Essays on Firm Dynamics and Macroeconomics

Stelios G. Giannoulakis
Department of Economics
Athens University of Economics and Business

This dissertation is submitted for the degree of
Doctor of Philosophy

Athens, Greece
May 2020

To my parents and brother

Acknowledgements

First and foremost, I would like to express my deepest gratitude to my supervisor Prof. Plutarchos Sakellaris for his wise guidance and continuous support. He has been a great mentor for me. His deep knowledge in many economic disciplines, his attention to detail and method, and his tireless industriousness have been a constant inspiration to me. Despite his busy schedules, he has always been there answering my questions and provide me with constructive suggestions which incented me to widen my research from various perspectives. His international academic stature and vast business work experience helped me in developing both a professional attitude and the vital skills of academic behavior. Without his steadfast support and constant feedback, this Ph.D. would not have been achievable. Finally, I wish to thank him for giving me the opportunity to be his teaching assistant for three consecutive years, providing me with an invaluable experience.

Besides my supervisor, I would also like to thank the Ph.D. committee members Associate Prof. Stelios Arvanitis and Associate Prof. Vanghelis Vassilatos for their valuable assistance, especially on the computational part of this thesis. My gratitude is also extended to the rest of my dissertation committee and particularly to Prof. George Alogoskoufis and Associate Prof. Christos Genakos for their insightful comments and academic support. I am also grateful to Assistant Prof. Alex Fakos for his invaluable help in processing the data used in this thesis.

I would also thank all my lab colleagues and friends for providing me a pleasant working environment. Special thanks belong to Stefanos Kalfas and Nikos Kanigaridis for the very interesting and constructive discussions we had on several matters regarding our theses. I am also thankful to my friends Dr. Dimitrios Anastasiou, Apostolis Katsafados, and Christos Tzomakas for providing me a great support for the accomplishment of my thesis.

I am also grateful to the State Scholarships Foundation (IKY) for financial support. This research is co-financed by the Greek government and the European Union (European Social Fund – ESF) through the Operational Programme "Human Resources Development, Education and Lifelong Learning" in the context of the project "Strengthening Human Resources Research Potential via Doctorate Research – 1st Cycle" (MIS-5000432), implemented by the State Scholarships Foundation (IKY).

Last but not least, I wish to thank my family wholeheartedly, my parents and brother, for believing me and showing it to all possible ways. I am indebted to them with more than I could ever repay.

Abstract

This thesis is about the role of firm dynamics in aggregate fluctuations. It was written in Greece during the period 2016-2020, i.e. during the Greek financial crisis and its immediate aftermath. Greece has suffered the largest economic crisis ever faced by an advanced economy. This Greek tragedy prompted this thesis to focus on addressing some of the concerns that have emerged from the crisis and its implications. More cynically, we can argue that we are using the Greek Depression as an economic laboratory to answer questions about financial crises and to suggest policies that alleviate their adverse effects.

The first chapter brings new evidence on the differences in responses of firms to financial crises by age, size, and finance. First, using a novel and large dataset on firms covering the entire Greek economy over the period 1998-2014, we find that although small and especially young firms are achieving more rapid sales growth rates during normal and even recessionary times, both age and size act as a business shield against severe sales declines and eventually bankruptcy during a downturn. Second, we quantify the differences in the impact of the financial crisis on the sales growth of Greek firms by age and size: the decline in the sales growth was substantially larger (more than 20 percentage points) in young relative to mature and small relative to large firms. Third, we demonstrate that a large part (26%) of this differential sensitivity is driven by financing constraints.

Finally, we find robust evidence that young firms are very important for aggregate fluctuations since an important part of the decline in the gross output of the Greek economy during the crisis stemmed from the credit constraints faced by young firms. Until now, EU and national policies have targeted businesses of a certain size, underestimating, or even ignoring the role of age. Our results indicate that policymakers should focus primarily on young firms and start-ups, adopting both credit-enhancing measures either through the banking system or through capital markets.

The second chapter is about the granular origins of large economic downturns caused by financial crises. Using a large and representative dataset on Greek firms covering all sectors of the economy over the period 2000-2014, we find that the contribution of firm-specific shocks to the volatility of aggregate sales growth increased substantially during the Greek financial crisis and dominated the contribution of macroeconomic and sectoral shocks. We also find that firm-specific shocks are propagated in the aggregate economy mainly through production and financial networks across firms. Our findings indicate that for a deep insight into the mechanics of financial crises, it is essetntial to model firm heterogeneity. In addition, it is crucial to study models that capture inter-firm network propagation mechanisms of idiosyncratic shocks to firms.

The last chapter presents a DSGE model with endogenous firm entry and financial frictions for fiscal policy analysis. During the 2007-09 contraction, the credit crunch in the U.S. economy coevolved with a dramatic and persistent decline (27%) in firm entry. In this chapter we examine whether and to what extent fiscal policy can deal with these two phenomena. First, using a VAR model, covering the period 1993Q3-2019Q4, we document empirically that expansionary fiscal policy can stimulate both the credit supply and the new business formation. Second, by building a New Keynesian DSGE model combining endogenous firm entry and firm-level financial constraints, we provide a theoretical framework to explain this finding. Our model implies that fiscal stimulus can relax credit constraints faced by firms, leading to a gradual and persistent rise in firm numbers. Finally, we show that firm entry is a crucial dimension for fiscal policy analysis in the presence of financial frictions since it substantially affects both the persistence of the impact of fiscal shocks on the aggregate economy and the size of fiscal multipliers, especially in the long run.

Contents

List of Figures

List of Tables

Chapter 1

Firm Growth Dynamics during Financial Crises: Evidence from the Greek Depression

Abstract

Using a novel and large dataset on firms covering the entire Greek economy over the period 1998-2014, we provide new evidence on the differences in responses of firms to financial crises by age and finance. First, we find that although small and especially young firms are achieving rapider sales growth rates during normal and even recessionary times, both age and size act as a business shield against severe sales declines and eventually bankruptcy during a downturn. Second, we quantify the differences in the impact of the financial crisis on the sales growth of Greek firms by age and size: the decline in the sales growth was substantially larger (more than 20 percentage points) in young relative to mature and in small relative to large firms. Third, we demonstrate that a large part (26%) of this differential sensitivity is driven by financing constraints. Finally, we show that young firms are very important for aggregate fluctuations since an important part of the decline in the gross output of the Greek economy during the crisis stemmed from the credit constraints faced by young firms.

1.1 Introduction

There is mounting evidence that young and small firms are special for economic growth and fluctuations, and that policymakers should foster their formation and growth[1]. Following the devastating and long-lasting effects of the recent financial crisis some concerns have emerged. Are financial crises particularly disruptive to small, and especially to young firms' growth? How important an effect do financial constraints have in this disruption? The answers to these questions are crucial in directing policymakers to design corrective policies that help entrepreneurs start and grow dynamic young firms even during crises[2]. The urgency for the answers to these questions is also dictated by the fact that although a bunch of EU and national policies[3] for support to weak enterprises were widely adopted in the wake of the 2008 global financial crisis, most of them have targeted businesses of a certain size, ignoring the role of age.

We contribute to the literature on firm life-cycle dynamics and aggregate fluctuations by studying the Greek financial crisis that erupted in 2010. Four years later, aggregate gross output had declined by almost a quarter. The magnitude and the length of the depression has no precedent among other countries and among previous economic recessions (see figures 1.1 and 1.2). We use a novel and large firm-level dataset representative of the whole Greek economy to show that young (small) firms were disproportionately hit in their sales growth by the crisis compared to mature (large) firms and to explain the reasons for this differential sensitivity. First, we examine the

[1]See e.g. Haltiwanger, Jarmin and Miranda (2013) as well as the literature cited later in this section.

[2]Sadlacek (2019) asserts that young firms are very important contributors to the recovery of an economy from severe recessions.

[3]See for instance the Enterprise Europe Network (EEN).

sales growth trajectories of Greek firms across the age and size distributions and we investigate the impact of the financial crisis on these paths. We also examine the dynamic relationships between firm survival and firm age and size. We find that although small and especially young firms are achieving faster sales growth during normal and even recessionary times, both age and size act as a significant business shield against severe sales disruptions and eventually bankruptcy during a large downturn associated to a financial crisis. More specifically, we find systematic inverse relationships between sales growth rates and firm age (controlling for size) and between sales growth rates and firm size (controlling for age)[4]. The eruption of the crisis didn't topple these inverse relationships. We also find systematic positive relationships between firm survival and firm age (controlling for size) and between firm survival and firm size (controlling for age). Naturally, the outbreak of the crisis has substantially reduced the estimated firm survival probabilities for all age and size groups. However, the smaller or younger a firm is, the larger the reduction in its survival probability.

Then, we quantify the differences in the impact of the financial crisis on the sales growth of Greek firms by age and size. The sales growth of young firms (controlling for size) dropped between 16.5 and 21 percentage points more than that of mature firms. Small firms were also severely hit by the crisis. The sales growth of small firms (controlling for age) dropped between 15 and 22 percentage points more than that of large firms. These results had important aggregate implications. We calculate that between 11% and 14.4% of the drop in aggregate gross output during the crisis was due to the differential impact of the crisis on young firms and that between 4% to

[4] These findings contradict the seminal work of Haltiwanger et al. (2013), which demonstrated that once we control for firm age effects there is no systematic inverse relationship between firm growth rates and firm size.

8.5% due to the differential impact of the crisis on small firms.

We find that credit constraints faced by firms play an important role in these differential declines in sales growth rates. In particular, they had real effects and impacted disproportionately young and small firms' sales growth rates, reducing it by 5.5 to 10 percentage points at the margin compared to mature firms and by 2 to 6 percentage points compared to large firms. We estimate that financing constraints accounted for between 15% and 48% of the estimated age-growth differential and for between 13% and 27% of the size-growth differential. In terms of their aggregate impact on output, financing constraints that impacted disproportionately young firms accounted for between 12% and 44% of the drop in output whist financing constraints that impacted disproportionately small firms accounted for between 12% and 24% of this drop.

Our empirical approach consists of three steps. First, we model the firm's sales growth process as dynamic, subject to first-order Markov disturbances. For the proper characterization of the the growth-size and the growth-age relationships we take into account the age-size dependence (see Haltiwanger et al., 2013). For the estimation of the growth equation, we use a dynamic panel generalized method of moments (GMM) estimator, employing the Wooldridge (2004) moment conditions augmented by a selection correction term. The latter is estimated from a first-stage sample selection binary choice model, based on the approaches of Olley and Pakes's (1996) and Rivers and Vuongs's (1988). It corrects for both endogenous firm selection due to exit and potential sampling bias[5]. An important benefit of a dynamic panel estimator is that it allows researchers to confront any potential issue

[5]Furthermore, this binary choice model allows us to investigate the impact of both firm size and age on the survival probability.

