost $f_l$ gives firms the ability to influence the government through costly lobbying in order to get tax benefits tailored to them. The cost of lobbying represents all the variable costs that firms have to pay in order to contact legislators at}

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\footnote{From a modeling point of view, the fixed cost $f_l$ is introduced to capture the empirical fact that only a fraction of public firms are engaging in lobbying for taxation issues as we saw in section 1.3. Bombardini (2008) also used fixed costs to rationalize this fact in the context of international trade.}
congress, and it is assumed to be given by

\[ \Upsilon(e_{st}) = he_{st}, \]  

(1.7)

where \( e_{st} \) is the lobbying effort of an agent of type \( s \) in period \( t \), and \( h > 0 \). As in Arayavenchkit et al. (2014), tax benefits are composed of two parts: 1) A part that is standard and applies to all firms, even those that did not pay the fixed cost \( f_i \); 2) A second part that is influenced by lobbying effort \( e_{st} \), which is only available to firms that are paying \( f_i \). Furthermore, given that most of the tax benefits that the government grants are associated with capital, the tax benefit schedule depends positively on the capital used by the firm. Taken together, the tax benefits is given by

\[ \bar{\tau}(k_{st}, \phi, e_{st}) = (1 - \tau) k_{st} (\mu e_{st}^\nu + \phi). \]  

(1.8)

The term \((1 - \tau) k_{st}\phi\) captures the returns that all firms are getting without any expenditure on lobbying. However, if they do decide to hire a lobbyist, firms obtain preferential treatments that is increasing in the lobbying effort \( e_{st} \). The amount of benefits per unit of lobbying depends on two parameters: the parameter \( \nu \in (0, 1) \), which is the elasticity that maps lobbying effort into changes in the tax benefits (and therefore the effective tax rate);

\[ 28 \text{Compared to that paper, I use a modified version of the tax benefit schedule. In their paper, they do not have this fixed cost and the government selects who is receiving the tax benefits based on the amount of lobbying expenditure. As a result, there is a cutoff lobbying effort such that if you can not reach that level you will not spend resources in equilibrium. In addition, they provide a partial equilibrium analysis without financial frictions and with differences in the timing of decisions.}

\[ 29 \text{We can think of } \phi \text{ as tax advantages that were introduced when the statutory tax on firms was set. The scaling by } 1 - \tau \text{ allows me to keep tractability when solving the problem of a lobbying firm.} \]
and the parameter $\mu$, which is a scale parameter.

In order to be consistent with the fact that the effective tax rates are bounded from below, the amount that firms can claim as tax benefits on capital are at most a fraction of the tax obligation with the government. Therefore, firms incorporate the following constraint when taking production and lobbying decisions:

$$(1 - \tau) k_{st} (\mu e_{st}^\nu + \phi) \leq \Theta \tau \tilde{\pi}_{st},$$

where $\tilde{\pi}_{st}$ is the operating income to be defined below and is a positive scale parameter.

1.4.2 Intermediate Firm

Now that we are familiar with the distortions affecting the operation of intermediate firms, we focus on their optimization problem. The timing of events is as follows: 1) conditional on running a firm in sector $s$, the agent has to decide whether or not to lobby the government by paying the fixed cost $f_l$; 2) the rental market opens, production is decided and lobbying takes place for those that paid the fixed cost. In equilibrium, and given the fixed cost of lobbying $f_l$, there is selection into lobbying activity depending on the flow of income generated in that activity. Next, I formulate and solve the problem of an intermediate firm for each case.

Lobbying Firm

Suppose the agent of type $s$ has decided to produce in sector $s$. Given his productivity and wealth, $(z_{st}, a_{st})$, the profit when a firm is engaging in lobbying activity is a slight modification
of the standard problem of a firm facing financial frictions. First, define pretax income by

\[ \tilde{\pi}_{st} = \left[ p_{st} y_{st} - w_{it} l_{st} - R_t (k_{st} + f_s) \right], \]  

(1.10)

where \( y_{st} = z_{st} \left( k_{st}^{1-\alpha} \right)^{\eta} \). After producing and selling the output, firms have to pay a statutory tax \( \tau \). However, this tax burden is reduced by the capital tax benefit \( \bar{\tau}(k_{st}, \phi, e_{st}) \) that depends on the lobbying effort \( e_{st} \). As described at the beginning of this section, the amount of capital tax benefits that a firm can claim is subject to the inequality (1.9). Putting everything together, the problem to solve is the following

\[
\pi^{lob}(a_{st}, z_{st}, \Omega_t) = \max_{k_{st}, l_{st}, e_{st}} (1 - \tau) \tilde{\pi}_{st} + (1 - \tau) k_{st} (\mu e_{st}^{\nu} + \phi) - h e_{st} - f_l R_t
\]

\[ s t \quad k_{st} + f_s + f_l \leq \lambda a_{st} \]

\[ 0 \leq \ominus \tau \tilde{\pi}_{st} - (1 - \tau) k_{st} (\mu e_{st}^{\nu} + \phi). \]

Here, \( \Omega_t \) is the set of aggregate variables that the firm takes as given when making decisions, and \( \pi^{lob}(a_{st}, z_{st}, \Omega_t) \) is the profit obtained after lobbying.

**Non-Lobbying Firm**

Suppose the agent of type \( s \) has decided to produce in sector \( s \). Given his productivity and wealth, \((z_{st}, a_{st})\), the profit when the firm is not participating in lobbying activity is almost identical to the previous one. However, because firms are not spending resources on lobbying activity, the reduction in the tax burden is given by \( \tilde{\tau}(k_{st}, \phi, 0) = (1 - \tau) k_{st} \phi \). Considering
this result, the problem for a non-lobbying firm is

\[ \pi^{nlob}(a_{st}, z_{st}, \Omega_t) = \max_{k_{st}, l_{st}} (1 - \tau) \left[ p_{st} y_{st} - w_{lt} l_{st} - R_t (k_{st} + f_s) \right] + \bar{\tau}(k_{st}, \phi, 0) \]

\[ \text{st } k_{st} + f_s \leq \lambda a_{st} \]

\[ 0 \leq \Theta \tau \bar{\pi}_{st} - (1 - \tau) k_{st} \phi, \]

where \( \pi^{nlob}(a_{st}, z_{st}, \Omega_t) \) is the agent can obtain if he is not doing lobbying.

**Discussion: Interaction Financial Frictions, Capital Tax Benefits and Lobbying**

The existence of financial frictions, capital tax benefits and lobbying have implications for the allocation of capital in the economy (misallocation). Additionally these factors have the potential to alter occupation choices, introducing a second channel of distortion. Below, I discuss each margin.

In order to understand the key mechanisms that produces misallocation of capital, it is useful to resort to the first order condition.\(^{30}\) Letting \( \delta^* \) be the lagrange multiplier on the collateral constraint we have,

\[
[k_{st}] \quad MPK(k_{st}) = [R_t - \mu \epsilon_{st}^\nu - \phi] + \frac{\delta^*_{st}}{(1 - \tau)}, \quad (1.11)
\]

\(^{30}\)The complete set of first order conditions and derivations can be found in appendix 1.10. Here, for simplicity, I assume that the collateral constraint on the tax benefits that firms u can claim is not binding. For the calibrated version of the model, this constraint is not relevant for most of the firms.
Following Hsieh and Klenow (2009), there is capital misallocation when the marginal product of capital ($MPK$) is not equal to the rental cost cost capital $R_t$. In the right hand side of (1.11) we have the three mechanisms at play: the financial frictions (in red), the existence of capital tax benefits (in blue) and lobbying for those benefits (in green). I first describe the effects having only financial frictions, and then I add each mechanism individually to reach all the elements of the right hand side of equation (1.11).

**Only Financial Frictions** In an economy where there are no tax benefits and firms can not lobby the government, the first order condition for capital is given by,

$$MPK(k_{st}) = R_t + \frac{\delta_{st}^*}{(1 - \tau)}.$$  
(1.12)

As is well known, the existence of financial frictions distorts the allocation of capital across firms. The key insight from the misallocation literature is that higher dispersion in the marginal product of capital indicates higher degree of misallocation of that factor. In other words, a reallocation of capital from unproductive and wealthy firms towards productive and constrained firms would allow a higher level of output, keeping the level aggregate capital constant. The distortion in the allocation of capital can be inferred from the presence of the lagrange multiplier $\delta_{st}^*$ in equation (1.12). For a given level of productivity, a firm that is financially constrained has a strictly positive multiplier $\delta_{st}^*$. This means that the $MPK$ is higher relative to a firm with the same productivity that has enough wealth to operate at the optimal scale of production. As a result, constrained firms have a lower level of capital, labor, production and profits other things equal. A reallocation of capital from firms with
Financial Frictions and Capital Tax Benefits Now, as a second step, suppose the economy has tax benefits but it does not allow for lobbying. The first order condition in this modified version would be

\[
MPK(k_{st}) = [R_t - \phi] + \frac{\delta_{st}^r}{(1 - \tau)}.
\] (1.13)

The introduction of tax benefits adds an extra term that affects the MPK. The capital tax benefits changes the optimal scale of production because now there is an additional source of revenue coming from the tax rebate. Figure (1.7) illustrates this point. A firm that is not financially constrained chooses capital to maximize operating income, which is equivalent to maximizing profits in the absence of tax benefits. The optimal value before tax benefits is given by \(k_1\). However, the introduction of tax benefits implies that firms will not maximize operating income \(\tilde{\pi}_s\), and instead will be maximizing considering that they have to pay taxes and receive tax benefits that depend on capital. In figure (1.7), that corresponds to \(k_2\).

With financial frictions, the tax benefit has a different impact for firms that are close to the constraint. For those firms that are financially constrained absent the tax benefit, the financial situation is worsened because they require much more capital in order to produce at the new optimal scale. There is a second group of firms that absent the tax benefit would not be financially constrained. However, once we introduce this tax advantage they become constrained, worsening the misallocation of capital. Finally, there is a group of firms that are wealthy enough so that this mechanism causes an increase in their size, leading to a higher
level of capital and lower MPK. Combining the three effects, the introduction of capital tax benefits increases the dispersion of the MPK and therefore the allocation of resources in this economy is worse than in the first case.

A final comment is worth mentioning. In the case of a tightening of the collateral constraint (the financial crisis), the common component will not play a role since it affects all firms symmetrically and does not vary with the crisis. Therefore, it will not have an effect on the allocation of resources.

**Full Model** Finally, we include lobbying as the last mechanism in the model. By introducing lobbying we generate another source of variability in the marginal product of capital, and therefore it is an amplifier of the effects described before. Financially unconstrained firms can now invest resources to obtain additional tax benefits, reducing the marginal product of capital even further. Financially constrained firms would also like to expand, making the financial friction more severe. Finally, those firms that without lobbying were producing at the optimal scale, could now become financially constraint due to fact that with lobbying there is a new optimal level of production. Notice that lobbying will play a role during the financial crisis. Because lobbying varies across individual firms and reacts to changes in the environment, it will have an effect on the allocation of capital during a credit crunch. I will discuss the implications of lobbying during a financial crisis in section (1.6).

The second channel through which the economy can be affected is selection, i.e the decision to run a firm. At the beginning of the period each agent of type $s$ has to decide an occupation based on the maximum earning available at that time, given his productivity
and his wealth. In other words, his decision is based on $\max \left\{ w_t, \bar{V}_s^p(a_{st}, z_{st}, \Omega_t) \right\}$ where $w_t$ is the market wage and $\bar{V}_s^p(a_{st}, z_{st}, \Omega_t)$ is the profit obtained by running a firm after the lobbying decision,

$$
\bar{V}_s^p(a_{st}, z_{st}, \Omega_t) = \max \left\{ \pi^{lob}(a_{st}, z_{st}, \Omega_t), \pi^{nlob}(a_{st}, z_{st}, \Omega_t) \right\}.
$$

In an economy without financial frictions, tax benefits, and lobbying, the decision to run a firm only depends on the productivity $z_{st}$. Those agents that generate profits above the market wage choose to run a firm, the rest sort into the labor market. With financial frictions, wealth is also a determinant of the decision to run a firm. Productive but poor agents end up working for a wage instead of running a firm, until they overcome the financial constraint through savings. On the other hand, unproductive but wealthy entrepreneurs remain in business. The incorporation of tax benefits and lobbying introduce new margins that distort the decision to run a firm. Wealthy but unproductive firms now have another source of revenue coming from the tax benefit and the possibility of lobbying. This feature could make some firms stay in business for a longer period of time. On the other hand, without tax benefits the unique source of cash flow for financially constrained firms is production. The introduction of tax benefits increases the current period profit, generating more resources that could be used for saving. With these additional funds, agents could overcome their financing constraint through self-financing much faster and therefore they could operate at the optimal scale.

Overall, the aggregate effect of having financial frictions and capital tax benefits that can
be influenced through lobbying is not unambiguously determined. In order to understand the aggregate implications of these mechanisms, a quantitative assessment is necessary.

1.4.3 The Problem of the Agent and Aggregation

Given financial wealth \( a_{st} \), productivity \( z_{st} \) and state variables \( \Omega_t \), the agent of type \( s \) maximizes expected utility by choosing consumption, financial wealth, his occupation, amount of lobbying, and production input choices (conditional on running a firm) subject to a sequence of budget constraints and financial constraints. The budget constraint for period \( t \) is given by

\[
\begin{align*}
da_{st} &= \left[ \max \left\{ w_t, V^p_s(a_{st}, z_{st}, \Omega_t) \right\} + r_t a_{st} - C_{st} + T_t \right] dt, \quad (1.14)
\end{align*}
\]

where \( \Omega_t \) is the vector of the aggregate states of the economy, \( r_t \) is the return on wealth and \( T_t \) is a lump sum transfer from the government. Here, the max operator is reflecting the fact that the agent is choosing his occupation by comparing the earnings from each activity.\(^{31}\)

Given preferences and budget constraints, the stochastic optimal control problem of the agent that can operate in sector \( s \) is given by

\[
\begin{align*}
V_s(a_{s0}, z_{s0}) &= \max_{\{C_{st}\}_{t=0}^{\infty}} E_0 \int_0^{\infty} e^{-\rho t} u(C_{st}) \quad s.t. \quad (1.15)
\end{align*}
\]

\(^{31}\)In order to do this computation, agents need to know the aggregate state of the economy. In particular, they need to know prices, and how the different choices that they are making will affect earnings. In a more complicated model with uncertainty about those variables, the agent would be choosing based on expectations about potential earnings.
\[
\frac{da_{st}}{dt} = \max \left\{ w_t, \tilde{V}^p_s(a_{st}, z_{st}, \Omega_t) \right\} + r_t a_{st} - C_{st} - T_t
\]

\[
dz_{st} = \mu(z_{st}) dt + \sigma(z_{st}) dW_t
\]

\[
a_{st} \geq 0, \quad t \geq 0, \quad a_{s0} \text{ and } z_{s0} \text{ given}
\]

\[
\tilde{V}^p_s(a_{st}, z_{st}, \Omega_t) = \max \left\{ \nu^{lob}_{st}(a_{st}, z_{st}, \Omega_t), \nu^{nlob}_{st}(a_{st}, z_{st}, \Omega_t) \right\}
\]

\[
s \in \{1, 2\}.
\]

The value function of the optimal control problem satisfies the Hamilton-Jacobi-Bellman (HJB), which can be used to characterize the solution of the agent’s problem

\[
\rho V_s(a_{st}, z_{st}, t) = \max_{C_{st}} u(C_{st}) + \frac{\partial}{\partial a} V_s(a_{st}, z_{st}, t) M_{st}(a_{st}, z_{st}, t) + \frac{\partial}{\partial t} V_s(a_{st}, z_{st}, t)
\]

\[
+ \frac{\partial}{\partial z} V_s(a_{st}, z_{st}, t) \mu(z_{st}) + \frac{1}{2} \frac{\partial^2}{\partial z^2} V_s(a_{st}, z_{st}, t) \sigma^2(z_{st}) + \frac{\partial}{\partial t} V_s(a_{st}, z_{st}, t),
\]

where \( \mu(z_{st}) \) and \( \sigma^2(z_{st}) \) are the drift and diffusion process of \( z_{st} \), and where \( M_{st}(a_{st}, z_{st}, t) \) is the optimal saving rule in period \( t \),

\[
M_{st}(a_{st}, z_{st}, t) = \max \left\{ w_t, \tilde{V}^p_s(a_{st}, z_{st}, \Omega_t) \right\} + r_t a_{st} - C_{st} - T_t.
\]
The HJB equation is a second order differential equation. The value function \( V_s \) depends on \( t \) due to the fact that prices may be changing along the transition path.

For the quantitative part, I will assume that \( \log z_{st} \) follows a mean reverting diffusion process given by

\[
d\log z_{st} = -\psi (\log \bar{z} - \log z_{st}) \, dt + \sigma dW_{st},
\]

where as before \( W_{st} \) is a Brownian Motion. In this particular process, the parameter \( \psi \) measures the speed of reversion and \( \log \bar{z} \) is the long run mean. One particular property of the process is the fact that the autocorrelation is given by

\[
corr[\log z_{st}, \log z_{st+k}] = e^{-\psi k} \in (0, 1].
\]

That is, the autocorrelation depends on \( \psi \) and the time interval. In addition, this process features a long run stationary distribution with mean \( \log \bar{z} \) and variance \( \frac{\sigma^2}{2\psi} \). Both properties will be useful for the calibration of the model in section (1.5).\(^{32}\)

In this economy, the aggregate state of the economy is represented by the joint distributions of productivities and wealth \( G_s(a, z, t) \) for each type of agent \( s \). The evolution of the distribution of type \( s \) agents over time is given by the the Kolgomorov forward (or Fokker-Planck) equation

\[
\frac{\partial g_s(a, z, t)}{\partial t} = -\frac{\partial}{\partial a} [M_s(a, z, t)g_s(a, z, t)] - \frac{\partial}{\partial z} [\mu(z)g_s(a, z, t)] + \frac{1}{2} \frac{\partial^2}{\partial z^2} [\sigma^2(z)g(a, z, t)],
\]

\(^{32}\)See Dixit and Pindyck (1994) and Stokey (2008) for details about these two properties of the process.
where I am omitting the sub-indexes on the state variables to save notation. Here, I denote $g_s(a, z, t)$ the density of the distribution $G_s(a, z, t)$.

For future reference, I denote $g^*_s(a, z, t)$ to the density scaled by the fraction of agents of type $s$. That is, $g^*_1(a, z, t) = qg_1(a, z, t)$ and $g^*_2(a, z, t) = (1 - q)g_2(a, z, t)$.

### 1.4.4 Government

The government in this model is passive and the amount of tax benefits granted to corporations is such that the budget is balanced in steady state

$$
ROI_t = \sum_{s=1}^{2} \left\{ \int_{z \in Z}^{\infty} \tilde{\tau}(k_{st}, \phi, e_{st}) \int_{0}^{\infty} g^*_s(a, z, t) \, da \, dz \right\} + T_t,
$$

(1.17)

The left hand side is the total revenue from the government, which for simplicity is only composed by taxes on operating income $ROI_t$. Those sources of funds need to be equal to the tax benefits granted to firms and the lump sum transfer to consumers $T_t$. Taxes on operating income are defined as

$$
ROI_t = \tau \left\{ \sum_{s=1}^{2} \int_{oc_{st} = \{s\}} \tilde{\pi}_s(a, z) \right\} g^*_s(a, z, t) \, da \, dz,
$$

(1.18)

where $oc_{1t} = \{1\}$ and $oc_{2t} = \{2\}$ denotes an agent operating a firm in sector 1 and sector 2 respectively.\(^{33}\) Out of steady state, transfers $T_t$ adjust every period in order to keep the budget balanced.

\(^{33}\)To be more specific, $oc_{st} = \{s\}$ is an indicator function that takes the value of 1 if agent of type $s$ is operating a firm and a value of 0 if it is a worker, for any period of time $t$. 

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1.4.5 Equilibrium

In this section, I describe the equilibrium conditions for this economy. Most of the features are standard definitions with the exception of the lobbying expenditure and the government budget constraint that considers tax benefits. For simplicity, I avoid explicitly denoting the dependence of all variable with respect to \( a_{st} \) and \( z_{st} \).

Given an initial joint distribution of wealth and entrepreneurial ability \( G_s(z, a, 0) \), and a marginal stationary distribution \( G_s(z) \), a recursive stationary equilibrium in this economy consists of: 1) policy functions for consumption, asset accumulation and occupational choices for each type of agent \( s \), \( \{C_{st}, M_{st}, oc_{st}\}_{t=0}^\infty \); 2) profits for lobbying and non-lobbying firms in each sector \( s \) \( \{\pi_{lob}^{st}, \pi_{nlob}^{st}\}_{t=0}^\infty \) and a sequence of demand functions for each intermediate; 3) a sequence of prices for the intermediate goods \( \{p_1, p_2\}_{t=0}^\infty \); 4) labor demands, capital demand, lobbying participation and lobbying spending in each sector \( s \), \( \{l_{st}, k_{st}, lob_{st}, c_{st}\}_{t=0}^\infty \); 5) a sequence of wages, interest rates, aggregate prices, gross interest rates, financial state and transfers \( \{w_t, r_t, P_t, R_t, \lambda_t, T_t\}_{t=0}^\infty \); 6) a sequence of distributions \( \{G_s(z, a, t)\}_{t=0}^\infty \) for each type of agents \( s \) and the corresponding probability density functions \( g_s(z, a, t) \), such that

1. Given \( \{p_1, p_2\}_{t=0}^\infty \) and \( \{w_t, r_t, P_t, R_t, \lambda_t\}_{t=0}^\infty \), \( \{l_{st}, k_{st}, lob_{st}, c_{st}\}_{t=0}^\infty \) solves the problem of intermediate firms, and \( \{\pi_{lob}^{st}, \pi_{nlob}^{st}\}_{t=0}^\infty \) are generated in each sector \( s \).
2. Given \( \{\pi_{lob}^{st}, \pi_{nlob}^{st}\} \) and \( \{w_t, r_t, P_t, R_t, \lambda_t\}_{t=0}^\infty \), \( \{C_{st}, M_{st}, oc_{st}\}_{t=0}^\infty \) solves the problem of each agent.
3. Labor market, capital market, and intermediates market clear

\[
\sum_{s=1}^{2} \left[ \int_{oc_{st} = \{s\}} l_s(a, z)g^*_s(a, z, t) \, da \, dz \right] = \int_{[1-oc_{st}] = \{s\}} g^*_s(a, z, t) \, daz \\
\]

\[
\sum_{s=1}^{2} \left[ \int_{oc_{st} = \{s\}} \left( k_s(a, z) + f_s + \int_{lab_{st} = \{s\}} f_t(\cdot) g^*_s(a, z, t) \, da \, dz \right) \right] \\
= \int_{a \in \mathbb{R}} \int_{z \in \mathbb{Z}} \int_{0}^{\infty} ag^*_s(a, z, t) \, da \, dz \\
\]

\[
\int_{oc_{1t} = \{1\}} y_1(a, z)g^*_1(a, z, t) \, da \, dz = \left[ \frac{p_2}{p_1} \frac{\gamma}{1 - \gamma} \right] \epsilon \int_{oc_{2t} = \{2\}} y_2(a, z)g^*_2(a, z, t) \, da \, dz \\
\]

4. The evolution of the density function \( g_s(a, z, t) \) over time is given by the the following

Kolgomorov forward equation:

\[
\frac{\partial g_s(a, z, t)}{\partial t} = -\frac{\partial}{\partial a} \left[ M_s(a, z, t)g_s(a, z, t) \right] - \frac{\partial}{\partial z} \left[ \mu(z)g_s(a, z, t) \right] + \frac{1}{2} \frac{\partial}{\partial z^2} \left[ \sigma^2(z)g_s(a, z, t) \right] \\
\]

which in steady state implies

\[
0 = -\frac{\partial}{\partial a} \left[ M_s(a, z)g_s(a, z) \right] - \frac{\partial}{\partial z} \left[ \mu(z)g_s(a, z) \right] + \frac{1}{2} \frac{\partial}{\partial z^2} \left[ \sigma^2(z)g_s(a, z) \right] \\
\]
5. The government satisfies the fiscal budget.

\[ ROI_t = \sum_{s=1}^{2} \left\{ \int_{0}^{\infty} \int_{z \in Z} \bar{\tau}(k_{st}, \phi, e_{st}) \right\} g^*_s(a, z, t) da, dz + T_t, \]

where \( g^*_1(a, z, t) = qg_1(a, z, t) \) and \( g^*_2(a, z, t) = (1 - q)g_2(a, z, t) \).

### 1.4.6 Effects on TFP and Output

As we saw in subsection (1.4.2), financial frictions and lobbying for capital tax benefits show up in the first order conditions as wedges in the marginal product of capital. Following the tradition started by Restuccia and Rogerson (2008) and Hsieh and Klenow (2009) I call that wedge \((1 + \tau_{kst})\), and I derive expressions for the sector level \( TFP \) and for aggregate \( TFP \) that are useful to map the model to the data.\(^{34}\) Relative to Hsieh and Klenow (2009), I derive the expressions assuming perfect competition at the industry level instead of monopolistic competition.

**Sector Level TFP**

It can be shown that the sector level output can be aggregated to a cobb douglas with decreasing returns to scale parameter \( \eta \).\(^{35}\)

\[ Y_{st} = TFP_{st} \left[ K_{st}^{\alpha} L_{st}^{(1-\alpha)} \right]^\eta, \]

---

\(^{34}\)I use \( i \) to denote a particular production unit to derive expressions for total factor productivity.

\(^{35}\)Derivations for this section are available upon request.
where the sector level $TFP$ is given by

$$TTFP_{st} = \int_{\Omega_{st}} z_i^{1-\eta} \left[ \frac{(w^2_{sit})^{\frac{1}{1-\eta}}}{\int_{\Omega_{st}} (z_{sit} w^2_{sit})^{\frac{1}{1-\eta}} di} \right]^{\alpha \eta} \left[ \frac{(w^1_{sit})^{\frac{1}{1-\eta}}}{\int_{\Omega_{st}} (z_{sit} w^1_{sit})^{\frac{1}{1-\eta}} di} \right]^{(1-\alpha) \eta} di,$$

where $\Omega_{st}$ is the set of operating firms in sector $s$ and $w^1_{sit}, w^2_{sit} \in (0, 1)$ are equal to

$$w^1_{sit} = \frac{1}{(1 + \tau_{k_{sit}})^{\eta \alpha}},$$

$$w^2_{sit} = \frac{1}{(1 + \tau_{k_{sit}})^{1-\eta(1-\alpha)}}.$$

Notice that when we do not have distortions on the allocation of capital we have that the efficient sector level $TFP_{st}$ is given by

$$TFP^e_{st} = \int_{\Omega_{st}} (z_{sit})^{1-\eta} di.$$

In addition, a standard result derived in this literature is that the dispersion in the wedge $(1 + \tau_{k_{sit}})$ implies reductions in sector level TFP. As a result, whenever there is an increase in the dispersion of the wedges, the will have a decrease in sector level TFP. This result will be important to understand the results in the quantitative part of this paper.