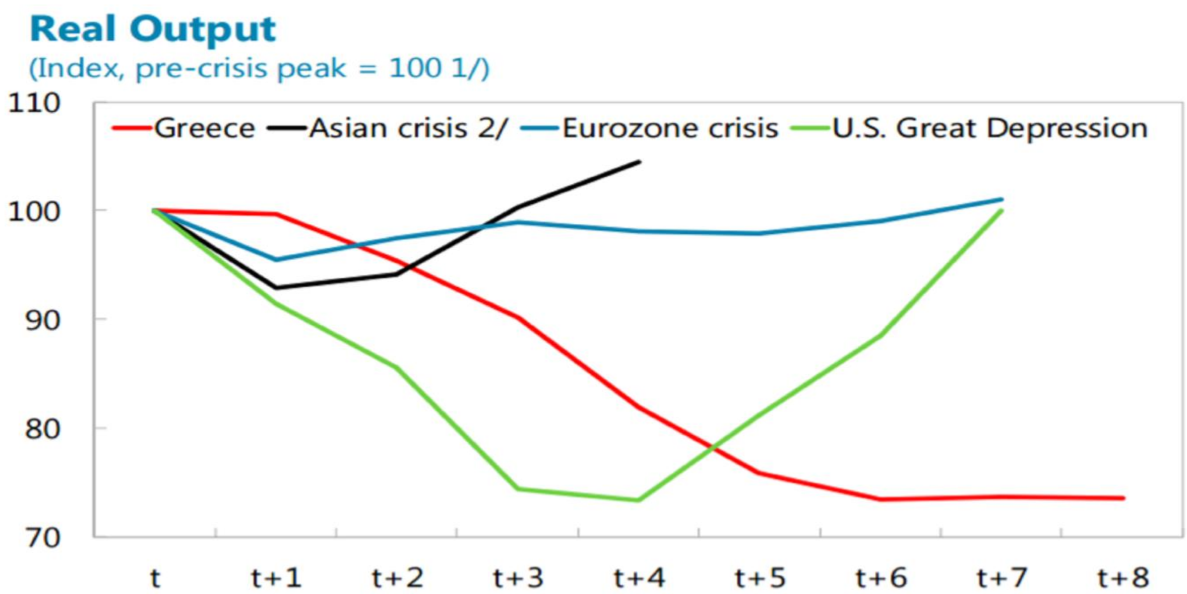


Figure 1.1: Greek crisis VS other crises

Source: International Monetary Fund, 2018 Country Report No. 18/248. **Notes:** (i) Pre-crisis peaks are 2007 for Greece, 1997 for Asian crisis, 2008 for Eurozone crisis, and 1929 for Great Depression, (ii) Asian Crisis includes Indonesia, Republic of Korea, and Thailand.

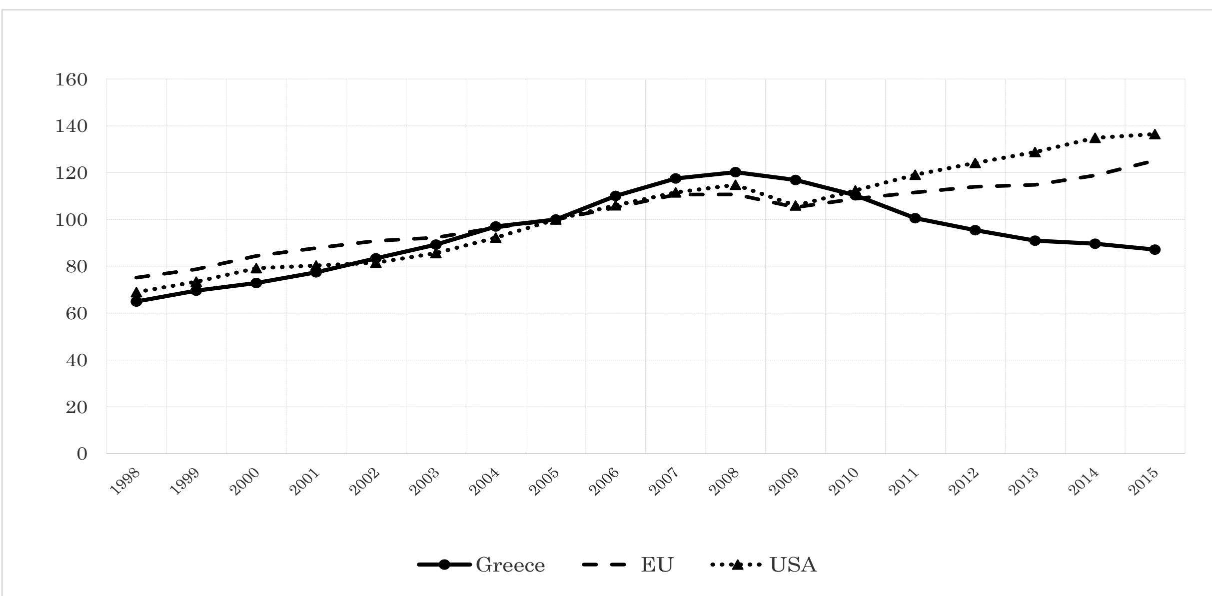


Figure 1.2: Evolution of Gross Output

Source: Eurostat

of endogeneity (Grieser and Hadlock, 2019), a problem that has not been put under the microscope in the previous literature on firm growth.

Next, we quantify the differential effect of the crisis on young relative to mature (and on small relative to large) Greek enterprises. Having sufficient evidence that the fall in sales growth rates due to the crisis was more severe in young (and in small) firms, we examine the role of financing constraints in this differential, along the lines of Duygan-Bump et al. (2015) and Siemer (2019). We identify financing constraints by using both an industry-level measure of external finance dependence, following the work of Rajan and Zingales (1998), and a firm-level measure, following the work of Giroud and Mueller (2016) and Fakos et al. (2019).

Finally, following the work of Chodorow-Reich (2014), we compute the aggregate implications of the differential impact of the Greek financial crisis on age (and size). The approach here is a partial equilibrium one. Additionally, we quantify the aggregate implications of more intense financial constraints on young relative to mature (and small relative to large) firms.

Our evidence comes from proprietary firm-level data obtained from ICAP Group, S.A., a private research company that collects detailed balance sheet and income statement information for S.A. and Limited-liabilities companies in Greece. All companies are legally required to publish their accounts annually and ICAP strives to cover the universe of Greek firms. ICAP data is used by commercial banks for credit decisions and by the central bank for credit rating information. Thus, the data are carefully controlled. Our dataset contains firm-level information for approximately 53,000 Greek firms operating in all sectors, except for banks and insurance companies, for the time period 1998 - 2014. The coverage in our sample is consistently high: the dataset covers roughly 60 percent of the gross output reported in the OECD for the Greek economy. To our knowledge, it is the first time that a so large and representative dataset is employed for the case of Greece. The fact that our data are not census-type leads to an attrition bias, but we deal with it – together with the endogenous selection bias that arises from the continuous exiting/entering market process – following the approaches of Olley and Pakes's (1996) and Rivers and Vuongs's (1988). Unlike the existing empirical literature - which typically ignores the proprietorships or "one person" companies (since employment is used as a measure for firm size) and often excludes start-ups, or lacks information on firm age entirely (e.g., Benmelech et al., 2011; Chodorow-Reich, 2014) - this study examines sales growth of firms of all age cohorts at both the intensive (continuing firms) and extensive (start-ups/entrants and exiters) margins.

This study is part of a large empirical literature on the macroeconomic implications of financial constraints that affect differentially the cross section of firms. The existing literature has mostly focused on differential effects of financial constraints on small and large firms (see among others Gertler and Gilchrist, 1994; Chari et al., 2007; Fort et al., 2013; Chodorow-Reich, 2014; Duygan-Bump et al., 2015; Kudlyak and Sanchez, 2017). We find that the Greek Crisis had a differential impact on small firms (after controlling for age). Quantitatively, however, this is not smaller than the differential effect of the crisis on young firms. The closest paper to ours is Siemer (2019), who showed that financial constraints during the Great Recession in the U.S. reduced employment growth by 7 to 9 percentage points in young relative to old firms. Our study has some key differences as we analyze a different episode of financial crisis, the Greek one, and our focus is on the dynamics of sales rather than employment. Another key difference is that our empirical framework explicitly allows for meaningful persistence in firm growth rates. Siemer (2019) assumes that firm growth rates are subject to i.i.d. shocks. Finally, another stance of this literature tried to explain the negative age-growth and size-growth relationships through financing constraints (Cooley and Quadrini, 2001; Clementi and Hopenhayn, 2006).

There is an important and growing literature on the link between firm life-cycle dynamics and aggregate fluctuations. A recent impetus has come from Haltiwanger, Jarmin and Miranda (2013) who demonstrate the important role of business startups and young businesses in U.S. job creation. Their findings highlight the need for theoretical models and empirical analyses that focus on the start-up process—both the entry process and the subsequent post entry dynamics. Clementi and Palazzo (2016) develop a model where the pro–cyclicality of entry and the positive association between age and firm growth deliver amplification and propagation of aggregate shocks in a competitive framework. Sedlacek (2019) emphasizes the role of young firms in shaping the recovery from economic recessions. He finds that young firms account for 40% of aggregate employment fluctuations in the U.S. (even though they employ only 16% of all workers). Sedlacek Sterk (2017) show that employment fluctuations of startups are procyclical and persistent, and cohort-level employment variations are largely driven by differences in firm size, rather than the number of firms. They emphasize that, during downturns, startups are of a different type that is less likely to grow. A related paper is Pugsley and Sahin (2019) who analyze the effect of the secular decline in the share of startups on the aggregate economy. They found that the employment growth rates state of young firms are more cyclical than those of mature firms. A common feature of the theoretical frameworks in the above papers is that finance does not matter. Our empirical results suggest that it is important to introduce financing constraints on young firms in such equilibrium models. This is likely to increase the level of amplification and propagation of shocks. Young firms have not established strong banking relationships or access to capital markets. Thus, they are more likely to be exposed to financial dislocation especially during financial crises.

The unique characteristics of the Greek depression together with the detailed information in our firm-level data, provides us also the opportunity to further examine the role of firm size and age on the growth process of a firm. In modern literature, a negative relation between firm growth rates and firm size can be considered as an "empirical regularity" (Sutton, 1997). There is plethora of both empirical studies (Evans, 1987; Hart and Oulton, 1996; Yasuda, 2005; Bentzen et al., 2012) and theoretical models (Jovanovic, 1982; Hopenhayn, 1992; Arkolakis, 2016) which support this attitude. Notwithstanding, the recent work of Haltiwanger et al. (2013) asserts that there is no link between a firm's growth and its size, once its age is taken into account. Hence, for the proper investigation of the growth-size relationship the role of age cannot be ignored. Concerning the firm growth-age relationship, although empirical research tends to a negative relationship in the last few years (Evans, 1987; Yasuda, 2005; Fort et al., 2013; Haltiwanger et al., 2013), there is still a dispute among researchers for the impact of age on firm growth. For instance, Barron et al. (1994) and Das (1995) found a positive firm growth-age relationship. Our results confirm the negative age-growth and size-growth relationships for the case of Greece, controlling for size and age respectively. These two relationships were not toppled for the outburst of the Greek financial crisis.

We contribute to the sparkling policy debate on appropriate governmental and EU actions for the support of enterprises during economic recessions. The design of an efficient policy has become urgent and imperative in the aftermath of the global financial Crisis that erupted in 2008. Governmental policies that attempt to alleviate credit constraints faced by small and medium - sized enterprises (SMEs hereafter) are widely adopted across countries. In USA, for instance, the Small Business Administration (SBA) provides support in small businesses through free business counseling, loan guarantees and help to win federal or government contracts. In EU, the Enterprise Europe Network (EEN) provides support to SMEs on access to market information, overcoming legal obstacles, and identifying potential business partners across Europe. Also, the European Investment Bank (EIB), through the European Investment Fund, facilitates the access of European SMEs to finance through a wide range of selected financial intermediaries. In Greece the program "Roots" of Athens Stock Exchange (ATHEX), in cooperation with the American-Hellenic Chamber of Commerce, was activated in 2018 in order to enhance the access of innovative Greek SMEs to external financing not through Greek banks but through the capital markets. The program combines advisory and training opportunities with access to an international network of experts to enable SMEs to reach the point of investment-readiness.

Until now all these public policies have targeted businesses of a certain size, underestimating or even ignoring the role of age[6]. Such policies will likely have limited success in improving net job creation challenges that start-ups and young firms face (such as regulatory challenges and market

[6]For instance, from the Horizon 2020 Programme, which is the biggest EU Research and Innovation program ever, a 3 billion fund (the so called "European Innovation Council-EIC Accelarator" or "SMEs Instrument") was and will be provided for the support of innovative SMEs across Europe. However, no age limit had been set.

failures), a fact which implies that further policy intervention is necessary. We find that, at least for the case of Greece, young firms were hit much more than small firms and surely credit constraints played an important role on this disruption. We also find that young firms are more important than small firms for the aggregate fluctuations. Therefore, age should not be ignored by policymakers anymore. Public policies should focus primarily on young firms and start-ups, adopting both credit-enhancing measures (not necessarily through the banking system, but more preferably through capital markets) and advisory support[7].

The remainder of this chapter is structured as follows. Section 1.2 details the data used and provides some stylized facts on the evolution of firm growth during the Greek financial crisis. Section 1.3 provides regression evidence on the growth-age and growth-size relationships and how they were affected by the Greek Crisis. In Section 1.4, we quantify the differential effect of the crisis on small relative to large and on young relative to mature Greek enterprises. Section 1.5 presents findings on the role of credit constraints in the decline of firm growth rates during the crisis and documents differential effects depending on firm age and firm size. Section 1.6 analyzes the aggregate implications of the financial crisis and of financial constraints on small and young firms. In Section 1.7, we compare our results with previous empirical findings in the literature. Finally, Section 1.8 concludes.

[7] A positive step towards this direction was the creation of the "Startup Europe" in 2011, of the "Startup Europe Partnership" in 2014 and of the "Startup Europe Week" in 2015. All of them were initiatives of the European Commision. All these initiatives try to facilitate the creation of stratups across Europe and their transformation into scaleups by linking them with investors and stock exchanges. However, none of these organizations inludes direct EU funding in its toolbox to achieve its goals.

1.2 Data

1.2.1 Description of Data

The firm-level data are proprietary and they have been obtained from the ICAP Group, S.A., a private research company which collects detailed balance sheet and income statement data for S.A. and Limited-liabilities companies in Greece, together with their establishment date, location and ownership status, for credit risk evaluation and management consulting. All companies are legally required to publish their accounts annually and ICAP strives to cover the universe of Greek firms. ICAP data is used by commercial banks for credit decisions and by the central bank for credit rating information. Thus, the data are carefully controlled.. Our dataset contains firm-level information for approximately 53,000 Greek firms operating in all sectors, except for banks and insurance companies, for the time period 1998 - 2014. For this study we use information on gross sales, gross output/revenue, total balance-sheet assets, long-term and sort-term liabilities, year of establishment, NACE2 codes, firm location and the accounting depreciation flow. ICAP's database was heavily updated in 2005. As a result of this update, some companies were removed from the sample without getting really bankrupt, while some were added into the sample without this indicating that they were established in 2005 (they may have been established earlier). Therefore, the entry and exit rates of 2005 cannot be reliable in our dataset. In any case, the update had a minor effect on the structure of the dataset. Nevertheless, we have to underline that firm age was not affected by the aforementioned data update. For its construction we used the ICAP's variable "year of establishment" which was taken from administrative records and therefore the update didn't affect it. The analytical cleaning process for the firm-level data and a description of the consequences of the 2005 update of ICAP's database can be found in Appendix A. Finally, the aggregate data and deflators for Greece are collected from two publicly available sources: the Eurostat and the Organization for Economic Cooperation and Development.

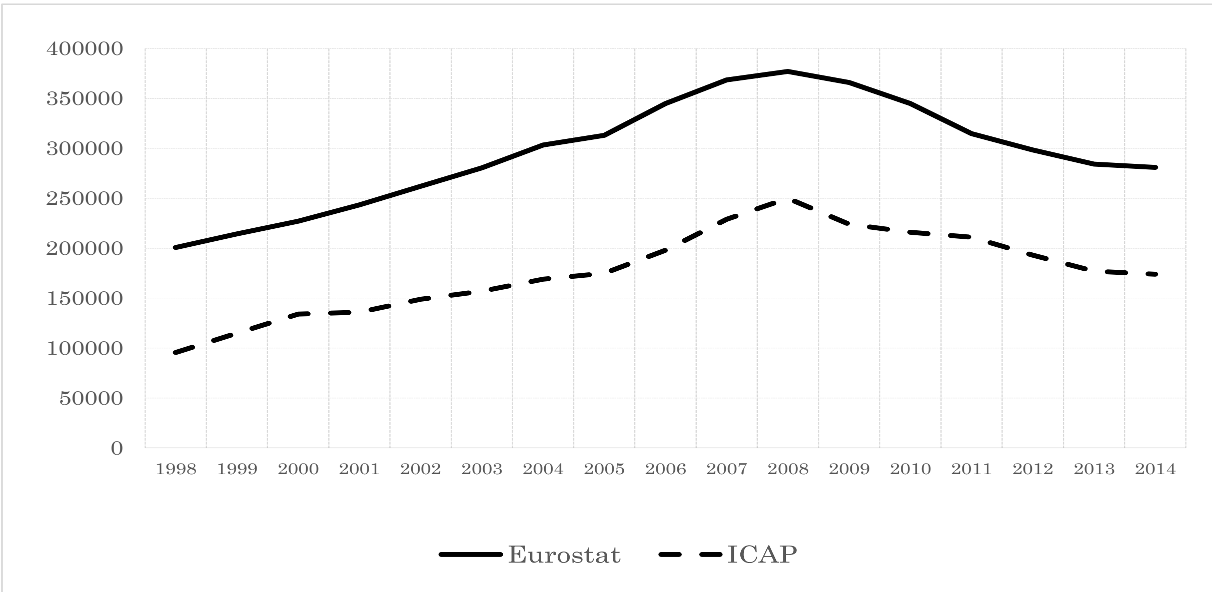


Figure 1.3: Aggregate Gross Output in ICAP and Eurostat databases

Notes: In this Figure, we compare the evolution of the aggregate gross output in our ICAP dataset with the same aggregate as it recorded by Eurostat. Gross output is defined by the Bureau of Economic Analysis (BEA) as: "a measure of an industry's sales or receipts, which can include sales to final users in the economy (GDP) or sales to other industries (intermediate inputs)". At the firm-level, gross output was measured by aggregate gross sales.

As far we know, it is the first time that a so large dataset is employed for the case of Greece. A natural question that might arise here is whether our firm-level dataset resembles the aggregate Greek economy. The coverage in our sample is consistently high (See Table A1 in Appendix A). In particular, the ratio of aggregate gross output[8] recorded in our sample relative

[8]Gross output is defined by the Bureau of Economic Analysis (BEA) as: "a measure of an industry's

to the same object at the national level averages roughly 58 percent for the aggregate economy. This percentage is conservative because we have dropped observations with missing, zero, or negative values for gross sales. The coverage is more or less the same and at industry level. Gross output collected from Eurostat, as reported by its Structural Business Statistics (SBS). The data in Eurostat are from Census sources and represent the universe of firms.

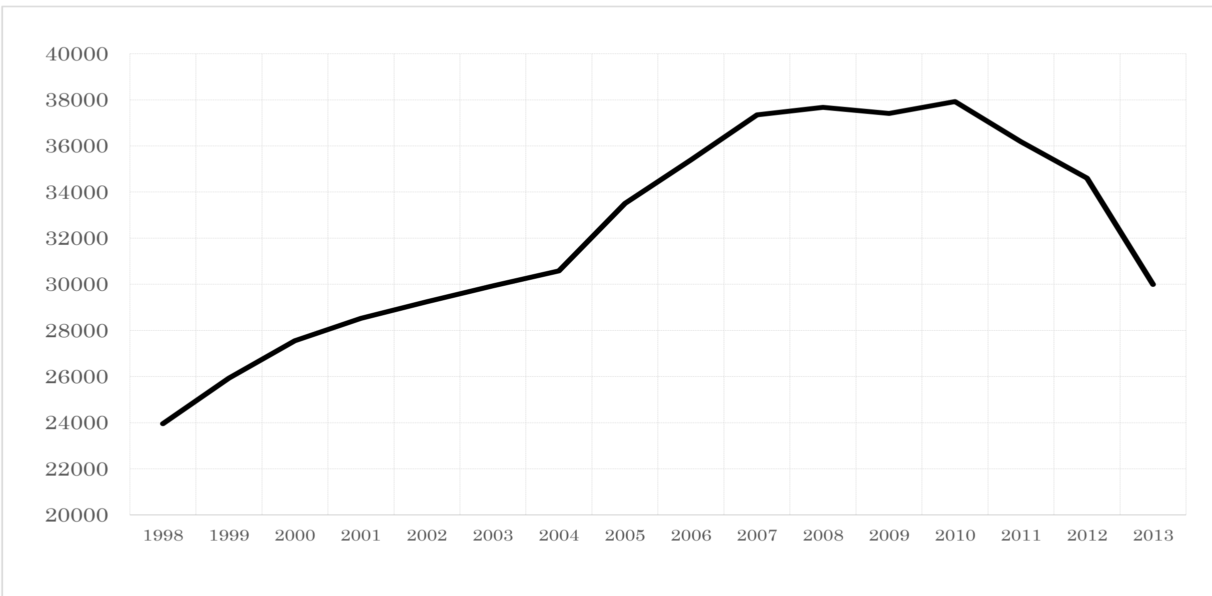


Figure 1.4: Number of Firms in our sample during the period 1998-2013

In Figure 1.3 we compare the evolution of the aggregate gross output in our ICAP dataset with the same aggregate as it recorded by Eurostat. We can see that the course of gross output at the firm-level is very similar to that at macroeconomic level, a fact which implies that our dataset is quite representative of the Greek economy. As we can observe, the outburst of the 2008 global financial crisis, which, for the case of Greece was followed

sales or receipts, which can include sales to final users in the economy (GDP) or sales to other industries (intermediate inputs). A the firm-level, gross output was measured by aggregate gross sales.

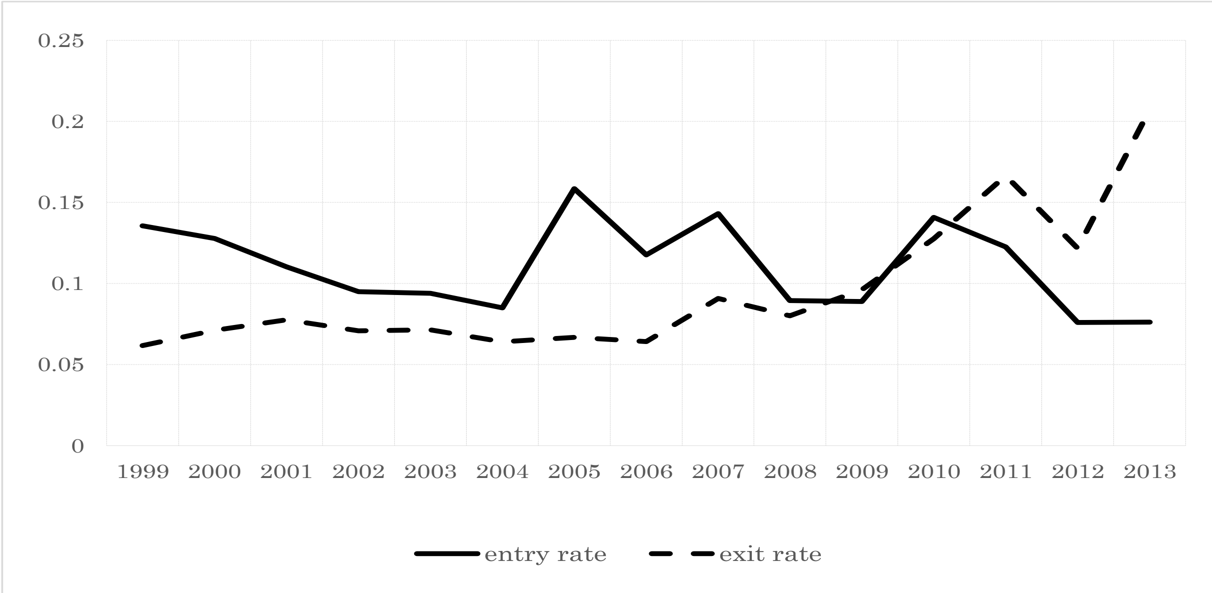


Figure 1.5: Entry and Exit Rates in our Sample

Notes: This figure presents the sample entry and exit rates in our sample. We define Entry as the first year for which a firm has valid size data in our data. In the same spirit, Exit is considered as the last year for which a firm has valid size data in our data. Entry rates are calculated as the number of newly registered firms divided by the number of total registered firms, namely, Entry = Entries/Incumbents. Finally, Exit rates are defined as: Exit = Exits/Incumbents. Recall that the 2005 entry rate cannot be considered reliable due to the 2005 update of the ICAP database.

by a severe sovereign debt crisis, led to a prodigious decline in gross output, which is quantitatively similar to the aggregate (25% from 2008 to 2014) and firm-level data (30% over the same period). The severity of the crisis was unprecedented. In particular, 25% of the Greek GDP was lost until 2015, whilst unemployment reached 25,6 % (50% for young people) by summer of 2015[9]. The course of Greek firms was both very unstable and recessionary during the crisis period. In Figure 1.4 we present the evolution of the number of firms in our sample. The number of Greek firms has importantly fallen after the eruption of the Greek financial crisis (by 20% from 2010 to 2013).