**Aggregate TFP**

The general form of the production function proposed in the paper for $S$ sectors is $Y_t = \left[ \sum_{s=1}^{S} \gamma_s (Y_{st})^{\frac{1-\eta}{\tau}} \right]^{\frac{1}{1-\eta}}$. Using the expressions obtained in (1.4.6) we get
\[ Y_t = \left[ \sum_{s=1}^{S} \gamma_s \left( TFP_{st}^{\frac{\alpha-1}{\alpha}} \left( K_{st}^{\eta \alpha \frac{1}{1-\alpha}} L_{st}^{\eta(1-\alpha) \frac{1}{1-\alpha}} \right) \right) \right]^{\frac{1}{\eta-1}}. \]

Now, we can use the fact that we can express sector level capital and labor as fractions of the corresponding aggregate

\[
K_{st} = K_t \frac{P_{st}^{\frac{1}{1-\eta}} \int_{\Omega_{st}} (z_{sit} w_{sit}^2)^{\frac{1}{1-\eta}} \, di}{\sum_s P_{st}^{\frac{1}{1-\eta}} \int_{\Omega_{st}} (z_{sit} w_{sit}^2)^{\frac{1}{1-\eta}} \, di} = K \bar{w}_{st}^1,
\]

\[
L_{st} = L_t \frac{P_{st}^{\frac{1}{1-\eta}} \int_{\Omega_{st}} (z_{sit} w_{sit}^1)^{\frac{1}{1-\eta}} \, di}{\sum_s P_{st}^{\frac{1}{1-\eta}} \int_{\Omega_{st}} (z_{sit} w_{sit}^1)^{\frac{1}{1-\eta}} \, di} = L \bar{w}_{st}^2,
\]

and we have that the aggregate production function takes a Cobb Douglas form,

\[ Y_t = TFP \left( K_t^\alpha L_t^{1-\alpha} \right)^\eta, \]

where \( TFP_t \) is given by

\[
TFP_t = \left\{ \sum_{s=1}^{S} \gamma_s \left[ TFP_{st}^{\frac{\alpha-1}{\alpha}} \left( (\bar{w}_{st}^1)^{\eta \alpha} (\bar{w}_{st}^2)^{(1-\alpha)\eta} \right)^{\frac{1}{\eta-1}} \right] \right\}^{\frac{1}{\eta-1}}.
\]

The efficient level of aggregate \( TFP \) is obtained by setting all the wedges equal to 1. By doing this, the efficient TFP is given by

\[
TFP^e = \left\{ \sum_{s=1}^{S} \gamma_s \left( TFP^e_s \right)^{\frac{\alpha-1}{\alpha}} \right\}^{\frac{1}{\eta-1}}.
\]

Based on the structure of the model, we can recover the evolution of \( TFP_t \) as in the growth
accounting literature based on data from national accounts and parameter values for $\eta$ and $\alpha$

$$TFP_t = \frac{Y_t}{(K_t^\alpha L_t^{1-\alpha})^\eta}.$$ 

1.5 Calibration

All parameters are calibrated to the U.S. economy prior to the great recession using an annual frequency. For the sake of clarity in the explanation, I will classify the parameters into four groups: 1) $\{\rho, \theta, \delta, \}$ are the standard parameters; 2) $\{\eta, \alpha, f_2, \gamma, \epsilon, \psi, \sigma\}$ are technological parameters; 3) $\{h, \phi, \nu, \mu, f_1\}$ are parameters related to the lobbying activity and tax benefits; 4) $\{\lambda_t, \tau, \Theta\}$ are the institutional parameters for the U.S. economy.

The strategy used to calibrate the parameters in steady state has 3 parts. First, I estimate the elasticity of substitution $\epsilon$ based on aggregate data using a reduce form equation coming from the model. Second, given the number of parameters to calibrate and the computational burden of this process, I set some of them according to existing microeconomic and macroeconomic evidence. Finally, given that the mapping between the model and the targeted data moments is multidimensional, I do a joint calibration of the remaining parameters. In subsection (1.5.1) I explain the numerical procedure to calibrate the model. Subsection (1.5.2) discusses the targeted moments and the relevance of each parameter to affect each moment. Subsection (1.5.3) evaluates the performance of the model to match moments of the data that are not targeted during the calibration. The last part of this section is devoted to the calibration of the credit shock that is used in the quantitative results.
1.5.1 Procedure for Calibration

For those parameters that are not taken from the literature or estimated using a reduce form equation, I implement a Simulated Method of Moments (SMM). Suppose we have a vector $A^d$ of $1 \times n$ moments from the data that corresponds to moments from the steady state distribution coming from the model.\textsuperscript{36} Given a vector $\Theta$ of parameters to estimate, the model produces a vector of $n$ corresponding moments $A^m(\Theta)$. The SMM estimator $\hat{\Theta}$ minimizes the weighted square sum of the distances between the model simulated moment and the corresponding counterpart in the data. Explicitly, it solves

$$\hat{\Theta} = \arg\min_{\Theta} \left[ A^d - A^m(\Theta) \right] W_d \left[ A^d - A^m(\Theta) \right]^\top,$$

where $W_d$ is a weighting matrix, which may be a function of the data. For now, the weighting matrix is going to be the identity matrix. As a result, the estimates are consistent, but not efficient.\textsuperscript{37}

The implementation of the estimation is as follows: for a given vector of parameters $\Theta$, I simulate the model and as a first step to find the vector $\hat{\Theta}$ that minimizes the objective function I use an annealing algorithm. This is a global optimization routine that jumps randomly around the parameter space while at the same time decreasing the frequency of landing in non-optimal areas in each iteration. After reaching a certain number of iterations

\textsuperscript{36}In particular, these $n$ moments include the market clearing conditions and budget constraint from the model.

\textsuperscript{37}If the model is overidentified, the weighting of each moment is extremely relevant as in the standard GMM. In particular, we need to put more weight on better identified moments. This would be implemented by using the inverse of the variance-covariate matrix of the data moments.
where the objective function seems to be reaching a global maximum, I use a local search method to obtain the calibrated parameters.\textsuperscript{38} In the next subsection, I describe the selected moments and the data used for the calibration.

\subsection*{1.5.2 Estimation and Moments}

First, I explain the methodology and results to estimate the elasticity of substitution of the intermediate inputs $\epsilon$ and then describe a set of relevant moments chosen to calibrate the remaining parameters. Even though all parameters affect the value of all moments, I also discuss the effects of each parameter on each moment individually.

**Estimation of the Elasticity of Substitution Between Intermediates**

To calibrate the elasticity of substitution $\epsilon$ between the two sectors, I follow a similar approach to Acemoglu and Guerrieri (2008). Using equation (1.6) and taking logs we obtain an equation that allows for estimation

\begin{equation}
\log \left[ \frac{p_{1t} Y_{1t}}{p_{2t} Y_{2t}} \right] = \log \left( \frac{\gamma}{1 - \gamma} \right) + \left( \frac{\epsilon - 1}{\epsilon} \right) \log \left( \frac{y_{1t}}{y_{2t}} \right). \tag{1.19}
\end{equation}

I exploit time variation in relative value added at current prices for the low and high financially dependent sector, and variations in the ratio of real value added $\frac{y_{1t}}{y_{2t}}$ to estimate the elasticity of substitution between intermediates $\epsilon$.

The data used to estimate equation (1.19) comes from EUKLEMS. I use data for the

\textsuperscript{38}To be more specific, I use the matlab function \textit{fminsearch} that comes with the optimization toolbox.
U.S. from 1970 to 2005. First, I separate the 2-digit SIC industries provided in EUKLEMS in low and high external dependence following the measure of Rajan and Zingales (1998) for manufacturing and services, excluding the financial sector. To construct sectoral value added at constant prices, I divide each industry current price value added by the corresponding price deflator and I sum across sectors to construct the low and high financially dependent sectors.\footnote{See appendix (1.9) for all the steps in the procedure.} Using those two inputs, I estimate $\epsilon$ using OLS with robust standard errors. The resulting value for $\epsilon$ is 0.67, which is in line with the estimates of Acemoglu and Guerrieri (2008) for a similar group of industries.\footnote{They estimate $\epsilon$ using data from NIPA for 22 industries classified with NAICS. Then, they separate those industries by capital intensity and they run the same regression.} Table (1.5) presents the results.

**Moment Selection and Calibration**

**Standard Parameters**  The impatience rate $\rho$ is calibrated to match the real interest rate for the period 2004-2007. Given an annual nominal interest rate for the period of 5% and a core annual inflation of 3%, I target a real interest rate $r$ of 2%. This implies a calibrated impatience rate of 0.05. The depreciation rate $\delta$ is taken to imply an average investment to capital ratio of approximately 6%, which corresponds to the average value for the private capital stock in the U.S. fixed asset tables, after considering for growth. Finally, I use a constant relative risk aversion coefficient $\sigma$ equal to 1.5, which is in the range of values used in quantitative studies with heterogeneous agents. The values of these parameters can be found in table (1.6).

**Technological Parameters**  Given $\epsilon$, we have 6 remaining technological parameters to
calibrate: \( \{\eta, \alpha, f_2, \gamma, \psi, \sigma\} \). Based on empirical evidence on estimates of the degree of returns to scale at the firm level, I set \( \eta = 0.78 \), in line with Thomas (2002), Pavcnik (2002) and Restuccia and Rogerson (2008).\(^{41}\) As usual, \( \alpha \) controls the share of payments to capital observed in the data, which is equal to 0.3. However, due to the presence of fixed cost and financial frictions, that share of payments will no longer be equal to \( \alpha \).\(^{42}\) In particular, the aggregate capital income share could be lower than the value of \( \alpha \).

To capture the sector specific fixed costs I match the relative capital intensity between the low and high financially dependent sectors. If there were no fixed costs, the capital intensities would be equalized across sectors since the financial frictions and lobbying fixed cost affect both sectors in the same way. Given a fixed value for \( f_1 \) and using the fact that \( f_1 < f_2 \), an increase in \( f_2 \) implies that the sector 2 is more capital intensive, that is, \( (k_2 + f_2)/l_2 > (k_1 + f_1)/l_1 \).\(^{43}\)

In this economy, the production of the intermediate sectors \( y_1 \) and \( y_2 \) are the only contributors to value added since the final producer only bundles those goods. In addition, they do not require any other intermediate good to produce. This implies that \( p_j y_j \) can be interpret as value added in sector \( j \). Following this logic, we can think of \( 1 - \gamma \) driving the share of the externally dependent sector in \( GDP \). Using the same data and the same classification for sectors used to estimate the elasticity of substitution of intermediates \( \epsilon \), on

\(^{41}\)Values for this parameter used in the literature range from 0.7 to 0.9. See references in Restuccia and Rogerson (2008) and in Atkeson and Kehoe (2005).

\(^{42}\)Even with no financial frictions this statement would be true due to the presence of rents to entrepreneurship. However, if we assume as in Gollin (2002) that those rents are splitted evenly between workers and capitalists, we return to a world with capital share of \( 1/3 \).

\(^{43}\)See Blaum (2013) for a discussion of partial versus general equilibrium identification of fixed costs in these types of models.
average during the period 1970 to 2005 the share in GDP of the high externally dependent sector is 70.4\%. I use this moment to calibrate \( \gamma \).

Finally, we have two parameters related to the stochastic process of productivity: \( \{ \psi, \sigma \} \). The parameter \( \psi \) measures the persistence of the process and therefore it has a direct impact on the wealth share of the top 10\% of households. I target the 2007 wealth share, which was equal to 73.1\%. In the case of \( \sigma \), it is calibrated to match the fraction of labor employed by the top 10\% of establishments, which is equal to 63\% according to the U.S. Census in 2012. The calibrated technological parameters can be found in table (1.7).

**Lobbying and Tax Benefit Parameters** To calibrate \( \{ h, \phi, \nu, \mu, f \} \), I resort to the microdata on lobbying and effective tax rates analyzed in section (1.3).

Although lobbying is in principle available to all firms, based on the micro data, there is a striking difference between public and private firms: most of the lobbying firms are public firms. In fact, as a share of private firms, lobbying firms are negligible in number. For this reason, I assume that there is a fraction \( m \in [0, 1] \) of all firms in the model that map to the “private” firms in the data. The difference between \( m \) and all the firms in the model is going to be defined as “public” firms. These firms will be used as a reference sample to match the moments related to lobbying activity.\(^45\)

\(^{44}\)This moment is taken from Wolff (2012). Using data from the Survey of Consumer Finance (SCF) he computed wealth distributions for a series of periods of time. For an intuition of the relationship between wealth concentration and persistence of the process refer to Moll (2014). To calibrate these parameters, I exploit the fact that the autocorrelation of the process depends on \( \psi \) and that given \( \psi \), the stationary variance is given by \( \frac{\sigma^2}{2\psi} \).

\(^{45}\)We can think of \( m \) as the fraction of potential agents that could start a private firm. In general, these agents will not have the connections or the information necessary to lobby at congress, at least for the short run.
To choose $m$, I compute the domestic (U.S.) gross value of production by public firms in Compustat and compare this aggregate of public firm output against the value of production of the non-financial corporate sector from the BEA. Using those numbers, I find that 57% of the production in the non-financial corporate sector is carried out by public firms for the pre-crisis period. In other words, 43% of the production of the non-financial corporate sector is due to private firms. Given that private firms usually have low level of employment and that in the model small firms do not choose to lobby, the set $m$ of firms is going to be composed of the smallest non-lobbying firms that accumulate 43% of the production in the model.\textsuperscript{46}

The fixed cost of lobbying $f_l$ has a first order effect on the share of lobbying firms in the economy. By increasing this parameter, the number of firms that can afford this costly activity is reduced. Given that in Compustat the number of lobbying firms for taxation issues is 7.1% on average between 2004 and 2007, I calibrate $f_l$ to obtain that fraction over the sub-sample of public firms from the model. The scale parameter $h$ controls how lobbying effort translates into lobbying expenditure. For this reason, I choose to match the average lobbying expenditure to sales from the microdata, which is equal to 0.08%.

The common component associated to the tax benefit $\phi$ is targeted to match the average effective tax rate of non-lobbying firms in Compustat, which is equal to 21.4%. The parameter $\nu$ controls the tax benefits that lobbying firms are obtaining from the government. Consequently, I target the effective tax rate of public lobbying firms, which in the data is equal to 18.8%. Finally, the parameter $\mu$ is the scale parameter of the tax benefit policy.

\textsuperscript{46}For a discussion of the main firm level characteristics of private firms versus public firms in the U.S. see Davis et al. (2007) and Asker et al. (2011).
which controls the amount of resources the government is losing due to tax benefits tied to capital. Based on statistics from the IRS, 33% of all the corporate tax revenue is lost in tax benefits. I calibrate $\mu$ so such that in the pre-crisis steady state that relationship holds. The values used for these parameters can be found in table (1.8).

**Institutional Parameters**  
There are 3 parameters to calibrate. I set the tax rate for firms to be equal to 35% in the benchmark economy. The parameter $\ominus$ determines the fraction of the firm level tax collection from the government that a firm can claim on tax benefits. In the benchmark calibration I set this to 1. The parameter that measures the degree of credit depth of the economy, $\lambda_t$, governs the aggregate ratio of external finance to capital. To measure this statistic in the data, I take the ratio of the stock of credit market liabilities to non-financial assets of the non-financial corporate sector. The numerator corresponds to credit market liabilities of the non-financial corporate sector, line 5 from table D.3 from the flow of funds coming from the Federal Reserve. The stock of non-financial assets is constructed using the net stock of fixed assets for the corporate non-financial sector from the U.S. Bureau of Economic Analysis (BEA). I adjust the value to level it to 2007 using current values. To calibrate $\lambda$ in steady state (pre-crisis), I target a ratio of external finance to non-financial assets of 0.65, which is the value at the peak of the pre-crisis period in 2007. The values of these parameters and moments can be found in table (1.9).

To sum up, there are 11 parameters that are jointly calibrated, given that $\rho$ is solved in

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47 Line 5 is the total credit market liabilities of the non-financial corporate business (series LA144104005.Q). It includes the stock of bank loans, and the stock of commercial papers, municipal securities and corporate bonds of the corporate sector.
general equilibrium for a given value of $\epsilon$:48

$\{\alpha, f_2, \gamma, \psi, \sigma, \lambda, h, \phi, \nu, \mu, f_l\}$. 

Despite solving a rather complicated multidimensional mapping, the model targets all moments quite closely. The only two moments that the model finds difficulty to match are the effective tax rate paid by lobbying firms, which is lower than the same moment in the data, and the right tail of the distribution of wealth that I am targeting with $\sigma$.

1.5.3 Model Testing

We have seen that the model hits the proposed targets quite closely after the calibration. Here, I evaluate the performance of the model using additional moments that were not targeted during the calibration. Table (1.10) shows some selected moments. Overall, the model behaves extremely well in matching the targeted moments and the non-targeted moments. For example, the model does a particularly good job in matching effective tax rates across sectors and in accounting for the dispersion in capital and marginal product of capital for public firms. In summary, I consider the results coming from this table as a success of the calibration strategy. Next, I discuss the calibration of the shock.

1.5.4 Credit Crunch Shock

Evidence

48As a reminder, this parameter has been estimated using a reduced form equation coming from the first order conditions of the model.
Between the second quarter of 2008 and the second quarter of 2010, small business loans made by commercial banks declined by over $40 billion (Duygan-Bump et al. (2015)). While this could be a result of a change in the demand for credit, evidence provided by Ivashina and Scharfstein (2010) suggests that there was a change in the supply of credit. Using data on syndicated new loans they find strong evidence of a reduction in lending around the 2007-2009 recession.\textsuperscript{49} Between 2007 and 2008 they found that loans targeted for investment in equipment and machinery fell 48%. Another piece of evidence can be found in the responses to the Federal Reserve’s Senior Loan Officer Survey on Bank Lending Practices. The surveyed banks indicated that they significantly increased the requirements to approve new commercial or industrial loans to firms around that period of time. More convincing evidence of an exogenous shock to the supply of credit is provided by Almeida et al. (2009), Duchin et al (2010) and Huang and Stephens (2011). Based on the evidence, I take a stand on the nature of the shock and model it as a credit supply shock that will affect the collateral constraint in the model.

**Calibration**

In order to replicate the dynamics of the credit conditions of the economy, I hit the model with an aggregate financial shock modeled as an unexpected decrease in the collateral constraint parameter $\lambda$. After the initial shock, the future path of $\lambda_t$ is perfectly known by all agents. This experiment is similar to the credit crunch in Khan and Thomas (2013), Buera et al. (2015a) and Shourideh and Zetlin Jones (2016).

The calibrated shock reduces the value of $\lambda$ upon impact and the effect of this shock

\textsuperscript{49}This market is the main vehicle through which banks lend to large corporations.
decays over time until the economy returns to the pre-crisis level (under perfect foresight). The initial shock implies a reduction of almost 20% to the value of the parameter $\lambda$, which is consistent with the actual decline in the ratio of external finance to capital observed in the data between the end of 2007 and the first quarter of 2010. Figure (1.8) depicts the evolution of the credit conditions in the model and in the data. The left panel shows the ratio of external finance to capital stock using the definitions described in subsection (1.5.1). For the model, I compute percentage deviations from steady state values. For the data, I show the difference with respect to the value in the fourth quarter of 2007 of the percentage deviation from HP-filter trend (in Q4-2007, the ratio was 4.8% above the HP trend). In comparison with the data, the model reproduces the qualitative path of the the external finance ratio quite well. Between 2008 and 2009, the model captures almost all the decline in the ratio of external finance to capital that is observed in the data, and therefore the calibration of the credit shock appears to be successful. However, the model goes back to the steady state much faster than in the data. The implied series of $\lambda_t$ used in the quantitative part is shown in the right panel of Figure (1.8).

### 1.6 Quantitative results

This section provides the main results of the paper. First, I discuss some of the main features of the model economy in steady state. After that, in section (1.6.2) I discuss the main findings of the paper in three parts. In the first, I ask whether the model can account

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50 The values for the collateral constraint are, $\{4.21, 2.95, 2.21, 2.71, 3.8\}$. After that, $\lambda_t = \lambda_{t-1} + 0.2(\lambda_{t-1} - \lambda^*)$ where $\lambda^*$ is the steady state value, which is equal to 4.21 in $t = 0$. The first period of the transition is 2007.
for the decline in TFP and the evolution of other aggregates relevant to the dynamics of the economy in the aftermath of the financial crisis. In the second part I study whether an economy with lobbying for capital tax benefits amplifies or mitigates the effects of the credit crunch. Lastly, I compare the micro implications for lobbying coming from the model and those found in section (1.3). I use this comparison as a test of the model. Section (1.6.3) evaluates the long run implications of lobbying for capital tax benefits, proposes some policy counterfactual and evaluates the implications of those policies in terms of welfare.

1.6.1 Benchmark Economy Steady State

Although the results presented in this subsection are not novel, I describe the main features from the benchmark stationary equilibrium for completeness. Two of the most important outputs of the stationary equilibrium of the benchmark economy are the stationary distribution for productivity and the wealth distribution. In particular, the model features a log-normal stationary distribution for productivity where an important proportion of the population have low levels of productivity (left panel in figure (1.9)). On the other hand, the distribution of wealth is also highly skewed, a result that is common in models with incomplete markets and with financial frictions, and that is derived from the optimal saving decisions of agents. One important consequence of this distribution of assets, is the fact that the model features agents that are financially constrained when operating the production technology. In order to produce, agents need to rent capital and to do so, they have to collateralize their wealth. Given that the distribution is skewed to the left and that there are decreasing returns to scale in production, an important fraction of the economy is operating
at sub-optimal levels. As a result, total factor productivity, output and capital stock will be lower relative to an economy with no financial frictions (see Greenwood and Jovanovic (1990), Jeong and Townsend (2007), Buera et al. (2011) and Moll (2014) among others).

Figure (1.10) shows the policy functions for saving for three types of agents in sector $s$. A feature of models with financial frictions is that the pattern of savings differ across agents. An economy without financial frictions generates saving decisions that are decreasing in wealth for all levels of productivity. However, when financial frictions are introduced, a non-linearity in the saving function arises. Highly productive agents (green dashed line) cannot operate the technology when poor and have to select into the labor market. After saving some funds, they are able to run a firm but under financing constraints. For this reason, they will start saving even more as they increase the scale of production, generating the increasing part of the saving policy function. At some level of wealth, agents running a firm reach their optimal level of production and the return to an extra unit of saving is equal to the prevailing interest rate in the market. After that point, consumption is more important than saving and the policy function starts decreasing. Notice that the non-linearity does not emerge for low productivity agents. Independently of the level of wealth, these agents are not productive enough to run a firm that generates profits higher than the current market wage.

1.6.2 Dynamics

In this section I examine the response of the model economy to an aggregate financial shock modeled as a tightening of the credit conditions in the economy. The evolution of the credit conditions are determined by the path of $\lambda$, which I have calibrated in (1.5.4). After the
initial shock, credit conditions in the economy recover slowly to the steady state value. In subsection (1.6.2) I study the behavior of the model in comparison with the data for the full model. Section (1.6.2) evaluates the role of lobbying to explain the dynamics of TFP and output for the non-financial corporate sector. In particular, I show that lobbying amplifies the aggregate effects generated due to the financial frictions when facing a financial shock. Finally, in subsection (1.6.2) I test whether the calibrated model can generate the patterns described in (1.3).

**Benchmark Economy**

Figure (1.11) displays the evolution of aggregate output, measured productivity (TFP), investment rate and lobbying expenditure for the data and the simulated economy. The data for output and TFP have been detrended using a Hodrick-Prescott filter with a quarterly frequency. For lobbying expenditure, the data has been detrended using a linear trend. In the case of output, TFP and lobbying expenditure, the impulse responses from the model are deviations from steady state. For the data, the figure shows differences with respect to the value of each series in the fourth quarter of 2007. In the case of the investment rate, the figure shows differences with respect to the steady state for the model, and the difference with respect to the fourth quarter of 2007 for the U.S. data.⁵¹

The blue line in each panel represents the full model with financial frictions, tax benefits, and lobbying. The model generates GDP dynamics close to the one observed in the data, explaining most of the decline in output. The credit crunch in the model generates a reduc-

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⁵¹ Appendix 1.9.7 explains in details the data used for the construction of each variable.
tion in output of almost 80% of the decline observed in the data between 2007 and 2009. By the end of 2009, the model predicts a fall of 5.9% of GDP relative to the steady state. For the same period of time the data showed a decline of 7.5%.

A second observation is that the model is able to generate TFP dynamics matching the data: a large fall at the beginning, followed by a slower but steady recovery. The TFP in 2009 was 4.2% below the level of the fourth quarter of 2007, and the model generates a decline of 4.4%. However, relative to the data, the model seems to converge to the steady state more quickly.

The reduction in output comes from two forces: the aforementioned decline in the aggregate productivity of the economy, and a small decrease in the stock of capital. The downward movement in TFP is the result of a sudden increase in the misallocation of resources in the economy, which is reflected in the increase in the dispersion of the marginal product of capital across firms in the right panel of figure (1.12).52 With the credit shock, the fraction of firms that are financially constrained rises, inducing a reduction in the demand for capital and labor. The fall in the demand for these factors of production translates into a decrease in the interest rate (figure (1.12)) and the wage of the economy. In response to this general equilibrium effect, large unconstrained firms expand and choose to produce at the new optimal scale, particularly the “public” firms in the model. By demanding more capital, large

52The increase in dispersion in the model is consistent with evidence provided by Bloom et. al (2009) and Chen and Song (2013). The first one shows that various measures of firm level dispersion increase during the last crisis. Chen and Song (2013) show that the dispersion in the marginal product of capital went up during the last U.S. recession using data from Compustat. Using plant level data, Kehrig (2015) finds that the dispersion in revenue productivity (TFPR) is greater in recessions. Given that TFPR is a weighted average of the marginal product of capital and marginal product of labor, this is also consistent with an increase in MPK.
firms reduce their marginal product of that input, while those that have to downsize will increase their misallocation due to worsening credit conditions. Combining these effects, the dispersion in the marginal product of capital increases.

For investment, the model generates a decline of almost 6% at its lowest point. This prediction is slightly counterfactual, since the decline in the data is close to 5%. To understand the U-shape pattern of investment, it is useful to look at the evolution of the interest rate in the economy at figure (1.12). With the credit crunch, the return on asset accumulation for the agents decreases, inducing a reduction in the supply of capital and a decrease in the investment rate of the economy that bottoms out in 2010. When the credit conditions start to go back to normal levels around 2010, the incentive to accumulate assets reappears and the investment rate turns around to return to steady state values. Overall, the model seems to be capturing extremely well the behavior of this aggregate, as well as TFP and output.

What is the role of the capital tax benefit and lobbying in this adjustment? The fact that we have capital tax benefits and a lobbying decision makes the reallocation of capital even stronger. In section (1.6.2) I show quantitatively that the dispersion in the marginal product of capital, hence the misallocation, is larger in a model with lobbying. Here, I discuss the implications of the credit crunch on aggregate lobbying, which is driven by the public firms in the model. This dynamic is influenced by three forces. Firms that were lobbying the government prior to the shock and that are still financially unconstrained increase lobbying expenditure due to the drop in the interest rate. Notice that these firms are public firms. Since lobbying and capital are complementary for unconstrained firms, the increase in the
capital stock for these firms induces an increase in lobbying that generates a second round effect on their demand for capital. We can see this from the first order conditions for capital and lobbying for firms that are not financially constrained,

$$MPK(k_{st}) = [R_t - \mu e_{st} - \phi], \quad (1.20)$$

$$e_{sit} = \left[ \frac{(1 - \tau) \nu \mu}{h} \right]^{\frac{1}{\nu}} k_{sit}^{\frac{1 - \nu}{\nu}}. \quad (1.21)$$

From equation (1.20) it is easy to see that when the interest rate drops, unconstrained firms increase capital. The second round effect is through equation (1.21). Since tax benefits are tied to capital, when capital increases firms try to increase lobbying expenditure in order to extract more tax benefits.

On the other hand, there is an increase in the fraction of firms that are lobbying the government as it becomes more profitable to pay the fixed cost and start lobbying as a result of the decline in factor prices. Lastly, the credit shock has a negative effect on firms that were engaging in lobbying activity but are now financially constrained. For these firms, the crisis induces a reduction in lobbying expenditure. This effect can also be seen from equation (1.21). For a constrained firms capital is determined by the collateral constraint. Since there is a decline in the amount a firm can rent during the crisis, the capital stock declines together with the lobbying effort. However, as we can see in figure (1.11), this reduction is not sufficiently strong to force an aggregate drop. Since lobbying firms in the model are the largest firms that are on average financially unconstrained, it is natural that the total effect
during the crisis is a rise in aggregate lobbying. Overall, the model predicts an increase in lobbying expenditure that is close to the one observed in the micro-data: by 2010, the model accounts for 75% of the increase in lobbying expenditure.

An implication coming from this adjustment in aggregate lobbying is that the dispersion in lobbying expenditure increases during a financial crisis. Do we observe that in the data? The answer for this lies in figure (1.13). As expected, the data confirms that during the crisis there was an increase in the dispersion of lobbying expenditure for taxation issues. Also, notice that when the economy starts recovering around 2009 the dispersion almost reaches its maximum and starts declining. This pattern is also observed in the model.

Before studying the role of lobbying in the adjustment of the economy, it is worth mentioning some evidence related to the mechanism described in the previous paragraphs. We have discussed that the largest firms are on average public and financially unconstrained firms. We have also mentioned that these are the firms that are driving the increase in lobbying as a result of the increase in production. If this is true, we should observe in the data that public firms expand during the credit crunch. Evidence provided by Shourideh and Zetlin Jones (2016) goes in this direction. Consistent with this mechanism, they show that the production of public firms increased during the last financial crisis.