[9]Source: Hellenic Statistical Authority.

In addition, Figure 1.5 provides a pictorial representation of sample entry and exit rates of Greek firms from the period 1998-2014. Recall that the 2005 entry rate cannot be considered reliable due to the 2005 ICAP's update of the dataset. As we can see, before the outburst of the 2008 global financial crisis the number of entries over-exceed the number of exits. However, this result was reserved during crisis.

We define firm size as the as logarithm of gross sales[10] in period t-1, deflated by the Producer Price Index (PPI). Firm age is defined as the difference between the current year of operation and the year of establishment for each firm. For startups firms, age is set equal to zero. Firm growth is defined as the difference $\Delta lnS_{i,t}$ where $S_{i,t}$ denotes the deflated gross sales of firm i at period t[11]. As survival probability we use an indicator function, $y_{i,t}$, that receives the value 1 if firm i is still active in period t and 0 otherwise. To simplify the analysis, we consider broad firm size and age groups. Specifically, following Fort et al. (2018) we separate firms into two age groups: firms are "young" if they are less than 6 years old and "mature" if they are 6 years old or older. The 23 percent of the firms in our sample are young. Regarding firm size, by breaking the size series in period t-1, into percentiles we classify the firms into three size groups: "small" for per-

[10] Three are the most widespread measures of firm size in the literature: employment, sales and total assets (Coad and Hölzl, 2010). Each variable can paint a different picture of the firm, so the choice depends on the purpose of the research (Delmar et al. 2003). Employment data are not reliable in the ICAP database. Furthermore, measuring size in assets may be problematic in industries where intangible assets are important for the process of economic growth and where firms in the sample have very different capital intensities. Thus, we employ sales as a proxy for firm size due to the fact that they are relatively insensitive to capital intensity.

[11] In a list of 10 alternative measures surveyed by Tornqvist et al. (1985), the log difference $\triangle lnS_{i,t}$ was found to be the most preferable measure of relative change as it is the only one that is symmetric, additive and normed. The drawback of the log differences as a measure of relative change, however, is that it is not defined for exiting and entering firms with $S_{i,t} = 0$ and $S_{i,t-1} = 0$, respectively. For this reason we employ as an alternative measure for firm growth the Davis, Haltiwanger and Schuh (1996) bounded growth rates $((S_{i,t} - S_{i,t-1})/0.5(S_{i,t} + S_{i,t-1}))$ in order to include in our analysis both entrants and exiting firms.

centiles 1-50, "medium" for percentiles 51-90 and "large" for the percentiles 91-100[12]. Furthermore,, we classify firms into 13 industries and 99 industrial sectors according to their 4-digit NACE2 codes.

We use two alternative measures for financing constraints, one at the firm-level and one at the industry-level. In particular, following Giroud and Mueller (2016) and Fakos et al. (2019) we use financial leverage (measured by the debt-to-assets ratio) at firm level as a proxy for credit constraints. We separate all firms in the economy into firms of high - and low - leverage, which are defined as those above and below the median of the 2007 leverage distribution[13], respectively. We assume that all firms were low-leveraged during the pre-crisis period. For our analysis, we create a dummy variable "high-leverage" which receives the value 1 for a firm of high leverage and 0 otherwise.

Moreover, we construct an industry-level measure for external financial dependence, which was originally proposed by Rajan and Zingales (1998), following the procedures described in Cetorelli and Strahan (2006). In particular, we define external financial dependence (EFD hereafter) as the proportion of capital expenditures financed with external funds, i.e.:

$$EFD_{j,t} = \frac{\sum_t CapEx_{j,i,t} - \sum_t CF_{j,i,t}}{\sum_t CapEx_{j,i,t}}$$

where $CapEx_{j,i,t}$ and $CF_{j,i,t}$ denote the "capital expenditures" and "operating cash flows" of firm "i" in sector "j" and year "t", respectively. A value of EFD smaller than zero indicates that a firm has more cash flow than capital expenditures and thus tends to have funds available. A value larger

[12]Under this size classification a firm can be considered as "small" if its annual gross sales are less than 750,000€, "medium" if its sales are more than 750,000€and less than 6,500,000€and "large" if its gross sales are more than 6,500,00€.

[13]2007 is the last year of the pre-crisis era in which leverage was still increasing.

than zero indicates that a firm might be financially constrained as capital expenditures exceed available cash flow and therefore the firm needs to raise additional capital to finance its investment.

The variable of capital expenditures it is defined as follows:

$$CapEx_{i,t} = \Delta(FTA)_{i,t} + Depr_{i,t}$$

where $\Delta(FTA)_{i,t}$ denotes the net change in fixed tangible assets and $Depr_{i,t}$ stands for the depreciation expense listed in the income statement. Moreover, the (operating) cash flows, net of changes in inventories, account receivable and accounts payable, are defined as follows:

$$CF_{i,t} = NI_{i,t} + DA_{i,t} + \Delta WC_{i,t}$$

where $NI_{i,t}$ and $DA_{i,t}$ denote the net income and depreciation & amortization respectively, whilst $\Delta WC_{i,t}$ denotes the change in working capital (i.e. the difference between current assets and current liabilities) of firm "i" in year "t".

After constructing the EFD ratio for each firm, we use the median value for all firms in each 4-digit NACE2 category as our measure of external finance needs for that industry. Finally, we separate all sectors in the economy into composite sectors of high - and low - EFD, which are defined as those above and below the median external financial dependence measure, respectively. For our analysis, we create a dummy variable "high-EFD" which receives the value 1 if a sector is highly financially constrained and 0 otherwise.

1.2.2 Stylized Facts: The Role of Firm Age, Firm Size and Finance in Firm Growth' patterns around the Crisis

In this section, we present results of our analysis of the evolution of firm growth before and during the crisis.We also examine the impact of age, size and finance on the firm sales growth and whether it changed after the outburst of the Greek financial crisis. A matter of high importance in the analysis of firm growth dynamics, that has been highlighted from very early in the literature (Mansfield, 1962), is the "selection effect or bias" that the firm entry-exit process creates. In order to investigate the role of the selection bias on the evolution of firm growth we examine the impact of age and size on both the unconditional and conditional firm growth rates, with the latter to imply the growth rate of the firms which survived until 2014 (i.e. the last available year in our sample).

In Figure 1.6 we present the dynamic patterns of both unconditional and conditional average annual firm growth rates of Greek firms for the time period 1998-2014. In order to investigate whether the growth rates of the firm-level data resemble the growth path of the Greek economy we include in the same graph the growth of the Gross Domestic Product (GDP hereafter) annual time series, collected from OECD Database. Both the firm-level and the macro-level series are on 2003 base in order to be comparable. We can discrete two phases of the economic cycle regarding the GDP growth: the "boom" phase (1998-2009) and the "bust" one (2010-2014). As we can see, the course of the conditional firm growth is quite similar with that of GDP. The 2008 global financial crisis led to a dramatic fall of both firm and economic growth which was considerably deteriorated after the outburst of the Greek financial crisis. After the 2013 an anemic recovery can be observed

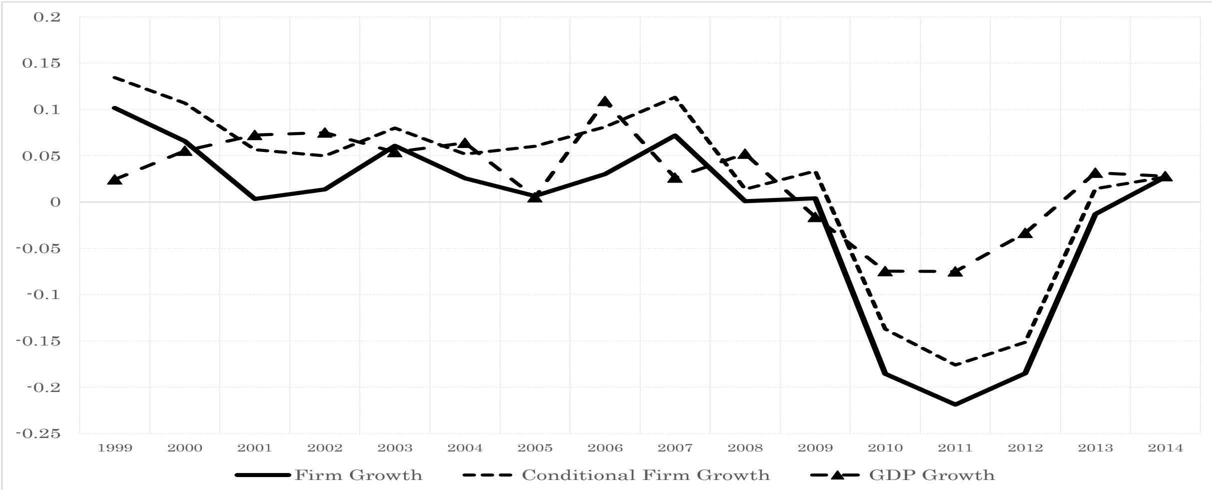


Figure 1.6: Dynamic Patterns of Firm Growth

Notes: This figure presents the dynamic patterns of average annual firm growth rates of Greek firms for the time period 1998-2014. In addition, in order to investigate whether the growth rates of the firm-level data resemble the growth path of the Greek economy we include in the same graph the growth of the Gross Domestic Product (GDP hereafter) annual time series, collected from OECD Database. Continuers are the firms which survived until 2014 (i.e. the last available year in our sample). Both the firm-level and the macro-level series are on 2003 base.

on both GDP and firm growth rates. Despite the fact that the trajectory of the conditional firm growth is very close to that of GDP, the unconditional firm growth has a more divergent and unstable path, a fact which underlines the importance of selectivity in the analysis of firm dynamics.

We now turn to exploring whether the firm growth vary by firm age and size over the cycle. Table 1.1 presents summary statistics for the 2 firm age and 3 firm size categories for both the "boom" and the "crisis" periods. Both firm age and firm size seems to have a negative impact on firm growth. In general, as a firm ages, it becomes larger, more profitable and more leveraged. Crisis seems to have a more severe negative effect on small relative to large and on young relative to mature firms. Figures 1.7 and 1.8 shows the patterns of firm growth by firm size and firm age

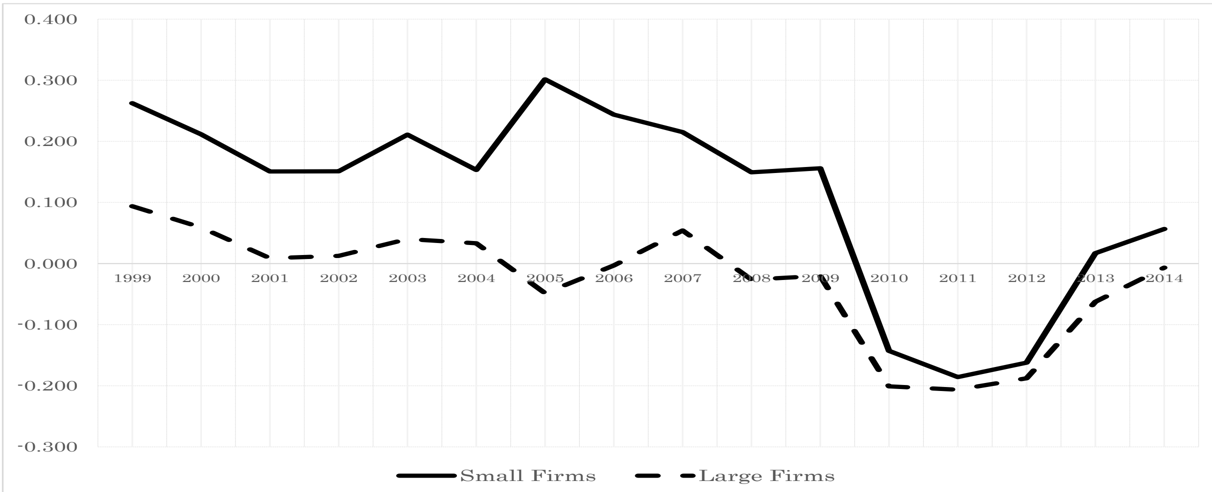


Figure 1.7: Firm Growth by Size Group

Notes: In this figure we present the dynamic patterns of firm growth rate by size group. Firm size is defined as the logarithm of gross sales in period t-1, deflated by the Producer Price Index (PPI). Firm growth is defined as the logarithmic difference of deflated sales. A firm is defined as "small" if it is size is below the 60th percentile of the size distribution and "large" if its size is larger than the 90th percentile of the size distribution.

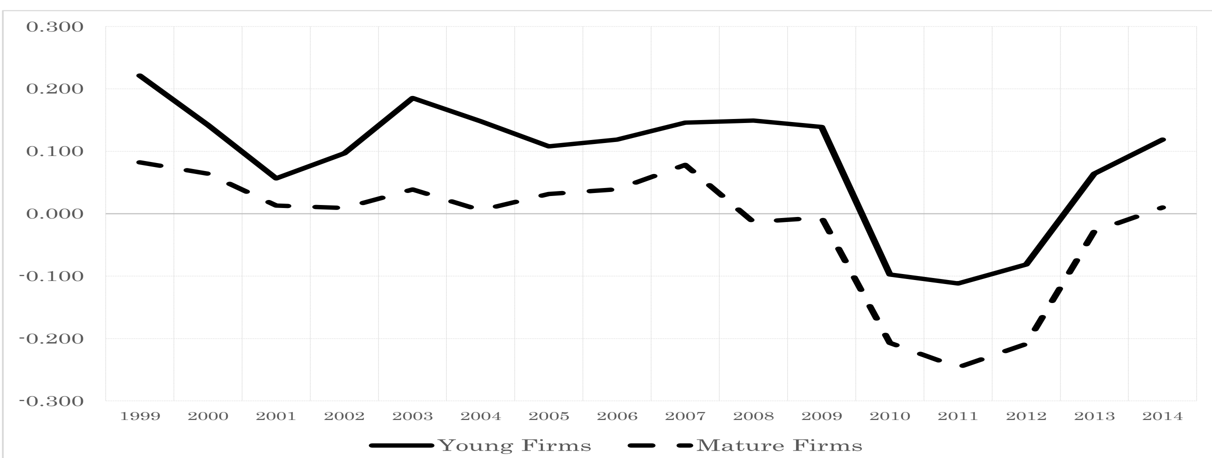


Figure 1.8: Firm Growth by Age Group

Notes: In this figure we present the dynamic patterns of firm growth rate by age group. Firm growth is defined as the logarithmic difference of deflated sales. A firm is defined as "mature" if its age is larger than 5 years and "young" otherwise.

from 1998-2014. Sales growth rates are higher for young/small firms than for their large/mature counterparts. All groups exhibit cyclicality but it is striking that the decline in Greek crisis for small firms is much larger than for large firms.

In figures 1.9 and 1.10 we investigate the role of financial constraints in the growth-age and growth-size relationships over the cycle. In particular, we present the average sales growth rates by age and size, before and after the outburst of the crisis, separately for highly and lowly leveraged firms. Again, sales growth rates are higher for young/small firms in both leverage categories. Two interesting remarks can be made regarding the role of leverage in the patterns of firm growth. Firms with high leverage had higher growth rates before the eruption of the crisis. However, it is striking that the decline in Greek crisis for high-leveraged firms is much larger than for low-leveraged firms. This result is very strong especially for young and for small firms. The implication is that at least part of the story for why sales growth rates for young/small firms fell so much during the crisis must be associated with the financial distress that young/small firms had to dealt with after the eruption of the crisis.

In Figure 1.11 we depict the number of firm exits by size-age groups. As we can see, the number of exits occurred is much larger for the “small and young” firms than for the “large and mature” ones throughout the period. Moreover, exits were dramatically increased for “small and young” firms after the outburst of the crisis, whilst “mature and large” firms seem to be robust to the consequences of the crisis in relative terms, though exits somewhat increased after 2008 for them, too. Thus, we expect that both firm age and size will have a positive impact on survival, that should become stronger during the crisis era.

	Statistic	$g_{i,t}$	$lnS_{i,t}$	$A_{i,t}$	$Sales_{i,t}$	$Assets_{i,t}$	$Margin_{i,t}$	$(\frac{Debt}{Assets})_{i,t}$
Boom Period (1998 - 2009)								
	Obs	120,221	120,221	120,221	120,221	116,225	116,225	116,225
Small	Mean	0.094	12.391	13.201	341	992	108	0.498
	SD	0.548	1.199	11.479	459	8,130	227	0.388
	Obs	33,365	33,365	33,365	33,365	33,397	33,397	33,397
Large	Mean	0.001	16.875	21.619	43,700	52,200	9,375	0.693
	SD	0.293	1.025	17.974	198,000	332,000	55,900	0.268
	Obs	61,129	61,129	61,129	61,129	59,941	59,941	59,941
Young	Mean	0.088	13.575	3.421	2,746	3,094	668	0.671
	SD	0.584	1.647	1.166	28,000	25,600	16,900	0.356
	Obs	211,922	211,922	211,922	211,922	206,341	206,341	206,341
Mature	Mean	0.007	14.068	18.549	7,681	10,000	1,729	0.586
	SD	0.430	1.838	13.191	78,900	135,000	20,800	0.335
Crisis Period (2010 - 2014)								
	Obs	77,192	77,192	77,192	77,192	70,632	70,632	70,632
Small	Mean	-0.064	12.104	15.855	335	1,418	108	0.544
	SD	0.506	1.240	12.280	325	12,900	195	0.455
	Obs	13,218	13,218	13,218	13,218	12,865	12,865	12,865
Large	Mean	-0.118	16.777	25.084	57,700	77,900	10,600	0.697
	SD	0.310	1.042	18.442	303,000	485,000	72,700	0.314
	Obs	22,265	22,265	22,265	22,265	20,536	20,536	20,536
Young	Mean	-0.113	12.724	3.526	2,091	3,698	492	0.685
	SD	0.765	1.795	1.171	15,800	35,400	5,711	0.450
	Obs	121,927	121,927	121,927	121,927	111,541	111,541	111,541
Mature	Mean	-0.160	13.489	20.549	7,210	11,700	1,489	0.588
	SD	0.582	1.933	13.349	101,00	170,000	24,800	0.401

Notes: A firm is defined as "small" if it is size is below the 60th percentile of the size distribution and "large" if its size is larger than the 90th percentile of the size distribution. A firm is defined as "mature" if its age is larger than 5 years and "young" otherwise. Firm size ($lnS_{i,t-1}$) is defined as the logarithm of gross sales in period t-1, deflated by the Producer Price Index - PPI. Firm growth is defined as the difference of the firm size ($\Delta lnS_{i,t}$). We dropped observations that are below the 1 percentile or above the 99 percentile of the firm growth distribution. Sales, Assets and Margin denote the gross sales, total assets and gross margin, respectively, and they are cited in thousands euros. Gross margin reflects total revenue minus cost of goods sold and can be found in the Income Statement. Debt denotes the sum of long-term and short-term debt.

Table 1.1: Descriptive Statistics

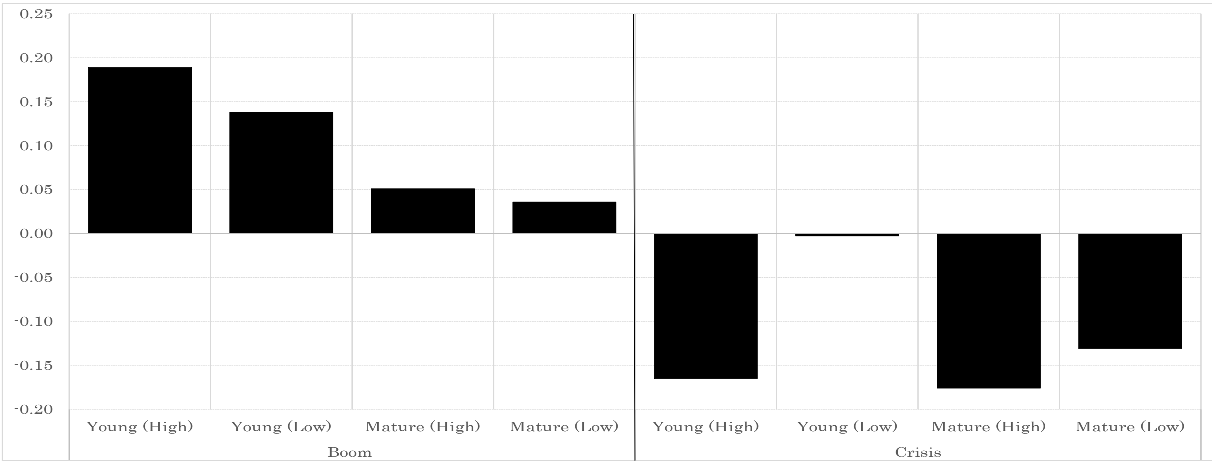


Figure 1.9: Firm Growth by Finance and Age Groups

Notes: This figure presents the average sales growth rates by age and finance groups. A firm is mature if its age is larger than 5 years and young otherwise. We separate all firms in the economy into composite firms of high - and low - leverage, which are defined as those above and below the median of the 2007 leverage distribution, respectively. We define leverage as the debt-to-assets ratio.