**Lobbying for Capital Tax Benefits and Misallocation**

To evaluate the role of lobbying for capital tax benefits for the dynamics of the economy, I simulate a credit crunch of a similar magnitude to the benchmark economy but abstract from the possibility of lobbying. In order to do this counterfactual, I set the lobbying fixed

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cost $f_i \to \infty$ and re-calibrate the model to compute the counterfactual steady state and the corresponding transition after the credit crunch. The results of this experiment for GDP are displayed in the left panel of figure (1.14) under the label “No Lobbying” (green dotted line). The model without the lobbying mechanism predicts a milder recession in comparison to the benchmark economy. Relative to each particular steady state, the model without lobbying generates a decline of GDP by the end of 2009 of 4.5% versus a reduction in the full model of 5.9%. This result indicates that lobbying for capital tax benefits amplifies the aggregate effect of the credit crunch by 1.4% of GDP, or that almost 24% of the reduction of the GDP by 2009 can be attributed to the lobbying mechanism.

The differences between the two dynamics for GDP can be mainly attributed to the aggregate productivity of the economy. The right panel of figure (1.14) contrasts the evolution of the benchmark economy with the one coming from the model without lobbying. The latter has a decline at the trough of the recession of 2.65% relative to the steady state, while the benchmark model suffered a reduction of 4.4%. This means that 1.77% of the decline in TFP would be associated with the amplification effect of lobbying.

In order to understand the forces driving the differences across these two models, it is useful to look at the reallocation of capital that results from the credit crunch in both models. As seen in figure (1.15), the difference in the dispersion in the marginal product of capital generates much of this difference. The green dotted line in the figure is the counterfactual dynamics of the model in the absence of lobbying for capital tax benefits. We see that the dispersion increases in both models, but the reallocation of capital triggered by the credit crunch is larger when we allow firms to lobby for capital tax benefits. With the reduction
in the interest rate, unconstrained firms that were doing lobbying prior to the credit shock now increase their demand for capital. Because lobbying is an increasing function of the amount of capital and firms can extract more rents according to lobbying, the marginal product of capital of these firms goes down even further and capital expands even more (see equation (1.11)). On the other hand, in a model with lobbying, constrained firms are facing tighter financial conditions after the shock: in an economy with perfect capital markets, they would like to expand relatively more in a model with lobbying than in a model without lobbying. Finally, there is an extensive margin of lobbying. The reduction in the interest rate makes lobbying profitable for some firms, generating an additional source of variation of the marginal product of capital given that these firms now expand relatively more than in a model without lobbying for capital tax benefits. The model predicts that the fraction of public firms doing lobbying increases to 9.7% by 2009, consistent with the surge in lobbying activity at the extensive margin documented in section (1.3.1). Combining these effects, the dispersion in the marginal product of capital increases relatively more with lobbying.

In order to decompose the effects of the extensive margin and the intensive margin of lobbying, I propose another counterfactual. Because the credit shock induces an increase in lobbying at the intensive margin as a result of the decline in the interest rate and the subsequent increase in the demand for capital, to study the contribution of this change in lobbying intensity on misallocation I propose a counterfactual where I keep the level of lobbying constant at the initial steady state values. In other words, I allow firms to lobby for capital tax benefits, but I prevent them from reacting to the new environment by changing the level of lobbying. What the model captures with this exercise is the increase in misallocation
that results only from the increase in the fraction of lobbying firms. As we can see in figure (1.14), the effects are almost identical to the case where we do not have lobbying. Even though the fraction of lobbying firms increases and the dispersion of the marginal product of capital increases as a result of more firms doing lobbying, the effects on TFP and output are negligible. This result suggests that almost all the increase in misallocation from the model with lobbying is generated by the intensive margin.

**Testing Implications for Lobbying and Tax Rates**

We have discussed the ability of the model to reproduce some of the most salient features of the U.S. credit crisis of 2007-2009, including the aggregate lobbying behavior in the economy. Here, I assess the performance of the calibrated model to match the empirical patterns documented in section (1.3).

**Changes of Effective Tax Rates**

Using data from Compustat, Section (1.3) established that after the financial crisis the effective tax rates paid by lobbying and non-lobbying firms declined sharply. In addition, consistent with the observed increase in lobbying activity for taxation, the decline is more drastic for lobbying firms.

Figure (1.16) compares the data and the model. For the model, I compute the effective tax rates for lobbying and non-lobbying public firms and I compute the cumulative change with respect to the value in 2007 for each case.\(^\text{53}\) The data shows differences with respect to

\[^{53}\text{In order to map the model to the data, I use the procedure described in section 1.5 to assign firms to the private and public groups.}\]
the tax rate in 2007.

In the case of the effective tax rate of lobbying firms, the left panel of figure (1.16) shows that the model fits the general pattern of the average tax rate for lobbying firms after the credit shock. In particular, it captures 53% of the decline in the effective tax rate by 2009. With the credit shock, lobbying firms start increasing their lobbying activity and as a result the amount of tax benefits they are obtaining is bigger. In addition, the amount of capital this firms are using is also higher, which also reduces the effective tax rate. As a result, the tax rates for those firms start declining until 2009. After bottoming in that year, the model converges to the steady state faster than in the data. This is explained partly because the interest rate returns to the steady state level after that period, inducing a reduction of the capital demand for public firms and in lobbying effort. Following that retraction in capital and lobbying, the amount of tax benefits goes down.

For the effective tax rate of non-lobbying firms, the general picture applies. The model captures the evolution of the average tax rate for that group pretty well until 2009. Similarly to lobbying firms, public non-lobbying firms on average expand. Because these firms are richer than private firms, typically they are not financially constrained and they react to the decline of prices with an expansion of production. Consequently, the demand for capital after the credit crunch increases and the amount of tax benefits claimed accompanies the pattern of capital for until 2009. After that, it returns back to steady state while the data keeps falling for one additional period of time. At that point, we see that the tax rate of non-lobbying firms turns around and starts returning to the pre-crisis value. Overall, the model performs surprisingly well in accounting for the decline in tax rates for lobbying and
non-lobbying firms.

**Increase of the share of Lobbying Expenditure of Sector 2**

Using data on lobbying for taxation issues, section (1.3) established that sectors that rely more on external finance increased their participation in total lobbying expenditure during the last financial crisis.

In the model, the presence of the fixed cost $f_2 > f_1$ affecting the collateral constraint makes the sector 2 more dependent on external funds and more capital intensive. We have seen in table (1.10) that the model over predicts the share of lobbying expenditure in that sector (65% in steady state versus 53% in the data). Here, I evaluate the performance of the model over time after the crisis. Fe (1.17) displays the difference with respect to the steady state for the model, and the difference from 2007 for the U.S. data. As in the data, the model generates an increase in the participation of the sector that depends more on external finance (sector 2) after the credit shock. In addition, the model also picks during the same year in comparison with the data. However, it can not capture the magnitude of the change: for the data, by 2010 the share of lobbying expenditure for taxation issues increases by 9.1%, while the model increases by 2.3%. In other words, the model accounts for almost 25% of the change in the share of lobbying expenditure incurred by those sectors that rely more on external finance. Finally, note that the model is successful in capturing the inverted U-shaped pattern of the data. However, and once again, it seems to be returning to the levels of the pre-crisis period in a shorter period of time.
Size-Dependent responses

In section (1.3.4) I showed that the response of firms with different sizes depends on external financial dependence (EFD). In particular, large firms in both sectors as well as small firms in sectors less dependent on external finance increase their lobbying expenditure relative to the pre-crisis period. Only small firms in sectors that rely more heavily on external finance exhibit a reduction in lobbying activity. In addition, sectors that depend more on external finance have larger differences in the change to lobbying expenditure due to the crisis. Next, I test the ability of the model to deliver those results based on a simulated model-based regression.

To consider the firm-level implications of the model for lobbying after a credit crunch, I simulate a sample of 500000 firms from the model and follow them for four periods after the shock, keeping track of the size in terms of employment. In section (1.3.4) I use the small-medium firm (SME) label for a firm with less than 500 employees following the classification used by the Trade Commission. The data from the Business Dynamics Statistics (BDS) for 2007 shows that the employment share of firms with less than 500 employees was equal to 50.4%, which is almost equal to the median of employment. In order to map my model to the size variable I look for the employment size such that below that level the employment share is equal to 50.4%. Then, I classify those firms below that level as SME and those above that as a large firm. As before, sector one in the model is represents sectors that rely less on external finance and sector two represents the remaining.

Table (1.11) reports the results of running the regression on equation (1.1) using the simulated data and it reproduces the same results from section (1.3.4). To run this regression,
I control for the same variables as in the empirical regression (capital, assets and sales). The table decomposes the results into two groups, low external dependence and high external dependence sectors. The model delivers almost all the signs of the regression, but misses the change in lobbying expenditure for small-medium firms in the sectors that rely less on external finance. While the data delivers a positive correlation, the model displays a negative one. Nevertheless, that coefficient is not statistically significant in the data. The model captures the sign of the changes for lobbying expenditure before and after the crisis for 3 groups: large firms in sectors that depend less on external finance; small-medium firms in sectors that rely more on external finance; and large firms in sectors that rely more on external finance. The model-based regression finds that the change in lobbying expenditure for small-medium firms in the sectors that rely less on external finance should be negative. In the data, the coefficient was found to be negative. However, given that the coefficient is not statistically significant and close to zero, the negative coefficient coming from the model it is certainly possible.

In the model, a reduction in input prices implies an increase in capital demand and lobbying activity for unconstrained public firms in both sectors. This mechanism drives the signs in the model based regression for the change in the intensity of lobbying in column (4) for firms in the low external dependence sector and in the high external dependence sector. On the other hand, with the credit crunch some public firms become financially constrained in the model and therefore the amount of capital used is lower than before. According to the model, the lobbying expenditure of those firms is also smaller and this effect drives the signs in columns (3) for both groups of firms.
To summarize, the evidence provided in this section shows that the modeling strategy is successful in capturing the micro level implications of lobbying during a financial crisis. In addition, it reinforces the validity of the calibration strategy. Together, these two features imply that the model could be used to study policy relevant questions with the certainty that the model represents closely the most salient features of this activity.

1.6.3 Normative analysis: Long Run Counterfactuals

In the previous sections I discussed the implication of lobbying at the business cycle frequency for output, TFP and micro-level implications. However, the model is also useful to answer questions related to the long run behavior of the economy. To that end, I propose several exercises that are relevant for policy and normative analysis.

Role of Misallocation in the Long-Run

In this experiment I try to assess the impact of lobbying on total factor productivity in the long run. Since lobbying acts as a subsidy on capital, eliminating this distortion has an impact on capital accumulation. Considering that firms can no longer get access to the preferential tax treatment that made them larger, there will be a reduction in the demand of capital. As a result, the capital stock in the economy would go down. To counterbalance this aggregate effect, and in the spirit of Restuccia and Rogerson (2008), I adjust the corporate tax rate $\tau$ so that the capital stock in the new steady state is the same as the initial value. In this sense, I am focusing on the TFP effects associated with the elimination of lobbying through reallocation of capital and selection. Operationally, I take the fixed cost of lobbying
(\(f_i\)) to infinity so that no firm can do lobbying in the new steady state and at the same time I reduce the corporate tax rate.

Column 2 in Table (1.12) shows selected statistics such as aggregate output, capital, consumption, wage and total factor productivity (TFP) for this experiment relative to the benchmark economy when both are in steady state. We can see that output and TFP increase by 0.7% and 0.9% respectively without lobbying. As discussed in section (1.4.2), lobbying increases the dispersion of the marginal product of capital relative to an economy without lobbying. Then, banning this activity implies gains in efficiency on the production side. An important point to stress is that the gains are larger in the second sector, which is the one where lobbying is more intensive. Because of this differential intensity of lobbying, the dispersion in the marginal product of capital is larger in that sector. Finally, notice that the combination of these policies increases the number of firms in the economy. Although wages are going up and therefore labor is more expensive, the reduction in the tax rate that the government is proposing makes running a firm more profitable for a group of agents.

**Institutional Reform: Banning Lobbying**

In the previous exercise I discussed the effects of banning lobbying while at the same time reducing the corporate tax rate in order to keep the level of capital constant. In this counterfactual I propose to analyze the full effect of banning lobbying without adjusting the corporate tax rate.

The results for the first experiment in the new steady state are shown in column 2. Relative to the benchmark steady state we observe that output decreases 1.2%, capital used
for production is 4% lower, TFP has an increase of 0.8%, and consumption goes up almost 1%.

The outcomes from this experiment follow from differences at both the intensive and the extensive margins of production. At the intensive margin, incumbent firms are negatively affected due to the elimination of the lobbying activity that was used in the benchmark equilibrium by constrained and unconstrained firms. As I previously discussed, the capital stock in this economy declines due to the lower incentive to accumulate assets in order to exploit the tax benefit schedule. The reduction in capital accumulation comes from three forces. Because lobbying generates an increase in the optimal size of firms, without this force firms reduce capital demand and therefore there has to be a downward adjustment in savings for these firms. Second, with lobbying, some firms accumulate wealth with the expectation that at some point they will be able to lobby. Abstracting from this activity removes this force and therefore there is a reduction in savings. Third, lobbying allows some financially constrained firms to increase saving in order to overcome financing constraints. Absent lobbying, those firms reduce their saving decisions and reduce capital accumulation.

In section (1.4.2) I discussed the implications of the tax benefit schedule on misallocation and selection. Without lobbying, we see that TFP in the economy goes up, indicating some misallocation as a negative consequence of lobbying. This is reflected in the decrease in the marginal product of capital in the counterfactual scenario.

At the extensive margin, there is a small increase in the number of firms in the economy, explained by the decline in wages and interest rate resulting from the reduction in inputs. However, this increase in new producers is counterbalanced with a decline of the average size
of firms (measured using labor or capital, since both are complements) and in the capital to labor ratio of the economy as a whole and in both sectors.

Finally, lobbying seems to be welfare improving as suggested by the decrease in total consumption when we move from the benchmark economy to an economy without lobbying. Lobbying increases factor demands, drives up wages and profits that more than compensate the increase in savings. However, we need to be careful about this last statement, which only considers consumption levels between steady states. In order to consider the implications for welfare, we should also take into consideration the transition from one steady state to the other. I consider this in section (1.6.3).

\textbf{Fiscal Reform: No Heterogeneity in Effective Tax Rates}

The evidence shows that effective tax rates that public firms pay are lower than the 35\% that the law establishes. In addition, there is a lot of heterogeneity even within this set of wealthy and large producers. Since the government is losing a considerable amount of resources to this group of firms that could be used for health, social security or foster small business growth, lobbying policy is an issue of constant debate in the media and the policy arena.\textsuperscript{54} Other arguments point to the ‘unfairness’ of lower tax rates for big corporations and the distortions that tax breaks generate to the economy.

In order to contribute to this debate, the second experiment proposes to take out all the sources of variation in the effective tax rate while at the same time keeping the government’s revenue constant. The economy starts in steady state, and the government decides to restrict

\textsuperscript{54}See the report by the Goverment Accountability Office (GAO 2013) or McIntyre et al. (2011) as examples in this debate.
lobbying \( (f_i \rightarrow \infty) \) and abolish the existence of common components of capital tax benefits. Because this implies that firms now face a higher effective tax rate, the government lowers the corporate tax rate in order to keep the revenue constant taking in consideration the revenues generated during the transition to the new steady state. Technically, the government keeps the revenue constant in present value terms.

This experiment measures the aggregate effects of equalizing the effective tax rate for all firms. In other words, if all firms face the legal corporate tax rate, what would be the macroeconomic consequences. According to the quantitative results, the corporate tax rate necessary to satisfy the same present value of revenue is equal to 31%. Column 3 of table (1.12) presents the results for this experiment. This counterfactual implies a reduction in long run output of 2.5%, an increase of 1.1% in TFP, and an increase in consumption of 1.3%. We see that misallocation is reduced due to the decrease in the dispersion of marginal product of capital, which is reflected in the increase in TFP. As discussed in (1.4.2), the introduction of the tax benefit schedule increases the dispersion of the marginal product of capital relative to an economy with financial frictions. Then, by making all firms pay the same effective tax rate we are abstracting from that source of variation and increasing efficiency in production.

Regarding capital, we see that in this economy it declines 9.4% for the same reason studied before: without any tax rebate associated to capital the optimal size of all firms shrink. With a lower optimal size, the demand for capital of firms will be lower in the aggregate, the incentives to save will be smaller, and the capital stock of the economy contracts.
Different from the previous case, we observe that consumption in this economy rises 1.3% as a result of the decline in savings. Because the optimal size of firms is smaller, it is not necessary to keep the levels of assets as in the benchmark economy.

Welfare

In this subsection, I turn my attention to the computation of welfare. First, I analyze the welfare implications for banning lobbying. Then, I compute the welfare implications for the fiscal reform.

For the case where we ban lobbying, we have seen that consumption in the new steady state declines. From there, we would be tempted to infer that welfare in this economy would be lower. However, in order to compute welfare, the correct comparison should consider the full transition path between steady states since that implies a sequence of consumption that are not incorporated when looking at steady states.

Denote the aggregate welfare in the benchmark stationary equilibrium by \( W_{\infty}^{full} \). This value is computed by integrating the individual value functions with respect to the invariant distribution of wealth and ability, accounting for each type of agent:

\[
W_{\infty}^{full} = q \int v_1^{full}(a, z)g_1^{full}(a, z)dadz + (1 - q) \int v_2^{full}(a, z)g_2^{full}(a, z)dadz,
\]

where \( v_s^{full}(a, z) \) for \( s \in \{1, 2\} \) is the individual value function in steady state of the benchmark model of agent of type \( s \), and \( g_s^{full}(a, z) \) for \( s \in \{1, 2\} \) is the joint probability distribution function for agents of type \( s \) in the stationary equilibrium of the benchmark model.
model.

To compute the welfare change $\Theta$ from eliminating lobbying, I construct the permanent consumption compensation necessary to make an individual indifferent between the benchmark stationary equilibrium and an economy with no lobbying but with financial frictions and capital tax benefits, accounting for the transition. This expression is given by

$$
\Theta = \left( \frac{W_{nlob}^{Tr}}{W_{\infty}^{full}} \right)^{\frac{1}{\tau}} - 1,
$$

where $W_{nlob}^{Tr}$ is the lifetime welfare of transitioning from the benchmark economy to an economy that forbids lobbying. This welfare value is given by

$$
W_{nlob}^{Tr} = q \int v_1(a, z)g_{1\infty}^{full}(a, z)dadz + (1 - q) \int v_2(a, z)g_{2\infty}^{full}(a, z)dadz,
$$

where $v_s(a, z)$ for $s \in \{1, 2\}$ is the value function that takes into account the transition from the benchmark stationary equilibrium to the new stationary equilibrium. In other words, $v_s(a, z)$ is the instant value after the change in policy.

The quantitative results show that there is welfare gain of 0.3% while banning lobbying, or a welfare cost of 0.3% of keeping it. By comparing steady states, we obtain that welfare decreases by 0.9%. The inclusion of the transition implies an offsetting effect over the welfare calculation derived from comparing steady states.

In the case of the fiscal reform, if one looks at steady state we observe that consumption increases. Then, welfare goes in the same direction as the transition and the fiscal reform generates a welfare gain of 1.1%.
1.7 Conclusions

In this paper, I document the increase in lobbying activity to affect the tax code that took place during the 2007-2009 U.S. financial crisis. Based on Compustat data matched with lobbying expenditure at the firm level, I show that this increase in rent-seeking behavior was driven by large firms in sectors that rely more on external sources of funds to finance capital expenditure. Based on this evidence, and given the creation and extension of tax provisions during that time, I study whether lobbying amplifies the misallocation created by the financial frictions when the economy suffers a credit crunch.

To address this question, I use a model with financial frictions in the form of collateral constraint and a government that grants tax benefits associated to capital and can be influenced through costly lobbying pressure. In this economy, all firms can claim tax benefits that are tied to capital. However, firms that decide to lobby can also modify the tax code to obtain preferential tax treatment on top of a common component. In order to lobby, firms have to pay a fixed cost, and as a result there is selection into lobbying activity where only a small fraction of firms engage in this activity.

The presence of lobbying in an environment with financial frictions simultaneously generates positive and negative effects on misallocation. Consequently, are not unambiguously determined and depend on which force dominates. To study the aggregate effects of the credit shock, I calibrate the model using micro-data on lobbying expenditure and effective tax rates that corporations paid before the crisis, and I calibrate the credit shock to replicate the observed decline in the ratio of external finance to capital for the non-financial corporate
sector.

One of the main findings of the paper is that lobbying increases the misallocation of resources that arises with financial frictions when the economy receives a financial shock. The presented model accounts for 80% of the decline in output and almost all the decline in TFP observed in the data by the end of 2009. Compared to an economy without lobbying, I find that the lobbying economy amplifies the distortions produced from by financial frictions, leading to a one-third larger decline in output. The model is also able to capture the increase in lobbying activity observed in the data, as well as the impulse responses of firms according to size and industry financial dependence.

A derived implications is that, not only is important to have policy tools during these events, but it is even more important the how the policy is designed and how in order to be effective. As we have seen, the government provides tax advantages, but most of those resources are assigned to unproductive and wealthy firm, enhancing the misallocation of resources. In this environment, and given the same fiscal cost, policies that subsidize credit to those firms in distress are more effective to foster the recovery.

Finally, the paper also discussed long run implications of lobbying and policy reforms, focusing on long run output, and TFP. Banning lobbying implies that in the long run output is lower due to lower capital accumulation, and TFP increases as a result of lower misallocation of capital. In terms of welfare, this institutional change implies a welfare gain of 0.3%. In terms of policy, an elimination of all capital tax breaks while at the same time keeping the revenue neutral by reducing the corporate tax rate have similar results in terms of signs, but the magnitudes are magnified. In this case, welfare increases by 1.1%.
One limitation of the analysis is the fact that firms can only adjust the production margin with the financial shock, which is a direct result of the perfect competition framework. However, the empirical evidence suggests that market power is a relevant feature in modern economies and therefore firms can also adjust prices during a downturn. The interaction between financial conditions and market power has been studied by Giuliano and Zaourak (2015) and by Gilchrist et al. (2015). The incorporation of market power in this framework is left for future research.
1.8 Tables and Figures

Table 1.1: Percentage Lobbying Expenditure by issue (Top 5)

<table>
<thead>
<tr>
<th>Issue</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taxes</td>
<td>11.1</td>
</tr>
<tr>
<td>Health</td>
<td>6.7</td>
</tr>
<tr>
<td>Energy</td>
<td>6.1</td>
</tr>
<tr>
<td>Trade</td>
<td>5.5</td>
</tr>
<tr>
<td>Budget/Appropriations</td>
<td>5.4</td>
</tr>
</tbody>
</table>

Table 1.2: Summary Statistics

<table>
<thead>
<tr>
<th></th>
<th>Lobbying</th>
<th>Non-Lobbying</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales ($ Million)</td>
<td>7396.58</td>
<td>1239.18</td>
</tr>
<tr>
<td></td>
<td>(19852.22)</td>
<td>(3882.16)</td>
</tr>
<tr>
<td>Capital ($ Million)</td>
<td>10551.09</td>
<td>816.22</td>
</tr>
<tr>
<td></td>
<td>(20047.52)</td>
<td>(5934.68)</td>
</tr>
<tr>
<td>Assets ($ Million)</td>
<td>29321.21</td>
<td>15728.29</td>
</tr>
<tr>
<td></td>
<td>(26109.74)</td>
<td>(3563.91)</td>
</tr>
<tr>
<td>Employment (Thousands)</td>
<td>43.32</td>
<td>5.96</td>
</tr>
<tr>
<td></td>
<td>(120.35)</td>
<td>(25.63)</td>
</tr>
<tr>
<td>Mean Lobbying exp. ($ Million)</td>
<td>0.27</td>
<td>0.7</td>
</tr>
<tr>
<td>Mean ETR(%)</td>
<td>18</td>
<td>21.1</td>
</tr>
<tr>
<td>Observations</td>
<td>2322</td>
<td>18090</td>
</tr>
</tbody>
</table>
### Table 1.3: Intensity of Lobbying

<table>
<thead>
<tr>
<th></th>
<th>Low External</th>
<th></th>
<th>High External</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SME</td>
<td>Large</td>
<td>SME</td>
<td>Large</td>
</tr>
<tr>
<td>Crisis</td>
<td>0.010</td>
<td>0.226**</td>
<td>-0.054*</td>
<td>0.342**</td>
</tr>
<tr>
<td>Small-Large</td>
<td>-0.216***</td>
<td></td>
<td>-0.396***</td>
<td></td>
</tr>
<tr>
<td>DDD</td>
<td>-0.180***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>20412</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Standard Errors clustered by SIC-2digits. Controls: Assets, sales, fixed effects at industry-state. * Significance at 10%; ** Significance at 5% ***1%.

### Table 1.4: Probability of Lobbying

<table>
<thead>
<tr>
<th></th>
<th>Low External</th>
<th></th>
<th>High External</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SME</td>
<td>Large</td>
<td>SME</td>
<td>Large</td>
</tr>
<tr>
<td>Crisis</td>
<td>0.002*</td>
<td>0.020**</td>
<td>-0.003*</td>
<td>0.032**</td>
</tr>
<tr>
<td>Small-Large</td>
<td>-0.019***</td>
<td></td>
<td>-0.035***</td>
<td></td>
</tr>
<tr>
<td>DDD</td>
<td>-0.0161***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>20412</td>
<td>20412</td>
<td>20412</td>
<td>20412</td>
</tr>
</tbody>
</table>

Note: Standard Errors clustered by SIC-2digits. Controls: Assets, sales, fixed effects at industry-state. * Significance at 10%; ** Significance at 5% ***1%.
Table 1.5: Estimation of the elasticity of intermediate inputs $\epsilon$

<table>
<thead>
<tr>
<th>Dep. var.</th>
<th>Ratio nominal value added</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real value added</td>
<td>$-0.4744^{***}$ (0.1274)</td>
</tr>
<tr>
<td>Constant</td>
<td>$0.7745^{***}$ (0.0658)</td>
</tr>
</tbody>
</table>

$R^2$ 0.2686
Observations 35

Note: Robust standard are shown in parenthesis.
* Significance at 10%; ** Significance at 5% ***1%

Table 1.6: Standard Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Target/Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount rate (jointly)</td>
<td>$\rho = 0.05$</td>
<td>$r = 0.02$</td>
</tr>
<tr>
<td>Coef. relative risk aversion</td>
<td>$\theta = 1.5$</td>
<td></td>
</tr>
<tr>
<td>Depreciation rate</td>
<td>$\delta = 0.06$</td>
<td></td>
</tr>
</tbody>
</table>

Note: In this table, $\rho$ is the only parameter that is jointly calibrated.

Table 1.7: Technological Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Target/Source</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Share of income to capital</td>
<td>$\alpha = 0.38$</td>
<td>NIPA accounts</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Fixed cost in sector 2</td>
<td>$f_2 = 1.15$</td>
<td>Cap. intensity between sectors</td>
<td>1.5</td>
<td>1.4</td>
</tr>
<tr>
<td>Weight of sector 2 in GDP</td>
<td>$\gamma = 0.23$</td>
<td>Share sector 2 in Val. Added (%)</td>
<td>70.4</td>
<td>70.4</td>
</tr>
<tr>
<td>Persistence of log $z_{sit}$</td>
<td>$e^{-\psi} = 0.89$</td>
<td>Top 10% of wealth share (%)</td>
<td>73.6</td>
<td>68.3</td>
</tr>
<tr>
<td>var. of log $z_{sit}$</td>
<td>$\frac{\sigma^2}{2\psi} = 0.43$</td>
<td>Emp.share of top 10% (%)</td>
<td>63</td>
<td>61.3</td>
</tr>
<tr>
<td>Return to scale</td>
<td>$\eta = 0.78$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1.8: Lobbying Activity and Tax Benefit

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Target/Source</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost scale</td>
<td>$h = 1.2$</td>
<td>Lobbying expend. to sales (%)</td>
<td>0.08</td>
<td>0.06</td>
</tr>
<tr>
<td>Common tax benefit</td>
<td>$\phi = 0.02$</td>
<td>Avg. ETR non-lobbying firms (%)</td>
<td>21.4</td>
<td>21.4</td>
</tr>
<tr>
<td>Tax benefit, exponent</td>
<td>$\nu = 0.2$</td>
<td>Avg. ETR of lobbying firms (%)</td>
<td>18.8</td>
<td>16.2</td>
</tr>
<tr>
<td>Fixed cost of lobbying</td>
<td>$f_l = 0.7$</td>
<td>Share of lobbying firms (%)</td>
<td>7.1</td>
<td>7.1</td>
</tr>
<tr>
<td>Tax benefit, scaling</td>
<td>$\mu = 0.003$</td>
<td>33% tax revenue lost %</td>
<td>33</td>
<td>33</td>
</tr>
</tbody>
</table>

Table 1.9: Institutional Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
<th>Target/Source</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collateral</td>
<td>$\lambda = 4.21$</td>
<td>External Financing</td>
<td>0.65</td>
<td>0.65</td>
</tr>
<tr>
<td>Maximum Benefit</td>
<td>$\Theta = 1$</td>
<td>Lower Bound ETR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tax rate</td>
<td>$\tau = 0.35$</td>
<td>IRS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 1.10: Non-Targeted Moments

<table>
<thead>
<tr>
<th>Moment</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Share of Lobbying Expenditure High External Dependence sector</td>
<td>53.6%</td>
<td>65.2%</td>
</tr>
<tr>
<td>Effective Tax Rate sector 1</td>
<td>20%</td>
<td>19.6%</td>
</tr>
<tr>
<td>Effective Tax Rate sector 2</td>
<td>16%</td>
<td>15.3%</td>
</tr>
<tr>
<td>std($MPK$) for Public Firms</td>
<td>1.81</td>
<td>2.1</td>
</tr>
<tr>
<td>std($k_i/K$) (lobbying firms over all public firms)</td>
<td>0.72</td>
<td>0.87</td>
</tr>
</tbody>
</table>

### Table 1.11: Intensity of Lobbying

<table>
<thead>
<tr>
<th>Data</th>
<th>Model</th>
<th>SME (1)</th>
<th>Large (2)</th>
<th>SME (3)</th>
<th>Large (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low External Dependence</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crisis</td>
<td></td>
<td>0.010</td>
<td>0.226**</td>
<td>-0.137</td>
<td>0.713</td>
</tr>
<tr>
<td>SME – Large</td>
<td></td>
<td>-0.216***</td>
<td></td>
<td>-0.85</td>
<td></td>
</tr>
<tr>
<td>High External Dependence</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crisis</td>
<td></td>
<td>-0.054*</td>
<td>0.342**</td>
<td>-0.361</td>
<td>0.981</td>
</tr>
<tr>
<td>SME – Large</td>
<td></td>
<td>-0.396***</td>
<td></td>
<td>-1.342</td>
<td></td>
</tr>
<tr>
<td>$(SME – Large)^{High} – (SME – Large)^{Low}$</td>
<td></td>
<td>-0.180***</td>
<td></td>
<td>0.492</td>
<td></td>
</tr>
</tbody>
</table>

Note: Standard Errors clustered by SIC-2digits. Controls: Assets and sales for the model and the data. Fixed effects at industry-state included for the data. * Significance at 10%; ** Significance at 5% ***1%.

### Table 1.12: Misallocation Effect

<table>
<thead>
<tr>
<th>Benchmark Economy</th>
<th>Constant Capital No lobbying</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\phi = 0.021, f_i = 0.7$</td>
<td>$\phi = 0.021, f_i = \infty$</td>
</tr>
<tr>
<td>Output</td>
<td>100</td>
</tr>
<tr>
<td>TFP</td>
<td>100</td>
</tr>
<tr>
<td>TFP sector 1</td>
<td>100</td>
</tr>
<tr>
<td>TFP sector 2</td>
<td>100</td>
</tr>
<tr>
<td>Consumption</td>
<td>100</td>
</tr>
<tr>
<td>Wage</td>
<td>100</td>
</tr>
<tr>
<td>Aggregate capital ($K$)</td>
<td>100</td>
</tr>
<tr>
<td>Firms</td>
<td>100</td>
</tr>
<tr>
<td>std. $MPK$</td>
<td>100</td>
</tr>
</tbody>
</table>

Note: All results are relative to the benchmark economy where the financial friction parameter is $\lambda = 4.21$.
### Table 1.13: Policy Reforms

<table>
<thead>
<tr>
<th></th>
<th>Benchmark Economy</th>
<th>No Lobbying Economy ((\phi = 0.021, f_l = \infty))</th>
<th>No Heterogeneity in Tax Rates ((\phi = 0.0, f_l = \infty))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>100</td>
<td>98.8</td>
<td>97.5</td>
</tr>
<tr>
<td>TFP</td>
<td>100</td>
<td>100.8</td>
<td>101.1</td>
</tr>
<tr>
<td>TFP sector 1</td>
<td>100</td>
<td>100.3</td>
<td>100.8</td>
</tr>
<tr>
<td>TFP sector 2</td>
<td>100</td>
<td>101.1</td>
<td>101.5</td>
</tr>
<tr>
<td>Consumption</td>
<td>100</td>
<td>99.2</td>
<td>101.3</td>
</tr>
<tr>
<td>Wage</td>
<td>100</td>
<td>98.8</td>
<td>97.6</td>
</tr>
<tr>
<td>Aggregate capital ((K))</td>
<td>100</td>
<td>95.9</td>
<td>90.6</td>
</tr>
<tr>
<td>Firms</td>
<td>100</td>
<td>100.3</td>
<td>101.6</td>
</tr>
<tr>
<td>std. (MPK)</td>
<td>100</td>
<td>93.4</td>
<td>90.8</td>
</tr>
</tbody>
</table>

Note: All results are relative to the benchmark economy where the financial friction parameter is \(\lambda = 4.21\)

### Figure 1.1: Lobbying Expenditure for Taxation

Note: The figure shows deviations from linear trend for the period 2001-2013. The raw data is in constant prices of 2007, deflated with the GDP deflator.
Figure 1.2: Intensity of Lobbying for Taxation Issues

Note: Intensity of lobbying for taxation issues is average lobbying expenditure. The figure shows deviations from linear trend for the period 2001-2013. The raw data is in constant prices of 2007, deflated with the GDP deflator.

Figure 1.3: Evolution of Effective Tax Rates

Note: This Figure shows the evolution of the effective tax rate payed by lobbying and non-lobbying firms
Figure 1.4: Difference in ETR of Lobbying and Non-Lobbying Firms

Note: This figure shows the interaction term coefficient of the lobbying for taxation dummy and a time dummy for each of the years after 2007. The dashed red lines are the confidence intervals for each particular coefficient.

Figure 1.5: Lobbying Expenditure and Financial Dependence

Note: the figure displays the total lobbying expenditure for taxation of sectors that rely more on external finance as a share of total lobbying expenditure for taxation.
Figure 1.6: Effective Tax Rate and Financial Dependence

Figure 1.7: Operating Income with Tax benefits
Figure 1.8: Calibration of the Shock

Note: The frequency for the external finance to capital ratio data is quarterly. The model frequency is yearly. I plot percentage deviations from steady state for the model. I compute percentage deviations from HP-trend for the data and I plot that series relative to the value obtained in the fourth quarter of 2007.

Figure 1.9: Stationary Equilibrium distributions

Figure 1.10: Saving Policy Function

Note: This figure displays savings for three different types of productivities: low (blue), medium (red), and high (green).
Figure 1.11: Dynamics in the Data and Full Model after a Credit Crunch

Note: For the model, I plot deviations from steady state for output, TFP and lobbying. In the case of investment, I take the difference with respect to steady state. For the data, I compute percentage deviations from HP-trend and I plot that series relative to the value obtained in the fourth quarter of 2007 for output, TFP and lobbying. In the case of investment, I take the difference with respect to fourth quarter of 2007.

Figure 1.12: Dispersion in Firm Level Capital and Interest Rate

Note: The left panel of this figure shows the percentage change relative to the value in steady state of the standard deviation of the marginal product of capital in the model. The right panel shows the evolution of the interest rate coming from the model.
Figure 1.13: Dispersion in Lobbying Expenditure for Taxation

Note: Own elaboration based on matched from Compustat and lobbying data from CRP. The figure plots the evolution of the log of lobbying expenditure for taxation.

Figure 1.14: Decomposition of Effects of the Credit Crunch with Lobbying
Figure 1.15: Counterfactual Dispersion of Capital

Note: The figure displays the evolution of the logarithm of the dispersion in the marginal product of capital relative to 2007 for the full model and the model without lobbying.

Figure 1.16: Effective Tax Rates

Note: The figure shows the cumulative change of the effective tax rate for public firms relative to the value of 2007 for the data and with respect to steady state in the model. The left panel shows values for lobbying firms, and the right panel for non-lobbying firms.
Figure 1.17: Share of Total Lobbying Expenditure by Sector 2

Note: The figure shows the cumulative change with respect to 2007 of the share of total lobbying expenditure by sector two.
1.9 Data Appendices

1.9.1 Construction of the Lobbying Data

The Center for Responsive Politics provides their own industry/sector classification called “catcode”. Using that information, I can clean part of the data in order to keep only those that belong to companies. The eliminated codes are: 156-161; 255-265; 267-290; 297-325; 407-413; 415-421 and 27, 180, 219, 225, 228. After dropping those categories, I use regular expression algorithms (and ocular inspection) to look for observations with specific keywords that relate to non-profits or associations of individuals. A “+” symbol in between words means that I looked for combinations of those words. The list of keywords is the following: “ASSN”, “COLLEGE”, “UNIVERSITY”, “ASSOCIATION”, “CITY OF”, “BUREAU”, “CHAMBER OF”, “FEDERATION OF”, “COUNCIL”, “ACADEMY”, “CULINARY”, “PROJECT”, “COALITION”, “AUTH”, “COMMITTEE”, “MINISTRIES”, “ALLIANCE”, “FRIENDS OF”, “CONSUMERS FOR”, “FEDERATION FOR”, “PHYSICIAN”, “AMERICAN SOCIETY FOR”, “NURSE”, “SURGERY”, “VISITING”, “REHABILITATION”, “PSYCHOANALYSIS”, “PSYCHOLOGY”, “PSYCHOTHERAPY”, “AMERICAN SOCIETY”, “CONGRESS”+“SOCIETY”, “AMERICAN”+“BOARD”+“ACAD”. After eliminating these observations, we end up with the firm level data set used as raw data to compute statistics and to match with Compustat.
1.9.2 Matching of the Datasets

After obtaining a list of parent companies and subsidiaries for Compustat, I attempt to find matches in the list of lobbying firms. In order to do that, I use open refine. Open refine is a reconciliation service that uses a probabilistic matching algorithm to obtain “likely” matches. This routine generated a score for each potential match, the score based on the inverse of the frequency of each word in the name. Potential matches that included unusual words in both the assignee name and the organization name received high scores. Scores for those matches above 95% were considered good matches. For scores between 60% and 95%, I manually check the potential matches using ORBIS and the internet. The advantage of openrefine is that it gives you a list of candidates to match, making the process a little bit less cumbersome.

After matching the data, I keep observations that have non-negative pre-tax income, that are domestic firms. After that, I eliminate all firms in agriculture and in the financial sector. I clean the data to exclude extreme values and missing values for the variables considered in regression 1.1. To run this regression, I use a balanced panel of with 20412 firm-year observations between 2005-2010.
1.9.3 Lobbying Disclosure Form

1.9.4 Sectors by External Financial Dependence

To compute the external finance measure, I sum the firm’s use of external funds across the whole period, and then divide that with respect to the sum of the capital expenditure in...
that period of time. In order to compute the cash flows of the firm, I only consider the cases where the cash flows from operations are not missing. If this is a non-missing value, we treat the rest of the variables as having non-missing values, even though some of them may be missing. See Cetorelli and Strahan (2006) for the complete methodology.

The following table displays 63 SIC two digits sectors in order of decreasing financial dependence following the methodology from Cetorelli and Strahan (2006) based on Rajan and Zingales (1998).

Classification by SIC and External Finance

<table>
<thead>
<tr>
<th>Sector</th>
<th>SIC</th>
<th>Ext finance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forestry</td>
<td>04</td>
<td>-3.22</td>
</tr>
<tr>
<td>Insurance carriers</td>
<td>63</td>
<td>-2.72</td>
</tr>
<tr>
<td>Leather &amp; leather products</td>
<td>31</td>
<td>-0.96</td>
</tr>
<tr>
<td>Apparel &amp; other finished prods of fabrics &amp; similar materials</td>
<td>23</td>
<td>-0.71</td>
</tr>
<tr>
<td>Stone, clay, glass and concrete products</td>
<td>32</td>
<td>-0.67</td>
</tr>
<tr>
<td>Tobacco products</td>
<td>21</td>
<td>-0.63</td>
</tr>
<tr>
<td>Services-educational services</td>
<td>82</td>
<td>-0.52</td>
</tr>
<tr>
<td>Services-engineering, accounting, research, management, and related services</td>
<td>87</td>
<td>-0.5</td>
</tr>
<tr>
<td>Security &amp; commodity brokers, dealers, exchanges &amp; services</td>
<td>62</td>
<td>-0.44</td>
</tr>
<tr>
<td>Services-social services</td>
<td>83</td>
<td>-0.43</td>
</tr>
<tr>
<td>Food and beverages</td>
<td>20</td>
<td>-0.34</td>
</tr>
<tr>
<td>Measuring, analyzing, and controlling instruments; photographic, medical and optical goods</td>
<td>38</td>
<td>-0.3</td>
</tr>
<tr>
<td>Services/miscellaneous repair services</td>
<td>76</td>
<td>-0.25</td>
</tr>
<tr>
<td>Legal services</td>
<td>81</td>
<td>-0.24</td>
</tr>
<tr>
<td>Fabricated metal products, except machinery and transportation equipment</td>
<td>34</td>
<td>-0.24</td>
</tr>
<tr>
<td>Furniture and fixtures</td>
<td>25</td>
<td>-0.23</td>
</tr>
<tr>
<td>Miscellaneous manufacturing industries</td>
<td>39</td>
<td>-0.2</td>
</tr>
<tr>
<td>Local &amp; suburban transit &amp; interurban hwy passenger transportation</td>
<td>41</td>
<td>-0.19</td>
</tr>
<tr>
<td>Business services</td>
<td>53</td>
<td>-0.13</td>
</tr>
<tr>
<td>Retail-apparel &amp; accessory stores</td>
<td>56</td>
<td>-0.1</td>
</tr>
<tr>
<td>Services-personal services</td>
<td>72</td>
<td>-0.12</td>
</tr>
<tr>
<td>Publishing or publishing and allied printing</td>
<td>27</td>
<td>0.12</td>
</tr>
<tr>
<td>Communications</td>
<td>48</td>
<td>0.07</td>
</tr>
<tr>
<td>Transportation equipment</td>
<td>37</td>
<td>0.1</td>
</tr>
<tr>
<td>Industrial and commercial machinery and computer equipment</td>
<td>35</td>
<td>0.01</td>
</tr>
<tr>
<td>Primary metal industries</td>
<td>33</td>
<td>0.03</td>
</tr>
<tr>
<td>Railroad transportation</td>
<td>40</td>
<td>0.02</td>
</tr>
<tr>
<td>Lumber &amp; wood products, except furniture</td>
<td>24</td>
<td>0.04</td>
</tr>
<tr>
<td>Rubber and miscellaneous plastics products</td>
<td>30</td>
<td>0.04</td>
</tr>
<tr>
<td>Mining &amp; quarrying of nonmetallic minerals (no fuels)</td>
<td>14</td>
<td>0.05</td>
</tr>
<tr>
<td>Papers and allied products</td>
<td>26</td>
<td>0.06</td>
</tr>
<tr>
<td>Petroleum refining and related industries</td>
<td>29</td>
<td>0.09</td>
</tr>
<tr>
<td>Textile mill products</td>
<td>22</td>
<td>0.1</td>
</tr>
<tr>
<td>Motor freight transportation and warehousing</td>
<td>42</td>
<td>0.1</td>
</tr>
<tr>
<td>Transportation services</td>
<td>47</td>
<td>0.1</td>
</tr>
<tr>
<td>Wholesale trade; non-durable goods</td>
<td>51</td>
<td>0.1</td>
</tr>
<tr>
<td>General merchandise stores</td>
<td>53</td>
<td>0.12</td>
</tr>
<tr>
<td>Coal mining</td>
<td>52</td>
<td>0.13</td>
</tr>
<tr>
<td>Food stores</td>
<td>54</td>
<td>0.16</td>
</tr>
<tr>
<td>Miscellaneous retail</td>
<td>59</td>
<td>0.16</td>
</tr>
<tr>
<td>Motion pictures</td>
<td>78</td>
<td>0.17</td>
</tr>
<tr>
<td>Amusement and recreation services</td>
<td>70</td>
<td>0.21</td>
</tr>
<tr>
<td>Electronic &amp; other electrical equipment and components, except comp. equipment</td>
<td>36</td>
<td>0.22</td>
</tr>
<tr>
<td>Electric, gas &amp; sanitary services</td>
<td>39</td>
<td>0.24</td>
</tr>
<tr>
<td>Eating and drinking places</td>
<td>58</td>
<td>0.25</td>
</tr>
<tr>
<td>Chemicals &amp; allied products</td>
<td>28</td>
<td>0.28</td>
</tr>
<tr>
<td>Fishing, hunting and trapping</td>
<td>9</td>
<td>0.31</td>
</tr>
<tr>
<td>Wholesale trade; durable goods</td>
<td>50</td>
<td>0.32</td>
</tr>
<tr>
<td>Health services</td>
<td>80</td>
<td>0.33</td>
</tr>
<tr>
<td>Real estate</td>
<td>65</td>
<td>0.38</td>
</tr>
<tr>
<td>Services-automotive repair, services &amp; parking</td>
<td>75</td>
<td>0.38</td>
</tr>
<tr>
<td>Automobile dealers and gasoline service stations</td>
<td>55</td>
<td>0.41</td>
</tr>
<tr>
<td>Oil and gas extraction</td>
<td>13</td>
<td>0.43</td>
</tr>
<tr>
<td>Hotels, rooming houses, camps &amp; other lodging places</td>
<td>70</td>
<td>0.45</td>
</tr>
</tbody>
</table>
1.9.5 Sectoral output for Low and High Externally Dependent Sector

Since I am interest in the long term behavior of the variables, I extract the cyclical component using the Hodrick-Prescott filter with an annual smoothing parameter of 100. Given my classification, I construct value added at current prices for the low financial dependent sector and for the high dependent. I take the ratio of those two, and I detrend the resulting time series using the HP filter. To construct sectoral value added at constant prices, I divide the industry current prices value added by the corresponding price deflator. After that, I aggregate to construct the low and high financially dependent sector and after taking the ratio I detrend the time series.

1.9.6 Firm Level Data

The tax data available in compustat includes taxes at the federal level, at the state level and foreign taxes. Since this paper is about lobbying at the federal level, I construct a measure of effective tax rate at that level. To do end, I use the following variables: Income taxes total (TXT), Deferred taxes-state (TXDS), Deffered taxes-federal (TXDFED), Deffered taxes-foreign (TXDFO), Income taxes-federal (TXFED), Income taxes-foreign (TXFO), Income
taxes-state (TXS), Special items (SPI), Interest Expense (XINT), Equity in Earnings (Equi-
UITY), Pre Tax Income-Domestic (PIDOM).

\[
ETR = \frac{Income\ Taxes\ Current}{Pre\ Tax\ Income - Equity\ in\ Earnings - Special\ Items + Interest\ Expense},
\]

where

\[
Income\ Taxes\ Current = TXT - TXS - TXF0 - TXDFED - TXDS - TXDFO.
\]

Value Added

Firms typically use many inputs in the productive process, such as materials, labor, energy,
capital, etc. Here, I include in materials everything that is not physical capital and labor
directly involved in production. Therefore, value added is defined as gross value of production
net of expenditures on materials as well as expenditures on other items.

One of the weaknesses of Compustat is that it lacks information on value added and
materials at the firm level. However, it contains information on operating income before
depreciation which can be used to measure materials. Specifically, to compute value added
\(P_{syt}\) I need sales minus materials. Sales are represented by the variable (SALE) while
materials have to be measured as total expenses minus labor expenses. Total expenses
is given by sales minus operating income before depreciation and amortizations (variable
OIBDP). Labor expenses is computed as number of employees (EMP) from COMPUSTAT
multiplied by industry average wage computed from the March current Population Survey
(CPS) at SIC 2 digits. I describe how to get those average wages in a separate section. Finally, in order to compute value added I deflate the obtained values using the producer price index (PPI) for each 2-sector digits SIC.

**Producer Price Index (PPI)**

I use the PPI provided by the Bureau of Labor Statistics (BLS) under the commodities classification. I tried to follow the SIC 2 digits classification as closely as possible. However, in some cases I had to make a decision regarding to which price to use. For example, for SIC 20 (Food and Beverages) I use the PPI for Food, since there is no such category available. For SIC 75 (Automotive repair, services and parking) I use the PPI for Retailing of all other goods, sales of prepared foods and repair services.\(^{55}\) In those sectors where the BLS does not provide a producer price index, I use the value added price deflator provided by the bureau of economic activity (BEA) in the NIPA tables.

**Average Annual Wage**

This part closely follows Krusell et al. (2000). I use the March current Population Survey (CPS) integrated by IPUMS (FLOOD ET AL, 2015) for the years 2004 to 2013. To compute the average annual wage at the 2 digits SIC I use data of all people, excluding self employed workers, unpaid family workers and the military force. I keep all the agents with ages between 16 and 70. After that, I drop all the observations with total annual hours worked less than a quarter of part time job (260 hours) in order to have a representative sectoral average wage.

\(^{55}\)This is included in gasoline stores
of a full time worker. Finally, topcoded income value for 2004 to 2013 are adjusted using the revised income topcode files published by the Census Bureau.

**Capital Stock**

To compute the marginal product of capital at the firm level, a time series of the capital stock is necessary. Unfortunately, Compustat does not provide a value of the capital stock, so I construct it based on gross value of property, plant and equipment (PPEGT) from compustat. Given that investment is made in different periods of time in the past, I compute the average age of capital in each year and then I apply an appropriate deflator. The assumption is that investment is made all in year \((current\ year - age)\). The gross book value of capital stock was deflated by an investment deflator. Investment deflator data is from the Bureau of labor statistics (BLS), In particular, I use Rental price tables from the Multifactor productivity section. For the investment deflator, I use the deflator corresponding to All Assets. In order to smooth out the age, I use a three year moving average. If it is not possible, I use a two year moving average or the last observation available. The average stock of capital is calculated by dividing accumulated depreciation [computed from Compustat item 8, property, plant and equipment (total-net)] by current depreciation from Compustat \((DP)\).

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56 The approach is based on Hall (1990) and Brynjolfsson and Hitt (2003).
1.9.7 Aggregate Macro Variables

Figure 1.11 plotted the evolution of the model and output. To construct the time series of output I use the quarterly real value added of the non-farm Business sector from the BEA tables, adjusted to exclude the financial sector. I use the HP filter to detrend the series using a penalty parameter of 1600. The plot is the difference between the value of the deviation from HP trend in the fourth quarter of 2007.

In order to construct TFP, data for labor and capital is necessary. I use quarterly data for labor hours used in production by the business sector coming from the labor productivity and costs statistics as the analog for labor in the computation (BLS). The capital stock is computed based on perpetual inventory method using gross investment from NIPA tables deflated by the price index of non-residential investment. To compute depreciation, I use the depreciation values coming from table 6.4 for the non-financial business sector. I adjust gross investment to account for the share of the financial sector in the economy.

For the time series of consumption, I use quarterly data of expenditure in non-durables and services. I use data from table 2.3.5 for personal consumption, and then I deflate all variables by the corresponding price index.

Since the Hodrick-Prescott filter requires long time series, all the variables that have been detrended start in 1960.
1.10 Derivations

1.10.1 Profit Maximization of the Final Producer

The problem of the final producer is:

$$\max_{y_1,y_2} P \left[ \gamma y_1^{\epsilon - 1} + (1 - \gamma) y_2^{\epsilon - 1} \right] - p_1 y_1 - p_2 y_2$$

the first order conditions imply:

$$\frac{p_1}{p_2} = \frac{\gamma}{1 - \gamma} \left( \frac{y_1 t}{y_2 t} \right)^{-\frac{1}{\epsilon}}$$

$$\left[ \frac{p_2}{p_1} \frac{\gamma}{1 - \gamma} \right]^\epsilon y_2 t = y_1 t.$$  

Zero profit condition in this sector implies that the aggregate price level is given by the following standard expression:

$$P = \left[ p_1^{1-\epsilon} \gamma^\epsilon + (1 - \gamma)^\epsilon p_2^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}}.$$  

From now on, we assume that this is the numeraire in the economy. Now, if the price index is the numeraire, we can write

$$p_2 = \left[ \frac{P^{1-\epsilon} - \gamma^\epsilon p_1^{1-\epsilon}}{(1 - \gamma)^\epsilon} \right]^{\frac{1}{1-\epsilon}}$$

so given a guess for $p_1$ and the numeraire, we can recover the price in the second sector.
The GDP is

\[ Y = \left[ \gamma y_{1t}^{1-\epsilon} + (1-\gamma) y_{2t}^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}} \]

then \( \dot{\gamma} \) solves:

\[ \gamma = \frac{Y^{1-\epsilon} - y_{2t}^{1-\epsilon}}{y_{1t}^{1-\epsilon} - y_{2t}^{1-\epsilon}} \]

### 1.10.2 Derivations for the Intermediate Firm

In this Appendix, I show the details to solve the model for each case of the lobbying decision. The general strategy is the following: first, I solve each case assuming perfect capital markets, with and without the constraint on benefits binding. Then, I solve assuming an economy with financial frictions.

**Non-Lobbying Firm**

Let \( \lambda^* \) be the multiplier of the constraint on tax benefit firms can claim. The Lagrangian of this problem with perfect capital markets (no financial frictions) is the following:

\[ L = (1-\tau + \lambda^* \otimes \tau) \left[ p_{st} z_{st} (k_{st}^{\alpha} l_{st}^{1-\alpha})^\eta - w_t l_{st} - R_t (k_{st} + f_s) \right] + (1-\lambda^*) [(1-\tau) k_{st} (\phi)] \]

Solving for the production inputs when \( \delta^* = 0 \) we get

\[
\begin{align*}
\eta^{\text{unc,nl}}_{st} & = \left[ \eta p_{st} z_{st} \left[ \frac{(1-\alpha)}{w_t} \right]^{1-\alpha \eta} \left[ \frac{\alpha}{R_t - \phi} \right]^\alpha \right]^{\frac{1}{1-\eta}} \\
k^{\text{unc,nl}}_{st} & = \left[ \eta p_{st} z_{st} \left[ \frac{(1-\alpha)}{w_t} \right]^{\eta(1-\alpha)} \left[ \frac{\alpha}{R_t - \phi} \right]^{1-\eta(1-\alpha)} \right]^{\frac{1}{1-\eta}}
\end{align*}
\]
where the subscript ”unc, nl” denotes an unconstrained solution for a non lobbying firm.

This is the solution assuming that the constraint on the limit of benefits is not binding

When $\lambda^* > 0$, we get that

$$\otimes \tau \left[ p_{st} z_{st} \left( k_{st}^{\alpha} t_{st}^{1-\alpha} \right)^\eta - w_t l_{st} - R_t \left( k_{st} + f_s \right) \right] = (1 - \tau) k_{st} (\phi)$$

In addition, the first order condition for labor still holds:

$$p_{st} z_{st} \eta (1 - \alpha) k_{st}^{\alpha \eta} l_{st}^{(1-\alpha) \eta - 1} - w_t = 0.$$  

From this equation, we can write labor as a function of capital

$$l_{st} = \left[ \frac{p_{st} z_{st} \eta (1 - \alpha)}{w_t} k_{st}^{\alpha \eta} \right]^{\frac{1}{1-\eta}}$$  

(1.22)

and replace in the first order condition for $\lambda^*$

$$\otimes \tau \left[ \left( \eta (1 - \alpha) \right)^{-1} - 1 \right] \left( \frac{p_{st} z_{st} \eta (1 - \alpha)}{w_t^{(1-\alpha) \eta}} \right)^{\frac{1}{1-\eta}} k_{st}^{\frac{\alpha \eta}{(1-\alpha) \eta}} - R_t \left( k_{st} + f_s \right) = (1 - \tau) k_{st} (\phi),$$

which is an equation in $k_{st}$ to be solved numerically.

In order to compute the solution, I first solve "as if" $\lambda^* = 0$ and check if the constraint on the maximum benefit is binding or not given the solution to that problem.

When we have financial frictions, the Lagrangian of the problem becomes
\[ L = (1 - \tau + \lambda^* \odot \tau) \left[ p_{st} z_{st} (k_{st}^{\alpha l_{st}^{1-\alpha}})^{\eta} - w_t l_{st} - R_t (k_{st} + f_s) \right] + \\
+ (1 - \lambda^*) [(1 - \tau) k_{st} \phi] + \delta^* [\lambda a_{st} - k_{st} - f_s - f_t] \]

where \( \delta^* \) is now the lagrange multiplier on the collateral constraint. If \( \delta^* > 0 \), \( k_{st} = \lambda a_{st} - f_s - f_t \).

As before, labor is given by (22). From here, it is straightforward to solve for the rest of the variables.