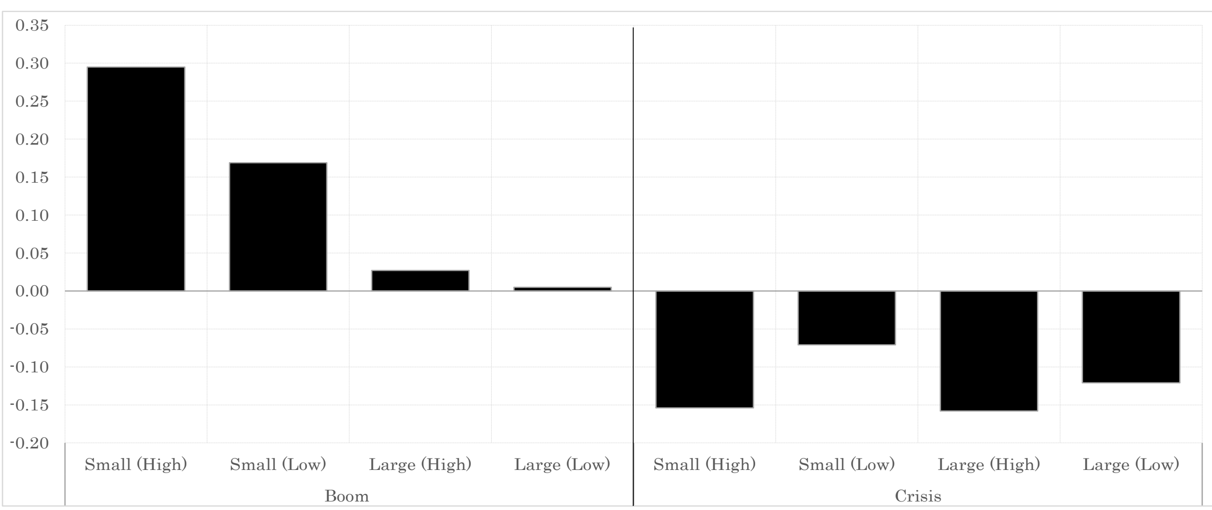


Figure 1.10: Firm Growth by Finance and Size Groups

Notes: This figure presents the average sales growth rates by size and finance groups. A firm is small if it is size is below the 6th decile of the size distribution, medium if its size is between the 6th and the 9th deciles and large if its size belongs to the 10th decile of the size distribution. We separate all firms in the economy into composite firms of high - and low - leverage, which are defined as those above and below the median of the 2007 leverage distribution, respectively. We define leverage as the debt-to-assets ratio.

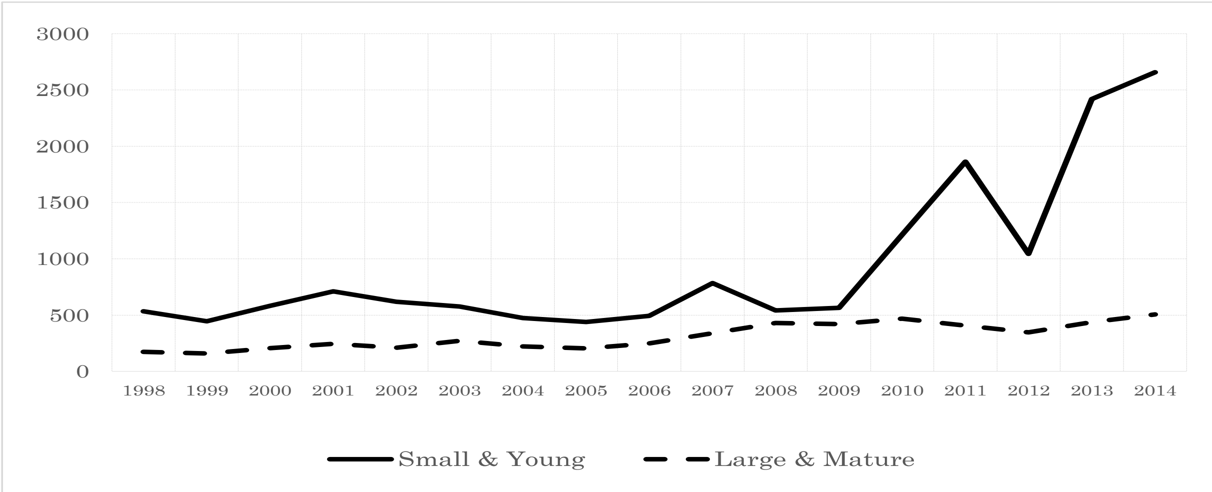


Figure 1.11: Firm Exits by Age-Size Group

Notes: This figure presents the evolution of sample exits by age-size groups. We define Firm Exit as the last year for which a firm has valid size data in our data.

	Decline in Aggregate Sales (2009-2014)	**Fall in Average (Sales) Growth Rate from Boom to Crisis**	**Growth Differentials**
Firm-level Data			
Young	-29%	-20 p.p.	Young-Mature
Mature	-21%	-16.7 p.p.	-3.3 p.p.
Small	-26%	-15.8 p.p.	
Large	-18%	-11.9 p.p.	Small-Large
All Firms	-22%		-3.9 p.p.
Macro Data	-23%	-8.8 p.p.	

Notes: In this Table we present the quantified impact of Greek Depression on the sales and growth rates of Greek firms according to our sample. The fall in average growth rate from boom to crisis is calculated as: (i) percentage: $\frac{g^{Cr,k}-g^{Bm,k}}{g^{Cr,k}}$,where Bm and Cr stand for the (1998-2009) and (2010-2014) periods respectively and k={young, mature, small, large}, (ii) percentage points (p.p.): $g^{Cr,k}-g^{Bm,k}$. With the term “growth differentials” we refer to the following expressions $(g^{yng}-g^{mtr})^{Cr}-(g^{yng}-g^{mtr})^{Bm}$ and $(g^{sml}-g^{lrg})^{Cr}-(g^{sml}-g^{lrg})^{Bm}$ with which we quantify the differential impact of Greek Depression to the growth rates of young relative to mature firms and of small relative to large firms respectively.

Table 1.2: The Impact of Greek Depression by Firm Age and Size

Finally, in Table 1.2 we quantify the impact of Greek Depression on the sales and growth rates of Greek firms according to our sample. Two interesting remarks can be made here. First, our sample gives almost the same quantitative reduction in gross output (or aggregate sales) as the data in national-level, a fact that implies that our firm-level dataset resembles at a large extent the aggregate Greek economy. Second, the crisis effect was significantly more severe in small/young firms than in large/mature firms. In particular, the fall in the firm growth due to crisis was 3.3 percentage points larger for young than for mature firms and 3.9 percentage points larger for small than for large firms.

For the above analysis, it is apparent that firm size, firm age and financial constraints play a vital role in the firm growth paths. Moreover, survival through selection seems to be very important for the analysis of these trajectories over the cycle. In the next section, we try to shed light in these linkages by estimating a dynamic growth model.

1.3 The Relationship of Firm Growth, Firm Size and Firm Age

1.3.1 Empirical Specification and Identification

Our first objective is to explore the relationship between firm growth and firm size and age. We use a non-parametric regression approach to quantify these relationships. More specifically, we regress sales growth at the firm-level on firm size and age classes. Following the work of Haltiwanger et al. (2013), we use more subtle groups than those we described in Section 1.2. In particular, we employ the following econometric specification:

$$g_{i,t} = \beta_0 + \beta_{1,j} S^j_{i,t} + \beta_{2,k} A^k_{i,t} + \beta_{3,j,k} (S^j \times A^k)_{i,t} + \beta_{4,j} (S^j \times Crisis)_{i,t} \\ + \beta_{5,k} (A^k \times Crisis)_{i,t} + \beta_{6,j,k} (S^j \times A^k \times Crisis)_{i,t} + \beta_7 Crisis_t + \varepsilon_{i,t} \quad (1.1)$$

where $g_{i,t}$ denotes the growth of firm "i" at period "t", $A^k_{i,t}$ is a categorical variable for age which receives the values 1-6 for the age groups K={1-3, 4-6, 7-10, 11-15, 16-20, 20+ years} and $S^j_{i,t}$ is a categorical variable for size which receives the values 1-6 for the size groups J={1-30, 31-60, 61-70, 71-80, 81-90, 91-100 percentiles}. For the proper characterization of growth-size (age) relationship we have to control for age (size). For this reason, we include the age-size interaction term in the model. Last but not least, since we seek to capture the effect of Greek financial crisis on the patterns of the firm growth, we include in the model a crisis dummy and its interaction with all the regressors. The crisis dummy receives the value 1 for the crisis period (2010 - 2014) and the value 0 for the pre-crisis period (1998 - 2009)[14].

In the modern both theoretical and empirical literature, it has been found that the firm growth process is driven by, apart from systematic factors, ex-ante firm heterogeneity and persistent ex-post shocks (Pugsley et al., 2018). Moreover, early and more recent empirical studies in firm growth considered annual autocorrelation patterns for firm growth (Coad, 2007). Therefore, we do the following identification assumptions for the disturbances of the growth regression equation 1.1:

Assumption 1: The firms' information set at time period t, $I_{i,t}$,

[14] We set the outburst of the crisis in 2010 for two reasons. First, 2010 was the first year in our sample that the average sales growth rate started to decline. Second, according to the work of Schularick and Taylor (2012) the collapse in economic activity during the Greek crisis was preceded by a credit boom during the period 2002–2009. Seeking to examine the role of credit constraints in the impact of crisis on Greek firms we comfort to a common pattern documented by these two authors.

includes current and past shocks $\{\varepsilon_{i,s}\}_{s=0}^{t}$ but does not include future shocks $\{\varepsilon_{i,s}\}_{s=t+1}^{\infty}$.

Assumption 2: The disturbance, $\varepsilon_{i,t}$, follows an exogenous first order Markov chain process. In other words, shocks evolve according to the distribution

$$P(\varepsilon_{i,t+1} \mid I_{i,t}) = P(\varepsilon_{i,t+1} \mid \varepsilon_{i,t})$$

This distribution is known to firms and stochastically increasing in $\varepsilon_{i,t}$.

Assumption 2 implies that we can predict the future value of the shock, $\varepsilon_{i,t+1}$, based solely on its present value, $\varepsilon_{i,t}$. In other words, the history of the stochastic part of the growth of the firm does not affect its future growth. Only the current value of the growth's stochastic part does. The assumption that firm growth follows a Markov process has been used from very early in the literature. See for example Ijiri and Simon (1967) and Champernowne (1973). Assumptions 1 and 2 imply that we can compose $\varepsilon_{i,t}$ into its conditional expectation at time t-1, and an independent and identically distributed (i.i.d.) innovation term, say $\xi_{i,t}$. That is,

$$\varepsilon_{i,t} = E(\varepsilon_{i,t} \mid I_{i,t-1}) + \xi_{i,t} = E(\varepsilon_{i,t} \mid \varepsilon_{i,t-1}) + \xi_{i,t} = g(\varepsilon_{i,t-1}) + \xi_{i,t}, \xi_{i,t} \sim N(0, \sigma_{\xi}^{2})$$

where, by construction, $E(\xi_{i,t} \mid I_{i,t-1}) = 0$. For simplicity, we assume:

$$g(\varepsilon_{i,t-1}) = \bar{\varepsilon}_t + \rho\varepsilon_{i,t-1}$$

where $\bar{\varepsilon}_t$ stands for an unobserved time effect which leads to unobserved heterogeneity.

By construction $E(\xi_{i,t} \mid I_{i,t-1}) = E(\varepsilon_{i,t} - \bar{\varepsilon}_t - \rho\varepsilon_{i,t-1} \mid I_{i,t-1}) = 0$, or in other words,$\xi_{i,t} \perp A_{i,t}^{k}, S_{i,t}^{j}$, namely $E(\xi_{i,t} \mid A_{i,t}^{k}, S_{i,t}^{j}) = 0$.

In order to deal with the Markovian disturbances, we employ a guasi-differencing transformation of model 1.1:

$$\begin{aligned} g_{i,t} = (1-\rho)\beta_0 + \rho g_{i,t-1} + \beta_{1,j} S^j_{i,t} + \beta_{2,k} A^k_{i,t} + \beta_{3,j,k}(S^j \times A^k)_{i,t} \\ + \beta_{4,j}(S^j \times Crisis)_{i,t} + \beta_{5,k}(A^k \times Crisis)_{i,t} + \beta_{6,j,k}(S^j \times A^k \times Crisis)_{i,t} + \beta_7 Crisis_t \\ - \rho[\beta_{1,j} S^j_{i,t-1} + \beta_{2,k} A^k_{i,t-1} + \beta_{3,j,k}(S^j \times A^k)_{i,t-1} + \beta_{4,j}(S^j \times Crisis)_{i,t-1} + \beta_{5,k}(A^k \times Crisis)_{i,t-1} \\ + \beta_{6,j,k}(S^j \times A^k \times Crisis)_{i,t-1} + \beta_7 Crisis_{t-1}] + \xi_{i,t} \quad (1.2) \end{aligned}$$

An important statistical concern arises in estimating the above econometric specification from endogenous firm selection due to exit, which due to the sampling design of our data, is also accompanied by an intensive sampling bias. The vital role of this problem in the analysis of firm dynamics has been pointed out very early in the literature (e.g. Mansfield, 1962; Evans, 1987; Hall, 1987). We solve this issue by using as an extra moment condition the predicted probability of a firm remaining in the sample estimated from a first-stage sample selection model, like in Olley and Pakes (1996). To be more precise, the endogenous firm selection and the sampling bias confine our data into a subsample of the survived firms. Thus, the equation 1.2 should be written as,

$$\begin{aligned} E[g_{i,t} \mid S^j_{i,t}, A^k_{i,t}, Crisis_t, y_{i,t}=1] = (1-\rho)\beta_0 + \rho g_{i,t-1} + \beta_{1,j} S^j_{i,t} + \beta_{2,k} A^k_{i,t} + \beta_{3,j,k}(S^j \times A^k)_{i,t} \\ + \beta_{4,j}(S^j \times Crisis)_{i,t} + \beta_{5,k}(A^k \times Crisis)_{i,t} + \beta_{6,j,k}(S^j \times A^k \times Crisis)_{i,t} + \beta_7 Crisis_t \\ - \rho[\beta_{1,j} S^j_{i,t-1} + \beta_{2,k} A^k_{i,t-1} + \beta_{3,j,k}(S^j \times A^k)_{i,t-1} + \beta_{4,j}(S^j \times Crisis)_{i,t-1} + \beta_{5,k}(A^k \times Crisis)_{i,t-1} \\ + \beta_{6,j,k}(S^j \times A^k \times Crisis)_{i,t-1} + \beta_7 Crisis_{t-1}] + E[\xi_{i,t} \mid S^j_{i,t}, A^k_{i,t}, Crisis_t, y_{i,t}=1] \quad (1.3) \end{aligned}$$

where $y_{i,t}$ is an indicator function that receives the value 1 if firm i is still active in period t and 0 otherwise.

The last term is the *bias term* due to endogenous selection and sampling bias. Following Olley and Pakes' (1996) approach, we consider this *bias term* as a function of the explanatory variables and the probability of being in data at period t. In other words,

$$E[\xi_{i,t} \mid S^j_{i,t}, A^k_{i,t}, Crisis_t, y_{i,t}=1] \approx f(S^j_{i,t}, A^k_{i,t}, S^j_{i,t-1}, A^k_{i,t-1}, Crisis_t, \hat{P}_{i,t}) \quad (1.4)$$

For simplicity, we assume a first order polynomial expansion in ($A^k_{i,t}$, $S^j_{i,t}$, $Crisis_t$, $\hat{P}_{i,t}$) of function $f(.)$.[15]

We obtain the probability of being in data at period t by estimating the following binary choice model:

$$\begin{aligned} Pr(y_{i,t}=1) = \Phi(&\alpha_0 + \alpha_{1,j}S^j_{i,t} + \alpha_{2,k}A^k_{i,t} + \alpha_{3,j,k}(S^j \times A^k)_{i,t} + \alpha_{4,j}(S^j \times Crisis)_{i,t} \\ &+ \alpha_{5,k}(A^k \times Crisis)_{i,t} + \alpha_{6,j,k}(S^j \times A^k \times Crisis)_{i,t} + \alpha_7 Crisis_t + \mu_{i,t}) \end{aligned} \quad (1.5)$$

We assume normal disturbances, i.e. $\mu_{i,t} \sim N(0, \sigma^2_\mu)$. The estimation of this model gives us also the opportunity to investigate the impact of both firm size and age on the survival probability.

The assumption of first order Markov disturbances makes our econometric specifications dynamic, a fact that renders the simple OLS estimation method inappropriate, since it will lead to biased and inconsistent coefficients. Therefore, we turn to a dynamic panel data (DPD) estimator. An important benefit of this family of estimators is that they allow researchers to confront any potential issue of endogeneity (Grieser and Hadlock, 2019), a problem that has not been put under the microscope in the previous literature on firm growth. To be more precise, we estimate the econometric specification 1.3 with a dynamic panel GMM estimator using the Wooldridge (2004) moments augmented by the predicted probability instrument like in

[15] Our estimation results are robust for a second and a third polynomial expansion in ($A^k_{i,t}, S^j_{i,t}, \hat{P}_{i,t}$) of function $f(.)$, too.

Olley and Pakes (1996). The exact moment conditions are presented below.

$$E\{g_{i,t}-\rho g_{i,t-1}-\delta_0-\delta_{1,j}S^j_{i,t}-\delta_{2,j}S^j_{i,t-1}-\delta_{3,k}A^k_{i,t}-\delta_{4,k}A^k_{i,t-1}+\delta_{5,j,k}(S^j\times A^k)_{i,t}-\delta_{6,j,k}(S^j\times A^k)_{i,t-1}$$
$$-\delta_{7,j}(S^j\times Crisis)_{i,t}-\delta_{8,j}(S^j\times Crisis)_{i,t-1}-\delta_{9,k}(A^k\times Crisis)_{i,t}-\delta_{10,j}(A^k\times Crisis)_{i,t-1}$$
$$-\delta_{11,j,k}(S^j\times A^k\times Crisis)_{i,t}-\delta_{12,j,k}(S^j\times A^k\times Crisis)_{i,t-1}-\delta_{13}Crisis_t-\delta_{14}Crisis_{t-1}$$
$$-\delta_P\hat{P}_{i,t}-\sum_{t=1}^{T}a_t d_t-\sum_{s=1}^{S}\gamma_s I_s-\sum_{c=1}^{C}\zeta_c L_c\}\otimes\begin{bmatrix}\tilde{d}_t\\ \tilde{I}_s\\ \tilde{L}_c\\ S^j_{i,t}\\ S^j_{i,t-1}\\ A^k_{i,t}\\ A^k_{i,t-1}\\ (S^j\times A^k)_{i,t}\\ (S^j\times A^k)_{i,t-1}\\ (S^j\times Crisis)_{i,t}\\ (S^j\times Crisis)_{i,t-1}\\ (A^k\times Crisis)_{i,t}\\ (A^k\times Crisis)_{i,t-1}\\ (S^j\times A^k\times Crisis)_{i,t}\\ (S^j\times A^k\times Crisis)_{i,t-1}\\ Crisis_t\\ Crisis_{t-1}\\ g_{i,t-2}\\ \vdots\\ g_{i,T-2}\end{bmatrix}=0 \quad (1.6)$$

where $\hat{P}_{i,t}$ denotes the predicted survival probability for the estimation of the econometric specification 1.5.

To abstract from cyclical or secular aggregate considerations we control for year effects by including a set of time dummies d_t. Moreover, since firm size and firm age distributions vary by industry as do growth rate patterns, we control for detailed industry fixed effects (I_s). Additionally, we control for location fixed effects by employing a set of prefecture dummies (L_j)[16]. Both industry and location dummies indicate the ex-ante firm heterogeneity. In the same spirit, we include the time, industry and location fixed effects in the first-stage survival equation 1.5.

To ensure the validity of our estimates we deal with several statistical issues that may arise in such estimators. First, we choose the set of our instruments in order to ensure the absence of second-order serial correlation in the error term, having as driver the relevant Arellano and Bond Test (1991)[17]. Second, following Roodman (2009), we deal with the well-known problem of too many instruments by "collapsing" the instrument set[18]. Finally, to achieve asymptotic efficiency, we calculate the two-step estimator instead of the one-step, using the corrected two-step covariance matrix derived by Windmeijer (2005)[19].

1.3.2 Estimation Results

We start with the estimation results for the first-stage survival model 1.2. Since this model is constituted by categorical variables and much more since these variables are interacted together, citing the regression coefficients would be misleading since they are fail to capture efficiently the partial effect

[16]ICAP database provides us information about the firm location among the 52 prefectures of Greece.

[17]A main assumption of Dynamic Panel Data – DPD estimators (Arellano and Bond, 1991; Blundell and Bond, 1998; Ackeberg et al., 2015) is that the instruments are orthogonal to the error term. Since lagged values of the dependent variable are used as instruments, unbiased estimates (i.e. the validity of the orthogonality assumption) require the absence of second-order serial correlation in the error term (Arellano and Bond, 1991).

[18]In the standard uncollapsed form each instrumenting variable generates one column for each time period and lag available to that time period, and therefore the number of instruments is quadratic in T. The "collapse" technique diminishes drastically the number of instruments by creating one instrument for each variable and lag distance, rather than one for each time period, variable, and lag distance, making the instrument count linear in T.

[19]Without this correction, the two-step standard errors tend to be severely downward biased (Arellano and Bond, 1991; Blundell and Bond, 1998).

of firm age or size on firm survival probability (Williams, 2012). Therefore following Haltiwanger et al. (2013), we present the marginal effects at means (MEMs hereafter) instead of the regression coefficients in order to capture the partial effects of both firm age and size on firm survival. Moreover, we find it easier to discuss the results with the aid of figures that illustrate the patterns of MEMs. Figure 1.12 presents the relationships between survival probability and firm age (panel A) and size (panel B). As we expected both firm size and age were found to have a positive significant effect on firm survival. Naturally, the eruption of the crisis significantly decreased the survival probabilities for all age and size groups. However, the smaller or younger a firm is, the larger the reduction in its survival probability.

Now, we focus on the estimation results for econometric specification 1.1. The dynamic nature of our model comprises the first lags of all regressors (as a residual of the quasi-differencing process), creating some "lagged effects"[20], wherein, in contrast to regression coefficients, MEMs can capture. Therefore, again we cite the MEMs instead of the regressions coefficients with the aid of figure 1.13[21]. Panel A displays results from growth-age relationship, whilst panel B displays the results for the growth-size relationship. Beginning with the main results in the upper panel, the plotted curve shows a clear inverse relationship between firm age and firm growth when we control for firm size. Moreover, the downward curve is much more steep for early ages (1-6 years) implying a much more strong negative age effect for young relative to mature firms. The effect declines more or less monotonically as the age of the firm increases. In general, the age effect remained negative during the crisis, although in a no clearly monotonic way. Now

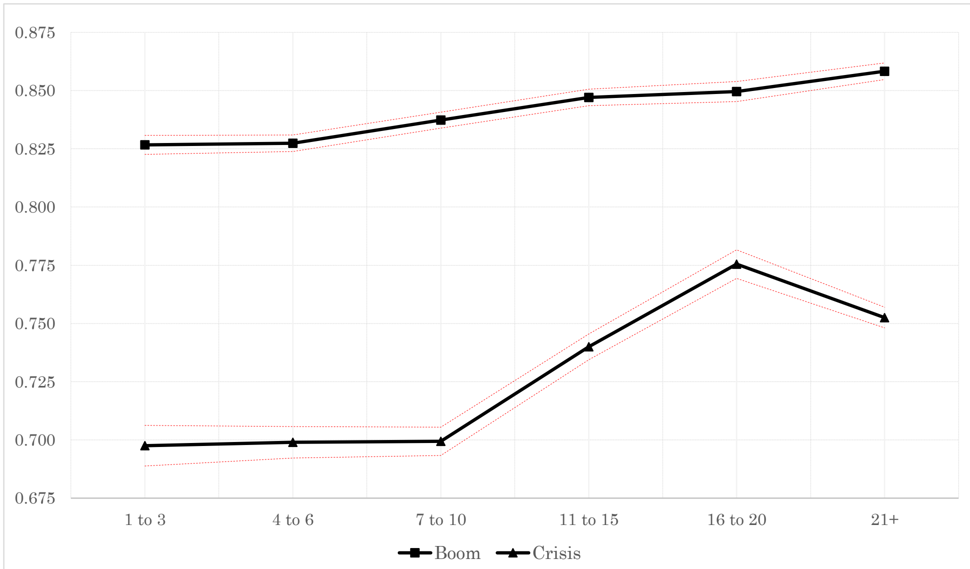
[20] A meticulous analysis of this issue can be found in Greene (2002), ch. 19, pp. 560-562.