**Lobbying Firm**

In this section, I solve the problem of a lobbying firm. As before, I solve the problem in the complete market benchmark as a first step, and after that I move to the case with financial frictions. The lagrangian when the financial frictions is not present is

\[ L = (1 - \tau + \lambda^* \odot \tau) \left[ p_{st} z_{st} (k_{st}^{\alpha l_{st}^{1-\alpha}})^{\eta} - w_t l_{st} - R_t (k_{st} + f_s) \right] + \\
+ (1 - \lambda^*) [(1 - \tau) k_{st} \phi] + \delta^* [\lambda a_{st} - k_{st} - f_s - f_t] \]

When \( \lambda^* = 0 \), the first order condition for lobbying (assuming an interior solution) implies a relationship between lobbying effort and capital,

\[ e_{st} = \left[ \frac{(1 - \tau) \nu \mu}{h} \right]^{\frac{1}{\nu}} k_{st}^{\frac{1}{1-\nu}} \] (1.23)

Replacing (1.23) and (1.22) in the first order condition for capital we get
\[ (\eta_p z_{st})^{1-(1-\alpha)_{\eta}}\frac{\alpha}{R_t} \left[ \frac{(1 - \alpha)_{\eta}}{w_t} \right]^{\frac{(1-\alpha)_{\eta}}{R_t}} k_{st}^{\frac{\eta-1}{R_t(1-\alpha)_{\eta}}} = \frac{1}{R_t} \left( R_t - \phi - \mu \left[ \frac{(1 - \tau) \nu \mu}{h} \right]^{\frac{\nu}{\nu}} k_{st}^{\frac{\nu}{\nu}} \right). \]

This is a nonlinear equation in \( k_{st} \) that has to be solved numerically. Given this solution, we recover the optimal choices for labor and lobbying when you are unconstrained in the choice of capital and the constraint on the amount of tax benefits you can get is not binding.

When \( \lambda^* > 0 \), we get that
\[ \Theta \tau \left[ p_{st} z_{st} (k_{st}^{\alpha(1-\alpha)})^\eta - w_{st} l_{st} - R_t (k_{st} + f_s) \right] = (1 - \tau) k_{st} (\mu e_{st}^\nu + \phi) \]

It is relatively straightforward to show that this problem reduces to the following system of equations in \( k_{sit} \) and \( \lambda^* \):

\[
1 - \left\{ h^* \frac{1}{k_{sit}} \left( \Theta \tau \left[ (\eta_{sit})^{1-(1-\alpha)_{\eta}} \frac{1}{k_{sit}^{\frac{1}{1-(\alpha)_{\eta}}}} - R_t \left( 1 + \frac{f_s}{k_{sit}} \right) \right] - \phi \right)^{\frac{\xi-\nu}{\nu}} \right\} = \lambda^* \tag{1.24}
\]

\[
(1 - \tau + \lambda^* \Theta \tau) \left[ \theta_{1s} z_{sit}^{\frac{1}{1-(1-\alpha)_{\eta}}} k_{sit}^{\frac{\eta-1}{1-(1-\alpha)_{\eta}}} \right] = R_t (1 - \tau + \lambda^* \Theta \tau) - (1 - \tau) (1 - \lambda^*) \left( \mu e_{sit}^{\frac{\nu}{\nu}} + \phi \right) \tag{1.25}
\]

where \( \theta_{1s} = (\eta_{p A} A_s)^{\frac{1}{1-(\alpha)_{\eta}}} \alpha \left[ \frac{(1 - \alpha)_{\eta}}{w_t} \right]^{\frac{(1-\alpha)_{\eta}}{1-(\alpha)_{\eta}}} \), \( \theta = \left[ (\eta (1 - \alpha))^{-1} - 1 \right] \), \( h^* = \frac{h}{(1-\tau)\nu \mu} \left( \frac{1}{\mu} \right)^{\frac{\xi-\nu}{\nu}}, \)
\( \eta_{st} = \frac{p_{st} z_{st} A_s \eta (1-\alpha)}{w_t^{1-(\alpha)_{\eta}}} \) and \( e_{st} = \left[ (1 - \lambda^*) \frac{(1-\tau)\nu k_{st} \mu}{h} \right]^{\frac{\nu}{\nu}}. \)

Finally, we need to analyze the case where there are financial frictions. Let \( \lambda^* \) the multiplier of the constraint on tax benefit you can get and \( \delta^* \) the constraint on the financial constraint. The
lagrangian of this problem with financial frictions is given by

\[
L = (1 - \tau + \lambda^* \otimes \tau) \left[ p_{st} z_{sit} A_s \left( k_{sit}^{\alpha} l_{sit}^{1-\alpha} \right)^{\eta} - w_{l sit} - R_t \left( k_{sit} + f_s \right) \right] + \\
+ (1 - \lambda^*) \left[ (1 - \tau) k_{sit} \left( \mu e^\nu_{it} + \phi \right) \right] \\
- h e^\varepsilon \frac{\xi}{\zeta} - f_l R_t + \delta^* \left[ \lambda a_{it} - k_{sit} - f_s - f_t \right]
\]

Suppose that \( \delta^* > 0 \). Then \( k_{sit} = \lambda a_{it} - f_s - f_t \). When \( \lambda^* = 0 \), the solution for labor is given by (22). In addition, lobbying effort is given by (1.23). Using all this, we can check whether the constraint on tax benefits is binding or not. If it is binding, \( \lambda^* > 0 \) and we have that

\[
\otimes \tau \left[ p_{st} z_{sit} A_s \left( k_{sit}^{\alpha} l_{sit}^{1-\alpha} \right)^{\eta} - w_{l sit} - R_t \left( k_{sit} + f_s \right) \right] = (1 - \tau) k_{sit} \left( \mu e^\nu_{it} + \phi \right)
\]  

(1.26)

Using the (1.26) and (1.22) we can solve for the lobbying effort,

\[
e_{it} = \left\{ \left\{ \frac{1}{(1 - \tau) \mu k_{sit}} \left[ p_{st} z_{sit} A_s \left( k_{sit}^{\alpha} l_{sit}^{1-\alpha} \right)^{\eta} - w_{l sit} - R_t \left( k_{sit} + f_s \right) \right] \right\} - \frac{\phi}{\mu} \right\}^{\frac{1}{\tau}}
\]

considering that capital is constrained by \( k_{sit} = \lambda a_{it} - f_s - f_t \).

\subsection{1.10.3 Equivalence Between Renting and Owning Capital with Taxes}

Following a similar approach to Moll (2014) and Shourideh and Zetlin Jones (2016), I show that the model where entrepreneurs rent capital is equivalent to owning capital and issuing risk free debt. From here, we can derive the appropriate rental rate of capital that each entrepreneur has
to pay.

Assume that the length of time is equal to $\Delta$. Let $d_t$ be the stock of debt an entrepreneur holds at period $t$. As in Buera and Moll (2015) and Gopinath et al. (2015), assume that the productivity of the entrepreneur in period $t$, $z_{st}$, is revealed at $t - \Delta$. This assumption is important in order to have an interesting role for credit. In this way, the decision to invest in physical capital occurs given full information about the return of the investment (there is no investment risk as in Angeletos 2007). Define $\tilde{k}_t = k_t + f$, where $f_t$ is a fixed cost in terms of capital used every period. Then, the budget constraint and law of motion for capital in the case of a lobbying firm is given by

$$0 = \Delta \left[ (1 - \tau) p_{st} y_{st} - w_t l_t - c_t \right] - \Delta x_{t+\Delta} + d_{t+\Delta} - d_t - r_t d_t \Delta + \Delta \tau(\phi, e_{st}) - \Delta \Gamma(e_{sit})$$

and

$$\tilde{k}_{t+\Delta} = \Delta x_{t+\Delta} + (1 - \Delta \delta) \tilde{k}_t$$

where as before $\tau(\phi, e_{st})$ is the lobbying return, $\Gamma(e_{st})$ is the lobbying cost and $x_{t+\Delta}$ is investment in new capital stock. Putting both together we obtain

$$k_{t+\Delta} - d_{t+\Delta} = \Delta \left[ (1 - \tau) \left( p_{st} y_{st} - w_t l_t - \delta \left( k_{t+\Delta} + f \right) \right) - r_t \frac{d_t}{1 - \tau} \right] - c_t + k_t + f - d_t + \Delta \tau(\phi, e_{sit}) - \Delta \Gamma(e_{sit}).$$

Define

$$d_t^- \equiv d_t - \Delta x_t, \quad k_t^- \equiv \tilde{k}_t - \Delta x_t$$

$^{57}$Notice that in the fixed cost I am including the fixed cost of lobbying and the one for production. The case of a non-lobbying firm is analogous to this derivation.
and forwarding by $\Delta$ we have

$$d_{t+\Delta} = d_t - \Delta x_{t+\Delta}, \quad k_{t+\Delta} = k_t - \Delta x_{t+\Delta}.$$

Using the definitions we have that the budget constraint is given by

$$k_{t+\Delta} - d_{t+\Delta} = \Delta \left[ (1 - \tau) \left( p_{st} y_{st} - w t_l - \frac{r_t}{1 - \tau} (d_t - \Delta x_t) - \delta \left[ \frac{k_t + f}{1 - \tau} \right] \right) - c_t \right] +$$

$$+ k_t - d_t + \Delta \tau (\phi, e_{sit}) - \Delta \Gamma (e_{sit}),$$

where $d_t$ and $k_t$ are debt and capital before investment is made (remember that we know the productivity of next period before investing and deciding next period’s debt). Noticing that

$$r_t [d_t + \Delta x_t] = r_t [d_t + k_t + f - k_t],$$

we have

$$k_{t+\Delta} - d_{t+\Delta} = \Delta \left[ (1 - \tau) \left( p_{st} y_{st} - w t_l - \frac{r_t}{1 - \tau} (d_t - k_t) - (k_t + f) \left( \frac{\delta + r_t}{1 - \tau} \right) \right) - c_t \right] +$$

$$+ k_t - d_t + \Delta \tau (\phi, e_{sit}) - \Delta \Gamma (e_{sit}).$$

Now, let $a_t = k_t - d_t$ (net worth or wealth) to get

$$a_{t+\Delta} = \Delta \left[ (1 - \tau) \left( p_{st} y_{st} - w t_l + \frac{r_t}{1 - \tau} a_t - k_t \left( \frac{r_t + \delta}{1 - \tau} \right) \right) - c_t \right] + a_t + \Delta \tau (\phi, e_{sit}) - \Delta \Gamma (e_{sit})$$

letting the rental rate be equal to $R_t = \left( \frac{r_t + \delta}{1 - \tau} \right)$, dividing by $\Delta$ and taking $\Delta \to 0$ we have

$$\dot{a} = [(1 - \tau) (p_{st} y_{st} - w t_l - k_t R_t)] + r a_t - c_t + \tau (\phi, e_{sit}) - \Gamma (e_{sit}).$$

To derive the budget constraint used in the paper, let the amount of debt that you can use
every period given by

\[ d_{t+\Delta} \leq \left( 1 - \frac{1}{\lambda} \right) \tilde{k}_{t+\Delta}. \]

It is straightforward to show using the definitions of \( d_{t}^{-} \) and \( k_{t}^{-} \) that

\[ \tilde{k}_{t} \leq \lambda a_{t}. \]

1.11 Numerical Methods

This appendix discusses the numerical method used in the quantitative section of the model.

1.11.1 Stationary Equilibrium

I solve the stationary equilibrium based on the method of Achdou et al. (2014), in particular when solving the Hamiltonian-Jacobi-Bellman equation (HJB) and the Kolgomorov forward equation.\(^{58}\)

The difference is that I have to iterate over interest rate, price in sector 1, transfers from the government and wages to check market clearing conditions. In addition, my static problem implies a couple of stages that I describe below. The full procedure is as follows

1. Guess Interest rate \( r^{l} \)
2. Guess price in sector 1 \( p_{1}^{l} \)
3. Guess transfer \( T^{l} \).
4. Guess wage \( w^{l} \)

\(^{58}\)Please, refer to that paper and references therein to have more details of the procedure.
5. Given the price in sector one, wage and interest rate, first I solve the the problem of a firm assuming that the financial friction is not binding

(a) For a non-lobbying firm, assume first that the constraint on the amount of benefits you can claim (I call it CC constraint) is not binding and solve the problem. After that, check that the constraint does not bind. If it binds, solve the problem with a binding constraint, which reduces to solving the following equation numerically in capital:

$$
\ominus \tau \left[ p_{st} z_{st} A_s \left( k_{st}^{\alpha (1-\alpha)} \right)^{\eta} - w_t l_{st} - R_t \left( k_{st} + f_s \right) \right] = (1 - \tau) k_{st} (\phi).
$$

(b) I follow a similar approach with firms that are doing lobbying. First I assume that the CC constraint is not binding, and then I check if that is true. If it binds, solve the problem with a binding constraint.

(c) As a result of this process, we obtain capital demand for unconstrained firms in the firm is lobbying and if it is not. After that, we recover the labor demand for each case that comes from the first order condition of labor. For lobbying firms, we solve the unconstrained level of lobbying effort $e_{st}$.

6. After obtaining solutions with no financial frictions, compare the solution obtained in step 1 against the availability of funds $\lambda_t a$ that is given by the collateral constraint:

(a) To solve for the constrained case in the non-lobbying case, we need to keep track of the unconstrained choice of a firm with productivity $z_{st}$. Given asset $a_{st}$, we check whether $k_{it}^{unc} + f_s > \lambda_t a_{st}$. In that case, the choice of capital is given by $k_{it} = \lambda_t a_{st} - f_s$

59 I assume that the the numeraire is the final good price $P$, and given that $p_1$ we solve for the price in sector 2 as $p_2 = \left[ \frac{p_1^{1-e} - \epsilon^e p_1^{1-e}}{(1-\rho)} \right]^{\frac{1}{1-e}}$. 

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where $k_{it}^{unc}$ is the solution of the problem without the collateral constraint for a firm with productivity $z_{st}$. In the case where $k_{it}^{unc} + f_s < \lambda t a_{st}$ capital is given by the solution without the collateral constraint obtained in the step 1. Compute $\pi_{st}^{nlob}(a, z)$

(b) In the case of a lobbying firm, the procedure is the same as in step but instead of using the unconstrained level of capital for lobbying firms. After solving the problem, we get the profit for lobbying firms $\pi_{st}^{lob}(a, z)$.

7. After obtaining payoffs $\pi_{st}^{lob}(a, z)$ and $\pi_{st}^{nlob}(a, z)$ I compute the lobbying decision. This is simply comparing payoffs, $\tilde{V}_P^P(a_{st}, z_{st}, \Omega_t) = \max\{\pi_{st}^{lob}(a, z), \pi_{st}^{nlob}(a, z)\}$, and occupation decision $\max\{w_t, \tilde{V}_P^P(a_{st}, z_{st}, \Omega_t)\}$ for each type of agent.

8. Given prices, payoffs and transfers from the government solve the HJB equation and the Kolgomorov forward equation using a finite difference method combined with an implicit method and upwind scheme.

9. Check if the labor market clears. If not, update $w^l$ according to the excess labor demand using a bisection method. Repeat steps 5-8 until $w^{l+1}$ clears the labor market.

10. Compute transfer $\tilde{T}$ that balances budget given prices, tax benefits granted and tax collection. Check if $\tilde{T}$ equals $T^l$. If not, set $T^{l+1} = \tilde{T}$ and repeat steps 4-9 until the transfer converges.

11. Check if the goods market clear, using the FOC from the final producer. If not, update $p_1^l$ according to the excess demand for good 1 using a bisection method. Repeat the steps 5-10 until $p_1^{l+1}$ clears the goods market.

12. Finally, check whether the capital market clears using $r^l$, $w^{l+1}$, $T^{l+1}$ and $p_1^{l+1}$. If not, update $r^l$ according to the excess demand for capital using Bisection Method. Repeat steps 5-11 until all the markets are in equilibrium.
1.11.2 Transition Dynamics

To compute the transition dynamics during the credit crunch, I have to iterate over wage, interest rate, price of good 1 and transfer sequences. Taking these as given, I solve the agent’s problem and then check if the labor market, the capital market, the intermediate markets clear and the government budget balances for \( t = 0, \ldots, T \). I choose \( T \) equal to a 100 as the time to return to the initial steady state, and I check that the results are robust to increase in \( T \). The computation of the time dependent HJB and the time dependent kolgomorov forward equation, for each type of agent \( s \), follow from Achdou et al. (2014). The algorithm is the following:

1. Guess Interest rate \( \{r^l_t\}_{t=0}^T \)

2. Guess price in sector 1 \( \{p^l_t\}_{t=0}^T \)

3. Guess transfer \( \{T^l_t\}_{t=0}^T \)

4. Guess wage \( \{w^l_t\}_{t=0}^T \)

5. Given sequences of prices and transfer, solve HJB for each type \( s \) with terminal condition \( v_s(a, z, T) = v_s(a, z) \) backward to get the sequence of value functions \( v(a, z, t) \), where \( v_s(A, z) \) is the initial stationary value function.

6. Using optimal decision rules obtained in 5, solve the Kolgomorov forward equation with initial condition \( g_s(a, z) \) to get a sequence \( \{g_s(a, z, t)\}_{t=0}^T \). Notice that \( g_s(a, z) \) is the initial stationary pdf for agent of type \( s \). Check if the labor market clears in each period. If not, construct a new sequence \( \{\tilde{w}_t\}_{t=0}^T \) that clears labor market in each period and update the sequence as: \( \{w^l_{t+1}\}_{t=0}^T = \eta_w \{\tilde{w}_t\}_{t=0}^T + (1 - \eta_w) \{w^l_t\}_{t=0}^T \) with \( \eta_w \in (0, 1) \). Repeat 5-6 until convergence.
7. After convergence in the labor market, compute the budget-balancing transfer sequence 
\( \{ \hat{T}_t \}_{t=0}^T \) and update the transfer \( \{ T_{t+1}^{l+1} \}_{t=0}^T = \eta_T \{ \hat{T}_t \}_{t=0}^T + (1 - \eta_T) \{ T_t^l \}_{t=0}^T \) if necessary with \( \eta_T \in (0, 1) \). Repeat 5-7 until convergence.

8. After convergence of the wage sequence and the transfer sequence, check whether the goods market clears in every period using the FOC from the final producer. If not, compute a sequence \( \{ \hat{p}_{lt} \}_{t=0}^T \) that clears the market in every period and update the price sequence with 
\( \{ p_{l+1}^{l+1} \}_{t=0}^T = \eta_p \{ \hat{p}_{lt} \}_{t=0}^T + (1 - \eta_p) \{ p_l^{l+1} \}_{t=0}^T \) with \( \eta_p \in (0, 1) \). Repeat 5-8 until convergence.

9. After convergence of the wage sequence, the transfer sequence and the price of good 1 sequence converges, check whether the capital market clears in every period. If not, compute a sequence \( \{ \hat{r}_t \}_{t=0}^T \) that clears the market in every period and update the interest sequence with 
\( \{ r_{l+1}^{l+1} \}_{t=0}^T = \eta_r \{ \hat{r}_t \}_{t=0}^T + (1 - \eta_r) \{ r_l^{l+1} \}_{t=0}^T \) with \( \eta_r \in (0, 1) \). Repeat 5-9 until convergence.
Chapter 2

Market Power and Aggregate Efficiency in Financial Crises
2.1 Introduction

Large financial crises in emerging economies are very costly in terms of output and productivity. To a large extent, their scope and magnitude as well as the mechanisms that shape aggregate dynamics, are not well understood.

One feature of financial crises whose implications have not been studied in detail is the resulting increase in market concentration. Using a detailed manufacturing database we document that during the Colombian 1998/99 financial crisis, large firms become relatively larger and small firms become relatively smaller. This is true if we look at concentration within narrowly defined sectors, with measures such as the Herfindahl Index, and is also true for the economy as a whole, as measured by the evolution of the share of production by the largest firms.

Our hypothesis is that the impact on concentration is the result of financial factors that affect firms asymmetrically. A vast number of studies have shown that smaller, younger firms are more likely to face liquidity constraints during downturns (see for example Gertler and Gilchrist (1994) or Perez-Quiros and Timmermann (2000)), for reasons that may not be directly related to productivity. Small firms, for example, usually lack the collateral and/or reputation needed to obtain a loan; they typically cannot access international credit markets; they don’t have the lobbying power to access discretionary public credit; they have less access to formal sources of external finance; etc.

In this paper we analyze the aggregate consequences of the change in market power across firms that results from a credit crunch. If firms translate their market power into higher markups, more concentration could, in principle, result in higher markup dispersion, which affects aggregate productivity negatively. On the other hand, the ability to change markups in response to a credit shock may act as a buffer that counteracts the distortions generated by the credit crunch. The overall quantitative effect will depend upon the calibration of the model.
We address this question quantitatively using a model where firms are subject to a collateral constraint on the amount of capital that they can rent. Based on Buera and Shin (2011), agents are heterogeneous with respect to their ability and wealth. Those that decide to be entrepreneurs are forced to self-finance at least a portion of their working capital needs. A financial crisis in this framework is modeled as an exogenous, unexpected tightening of the collateral constraint, or, alternatively, an increase in the fraction of working capital that needs to be self-financed by entrepreneurs.

To allow for heterogeneous market power across firms we depart from the canonical model of constant markups. In our framework, large firms set higher markups than small firms. This results from a demand system of the Kimball (1995) family, that allows for price elasticity to decrease with quantities. Large firms face a more inelastic demand for their differentiated product and thereby charge higher markups.

We discipline the model to match salient features of the Colombian economy before the 1998/99 financial crisis. To that end we use balance sheet data from Supersociedades, and data from the annual manufacturing survey by Colombia’s statistical agency, DANE. A convenient feature of the variable markups model that we adopt is that it nests the standard model of constant markups as a special case. We then calibrate two versions of the model: one with variable markups and another one where we restrict markups to be constant, across firms and time.

We use the model to measure the extent to which changes in market power that result from a financial crisis matter at the aggregate level. To do so we shock the economy with an unexpected tightening of financial conditions, intended to reproduce the actual credit crunch faced by firms, which can be inferred—with the help of the model—from financial data. To identify the role of

---

1In what follows, unless otherwise noted, we use quantities produced as the measure of a firms size. In the model this is equivalent to hiring more workers or using more intermediate inputs.
market power quantitatively, we contrast the transition dynamics of the two versions of the model, variable vs. constant markups.

We find that heterogeneous markups dampen the negative response of output and aggregate productivity that follows a credit crunch. They act as a buffer that partially offsets the misallocation forced by the financial crisis. Intuitively, the credit crunch forces previously constrained firms (and firms that were close to the threshold before the credit crunch) to downsize. Large, unconstrained firms take the slack by increasing production in the constant markup case, and by (partially) increasing their markup in the variable markup case. The response in quantities is hence smaller in the variable markup case than in the constant markup case. Market power thus acts as a real rigidity, preventing firms from changing quantities (and prices) too much with respect to the initial equilibrium.

There are two sources of distortions in this model: financial frictions and heterogeneous markups. Financial frictions are exogenous to the firm, which tries to circumvent it through the accumulation of assets for self-financing purposes. Since the collateral constraint is imposed over capital, it affects the optimal capital-labor allocation, and is equivalent to a wedge on the capital-labor ratio. Heterogeneous markups are endogenous, in the sense that they can be interpreted as the deliberate decision of a firm to raise or lower their price in response to the competitive environment. It is equivalent to an endogenous wedge on size, or, as has been recently called by Bils et al. (2014), a product market wedge.

The assumption of heterogeneous markups, with larger firms charging higher markups, is informed by empirical evidence. First, revenue productivity, which should be equalized across firms if firms have the same markup, is increasing in size in the data. While markups are not the only reason for this pattern to hold, as any type of correlated distortion would generate such a pat-
tern, it is certainly a possibility that this is the result of markups. Second, the ratio between
the gross value of production and the value of intermediate inputs, which is positively related to
markups, is increasing in size. In the next section we will further discuss the empirical evidence on
heterogeneous markups.

There is yet another reason to include heterogeneous markups. One of the results of our
quantitative exercise shows that a model of constant markups calibrated to the Colombian economy
fails to reproduce the increase in market concentration triggered by a credit crunch. Variable
markups are required to reproduce the pattern.

The contribution of this paper is twofold. First, it documents the increase in concentration that
occurs during a financial crisis, a feature that, to our knowledge, has not been previously discussed.
Second, we contribute to the literature on resource misallocation over the business cycle, identifying
specific sources of misallocation and analyzing the aggregate implication of their interaction under
disruptive events.

This paper relates to many strands of literature. First, it relates to the literature that studies
the misallocation of resources as an important determinant of aggregate productivity. Restuccia
and Rogerson (2008) and Hsieh and Klenow (2009) focus on distortions in the form of wedges that
act as implicit taxes/subsidies that distort the allocation of capital and labor across firms. This
group of papers, typically known as the "indirect" approach, are often silent about the underlying
channels through which misallocation takes place and consider the overall effect of all the potential
sources of distortions in the economy.\textsuperscript{2} On the opposite side, those papers where misallocation

\textsuperscript{2}Bartelsman et al. (2013) is part of this set of papers. They followed a different method to measure cross
country differences in the allocation of resources. However, the qualitative results are similar to the ones
found in the aforementioned papers: the correlation between size and productivity is weaker in developing
countries.
arises as a result of a particular policy or institution are referred to as the "direct" approach. This branch of the literature typically picks a particular friction and using quantitative models tries to assess its contribution to the misallocation of resources and its impact on aggregate TFP.

Whereas those seminal articles study cross-country income differences at a point in time, our paper focuses on time-series dynamics. We share this interest with Oberfield (2013) and Sandleris and Wright (2014), who document that misallocation of resources across firms accounts for a large portion of TFP losses during crises. We differentiate from these papers in two ways. First, they do not point to a particular source of misallocation (i.e. they take an indirect approach). We take a stance on the specific sources of misallocation (namely: financial frictions and heterogeneous markups) and evaluate their interaction in response to a financial crisis. Recently, Bils et al. (2014) used US data to argue that distortions in the form of product market wedges (markups) deserve a central place in macroeconomic research. Second and most important, while their approach is closer to Hsieh and Klenow (2009) in the sense that they perform an accounting exercise, we propose a model that accounts for optimal responses based on forward looking behavior over a transition path.

Our paper also relates to the vast literature that studies quantitatively the interaction between financial frictions and aggregate TFP (Amaral and Quintin (2010); Buera et al. (2011); Buera and Shin (2011); Midrigan and Xu (2014); Moll (2014)). Following those papers, we model financial frictions as a collateral constraint that represents a limited commitment problem between borrowers and lenders. The main difference between these papers and ours is the existence of competitive effects in product markets. We relate to the many quantitative models that explore the macro and

---

3 The name of these approaches was first introduced by Restuccia and Rogerson (2013).

4 For a more exhaustive description of the resource misallocation literature see Hopenhayn (2014), Jones (2011), Restuccia and Rogerson (2013) and references therein. For a review focused on financial frictions and entrepreneurship, see Buera et al. (2015b).
micro implications of heterogeneous markups in different scenarios. Atkeson and Burstein (2008), for example, use a model where variable markups arise from imperfect competition and strategic interaction to explain deviations from relative purchasing power parity. For simplicity, our model abstracts from strategic interactions, but still captures the main prediction of that model: larger firms set higher markups. Edmond et al. (2015) studied the role of pro-competitive effects in reducing product market distortions in a trade liberalization event. Opening the economy to international trade could generate a reduction in markup variability as the result of more competition in the domestic market. They provide conditions under which a trade reform could push the economy closer to the pareto optimum allocation. Instead of focusing in trade reform, our paper studies the interaction of these forces with a tightening in credit conditions faced by domestic firms. Peters (2012) explores the interaction between innovation, entry-exit decisions of firms and markup adjustment when entry costs are modified. He finds that reductions in entry costs reduce misallocation derived from the markups, and that fosters the growth rate of the economy through innovation. In our model, the occupational choice of agents will determine the entry and exit of the economy, and will also have a key role in the intensive margin of competition. However, by introducing a financial shock that affects incumbents in a heterogeneous way, our model will also have implications for the intensive margin of competition through changes in market shares.

As we explain in detail below, the way we introduce variable markups follows the model first developed by Kimball (1995), and implemented by Klenow and Willis (2006) and Gopinath and Itskhoki (2010).\(^5\) They propose a demand system that allows for non-constant price elasticity, but that nest the standard constant elasticity benchmark as a special case. This allows us to contrast the variable markup case with constant markup case parsimoniously, by changing the value of a

\(^{5}\text{A different implementation is suggested in Dotsey and King (2005).}\)
single parameter.

This paper is structured as follows. In the following section, we present some motivating facts: the increase in concentration that occurred during the financial crisis and evidence on heterogeneous markups. We then present the model that we use as framework. In Section (2.4) we present the data and calibration strategy, with a brief description of the Colombian crisis. Section (2.5) shows our quantitative exercise. Section (2.6) concludes.

2.2 Motivating Facts

2.2.1 Increase in Concentration

In this section (and in the calibration of the model) we use data from Colombia’s Annual Manufacturing Survey (AMS). The AMS is conducted by DANE, Colombia’s statistical agency. It surveys all plants with at least 10 employees, or a minimum gross value of production that is updated periodically. It has about 8,000 observations per year, all in manufacturing. Surveyed firms produce over 95% of aggregate value added. It has information on sales, production, number of workers, wages, value of intermediate inputs, etc. It classifies plants in 4-digit ISIC sectors, and has information on prices and products at a 7-digit level.\(^6\)

The Colombian economy suffered its most severe economic crisis since the 1930s in 1998/99, with real GDP falling approximately 5\%.\(^7\) As a result, the Colombian economy became more concentrated, as measured by several indicators. Figure (2.1), for example, shows the evolution of the

\(^6\)A version of the database built by Eslava et al. (2004) with data covering the 1982-1998 period is readily available online. Microdata for a different time period (or to analyze different variables) can be accessed upon request in-situ, in the DANE offices in Bogotá.

\(^7\)We leave a more detailed description of the Colombian crisis for later.
average (and median) Inverse Herfindahl Index (IHI) across sectors in Colombian manufacturing.\textsuperscript{8} The IHI is defined as the inverse of the square sum of market shares within an industry. It is interpreted as the number of "effective competitors" within an industry: the lower the IHI, the more concentration in a sector. The fall in the IHI that results from the crisis is approximately 13\%.\textsuperscript{9} This pattern is partially explained by firm exit, but it also holds for continuing firms. Concentration as measured by the maximum market share also increases, on average, from 66\% in 1997 to 70\% in 1999.

Another measure of concentration used in quantitative applications is the value of production produced by the largest firms, as a share of total output. This measure also shows a (milder) increase of concentration. Before the crisis, the largest 10\% of firms produced 79\% of total value of production. At the height of the crisis they produced 81\%.

A caveat on the results above is that we are no including imported varieties in our computations. We think that, if anything, we are underestimating the increase in concentration, since financial crises in developing economies usually involve local currency depreciation that increases the relative price of imported varieties, many of which drastically reduce their market share or even disappear in local markets.

### 2.2.2 Heterogeneous Markups

There is evidence in Colombian microdata that firms set heterogeneous markups; more specifically, that larger firms set higher markups. The first evidence is given by revenue productivity. The literature on resource misallocation uses revenue productivity ($tfpr$) as a summary measure of distortions in an economy. It is defined as the price set by a firm times its physical productivity (i.e.

\textsuperscript{8}A sector is defined at the 7-digit NAICS classification level.

\textsuperscript{9}The fall is similar if we define sectors at the 4-digit NAICS level.
It is easy to show that if prices are set as a constant markup over marginal costs, absent other distortions \( tfpr \) is constant across firms.\(^{10}\) This does not hold in the data. Figure (2.2) shows a kernel regression between revenue productivity and firm size for Colombian manufacturing firms. The relationship is positive, consistent with larger firms setting higher markups.

More direct evidence on heterogeneous markups can be inferred from the ratio of the gross value of production to the value of intermediate inputs. De Loecker et al. (2012) show that markups are positively related to this ratio. Specifically:

\[
\mu_i = \nu \frac{p_i y_i}{p_i^{mc} m_i}
\]

where, \( \nu \) is the elasticity of output with respect to intermediate inputs and \( \mu \). Assuming that this elasticity is constant across firms (or that there is no systematic correlation between elasticity and firm size), markups move one to one with changes in this ratio. Figure (2.3) shows that, controlling by sector, this ratio is positively correlated with size.\(^{11}\)

### 2.3 A Model of Financial Frictions with Variable Markups

Based on the evidence presented above, we build an heterogeneous agents model where larger firms set higher markups. Following Buera and Shin (2011), we model financial frictions as a collateral constraint on the amount of capital that a firm can rent. That is, firms are forced to self-finance a

---

\(^{10}\) Under constant returns to scale, and absent other distortions, marginal costs take the form \( mc_{it} = \Gamma_{i} z_{it} \), where \( \Gamma_{i} \) is constant across firms. Hence, under constant markups \( tfpr_{it} = \text{markup} * \frac{\Gamma_{i}}{z_{it}} * z_{it} = tfpr \) i.e. constant across firms.

\(^{11}\) We use deviations from industry means, where industry is defined at the 4-digit level. We do this to control for potential differences in technology parameter \( \nu \) across firms, i.e., firms within narrowly-defined sectors are more likely to have similar technologies. Examples of 4-digit sectors are "Soap and Detergent", and "Refrigerators and Washing Machines".
fraction of their capital rental. A financial crisis in this environment is modeled as an exogenous increase in the fraction of capital that needs to be self-financed.

Agent Heterogeneity and Occupational Choice

There is a continuum of mass 1 of infinitely-lived agents i. They have standard CRRA preferences over the consumption of a final good, and are heterogeneous with respect to their entrepreneurial ability and financial wealth. Each period, with probability $\gamma$, an agent loses her entrepreneurial ability $z_i \epsilon Z$ and has to re-draw from the invariant distribution $G(z)$. To match some features of the data, in our calibration exercise we assume that $G(z)$ is a Pareto distribution with shape parameter $\phi$. Financial wealth $a_i$ is determined endogenously from savings decisions. Savings take the form of risk-free claims on physical capital. As we will discuss below, savings will serve two purposes: as self-insurance against idiosyncratic shocks, and as collateral to finance working capital requirements (if the agent is an entrepreneur). We implicitly assume throughout that agents cannot borrow (i.e. it has to be the case that $a \geq 0$, as in Aiyagari (1994)).

Every period, an agent makes an occupational choice: she decides to work for a wage $w_t$ or run her own business for a profit $\pi_{it}$. Formally, it chooses $o(z_{it}, a_{it}) \epsilon \{0,1\}$, where $o(z_{it}, a_{it}) = 1$ if $w < \pi_{it}$, and $o(z_{it}, a_{it}) = 0$ otherwise. The problem of an agent in period $t$ can be expressed recursively as:

$$V_t(z_{it}, a_{it}) = \frac{C^{1-\sigma}}{1-\sigma} + \beta E [V_{t+1}(z_{it+1}, a_{it+1}) | z_{it}]$$

This restriction can potentially be binding for workers only, not for entrepreneurs, as they need $a \geq 0$ to run their business, as we will discuss below.

For simplicity, we abstract from explicitly mentioning the aggregate states (price, output, and financial friction parameter -see below-).
subject to

\[ C_{it} + a_{it+1} = \max \{w, \pi_{it}(z_{it}, a_{it})\} + (1 + r_t)a_t \]  

(2.1)

where \( C_{it} \) is the consumption of the final good, which bundles all varieties in the economy. Notice how profits depend on both the ability of the entrepreneur that runs the firm, and her wealth; the latter as a result of the financial frictions. We explain the problem of the firm below.

**Final Good**

The only final good in this economy is produced by a competitive firm that aggregates all intermediate varieties using a constant return to scale aggregator of the family first described in Kimball (1995). Kimball’s aggregators are implicitly defined as \( \frac{1}{\Omega_t} \int_{\Omega_t} \Upsilon \left( \frac{\Omega_t y_{it}}{\Upsilon_t} \right) di = 1 \), where \( \Upsilon(1) = 1, \Upsilon' > 0 \), and \( \Upsilon'' < 0 \), and \( \Omega_t \) is the measure of varieties. We use a particular specification of the Kimball aggregator, proposed by Klenow and Willis (2006) and later used in Gopinath and Itskohiki (2010). Under this specification, the demand for intermediate varieties takes the following form:

\[
y_{it} = \begin{cases} 
\left[ 1 - \eta \ln \left( \frac{p_{it}}{P_t} \right) \right]^\frac{\sigma}{\eta} Y_t & \text{if} \quad 1 - \eta \ln \left( \frac{p_{it}}{P_t} \right) > 0 \\
0 & \text{otherwise}
\end{cases}
\]  

(2.2)

It is easy to show that the price elasticity of demand faced by firm \( i \) at time \( t \), \( \varepsilon_{it} \) is given by:

\[
\varepsilon_{it} = \frac{\sigma}{1 - \eta \ln \left( \frac{p_{it}}{P_t} \right)}
\]  

(2.3)

\[14\] More details on the Klenow and Willis (2006) specification can be found in Appendix (2.8.1). See Dotsey and King (2005) for an alternative specification.
This illustrates two important features of this demand system. First, for a given level of $\eta$ and $\sigma$, demand is more elastic the higher the relative price. Second, this model nests the standard constant elasticity of substitution (CES) case, since when $\eta \to 0$, $\varepsilon_{st} \to \sigma$. This will be useful to use as a constant markup benchmark in the quantitative exercises.

Parameter $\eta$ pins down the rate at which demand elasticity changes along the demand curve, or superelasticity $\varepsilon_s^s$:

$$\varepsilon_s^s = \frac{\eta}{1 - \eta \ln \left( \frac{p_{it}}{P_t} \right)} \quad (2.4)$$

Again, when $\eta \to 0$, $\varepsilon_s^s \to 0$; i.e. elasticity is constant along the demand curve. Figure (2.4) displays the resulting demand functions for different values of $\eta$. As mentioned before, $\eta = 0$ corresponds to the CES case.

### The Problem of the Entrepreneur

Agents that decide to become entrepreneurs in period $t$ hire labor, materials and capital to produce a differentiated intermediate good $y_{it}$. They have access to a constant returns to scale Cobb-Douglas technology indexed by their own ability: $y_{it} = z_{it} \left( k_{it}^{\alpha} l_{it}^{1-\alpha} \right)^{\nu} m_{it}^{(1-\nu)}$. The amount of capital that an entrepreneur can rent in any period is subject to a collateral constraint of the form $k_{it} \leq \lambda_t a_{it}$. The economy-wide parameter $\lambda_t$ ($\geq 1$) summarizes in a parsimonious way the degree of financial frictions or credit constraints in the economy. A low $\lambda_t$ is associated with a high degree of financial frictions in an economy. In the limit, when $\lambda_t \to 1$, firms must self-finance all of their capital rental. At the other extreme, when $\lambda_t \to \infty$, the economy has perfect capital markets. In this case, saving decisions are independent of production decisions and have consumption smoothing as their sole
motive.\footnote{Financial constraints of this form capture in a simple way patterns that arise endogenously in limited commitment environments. See Buera and Shin (2011) for further details.} Materials is a composite good, produced with the same technology as the final good, as in Basu (1995). Its price is thus equal to that of the final good in equilibrium. We introduce materials to the model to better back up markups from the data, as we explain below.

Let $mc_{it}$ stand for the marginal cost. In this setting the problem of the entrepreneur is:

$$\pi_t(z_{it}) = \max p_{it}y_{it} - mc_{it}y_{it}$$

subject to

$$y_{it} = \left[1 - \eta \ln \left(\frac{P_{it}}{P_t}\right)^{\frac{\sigma}{\eta}} Y_t \right]$$

$$k_{it} \leq \lambda_{ia_{it}}$$

In an unconstrained optimum (i.e. $k_{it}^* < \lambda_{ia_{it}}$) $mc_{it} = \frac{\Gamma_t}{z_{it}}$, where

$$\Gamma_t = \left(\frac{w_t}{1-\alpha}\right)^{\nu} \left(\frac{r_t}{\alpha \nu}\right)^{\nu} \left(\frac{p_{it}}{P_t}\right)^{(1-\nu)}.$$ That is, given factor prices and entrepreneurial ability, the marginal cost of production is constant for the unconstrained entrepreneur. In that case, the optimal pricing rule is:

$$p_{it} = \frac{\varepsilon_{it}}{(\varepsilon_{it} - 1)} mc_{it}$$

(2.5)

Substituting $\varepsilon_{it}$ by the expression in (2.3), the (gross) markup set by firm $i$ at time $t$, $\mu_{it}$, is given by:
\[
\mu_{it} = \frac{\sigma}{\sigma - 1 + \eta \ln \left( \frac{p_{it}}{\pi} \right)}
\] (2.6)

Unsurprisingly, the markup charged by an unconstrained firm is a function of the demand elasticity it faces, which varies along the demand curve as long as \( \eta > 0 \). Specifically, markups are higher the more inelastic the demand. Once again, when \( \eta \to 0 \) markups are constant and equal to \( \left( \frac{\sigma}{\sigma - 1} \right) \).

This model does not deliver imperfect competition through any type of strategic interaction. It does, however, capture in a simple way the main predictions of such models, namely: the fact that larger firms set higher markups.\(^{16}\) We will refer to this fact, somewhat loosely, as large firms exploiting their market power.

In a constrained optimum (i.e. \( k_{it}^* > \lambda_t a_{it} \)), the entrepreneur leverages as much as possible, sets \( k_{it}^c = \lambda_t a_{it} \), and marginal cost become an increasing function of \( y_{it} \).\(^{17}\) Two firms with the same productivity but different net worth (i.e. different \( a_{it} \)) may charge different prices, if the collateral constraint is binding for the poorest one.

For illustration purposes, Figure (2.5) shows a simple partial equilibrium example of two such firms facing a linear demand. In a world with perfect credit markets (or with imperfect credit markets but where firms are wealthy enough), marginal costs are constant for both firms, and equal to \( mc_u \), they both produce at the unconstrained optimum \( q_u \), charge unconstrained prices \( p_u \), and set a markup given by the vertical segment CD. If instead there is a collateral constraint that is binding for one of the firms, the marginal cost curve for that firm becomes \( mc_c \), increasing

\(^{16}\)See for example Atkeson and Burstein (2008).

\(^{17}\)More details on the algebraic expression for marginal costs of the constrained firm can be found on Appendix (2.8.2).
in quantities from the point the firm becomes constrained. The constrained firm now produces at the point where constrained marginal costs are equal to marginal income, \( q_c < q_u \), and charges a price \( p_c > p_u \). Markups for the constrained firm are given by the vertical segment AB. The markup set by a constrained firm will then be equivalent to that of an unconstrained firm with marginal costs depicted as an horizontal line through point B.

**Equilibrium**

Given an initial joint distribution of wealth and entrepreneurial ability \( G_0(z,a) \), an equilibrium in this economy consists of allocations

\[
\{C_s(z_t, a_t), a_s(z_t, a_t), k_s(z_t, a_t), l(z_t, a_t), m_s(z_t, a_t), oco_s(z_t, a_t)\}_{s=t}^{\infty}
\]

for all \( t \geq 0 \), sequences of joint distribution for wealth and entrepreneurial ability \( \{G_t(z,a)\}_{t=1}^{\infty} \), individual prices \( \{p_s(z_t, a_t)\}_{s=t}^{\infty} \), and aggregate prices \( \{w_t, r_t, p_t^m, P_t\}_{t=1}^{\infty} \), such that

1. Given \( \{w_t, r_t, p_t^m, P_t\} \), \( z_t \), and \( a_t \),

\[
\{C_s(z_t, a_t), a_s(z_t, a_t), k_s(z_t, a_t), l(z_t, a_t), m_s(z_t, a_t), oco_s(z_t, a_t)\}_{s=t}^{\infty},
\]

solves the agent’s problem for all \( t \geq 0 \).

2. Markets for labor, capital, and final goods clear

\[
\int_{z \in Z} \int_{a(z_t)}^{\infty} l_t(z_t, a_t)G_t(da, dz) = \int_{z \in Z} G_t(a(z_t), dz)
\]

\[
\int_{z \in Z} \int_{a(z_t)}^{\infty} l_t(z_t, a_t)G_t(da, dz) = \int_{z \in Z} aG_t(a(z_t), dz)
\]

\[
\int_{z \in Z} \int_{a(z_t)}^{\infty} C_t(z_t, a_t)G_t(da, dz) + \int_{z \in Z} \int_{a(z_t)}^{\infty} m_t(z_t, a_t)G_t(da, dz) +
\]

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+ \int_{z,a} (a_{t+1}(z_t, a_t) - (1 - \delta) a_t(z_{t-1}, a_{t-1})) G_t(a_t, d z) = Y_t

3. The joint distribution of wealth and entrepreneurial ability

\{G_t(z, a)\}_{t=1}^{\infty} evolves according to the following law of motion:

\[ G_{t+1}(a, z) = \gamma \int_{a_{t+1}(a, z) \leq a} G_t(da, z) \]

\[ + (1 - \gamma) J(z) \int_{a_{t+1}(a, z) \leq a} G_t(da, z) \]

2.4 Data and Calibration

We calibrate the model to match salient features of the 1998-1999 financial crisis in Colombia. We chose Colombia for several reasons. First, it is a country where financial frictions are prevalent. According to the World Bank’s World Enterprise Survey, which surveys managers on a number of issues regarding the business environment, access to external finance is the biggest obstacle faced by firms.\(^{18}\) Second, it suffered a large financial crisis in 1998-99 (see subsection below). Third, it has wide availability of high-quality microdata that spans the crisis period.

The Colombian 1998/99 Financial Crisis

One of the most salient features of the Colombian economy relative to other Latin American countries is its macroeconomic stability in terms of business cycles. Even though there were some

\(^{18}\)Specifically, 29% of the managers surveyed in Colombia identified access to finance as the biggest obstacle, (in Latin America the average is 15% and in emerging economies 17%). 41% see it as a major constraint, also the highest ranked constraint in Colombia (compare to 30% in Latin America, 29% in emerging economies).
minor recessions in 1983, 1991 and 1996, the crisis of the end of the twentieth century in Colombia 1998/99 was the most severe since the 1930s, both in terms of depth and duration. To be more specific, Colombian GDP fell about 5% between 1997 and 1999, while the unemployment rate rose to a peak of 20.5% in the third quarter of 2000.

As we can see in Figure (2.6), the decrease in output was generalized in all sectors. Agriculture, Manufacturing and Services suffered an important decline in production during that period.

Carrasquilla et al. (2000), Garzón (2001), and Urrutia and Llano (2011) present evidence suggesting that the reduction in economic activity was due to a big drop in the in the supply of credit which is typically refer in the literature as *credit crunch*. The magnitude of the credit crunch was remarkable. Figure (2.7) and Figure (2.9) shows the evolution of the amount of loans in Colombia (in real terms), and its deviations from trend, respectively. Total credit was 20% below trend at the height of the crisis, a fall of over 30% in absolute terms. The decline was common to all major lines of credit (see Figure (2.8)). Between January of 1998 and December of 1999, the stock of loans fell by 17%.

The natural question then is, what are the mechanism behind this reduction in the supply of credit? Two key factors have been pointed out in the literature:

1. A reduction in external supply of credit due to the financial crisis in Asia and Russia.

2. An increase in the perception of risk by banks due to a worsening in the quality of bank’s portfolios.

The decrease in the flow of funds from the rest of the world was a consequence of the increase perception of risk in the global economy due to the financial crisis in Asia in the first place, and then it was exacerbated with the Russian crisis in mid 1998.

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19 See for example Lorenzoni and Guerrieri (2009) or Buera and Moll (2015).
In this paper, we do not take a stand on any particular mechanism leading to the credit crunch. Without loss of generality, we take a reduced form approach and parsimoniously model it as an exogenous tightening of the collateral constraint over the rent of capital.

Data Sources

We use two main data sources to discipline the model quantitatively: the Annual Manufacturing Survey (previously described), and balance sheet data.

Balance sheet data comes from Supersociedades, the government office that regulates corporations. The database includes all firms with assets or income over 20,000 monthly minimum wages, multinational corporations, or firms owned at least 20% by multinationals. Firms that do not comply with any of those requirements may still be included if the Superintendent decides to do so. Coverage varies across years, but the data set contains around 9,000 observations per year, starting in 1995. Manufacturing observations amount to about 2,500 per year.

Calibration of the Steady State

We calibrate a quantitative version of the model to the state of the Colombian economy before the 1998/99 financial crisis. To solve quantitatively for the steady state, we discretize the state space of entrepreneurial abilities and asset levels \((z, a)\), and use value function iteration. We rely on parallelization methods for efficiency purposes.\(^{20}\) The model has 10 parameters, namely \(\{\beta, \delta, \rho, \alpha, \nu, \gamma, \phi, \lambda, \eta, \sigma\}\). The first 5 parameters are relatively standard, and we borrow them from related literature. We set the time preference parameter \(\beta = 0.93\) and the utility preference parameter \(\rho = 1.5\). We set the depreciation rate \(\delta = 0.06\). We set \(\alpha\), the share of capital in value added equal to 0.33. The elasticity of output with respect to intermediate inputs is taken

\(^{20}\)See Appendix (2.8.3) for further technical details on the computational procedures.
from Eslava et al. (2004), who estimate it using Colombia’s AMS for the pre-crisis period. We set \( \nu = 0.54 \).

We choose the probability of losing ability \( z \) in any given period to match firm exit rate in the AMS. This results in \( \gamma = 0.1 \).

We calibrate \( \lambda \) from financial data. In the model, constrained firms have \( \frac{k-a}{a} = \lambda - 1 \), and unconstrained firms have \( \frac{k-a}{a} < \lambda - 1 \). The numerator in the left hand side represents the intra-period loans that the firm uses to finance its working capital requirements. The denominator, the assets that the firm uses as collateral. Figure (2.10) shows the model implications for the relationship between this ratio and firm size, as measured by collateralizable assets. Smaller firms display the same ratio since they are, on average, constrained. We use this feature of the model to discipline \( \lambda \) in steady state. In particular, we use balance sheet data to compute the ratio of short-term loans to fixed assets (which we use as proxy to collateralizable assets) for the smallest 25% of firms. This results in \( \lambda = 2.75 \).

The remaining parameters are the price elasticity parameter \( \sigma \), the parameter driving the superelasticity, \( \eta \), and the shape of the Pareto distribution of abilities \( \phi \). In our quantitative exercise we contrast the response of a constant markup vs. a variable markup model, so these parameters may vary across calibrations.

In the variable markup specification, our strategy is to recover markups from AMS microdata. To do so we rely on the previously mentioned result by De Loecker et al. (2012) (reproduced here for convenience):

\[
\mu_i = \nu \frac{p_i y_i}{p_i^2 m_i}
\]

21 We will show in our quantitative exercise that different potential measures of \( \lambda \) from financial data display the same evolution before, during, and after the crisis.
That is, given the production function parameter for intermediate inputs, we recover markups from the ratio of gross value of production to expenditure on intermediate inputs, data available in the AMS.\(^{22}\) We set \(\sigma = 6\) to match the average markup of 1.19 observed in the data. We jointly calibrate \(\eta = 0.5\) and \(\phi = 2.6\) to match the variability of markups and the share of gross value of production produced by the largest 10% of firms.

For the constant markup model we set trivially \(\eta = 0\). i.e. markups do not vary across firms. Again, we set \(\sigma = 6\) such that the average markups matches the data and the variable markup specification. We calibrate \(\phi = 2.3\) to match concentration at the top 10% of firms. Tables (2.1) and (2.2) summarize the calibration just described.

### 2.5 Quantitative Exercise

How do aggregate variables respond to a credit crunch if firms have market power? To answer this question, we compare the transition dynamics of aggregate variables in a variable markups model with those in a constant markups model.

To simulate a credit crunch, we assume a one-time, unexpected shock to the financial friction parameter \(\lambda\). The future path of \(\lambda\) is perfectly known by all agents after the initial shock. We back up the path of \(\lambda\) from the median ratio of short-term loans to fixed assets for relatively small firms, as described in the Calibration section. Figure (2.11) displays the evolution of this ratio using different balance-sheet concepts for short-term loans and collateralizable assets. The solid line is our preferred choice. Their paths are similar, so we are confident that the shock that we feed into the model resembles the financial frictions actually faced by Colombian firms during that period.

\(^{22}\)See Appendix (2.8.4) for details on how the De Loecker et al. (2012) framework map into our model with financial frictions.
Figure (2.11) shows that it took approximately 6 years for the financial conditions prevailing before the crisis to fully recover. From then, we assume that $\lambda$ remains constant forever.

For the following transition exercise we assume a small open economy where the interest rate remains unchanged at its steady state level. We take this approach to reflect the fact that Colombia is a small country, with a relatively open capital account. This assumption also yields more computational precision, since it allows the program to run more efficiently.

Figure (2.12) shows the evolution of concentration in economic activity that results from the financial crisis. We measure concentration as the gross value of production produced by the top 10% firms. The dashed line is actual data, the dotted line correspond to the constant markup case, and the solid line to the variable markup model. The constant markup model calibrated as explained above fails to reproduce the increase in concentration that follows the credit crunch. In fact, it results in less concentration. If instead we allow for market power, the model generates the concentration patterns observed in the data.

Regarding output, Figure (2.13) contrasts the evolution of yearly, hp-detrended aggregate output with those from the models. The first thing to note is how both the variable markup and constant markup models reproduce quite well the qualitative path of aggregate output: a large fall, followed by a slower but steady recovery that takes about 6 years. We think of this as a success of our calibration strategy for the financial shock, since even though it does not rely on targeting aggregate variables (but rather on looking at the model-implied financial conditions of small firms), it still delivers the same aggregate pattern.

The orders of magnitude are also similar, but the output losses predicted by the variable markup model are milder. The same is true for aggregate productivity, depicted on Figure (2.14): it displays roughly the same patter in the model and in the data, but the fall is not as steep in the variable
markup case. In particular, aggregate productivity explains half of the fall in output in the data, but only a third of aggregate aggregate output in the constant markup model, and less than that in the variable markup case.

Overall, heterogeneous markups act as a buffer of a credit crunch. What drives the differences across models? Part of the answer lies in the larger reallocation of capital that results from a credit crunch in a constant markup model. Figure (2.15) displays the evolution of capital dispersion across firms. Dispersion increases in both models, but the increase is larger in the constant markup case. That is, the reallocation of capital across firms triggered by the credit crunch is larger in the standard constant markup model. Intuitively, the credit crunch forces previously constrained firms (and firms close to the threshold before the credit crunch) to downsize. Large, unconstrained firms take the slack by increasing production in the constant markup case, and by (partially) increasing their markup in the variable markup case. Market power thus acts as a real rigidity, preventing firms from changing prices too much with respect to the initial equilibrium.

Another reason is that the average size of firms in the constant markup case is smaller than in the variable markup case, which translates into larger TFP losses. This follows from differences at the intensive and extensive margins across models. At the intensive margin, incumbent entrepreneurs that are negatively affected by the credit crunch downsize more in the constant markup case, for the reasons explained above. At the extensive margin, the entry of infra-marginal entrepreneurs is higher in the constant markup case, which also reduces the average firm size.

The fact that there is net entry of entrepreneurs under both versions of the model may seem at odds with the intuition of higher exit rates of firms during crises. It is, however, consistent with existing evidence on the countercyclical nature of self-employment, as documented for example in Mondragón Vélez and Pena (2008) for Colombia, or in Earle and Sakova (2000) for eastern
European countries. Figures (2.16) and (2.17) show the differences across models at the extensive margin. The model with constant displays a fatter left tail after the crisis than the model with heterogeneous markups, i.e. there’s more entry of low productivity entrepreneurs into self-finance.

2.6 Conclusion

In this paper we document the increase in market concentration that resulted from the 1998/99 Colombian financial crisis. We analyze the extent to which market power helps shape aggregate dynamics. We find that heterogeneous markups are needed in order to reproduce the concentration patterns that follow from a financial crisis. However, variable markups dampen the response of output and productivity in a credit crunch, since they partially offset the resource misallocation that follows. This does not mean that there is less resource misallocation in steady state in an environment with market power, but rather it illustrates the dynamics that follow a negative credit shock.

In line with recent research, we find that resource misallocation can help explain a non-negligible share of the large output losses during financial crises. But we bring attention to the fact that more distortions do not necessarily result in larger losses. The interaction between financial frictions and heterogeneous markups during a negative credit shock is an example of the ambiguous effect of distortions in a second best world.
### 2.7 Tables and Figures

Table 2.1: Calibration 1

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Concept</th>
<th>Target/Source</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>Intertemporal preference</td>
<td>Literature</td>
<td>0.93</td>
</tr>
<tr>
<td>$\rho$</td>
<td>Preference parameter</td>
<td>Literature</td>
<td>1.5</td>
</tr>
<tr>
<td>$\delta$</td>
<td>Depreciation</td>
<td>Literature</td>
<td>0.06</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>Capital share in value added</td>
<td>Literature</td>
<td>0.3</td>
</tr>
<tr>
<td>$\nu$</td>
<td>Production function parameter</td>
<td>Eslava et al. (2004)</td>
<td>0.57</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>Ability loss probability</td>
<td>Exit Rate</td>
<td>0.1</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>Financial fricition</td>
<td>Liab./F. Assets</td>
<td>2.75</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>Elasticity</td>
<td>Average Markups</td>
<td>6</td>
</tr>
</tbody>
</table>
## Table 2.2: Calibration 2

Vary Across Calibrations

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Concept</th>
<th>Target/Source</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Constant Markups</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \eta )</td>
<td>Superelasticity</td>
<td>Exogenous</td>
<td>0</td>
</tr>
<tr>
<td>( \phi  )</td>
<td>Pareto Shape</td>
<td>Concentration top 10%</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td><strong>Variable Markups</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \eta )</td>
<td>Superelasticity</td>
<td>Markup Variability</td>
<td>0.5</td>
</tr>
<tr>
<td>( \phi  )</td>
<td>Pareto Shape</td>
<td>Concentration top 10%</td>
<td>2.3</td>
</tr>
</tbody>
</table>
Figure 2.1: Inverse Herfindahl Index (1997=100)

Source: Annual Manufacturing Survey.

Figure 2.2: Revenue Productivity and Size

Source: Annual Manufacturing Survey.
Figure 2.3: GVP-to-Materials Ratio and Size

Source: Annual Manufacturing Survey.

Figure 2.4: Demand for Different Superelasticities
Figure 2.5: Partial Equilibrium Example

Figure 2.6: Real Gross Domestic Product (1997=100)

Source: DANE.
Figure 2.7: Real Net Credit (1997=100)

Source: Central Bank of Colombia.

Figure 2.8: Credit as a Share of GDP

Source: Central Bank of Colombia.
Figure 2.9: Real Net Credit, Deviations from Trend (1997=100)

Source: Central Bank of Colombia.

Figure 2.10: Model Implied Leverage vs. Size
Figure 2.11: Different Measures of Credit Crunch (1997=1)

Source: Own computations from Supersoci\'edades.

Figure 2.12: Value of Production by Top 10% Firms

Source: Own computations and Annual Manufacturing Survey.
Figure 2.13: Aggregate Output

Source: Own computations and DANE.

Figure 2.14: Aggregate Productivity

Source: Own computations and DANE.
Figure 2.15: Dispersion of Capital Across Firms

Figure 2.16: Cummulative Distribution of Entrepreneurs. Constant Markups
Figure 2.17: Cumulative Distribution of Entrepreneurs Variable Markups


2.8 Appendices

2.8.1 Kimball Aggregator and Demand Approximation

As stated above, Kimball’s aggregator satisfies:

$$\frac{1}{\Omega_t} \int_{\Omega_t} \Upsilon \left( \frac{\Omega_t y_{it}}{Y_t} \right) \, di = 1$$

In the Klenow-Willis specification, function \( \Upsilon(x) \) Takes the following form:

$$\Upsilon(x) = 1 + (\varepsilon - 1) \exp \left( \frac{1}{\eta} \right) \eta^{\varepsilon - 1} \left( \Gamma \left( \frac{\varepsilon}{\eta}, \frac{1}{\eta} \right) - \Gamma \left( \frac{\varepsilon}{\eta}, \frac{x}{\eta} \right) \right)$$

where:

$$\Gamma(u, z) = \int_{z}^{\infty} s^{u-1} e^{-s}$$

Demand for intermediate variety \( i \) is: 23

$$y_{it} = \left[ 1 - \eta \ln \left( \frac{\sigma x_i}{\sigma - 1} \right) \right]^{\frac{\eta}{\sigma}} Y_t$$

where \( x_i = D_t \frac{P_{it}}{P_t} \), \( \sigma > 1 \), \( \eta > 0 \), and

$$D_t = \frac{\sigma - 1}{\sigma} \int \frac{y_{it}}{Y_t} \exp \left\{ \frac{1}{\eta} \left[ 1 - \left( \frac{\Omega_t y_{it}}{Y_t} \right)^{\frac{\eta}{\sigma}} \right] \right\} \, di$$

Gopinath and Itskohki (2010) show that, up to a first order approximation, \( D_t \approx \frac{\sigma - 1}{\sigma} \). Using this

\[ 23 \text{See Klenow and Willis (2006) for further details on the derivation of the demand function.} \]
result, demand for variety $i$ becomes:

$$y_{it} = \left[ 1 - \eta \ln \left( \frac{p_{it}}{P_t} \right) \right] \frac{\sigma}{\eta} Y_t$$

which is the expression presented in the body of the text.

### 2.8.2 Pricing Decisions for the Constrained Firms

As we mentioned in the text, we can think of the profit maximization problem in two stages. First, firms solve the unconstrained problem (as in the no financial frictions case), where $m_{ci} = \frac{\Gamma}{z_{it}}$. If unconstrained capital is $k_{it}^u \leq \lambda_t a_{it}$ then the unconstrained solution holds and firms set their prices according to

$$p_{it} = \frac{\varepsilon(x_i)}{\varepsilon(x_i) - 1} \frac{\Gamma_t}{z_{it}}$$

If $k_{it}^u > \lambda_t a_{it}$, then the entrepreneur will set $k_{it} = \lambda_t a_{it}$. We can derive the pricing decision in the following way. From the first order conditions of the cost minimization problem of an unconstrained entrepreneur, we have $m_{it} = \frac{(1-\nu)}{\nu(1-\alpha)} \frac{w_t}{p_t} l_{it}$. Plugging this in the production function of a constrained firm yields $y_{it} = z_{it}(\lambda_t a_{it})^{\alpha \nu} l_{it}^{(1-\alpha \nu)} \left[ \frac{(1-\nu)}{\nu(1-\alpha)} \frac{w_t}{p_t} \right]^{(1-\nu)}$, so we can express the conditional labor demand as $l_{it} = \left[ \frac{y_{it}}{z_{it}(\lambda a_{it})^{\alpha \nu} \left[ \frac{(1-\nu)}{\nu(1-\alpha)} \frac{w_t}{p_t} \right]^{(1-\nu)}} \right]^{\frac{1}{1-\alpha \nu}}$, and use this in the objective function to expres the constrained problem as:

24In the quantitative exercises, we use this approximation to compute the results and then check that it holds in equilibrium.

25Notice that this is equivalent to having $m_{ci}(y_{it}) = \left[ 1 + \frac{(1-\nu)w_{1-\alpha \nu}}{\nu(1-\alpha)} \right] (1-\alpha \nu) \Delta \frac{1-\alpha \nu}{\alpha \nu} \left[ y_{it} \right]^{\frac{\alpha \nu}{1-\alpha \nu}}$ (plus a fixed cost in the form of $r\lambda_t a_{it}$).
\[
max_{p_{it}}\ p_{it}y_{it} - \left[1 + \frac{(1 - \nu)w^{1 - \alpha \nu}}{\nu(1 - \alpha)}\right] \Delta^{1 - \alpha \nu} [y_{it}]^{1 - \alpha \nu} - r \lambda a_{it}
\]

\[
st. \ y_{it} = Y_t \left[1 - \eta \ln \left(\frac{p_{it}}{P_t}\right)\right]^\frac{\eta}{\eta}
\]

with

\[
\Delta = \frac{w^{1 - \alpha \nu} y_{it}}{z_{it}(\lambda a_{it})^{\alpha \nu} \left[\frac{(1 - \nu)}{\nu(1 - \alpha)} \frac{1}{P_t^{\alpha \nu}}\right]^{1 - \nu}}
\]

For simplicity, let \(\Delta' = \left[1 + \frac{(1 - \nu)w^{1 - \alpha \nu}}{\nu(1 - \alpha)}\right] \Delta^{1 - \alpha \nu},\)

Plugging in the demand into the objective function, and letting \(\Xi \equiv 1 - \eta \ln \left(\frac{p_{it}}{P_t}\right)\)

\[
max_{p_{it}}\ p_{it}y_{it} - \left[1 + \frac{(1 - \nu)w^{1 - \alpha \nu}}{\nu(1 - \alpha)}\right] \Delta^{1 - \alpha \nu} [y_{it}]^{1 - \alpha \nu} - r \lambda a_{it}
\]

\[
st. \ y_{it} = Y_t \left[1 - \eta \ln \left(\frac{p_{it}}{P_t}\right)\right]^\frac{\eta}{\eta}
\]

with

\[
\Delta = \frac{w^{1 - \alpha \nu} y_{it}}{z_{it}(\lambda a_{it})^{\alpha \nu} \left[\frac{(1 - \nu)}{\nu(1 - \alpha)} \frac{1}{P_t^{\alpha \nu}}\right]^{1 - \nu}}
\]

For simplicity, let \(\Delta' = \left[1 + \frac{(1 - \nu)w^{1 - \alpha \nu}}{\nu(1 - \alpha)}\right] \Delta^{1 - \alpha \nu},\)

Plugging in the demand into the objective function, and letting \(\Xi(p_{it}) \equiv 1 - \eta \ln \left(\frac{p_{it}}{P_t}\right)\)

\[
max_{p_{it}}\ p_{it}Y_t [\Xi(p_{it})]^\frac{\eta}{\eta} - \Delta' Y_t^{1 - \alpha \nu} [\Xi(p_{it})]^\frac{1}{\eta} - r \lambda a_{it}
\]

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\[
\left( \Xi(p_{it}) \right)^{\sigma \eta} - \sigma \left[ \Xi(p_{it}) \right]^{\sigma \eta} P_t + \Delta' Y_t^{\alpha / (1-\alpha)} \frac{1}{\eta (1-\alpha)} \left[ \Xi(p_{it}) \right]^{\sigma - \eta (1-\alpha)} \frac{1}{P_t} = 0
\]

If \( P_t = 1 \)

\[
\left( \Xi(p_{it}) \right)^{\sigma \eta} - \sigma \left[ \Xi(p_{it}) \right]^{\sigma \eta} + \Delta' Y_t^{\alpha / (1-\alpha)} \frac{1}{1-\alpha} \left[ \Xi(p_{it}) \right]^{\sigma - \eta (1-\alpha)} \frac{1}{p_{it}} = 0
\]

Solving quantitatively for \( p_{it} \) in the equation above yields the pricing decision for the constrained firm.

### 2.8.3 Solution Algorithm

We solve quantitatively for the steady state of the model as follows. We first discretize the space of abilities on a grid with 40 points. We set \( z_1 = 1 \), and choose \( z_{38} \) such that the cumulative probability up to \( z_{38} \) is 0.99 according to a pareto distribution (i.e. \( G(z_{38}) = 0.99 \)). The grid is equally spaced between \( z_1 \) and \( z_{38} \). We set \( z_{39} \) and \( z_{40} \) such that \( G(z_{39}) = 0.995 \) and \( G(z_{40}) = 0.999 \).

The grid for asset holdings consist of 1451 points. The first 400 points are relatively close to each other, and are equally spaced. The second part of the grid (the last 1051 points) is coarser. For interpolation purposes during the value function iteration routine, each bin in the grid is divided in 400 sub-bins, such that the value function is evaluated at 1451*400=580,400 points.

We normalize the price of the aggregate good to 1. Given aggregate output, wages, and the rental rate, we compute profits for constrained and unconstrained entrepreneurs, and check for the occupational choice condition. We then solve the recursive problem of the agents through value function iteration. We compute the invariant distribution of assets iterating over the joint
distribution of assets and abilities. We then check the market clearing conditions for the rental rate, wages and aggregate output (the loop variables).

The algorithm is written in Fortran 90, and we use MPI parallelization methods to solve over 40 nodes, where each node is a point in the ability space.

To compute the transition dynamics of the system, we assume that agents suffer a completely unexpected shock, and then have perfect foresight over the future path of exogenous $\lambda_t$. For computational reasons, we compute the transitions of the system assuming a small open economy, such that $r$ is given.
2.8.4 Markups from Microdata

As in De Loecker et al. (2012), suppose we have a production function that produces using \(V\) variable inputs (e.g. labor, materials, energy), and one factor that is treated as a dynamic input (capital). In general, the production function of firm \(i\) in period \(t\) is given by:

\[
Y_{it} = Y_{it}(X_{it}^1, \ldots, X_{it}^V, K_{it})
\]

where \(X_{it}^v\) \(v = 1, \ldots, V\) are variable inputs with no adjustment cost, and \(K_{it}\) is the capital stock.

Assuming that producers in this economy are minimizing cost when producing, we have that the lagrangian in an economy with financial frictions is given by:

\[
L(X_{it}^1, \ldots, X_{it}^V, K_{it}) = \sum_{v=1}^{V} P_{it}^v X_{it}^v + r_{it} K_{it} + \Lambda_{it} [Y_{it} - \bar{Y}_{it}(\cdot)] + \Psi_{it} [\lambda a_{it} - K_{it}]
\]

where \(P_{it}^v\) is the price of input \(v\) and \(r_{it}\) is the rental rate of capital. In this case, \(\Lambda_{it}\) is the lagrange multiplier of the production function, and \(\Psi_{it}\) is the lagrange multiplier of the collateral constraint of the firm. The first order conditions using Kuhn Tucker for the factors are given by:

\[
\begin{align*}
[X_{it}] : & \quad P_{it}^v = \Lambda_{it} \frac{\partial Y_{it}(\cdot)}{\partial X_{it}^v} \\
[K_{it}] : & \quad r_{it} = \Lambda_{it} \frac{\partial Y_{it}(\cdot)}{\partial K_{it}} + \Psi_{it}
\end{align*}
\]

Now, defining the markup as \(\mu_{it} \equiv \frac{P_{it}}{mc_{it}}\) where \(mc_{it}\) is the marginal cost of the firm in the optimal solution, and using the fact that lagrange multiplier \(\Lambda_{it}\) is the marginal cost of the firm we have that
\[
\frac{\partial Y_{it}(\cdot)}{\partial X_{it}^v} \frac{X_{it}^v}{Y_{it}(\cdot)} = \mu_{it} \frac{p^m m}{p_{it} y_{it}}
\]

where \(\frac{\partial Y_{it}(\cdot)}{\partial X_{it}^v} \frac{X_{it}^v}{Y_{it}(\cdot)}\) is the elasticity of output with respect to materials, which in our model is equal to \((1 - v)\). That is, the derivation of markups from the ratio of the gross value of production to the value of materials presented in De Loecker et al. (2012) holds in our framework.
Chapter 3

Innovation Effort in a Model of Financial Frictions: The Case of Reforms
3.1 Introduction

Some of the main empirical features from the Asian development after the first half of the last century are (1) the increase in research and development expenditures, (2) the slow but steady increase in total factor productivity (TFP), (3) the increase in income per capita over time, and (4) the increase in investment rates.\footnote{As it was pointed out by Buera and Shin (2013), standard models with representative agents cannot account for these patterns. For that reason, they proposed a theory to explain facts two to four. However, even though their model predicts quite well the evolution of the investment rate and income per capita over time, the model delivers dynamics of TFP that are counterfactual: relative to the data, the evolution is too fast. The goal of the paper is to serve as a first step to understand these transitional dynamics by providing a theory that can account for a closer TFP dynamics.}

As in Buera and Shin (2013) I use a model with some key features of the Asian development. First, the beginning of the growth miracles were due to a series of large reforms that dismantled distortions in the economy. Those distortions allowed low productivity firms to use large amounts of factors of production that were supposed to be used by productive firms. As a result of the reforms, large reallocation of resources were observed. Second, agents in the pre-reform economy were subject to financial frictions. Finally, and motivated by the sustained increase in research and development expenditures observed during those episodes, I introduce endogenous innovation in order to affect the productivity process at the micro level.

The contribution of the paper is to study the interaction between innovation and financial frictions in two economies that differ in their degree of resource misallocation. In the first economy,
which I refer to the pre-reform economy, misallocation arises due to the existence of financial frictions and due to the presence of idiosyncratic distortions (taxes and subsidies on revenue) that affect the optimal size of firms. This economy can be interpreted as the initial steady state of the Asian countries. The second economy, which I refer to post-reform economy, represents the steady state where there the reforms removed all the idiosyncratic distortions.

The quantitative results show that the existence of misallocation of resources coming from the idiosyncratic distortions has a negative impact on the incentives to innovate, affecting both the intensive margin of innovation (the amount of innovation for a given agent) and the extensive margin (the number of agents). This means that TFP is affected directly by distorting the allocation of resources, and indirectly through innovation decisions. In addition, the presence of financial frictions induces differences in innovation behavior depending on the agent’s financial position. In general, innovation has an inverted U-shape pattern: increasing for low levels of wealth and decreasing for high levels of wealth. All these results suggest that the introduction of endogenous innovation could slow down the evolution of TFP over time.

Going into the details, I develop a dynamic stochastic general equilibrium model that builds on Aiyagari (1994) and Buera and Shin (2013). I augment those frameworks by introducing an innovation technology similar to Luttmer (2007) and Atkeson and Burstein (2010). Agents are heterogeneous with respect to their productivity and wealth. Productivity is subject to idiosyncratic stochastic shocks that can be affected by innovation investment, while wealth is determined by saving decisions. In this economy agents have to decide between being a producer and use their productivity level, or workers for a wage. Producers face a collateral constraint on the amount of capital they can rent, preventing them from borrowing more than a fraction of their wealth whenever they decide to run a firm. Production is subject to decreasing returns to scale which
ensures that there is a meaningful notion of size.

Agents in this economy have an exogenous probability of increasing their productivity. However, they can decide to do research and development expenditure in order to increase the chance of moving upward in the productivity ladder. As in Chiu et al. (2011) agents have an opportunity to innovate, but in this model the probability of success of the innovation is chosen endogenously and depends both on the productivity level and the asset holding.

To perform the quantitative analyses I discipline the model in three steps. First, I take the parameters related to the innovation technology from the literature. Second, as in Ranasinghe et al. (2016), Buera and Shin (2013) and Akcigit et al. (2014) I parametrize some of the parameters to math moments of the US data. Third, I calibrate the remaining parameters to match moments in the pre-reform economy.

The quantitative results after calibrating the model suggest that for the economy without “distortions” innovation effort is higher for those agents that are close to turn into entrepreneurs. In general, innovation is going to be increasing for those agents with low wealth, and whenever agents become wealthier enough, innovation effort starts decreasing. Surprisingly, innovation vanishes after a certain heterogeneous level of asset holding, because the incentives to innovate disappear very quickly. In terms of quantitative results, TFP in the economy post-reform economy is 10% higher than in the pre-reform economy, as a result of reallocation of resources, the increase in innovation coming from the increase in the number of agents innovating and the increase in the average innovation.

**Related Literature:** The closest paper to this one is Buera and Shin (2013). While in their paper the evolution of productivity is exogenous, this paper emphasizes the fact that this is not a completely exogenous process to the agents but it is based on a cost-benefit analysis.
This paper fits into the literature that studies differences in income and TFP across countries as a result of a sub-optimal allocation of resources or misallocation. Using firm level microdata, Hsieh and Klenow (2009) finds that there are large deviations in the allocation of capital and labor relative to the allocation that maximizes output. To rationalize this, they resort to the same type of idiosyncratic taxes and subsidies that are used in this paper. Banerjee and Duflo (2005) provide a very extensive survey of some of the main reasons that could generate resource misallocation, and the effects over aggregate TFP. They also show empirical evidence related to the heterogeneity of rate of returns, which is a direct implication of the existence of misallocation of resources. For example, they provide evidence for India, where at the same time coexist sectors with high rates of return to capital, and sectors with low rates of return to capital as a product of misallocation.\(^2\)

As in Restuccia and Rogerson (2008) and Guner et al. (2008) I assume the existence of generic distortions on revenue in the pre-reform economy without specifying what are the forces or mechanisms behind. As in those papers, what is important for the analysis is that independently of the mechanism behind, the result is a suboptimal firm-level size.

Instead of using abstract distortions that can be interpreted as subsidies and taxes, a very close line of research highlights specific policies or frictions. The mechanisms studied range from the effects of firing costs (HopenhaynRogerson1993) to the negative impact of extortions and how the rule of law affects the extent of that activity (Ranasinghe (2015)).\(^3\) I share with Peters (2012) my interest on the effects of misallocation on firm level innovation. While I focus on abstract wedges and financial frictions, he explores the implications of having an environment with imperfect competition and endogenous markups.

\(^2\)For additional evidence, see Collard-Wexler et al. (2011) or Bartelsman et al. (2013)

\(^3\)The list of mechanisms is growing relatively quickly. For an excellent review of the literature see Hopenhayn (2014), Jones (2011), Restuccia and Rogerson (2013) and references therein.
Finally, this paper also relates to the enormous literature that studies quantitatively the interaction between financial frictions and aggregate TFP ((Amaral and Quintin (2010); Buera et al. (2011); Buera and Shin (2011); Moll (2014)). I share with those papers the use of a collateral constraint that represents a reduce form of a limited commitment problem between borrowers and lenders. Relative to those papers, I focus on the interaction between financial frictions and innovation decisions and how that affects TFP determination. A close paper in this literature is Midrigan and Xu (2014). They stress the role of financial frictions to affect TFP through two channels: entry and technology adoption. This paper is not considering entry as it is understood in the literature of heterogeneous firms, but we have endogenous separation between workers and entrepreneurs. Also, I do not have technology adoption, but the model has endogenous innovation that allows an improvement in the technology in the similar way as in Atkeson and Burstein (2010).

The rest of the paper is organized as follows. Section (3.2) presents the model and the definition of equilibrium in the economy. Section (3.3) presents the calibration of the model. Section (3.4) presents the quantitative results. Finally, section (3.5) presents concluding remarks and some ideas for future research.

### 3.2 The model

#### 3.2.1 Heterogeneity and Innovation

Each agent is going to be endowed with a productivity level $z$ and an asset or wealth $a$. The productivity is drawn from an invariant discrete distribution denoted by $\Gamma(z)$. Asset levels are going to be determined endogenously subject to a borrowing constraint as in Huggett (1993) and

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4For an example of a model with endogenous entry of firms see Ghironi and Melitz (2005)
Aiyagari (1994). In this model, the productivity level evolves over time according to a stochastic innovation process as in Atkeson and Burstein (2010). According to those authors, the productivity increases from \( z \) to \( z^{\text{up}} = z + \Delta \) with probability \( P(q) \), but with probability \( 1 - P(q) \) the productivity is going to depreciate by \( \Delta \) to \( z^{\text{down}} = z - \Delta \). Here, \( q \) denotes the innovation expenditure or effort that an agent is performing. In order to do that, an agent has to incur a cost \( \exp(z_s)\Phi(q_s) \), which is a convex function of \( q \).

One difference between Aiyagari (1994) and the present one is the role of assets. In those papers, asset accumulation is a way of hedging yourself against income fluctuations. In the present model the "buffer stock" motive is still present due to the randomness of the productivity. However, there is an additional reason to accumulate assets to be discussed below.\(^5\)

Although quite similar, my modeling strategy for the productivity process differs from the one chosen in Buera and Shin (2013). In their paper the productivity evolves in the following way: with an exogenous and given probability \( \gamma \) agents can “gamble” a new productivity that may be better or worse than the one that they have, and with probability \( 1 - \gamma \) they keep the productivity. I believe that the presented approach is more realistic, because we can treat the productivity as an intangible capital that may depreciate completely if you do not “invest in it”. Therefore, I am going to introduce endogenous innovation to the model, which is going to be determined optimally by each agent given their current state and taking into account potential benefits and costs associated.

\(^5\)Producer will need to accumulate assets in order to produce. This will be explain in the next sections.
3.2.2 Preferences

In this model, preferences over consumption are standard. Individuals discount the expected stream of consumption using the same factor $\beta$. The expected utility function is:

$$E_t \sum_{s=t}^{\infty} \beta^{s-t} u(c_s)$$

(3.1)

3.2.3 Technology

Each period individuals face a choice between being workers that receive a fixed wage or being entrepreneurs that use their own specific technology for production in order to get a profit. The technology available to the entrepreneur depends on his level of productivity $z$, on the amount of labor $l$ hired $n$, and on the units of capital $k$ rented. This maps into a production function $f(z,k,l)$.

For this paper, I will assume that the production function has a Cobb-Douglas specification with decreasing return to scale:

$$f(z,k,l) = z \left( k^{\eta} l^{1-\eta} \right)^{1-v}$$

(3.2)

where $1 - v$ is the span of control coefficient. Here, $1 - v$ denotes the share of output that goes to the variable inputs, and from that, a fraction $\eta$ goes to capital and $1 - \eta$ goes to labor. In addition, I assume that the productivity of each agent is private information, and that there is no market for ideas or technology transfer. In one recent paper, Silveira and Wright (2010) developed a theoretical model of the market for ideas. Entrepreneurs can search in a decentralized market for ideas (productivities), which are provided by innovators. However, the exchange of those new processes are subject to liquidity constraints due to moral hazard. In this paper, we are not allowing
interactions of this sort, but potential interesting interactions may emerge, and would be interesting
to explore in the future.

3.2.4 Financial Markets

As in Buera and Shin (2011), I assume that entrepreneur’s capital rental $k$ is limited by a collateral
constraint $k \leq \lambda a$, where $a \geq 0$ is the individual financial wealth and $\lambda$ measures the degree of
credit friction. A low value for $\lambda_t$ is associated with low access to credit. In particular, in the
case where $\lambda_t = 1$ firms have to self-finance all their capital rental and therefore there is a strong
incentive to save in order to allow production. On the other extreme, when $\lambda_t \to \infty$ there are
perfect capital markets. In this case, saving decisions are independent of production decisions and
the only motive for saving in this economy is consumption smoothing.

In Friedman’s permanent income hypothesis, households responds relatively more to permanent
income shocks shocks than to transitory shocks. This is because of the self insurance mechanism
through borrowing and lending that it is assumed. Therefore, as in most of the literature of
heterogeneous agents models, I will assume that agents are not allowed to borrow for intertemporal
consumption smoothing.\footnote{See for example, Heathcote (2005) or Conesa et al. (2007) for more details.} This is represented by assuming that asset holdings for next period has
to satisfy, $a' \geq 0$. Notice that almost trivially, in a world where production is subject to financial
frictions, this constraint only matters for Workers. Entrepreneurs by the set up we have chosen,
has to hold assets in order to produce next period, and therefore this restriction is not going to be
binding for them.
3.2.5 Individual’s Problem

The problem that an agent has to solve can be represented in a sequence problem or using a dynamic programming approach. I choose the last option, because it is standard in the literature to do so. In particular, an agent maximizes (3.1) by choosing the sequence of consumption, financial wealth, occupation, capital/labor inputs if they want to be entrepreneurs, subject to a sequence of budget constraints and collateral constraints.

At the beginning each period, the individual state is summarized by his wealth \( a \) and a productivity \( z \). He then chooses whether to be a worker or to be an entrepreneur. The value for him at this stage, \( V(a, z) \) is given by

\[
V(a_s, z_s) = \max \{ V^W(a_s, z_s), V^E(a_s, z_s) \}
\]

where \( V^W(a_s, z_s) \) is the value of an agent that becomes a worker, \( V^E(a_s, z_s) \) is the value of an agent that chooses to be an entrepreneur, and where I denote the optimal occupation choice as \( o(a_s, z_s) \in \{W, E\} \)

Conditional on being a worker, the agent solves:

\[
V^W(a_s, z_s) = \max_{c_s, a_{s+1}, q_s \geq 0} \left[ u(c_s) - \exp(z_s)\Phi(q_s) + \beta \left\{ P(q_s) V(a_{s+1}, z^{up}) + [1 - P(q_s)] V(a_{s+1}, z^{down}) \right\} \right]
\]

subject to

\[
c_s + a_{s+1} = w_s + (1 + r_s)a_s
\]
where $w_s$ is the labor income, $z_{up} = z_s + \Delta$, $z_{down} = z_s - \Delta$, $P(q_s) = \gamma + 1 - e^{-q_s}$ is the endogenous probability of innovation and $\exp(z_s)\Phi(q_s)$ is the cost of innovation in terms of effort, which is a convex function of $q$.

Alternatively, if the agent decides to be an entrepreneur he solves the following dynamic programming problem

$$V^E(a_s, z_s) = \max_{c_s, a_{s+1}, q_s \geq 0} u(c_s) - \exp(z_s)\Phi(q_s) + \beta \left\{ P(q_s)V(a_{s+1}, z_{up}) + [1 - P(q_s)]V(a_{s+1}, z_{down}) \right\}$$

subject to

$$c_s + a_{s+1} = \pi(z_s, a_s, w_s, r_s) + (1 + r_s)a_s \quad (3.5)$$

where $\pi(z_s, a_s, w_s, r_s)$ is the profit function obtained from running his own technology. The profit function is the solution to the following static problem,$^8$

$$\pi(z_s, a_s, w_s, r_s) = \max_{l_s, k_s \leq \lambda a_s} (1 - \tau_i)f(z_s, k_s, l_s) - w_sl_s - (\delta + r_s)k_s \quad (3.6)$$

In this problem we have two things that are relevant for the analysis. On the one hand, each firm is constrained by the same parameter $\lambda$ that measures the financial frictions present in the economy. As it is well known, the financial frictions affect the capital-labor ratio that this firm will choose, and therefore it has an effect on the size of the firm. On the other hand, each firm is going

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7The modeling strategy of the cost of effort is for simplicity in the computational part. If instead of modeling the cost of innovation as utility, we use a cost in terms of the final good the computational strategy would be much complicated. That is why for this paper, I have chosen tractability over realism.

8The solution to this problem can be found in appendix (3.7.1).
to be subject to an individual-specific distortion $\tau_i$. This distortion affects directly the optimal size of firms but do not affect the relative choice of capital and labor. In this paper, a reform will be equivalent to the elimination of these idiosyncratic distortions affecting the size distribution of firms.

Looking closely to the problem of the worker and the entrepreneur we can realize that both problems only differ in the income they received in the optimal occupation. Consequently, we can write the problem in a more compact way as:

$$V(a_s, z_s) = \max_{c_s, a_{s+1}, q_s \geq 0} u(c_s) - \exp(z_s)\Phi(q_s) + \beta \left\{ P(q_s)V(a_{s+1}, z_{\text{up}}) + \left[ 1 - P(q_s) \right] V(a_{s+1}, z_{\text{down}}) \right\}$$

subject to

$$c_s + a_{s+1} = \max \{ \pi(z_s, a_s, w_s, r_s), w_s \} + (1 + r_s)a_s$$

(3.7)

where the max operator determines if the agent is a worker or an entrepreneur. The optimal choice decision can be represented by the following policy rule:

$$o(z_s, a_s, w_s, r_s) = \begin{cases} 1, & \text{if } \pi(z_s, a_s, w_s, r_s) \geq w_s \\ 0, & \text{otherwise} \end{cases}$$

(3.8)

where $o(z_s, a_s, w_s, r_s) = 1$ means that the agent is an entrepreneur for a given value of asset $a_s$ and productivity $z_s$.\(^{10}\)

The fact that all the choices depend on the subscript $s$ is due to the possibility of analyzing the

\(^9\)In the literature this is also called a wedge.

\(^{10}\)Notice that there is going to be a threshold productivity for every value of asset $a_s$. That is, $\pi(z_s, a_s(z_s), w_s, r_s) = w_s$ determines the threshold.
economy outside an stationary equilibrium. In particular, after a large scale reform that eliminates
the idiosyncratic distortions there is going to be a transition towards a post-reform steady state.
During that transition, the policy rules are going to be different because the aggregates of the
economy are changing. In some sense, the economy is behaving during the transition as if there
were aggregate shocks like in Krusell and Smith (1998). This is going to happen until the point
where the economy reaches the new steady state, and it is only at that point that they become
invariant over time.

From a technical point of view, we can ensure that the problem is well defined since
\[ V(a_s, z_s) \] will
inherit the concavity of the utility function, and also will satisfy the Blackwell sufficient conditions
for a contraction.\footnote{For a discussion of this properties see Stokey et al. (1989)} Given this, and assuming the completeness of the space of choices, we can
ensure that there is a fixed point of our contraction and therefore we can find the value function
using an iterative procedure.

From the solution, it is worth discussing the first order condition for innovation/effort. In this
specific case, the first order condition for \( q \) is:

\[ \beta P'(q_s) \left[ V(a_{s+1}, z_{s}^{up}) - V(a_{s+1}, z_{s}^{down}) \right] \leq e^{z_s} \Phi'(q_s) \quad \text{with equality if } q_s > 0 \quad (3.9) \]

One important difference between models with capital market imperfections relative to perfect
capital markets is that the amount of wealth each agent have matters for production purposes. In a
world where producers are not financially constrained by a collateral constraint, the characteristic
that determines the occupational choice is the level of productivity. Agents can rent as much
capital as they want due to the completeness of capital markets and produce at their financially
unconstrained level. Therefore, asset holdings are not important to decide an occupation: agents
compare wages with the potential profit that they could generate given their productivity. A corollary of this reasoning is that the accumulation of assets for production purposes disappear, and only reason to accumulate assets is consumption smoothing.

Finally, from equation (9) we see that the choice of \( q \) depends on the optimal asset chosen to carry next period. For that reason, the fact that there are financial frictions in production and that you have to accumulate assets over time to overcome financing constraints will be also affecting innovation decisions.

### 3.2.6 Stationary Competitive Equilibrium

Given a distribution of assets and productivity \( G_0(a, z) \) and an exogenous distribution of productivity \( \Gamma(z) \), a stationary competitive equilibrium is composed of policy functions \( \{c_s(a, z), a_{s+1}(a, z), o_s(a, z), q_s(a, z), l_s(a, z), k_s(a, z)\}_{s=0}^{\infty} \) for all \( t \geq 0 \), prices \( \{w_s, r_s\}_{t=0}^{\infty} \) and a sequence of joint distribution of asset and productivity \( \{G_t(a, z)\}_{t=0}^{\infty} \), such that:

1. Given \( \{w_s, r_s\}_{s=0}^{\infty} \) the policy functions \( \{c_s(a, z), a_{s+1}(a, z), o_s(a, z), q_s(a, z), l_s(a, z), k_s(a, z)\}_{s=0}^{\infty} \) for all \( s \geq 0 \).

2. The labor, the capital and the goods markets clear for all \( s \geq 0 \);

\[
\int_{a_s(z, w, r)} \int l_s(z, a, w, r) dG_s(a, z) = \int \int dG_s(a, z) \quad \text{labor market}
\]

\[
K_s = \int_{a_s(z, w, r)} \int k_s(z, a, w, r) dG_s(a, z) = \int \int a_s dG_s(a, z) \quad \text{capital market}
\]

3. The distribution of productivity and wealth evolves using the following rule:

---

\(^{12}\)To save notation, I am omitting the dependence of the state variables \( a \) and \( z \) with respect to time \( s \)
\[ G_{s+1}(a^*, z^*) = \int \int I(u = a_{s+1}(v, z^* + \Delta)g_s(v, z^* + \Delta)(1 - P_s(u, z^* + \Delta))dvdv\]
\[ + \int \int I(u = a_{s+1}(v, z^* - \Delta)g_s(v, z^* - \Delta)P_s(u, z^* - \Delta)dvdv \]

where \( I() \) is the indicator function.

To summarize, a stationary equilibrium is a situation where the policy rules are optimal given prices, markets clear given the optimal policy rules, and finally the law of motion for the joint distribution of assets and productivity evolves according to the third condition. In particular, in a stationary equilibrium there is going to be a fixed point of that equation.

### 3.3 Calibration

In order to perform the quantitative exercise, I need to specify preferences, parameter values, the cost function, and remaining parameters and functional forms. In this section, I am going to describe and give some details about these issues. The relevant values used for the analysis can be found in table (3.1).

---

\(^{13}\)In principle I should check the labor and the capital markets due to Walras Law. However, since these are small open economies the interest rate is going to be determined by the rest of the world. As a result I only need to check the labor market because differences between capital demand and supply will be balanced with external funds.
3.3.1 Preferences and Technology

First, I assume that the utility function takes the following functional form:

\[ u(c) = \frac{c^{1-\sigma}}{1-\sigma} \]  

(3.10)

This utility function is widely used in the literature, so I think this decision is not controversial. I am going to take from Mehra and Prescott (1985) the parameter of risk aversion \( \sigma \) and set it to 1.5.

Meanwhile, the cost function for innovation used to simulate the model takes an exponential expression:

\[ \Phi(q) = he^{bq} \]  

(3.11)

This cost function is not novel in the literature, it is the same expression as in Atkeson and Burstein (2010). This function is determined by two parameters: the scale parameter \( h \), and the curvature parameter \( b \). Notice that when the convexity parameter is high, the cost of effort increases rapidly, and therefore small changes in the incentives to do effort (in other words, the differences between the value functions) are not having much effect in the optimal decisions. For this particular paper, I take from Atkeson and Burstein (2010) the values for \( b \) and \( h \). In particular, I set them to 10 and 0.03 respectively. The step size of the innovation process \( \Delta \) is set to 0.15, in lines with the values used in Atkeson and Burstein (2010). Finally, the numerical calibration is such that I ensure that the optimal innovation is inside the support of \( q \).\(^{14}\)

I set the annual depreciation rate at \( \delta = 0.06 \). The parameters of the production function are

---

\(^{14}\)In order to have a well define probability, \( 0 \leq P(q) \leq 1 \). Then, in the optimal solution we need to have that \( q(a, z) \leq -log(\gamma + 1) \), which is satisfied for the parameter values and cost function that I am using.
chosen such that the implied return to scale is equal to 0.8. That is, we have that \( \eta (1 - v) + (1 - v)(1 - \eta) = 0.8 \). Also, we require that the share of output that goes to capital is 1/3. Therefore, using this information we get that \( \eta = 0.266 \) and \( v = 0.2 \). To calibrate the discount factor \( \beta \) and the exogenous probability of improving the productivity \( \gamma \) I target an exit rate of 10% as in the US economy and a real interest rate of 3.0%. To calibrate these two parameters, I assume perfect capital markets (\( \lambda = \infty \)) and an economy without distortions to replicate the US economy. I follow standard procedures and I change \{\beta, \gamma\} to match the two previously mentioned moments. As a result, we get a value of \( \gamma = 0.23 \) and \( \beta = 0.94 \).

### 3.3.2 Productivity, Misallocation Parameters and Financial Frictions

As stated before in the firm’s problem, each individual agent is going to be subject to a financial constraint that is common in the economy and to an idiosyncratic distortion. Following Buera and Shin (2013) I assume that in the pre-reform economy the abstract distortions are randomly assigned and that there are only two states for the grid of wedges, \( \tau_i \in \{\tau_1, \tau_2\} \), with \( \tau_1 \geq 0 \) and \( \tau_2 \leq 0 \). In addition, we have that \( Pr(\tau_i = \tau_1) = 1 - e^{\exp(-z)} \) and that over time the idiosyncratic distortion has an equal probability to change the value of the \( \tau_i \).

In order to calibrate \( \tau_1 \) and \( \tau_2 \) I assume that \( \tau_2 = -\tau_1 \) and I impose a balance budget in the pre-reform stationary steady state. As a result, I get that \( \tau_1 = 0.17 \) and \( \tau_2 = -0.17 \). Finally, I calibrate a value of \( \lambda = 1.9 \), in order to match a ratio of external finance to GDP of 0.78 for the pre-reform economy.\(^{15}\)

\(^{15}\)Average for China, Japan, Korea, Malaysia, Thailand, Taiwan and Singapore.
3.4 Quantitative Analysis

3.4.1 Small Open Economy with Endogenous Innovation

In this section, I provide results for Small Open economy version of the model. As it was mentioned before, this implies that the real interest rate of the economy is going to be determined by the rest of the world. In particular, I will assume an interest rate equal to 3%. In the appendix (3.7.2) you can find a sketch of the algorithm used to compute the stationary equilibrium in both, the undistorted and distorted economy. Basically, to find the optimal policy rules I used value function iteration taken as given the interest rate, the wage, and the optimal policy rule for innovation computed using the value function guess. The convergence is guaranteed since all the desired properties for a contraction are satisfied. However, to improve the computational efficiency of the code, I solved the maximization problem (given a value function) by vectorized Golden Search Method.\textsuperscript{16} over a discretized grid for assets with $a_{\text{min}} = 0$ and $a_{\text{max}} = 2000$, but keeping a very fine grid to have smooth policy functions. The number of productivities used for the case without misallocation is three, so when I compute the equilibrium in the economy with misallocation we have six value functions to compute.\textsuperscript{17}

After obtaining the optimal rules and the value functions, I use simulation methods to obtain the invariant distribution for a given interest rate and wage. I simulate the economy for 450000 agents, and to avoid dependence of the initial conditions we drop the first 50000 observations. In order to compute the distribution, I draw 450000 $z_i$ iid shocks, and I simulate for a given initial

\textsuperscript{16}The golden search method is a derivative-free search algorithm that guarantees to find the global maximum (minimum) when the function is strictly concave( convex). The main advantage of this search method is the fact that we do not need to compute derivatives, which may make a code really inefficient. See Miranda and Fackler (2004) or Judd (1998) for more details about optimization routines.

\textsuperscript{17}For the future I am planning to increase the size of the productivity grid, in order to enrich the model. However, for the sake of simplicity and for computational time, I have decided to work with only three levels.
condition the demand for assets and the endogenous choice for innovation. Then, I compare each
draw of the shock $z_i$ with the endogenous probability that emerges from the optimal choice of asset.
Using this stationary distribution, we can compute the excess demand for labor, and check if the
market is clear. If not, we choose another value of wage using bisection methods and interpolation
methods, until the market is clear.

The results of this exercise can be found in section (3.6). In figure (3.1), I plot the value
functions for the economy without misallocation. The figure shows that for low levels of assets
the utilities diverge very quickly. After a while, the differences persist, but in smaller quantities.
In figure (3.2) I display the optimal choice of assets given the current state. Intuitively, at low
wealth levels, agents with a medium or high productivity accumulate assets in order to become
entrepreneurs and be allowed to use as much capital as possible, given the collateral constraint.
For the low types, the optimal policy rule implies that they have to reduce asset holdings in order
to consume. Related to this, the numerical results show that the low types are going to be workers
in all cases. In terms of the consumption profile for each agent, the results for the economy without
misallocation is reflected in figure (3.3). The plot shows that consumption is strictly increasing for
all levels of asset holding, independently of the level of productivity.

The principal result of the paper is to show the relevance of endogenous innovation effort in a
model of heterogeneous firms and financial frictions. Figure (3.4) reflects the results of the optimal
choice of innovation for different types of productivity, net of the exogenous part $\gamma$. Agents use
innovation effort to increase the chance of having a higher productivity in next period. In particular,
I obtain that those agents who are close to the entrepreneur cutoff have more incentives to innovate.
As it can be seen in figure (3.4), innovation effort is higher for all types at lower levels of asset
holdings. However, the optimal innovation policy is not a monotonic function as expected. In fact,
it is a concave function. It is increasing at lower levels of the asset grid, picking at some intermediate value, and after that decreases monotonically. It is interesting to notice that after a certain level of wealth that is heterogeneous across productivity levels, the optimal innovation effort becomes zero. The reason for this is because the differences of the value functions in equation (9) are less than 1, and therefore the incentives to innovate disappear.\textsuperscript{18} From the figure, we also observe that the ones that exert more effort at lower levels of asset holdings are the medium type. This is very intuitive, because those are the agents whose incentives are higher: they have a lot to win because they could increase their productivity, and they could lose a lot because they may have the lowest productivity next period. Using the model, I computed the percentage of individuals in each type of productivity. Low type agents represent 90% of the population, and the model simulation indicates that these are workers of this economy. High type productivity agents represent 1% of all the population, and most than 85% of those agents are entrepreneurs. Medium type agents represent the remaining share in the population, from where almost 60% are workers. These numbers are consistent with what is found in the literature.\textsuperscript{19}

Figure (3.5) shows the asset distribution for the post-reform economy, and a kernel estimation of the density. A well known result coming from these type of models it that the wealth distribution is right tailed. However, two things are worth pointing out. First, the steady state in this economy suggests that the number of households at the borrowing constraint is smaller than in other models of heterogeneous agents. The reason for this is the interaction between endogenous innovation and the financial friction. If you are close to the entrepreneur cutoff, you want to invest in innovation effort. That means that if you are close, you also want to accumulate as much assets as you can,

\textsuperscript{18}To compute the optimal level of innovation effort, we have to take the log of that difference. In most cases, when the difference of that term is less than 1, the optimal $q = 0$.

\textsuperscript{19}See Quadrini (2000) for a discussion of the empirical facts.
just in case you become a producer. As a result, there is more demand for assets in this economy. If instead of having the cost of innovation in terms of utility, we had it in terms of goods, it may be the case that this effect vanishes because of the substitutability of innovation and asset demand. However, we need to explore this possibility, and I leave it for future research.

For the pre-reform economy, I follow exactly the same procedure. I randomly assign the wedges to the 400000 simulations, and I compute the stationary equilibrium in that economy. As we can see

Column 1 in Table (12) shows selected statistics comparing the results of the pre-reform economy relative to the post-reform economy, both in their corresponding steady states. We can see that output and TFP are 12% and 10% lower than in the post-reform economy. This increase in TFP in the post-reform economy is due to the reduction in the dispersion of marginal products that are generated by the idiosyncratic distortions, and due to the increase in innovation that it is observed.\textsuperscript{20} In addition, the fact that in the post-reform some firms are now more profitable due to the reduction in distortions, makes them accumulate assets to overcome financing constraints. As a result of the smaller income in the pre-reform economy, consumption is 20% lower. Figures (3.6) to (3.10) also correspond to this case. In the economy with distortions, we see that the utilities for each level of asset are more concentrated. This can be seen in figure (3.6). This is the result of consumption that are more similar across levels of productivity-wedge pairs. However, the most interesting picture is the one of innovation effort in this economy. As we can see in figure (3.9), the result of the incorporation of wedges is a reduction in innovation effort of the agents. This effect is accounting for most of the reduction of TFP in this economy, and whenever we make the remove all the wages there is going to be an increase in innovation as in figure (3.4). Notice that

\textsuperscript{20}(see below for a discussion of the implications for innovation)
in that figure, all types of agents are doing innovation for low levels of asset. Here, only the low and medium subsidized are exerting effort. This is also reflected in the distribution of assets. Now, without the interaction between innovation and financial frictions that we were talking before, we observe that more agents are at the borrowing constraint.

3.5 Conclusion

As a first step to understand the transitional dynamics of an economy that makes a reform and generates a slow but progressive increase in TFP, I propose a very simple dynamic general equilibrium model with endogenous innovation that affects the evolution of the productivity. The other main ingredients of the model are financial frictions on the production side, occupational choices for the agents in the economy, and idiosyncratic distortions in the form of taxes and subsidies that generate misallocation of resources. I compare the interaction of this mechanisms simulating the stationary equilibrium of the pre-reform economy and a post-reform economy where the idiosyncratic distortions are eradicated.

The results suggest that there is an interaction between innovation, financial frictions and the idiosyncratic distortions. In the economy without this last element, agents that are close to the entrepreneur cutoff increase the innovation effort to become entrepreneurs. The optimal policy rule for innovation in the post-reform economy is a non monotonic function: it is increasing at low levels of wealth, and after a certain level it starts decreasing and converging to zero. At low levels of wealth, agents that are workers are relatively close to the entrepreneur cutoff, and therefore they increase the innovation effort in order to have a chance of becoming producers more quickly. On the other hand, in the economy pre-reform economy innovation effort behaves differently. The simulations of the model show that the removal of misallocation increase TFP by 10%, and part
of this positive shock is due to the increase in innovation through two channels. First, more types
and agents are innovating in the economy without distortions (the extensive margin). Second,
each agent on average is innovating more (the intensive margin). In terms of future research, the
next step is to compute the transitional dynamics from an economy with distortions to an economy
without distortions in a model with endogenous innovation and financial frictions. With that in
hand, I will be able to compare the proposed model with the data in order to evaluate the success of
the theory. A sketch of the algorithm that I am planning working on can be found in the appendix.

In addition, it would be interesting to compare the results obtained in this paper with those
that could be obtained in a model where the cost of innovation is in terms of the final good. In
this paper, I assumed that the cost of increasing the productivity is given by a reduction in utility.
This assumption is not a very realistic, but it was necessary to gain computational efficiency.

Finally, an exploration of the impact of different types of financial frictions may be worth
exploring. For example, it would be interesting to perform some exercises in this framework but
using Limited Enforcement constraint as in Albuquerque and Hopenhayn (2004). Instead of having
a financial constraint that is history dependent (the collateral constraint), we would have a forward
looking constraint that takes into account the future flows of income generated by the reform.
### 3.6 Tables and Figures

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Concept</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma$</td>
<td>1.5</td>
<td>Risk aversion</td>
<td>Mehra and Prescott (1985)</td>
</tr>
<tr>
<td>$\beta$</td>
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<td>Discount factor</td>
<td>Own calibration</td>
</tr>
<tr>
<td>$b$</td>
<td>10</td>
<td>Curvature of cost function</td>
<td>Atkeson and Burstein (2010)</td>
</tr>
<tr>
<td>$h$</td>
<td>0.03</td>
<td>Scaling factor of cost</td>
<td>Atkeson and Burstein (2010)</td>
</tr>
<tr>
<td>$\Delta$</td>
<td>0.15</td>
<td>Step size</td>
<td>Baseline</td>
</tr>
<tr>
<td>$\eta$</td>
<td>0.266</td>
<td>Parameter of production function</td>
<td>Buera and Shin (2013)</td>
</tr>
<tr>
<td>$v$</td>
<td>0.2</td>
<td>Span of Control</td>
<td>idem</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.06</td>
<td>Depreciation rate</td>
<td>Own Calibration</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>1.9</td>
<td>Collateral parameter</td>
<td>Own Calibration</td>
</tr>
<tr>
<td>$\tau_1$</td>
<td>0.17</td>
<td>Misallocation (tax)</td>
<td>Baseline</td>
</tr>
<tr>
<td>$\tau_2$</td>
<td>-0.17</td>
<td>Misallocation (subsidy)</td>
<td>Baseline</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>0.2</td>
<td>Exogenous part of transition</td>
<td>Baseline</td>
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Table 3.2: Comparison of the Economies

<table>
<thead>
<tr>
<th></th>
<th>Pre-reform Economy</th>
<th>Post-reform Economy</th>
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</thead>
<tbody>
<tr>
<td>TFP</td>
<td>0.9</td>
<td>1</td>
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<tr>
<td>Output</td>
<td>0.88</td>
<td>1</td>
</tr>
<tr>
<td>Consumption</td>
<td>0.80</td>
<td>1</td>
</tr>
<tr>
<td>Avg. capital/labor</td>
<td>0.78</td>
<td>1</td>
</tr>
<tr>
<td>Avg. size</td>
<td>0.82</td>
<td>1</td>
</tr>
<tr>
<td>Avg. innovation rate</td>
<td>0.4</td>
<td>1</td>
</tr>
<tr>
<td>Share of entrepreneurs</td>
<td>0.95</td>
<td>1</td>
</tr>
</tbody>
</table>

Results are relative to the post-reform economy. In both cases $\lambda = 1.9$
Figure 3.1: Value Function without Misallocation

![Value Function without Misallocation](image1)

Figure 3.2: Optimal Policy Rule for Assets without Misallocation

![Optimal Policy Rule for Assets without Misallocation](image2)
Figure 3.3: Optimal Policy Rule for Consumption without Misallocation

![Graph of consumption with productivity levels]

Figure 3.4: Optimal Policy Rule for Innovation without Misallocation (net of $\gamma$)

![Graph of probability with productivity levels]
Figure 3.5: Stationary Distribution without Misallocation

Figure 3.6: Value Function with Misallocation
Figure 3.7: Optimal Policy Rule for Assets with Misallocation

![Graph showing the optimal policy rule for assets with misallocation.](image)

Figure 3.8: Optimal Policy Rule for Consumption with Misallocation

![Graph showing the optimal policy rule for consumption with misallocation.](image)
Figure 3.9: Optimal policy rule for Innovation with Misallocation (net of $\gamma$)

Figure 3.10: Stationary Distribution with Misallocation
3.7 Appendices

3.7.1 Solving the Firm’s Problem

In this appendix I will solve the optimal quantities in equilibrium with wedges that affect output production that are individual specific. Therefore, the problem of an entrepreneur is:

$$\pi(z_i, a_i, w, r) = \max_{l_i, k_i \leq \lambda a_i} (1 - \tau_i) f(z_i, k_i, l_i) - wl_i - (\delta + r)k_i$$ (3.1)

Here, we assume for simplicity that

$$f(z, k, l) = z \left(k^{\theta} l^{1-\eta}\right)^{1-v} = z_i k_i^\alpha l_i^\theta$$ (3.2)

so that $\eta(1 - v) = \alpha$ and $(1 - \eta)(1 - v) = \theta$. The FOC are:

$$\theta(1 - \tau_i)z_i k_i^\alpha l_i^{\theta-1} = w$$ (3.3)

$$\alpha(1 - \tau_i)z_i k_i^\alpha l_i^{\theta-1} = r + \delta + \mu$$ (3.4)

where $\mu$ is the lagrange multiplier of the collateral constraint.

If the constraint is not binding, the we have $\mu = 0$ and the optimal solution is

$$l_i^*(z, w, r, a) = \left[ \left( \frac{\alpha}{r + \delta} \right)^\theta \left( \frac{\theta}{w} \right)^{1-\alpha} z_i (1 - \tau_i) \right]^{\frac{1}{1 - \theta - \alpha}}$$ (3.5)
\[ k^*_i(z, w, r, a) = \left[ \left( \frac{\alpha}{r + \delta} \right)^{1-\theta} \left( \frac{\theta}{w} \right)^\theta z_i(1 - \tau_i) \right]^{\frac{1}{\theta - \alpha}} \]  

(3.6)

However, if the constraint is binding, we have that

\[ k^*_i(z, w, r, a) = \lambda a_i \]  

(3.7)

and then the optimal choice for labor is

\[ l^*_i(z, w, r, a) = \left[ \frac{w}{\theta z_i(1 - \tau_i) (\lambda a_i)^\alpha} \right]^{\frac{1}{\theta - 1}} \]  

(3.8)

Using this optimal allocations, we can compute the profit of the firm. In the case of unconstrained firms we have:

\[ \pi_i(z, a, w, r) \propto z_i(1 - \tau_i) \left( \frac{1}{r + \delta} \right)^\alpha \left( \frac{1}{w} \right)^\theta \left[ \frac{1}{1 - \alpha - \theta} \right] \]  

(3.9)

All these expressions are inputs for the matlab codes used to complete the quantitative exercise.

### 3.7.2 Stationary Equilibrium

The numerical procedure to solve for the Stationary Equilibrium of the model is as follow:

We solve for the stationary equilibrium of this economy based on algorithm of Aiyagari (1994). Here we have to iterate over wage \( w \), interest rate \( r \) until the labor market and the capital are in equilibrium, given that we solve optimally for the endogenous probability of innovation. The computational procedure can be summarized as follow:
1. Guess the interest rate in the invariant distribution, $r_i$

2. Guess the wage in the invariant distribution, $w_{ij}$

3. Given the guesses on interest rate and wage, solve the individual’s problem in the stationary equilibrium. Given the optimal decision rule, simulate the economy.

4. To solve the individual’s problem, guess the value function $V(a, z)$, solve for the optimal $q$ from the FOC for $q$, plug in the Bellman equation and iterate until convergence of $V(a, z)$. Notice that after each iteration of that $V(a, z)$, $q$ will be updated optimally.

5. Check the labor market clearing condition. If there is excess labor demand (supply), choose a new wage $w_{i,j+1}$ that is greater (smaller) than $w_{i,j}$

6. Repeat Steps 3-5 until the labor market clears.

7. Check the capital market clearing condition. If there is excess capital demand (supply), choose a new interest rate $r_{i+1}$ that is greater (smaller) than $r_i$.

8. Repeat Steps 2-7 until the capital market also clears.

This is the general version of the code. In the Small open economy version, we assume that the interest rate is given by the international markets, and therefore we do not have the outer loop over the interest rate. In this way, the computational time of the program is reduced considerably.

3.7.3 Transition Dynamics

To compute the entire transition dynamics, we have to iterate on the wage and interest rate sequences.
The computational procedure can be summarized as follow:

1. Guess an interest rate sequence, \{r_i^t\}_{t=0}^T.

2. Guess a wage sequence \{w_{ij}^t\}_{t=0}^T. Compute the value function of the stationary equilibrium, and let \(v_T(a, z) = v(a, z)\). Solve using backward induction, using guessed sequences of wages and interest rate the value functions \(v_t(a, z)\) for \(t = 0, 1, \ldots, T - 1\). With the value functions, you can compute the optimal innovation, given that we now what is going to be the value function next period. Use the policy rules obtained and simulate the model the \(T\) periods forward. Check if the labor market clears in each period. Taking individuals capital holdings, create a new sequence of wages \(\tilde{w}_{ij}^t\) that clears the market each period. Update the wage sequence using a convex combination between the guess and the new update. Iterate until convergence.

3. After the wage sequence converge, check if the capital market clears in all periods. Taking the individual asset holdings, construct a sequence of interest rate that clears the static capital market in each period of the transition. Update with that sequence a new one.

4. Repeat 2-3 until both markets clear in each period.
Bibliography