[21] All coefficients are significant at 1% significant level. The marginal effects with their standard errors can be found in Appendix B.

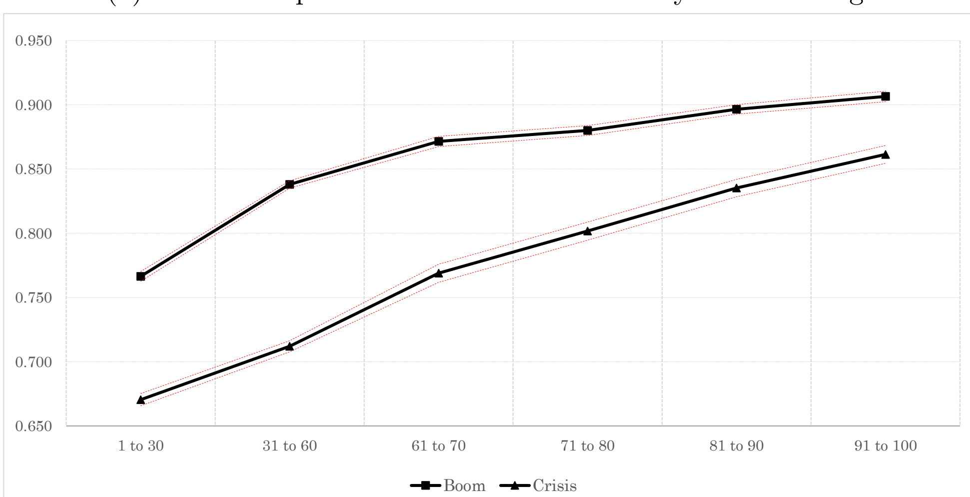
we turn to panel B. The panel reveals a crystal clear negative monotonic relationship between firm size and firm growth when we control for firm age, a violation of the weak form of Gibrat's law according to which the mean growth rate of a firm is independent of firm size. Moreover, this finding lies in contrast with the seminal paper of Haltiwanger et al. (2013), in which the authors asserted that the negative growth-size relationship is vanished once we control for firm age. The negative size effect also is much stronger for very small firms (namely, for 1-60 percentiles). The same results hold for the crisis period, too.

Both growth-age and growth-size patterns are robust to controlling for firm size and age respectively, and they clearly indicate that the fastest-growing firms are young (under the age of 5) and small. These dynamics constitute an important feature of market-based economies and lay in accordance with many stances of the theoretical literature on firm dynamics. In particular, these patterns are consistent with predictions in models in which firm dynamics are attributed either to market selection and learning (see Jovanovic, 1982; Hopenhayn, 1992; Ericson and Pakes, 1995; Arkolakis et al., 2018), or to entrepreneurial choice under credit constraints (Evans and Jovanovic, 1989), or to idiosyncratic productivity shocks and firm market penetration choices (Arkolakis, 2016).

Finally, from both panels is clear that the financial crisis led to a significant decline in growth rates of Greek firms and a notable increase in their volatility since it was a prolonged period of high uncertainty. Although small and especially young firms are achieving rapider sales growth rates during normal and even recessionary times, Figure 1.12 illustrates that both age and size act as a business shield against severe sales declines and eventually bankruptcy during a downturn.



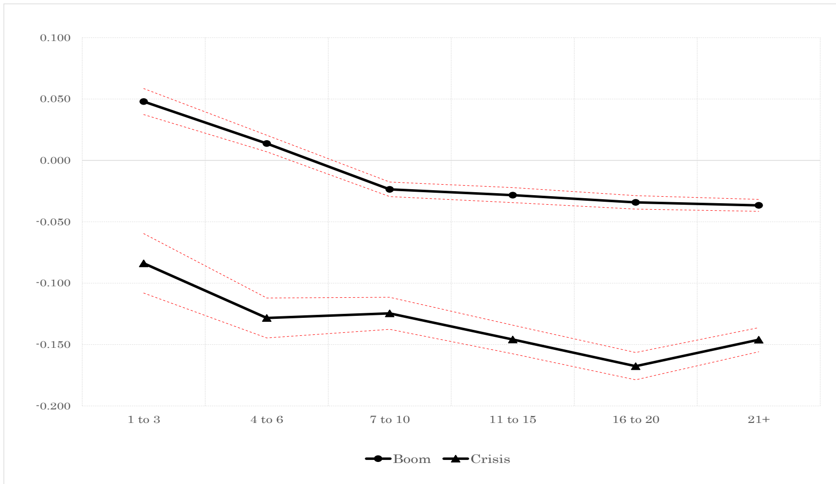
(a) Relationship between Survival Probability and Firm Age



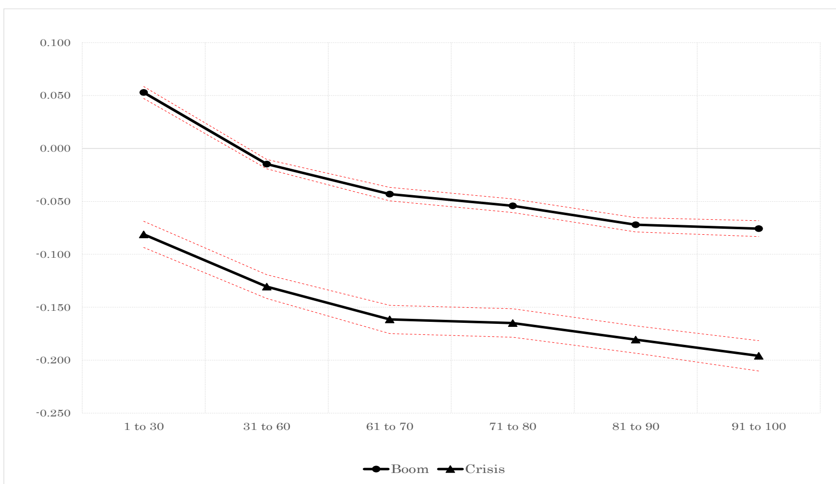
(b) Relationship between Survival Probability and Firm Size

Figure 1.12: Relationship between Survival Probability and Firm Age and Size

Notes: In this figure, we explore the role of firm age and firm size in firm survival before and during crisis. The cited average marginal effects were obtained by the estimation of econometric specification $Pr(y_{i,t} = 1) = \alpha_0 + \alpha_{1,j} S^j_{i,t} + \alpha_{2,k} A^k_{i,t} + \alpha_{3,j,k}(S^j \times A^k)_{i,t} + \mu_{i,t}$. We compute marginal effects of firm size (age) from that model holding the age (size) distribution of sales constant at the sample mean. We included time, industry and prefecture fixed effects in all cases. We assumed normal disturbances. Firm size is defined as the logarithm of gross sales in period t-1, deflated by the Producer Price Index - PPI. Age categories are defined in years, whilst size categories are defined in percentiles of the size distribution. All coefficients are significant at 1 percent significant level.



(a) Relationship between Firm Growth and Firm Age



(b) Relationship between Firm Growth and Firm Size

Figure 1.13: Relationship between Firm Growth and Firm Age and Size

Notes: In this figure, we investigate the role of firm age and firm size in firm growth before and during crisis. The cited average marginal effects were obtained by the estimation of econometric specification $g_{i,t} = \beta_0 + \beta_{1,j} S^j_{i,t} + \beta_{2,k} A^k_{i,t} + \beta_{3,j,k}(S^j \times A^k)_{i,t} + \varepsilon_{i,t}$. We compute marginal effects of firm size (age) from that model holding the age (size) distribution of sales constant at the sample mean. We included time, industry and prefecture fixed effects in all cases. We assumed first-order Markovian disturbances. Firm size is defined as the logarithm of gross sales in period t-1, deflated by the Producer Price Index (PPI). Age categories are defined in years, whilst size categories are defined in percentiles of the size distribution. The red dashed lines show the 95 condifence interval for the predictions. All MEMs are significant at 1 percent significant level.

Given that firm age and firm size constitute two pivotal drivers of firm growth, in the next section we are examining whether there is a differential crisis effect on small relative to large and on young relative to mature firms.

Robustness: The definition we use for firm growth, $\Delta lnS_{i,t}$, is defined only for continuing firms and not for exiting and entering firms with $S_{i,t} = 0$ and $S_{i,t-1} = 0$, respectively. For this reason we re-estimate model 1.1 using the Davis, Haltiwanger and Schuh's (1996) bounded growth rates (DHS hereafter) $(S_{i,t} - S_{i,t-1})/0.5(S_{i,t} + S_{i,t-1})$ in order to include in our analysis both entrants and exiting firms. The DHS definition also mitigates potential "regression-to-the-mean" effects[22]. In order to use properly the DHS growth rates we use the "average" definition for firm size (Haltiwanger et al., 2013). "Average" size is defined as the logarithm of average gross sales (deflated by the Producer Price Index) in years t -1 and t. Moreover, we re-estimate model 1.1 only for continuers, using the DHS definition, in order to disentangle the role of firm entry and exit in our analysis. The results of these robustness checks can be found in Appendix B. Our results were found to be consistent to the choice of the definition of firm growth.

1.4 The Differential Effect of Financial the Crisis

In this section, we examine whether the Greek financial crisis had a different repercussion on small relative to large and on young relative to mature Greek enterprises. To do this, we estimate the following econometric speci-

[22] Haltiwanger et al. (2013) note that firms that recently experienced negative transitory shocks (or even transitory measurement error) are more likely to grow, while businesses recently experiencing positive transitory shocks are more likely to shrink. This "regression-to-the-mean" effect is particularly important when studying the business size–growth relationship.

fications, following the work of Siemer (2019):

$$g_{i,t} = \gamma_0 + \gamma_1 Young_{i,t} + \gamma_2 Young_{i,t} \times Crisis_t + \gamma_3 Crisis_t + \zeta' X + v_{i,t}^{(1)} \tag{1.7}$$

$$g_{i,t} = \delta_0 + \delta_1 Small_{i,t} + \delta_2 Small_{i,t} \times Crisis_t + \delta_3 large_{i,t} + \delta_4 large_{i,t} \times Crisis_t + \delta_5 Crisis_t + \xi' X + v_{i,t}^{(2)} \tag{1.8}$$

where $g_{i,t}$ denotes the growth of firm "i" at period "t", $Young_{i,t}$ is a dummy variable for age which receives the values 1 if a firm is young and the value 0 otherwise, $Small_{i,t}$ is a dummy variable which receives the value 1 if a firm is small and the value 0 otherwise, $large_{i,t}$ is a dummy variable which receives the value 1 if a firm is large and the value 0 otherwise[23], and $Crisis_t$ is a dummy variable that receives the value 1 for the crisis period (2010 - 2014) and the value 0 for the pre-crisis period (1998 - 2009). The age and the size categories have been defined in Section 1.2. X is a set of controls that contains year, industry and location fixed effects. Also in order to avoid potential confounding effects X also contains size, for model 1.7, and age, for model 1.8, fixed effects[24]. Again, we assume that the disturbances follow a first-order Markov process.

For the estimation of the above specifications, we follow the same estimation strategy as in the previous section: we use a dynamic panel GMM estimator, after quasi-differencing in order to deal with the Markov disturbances, using the Wooldridge's (2004) moments augmented with the predicted survival probability to correct for both endogenous selection and

[23] We define the medium size group as the omitted base category.

[24] In particular, we divide the age and size distributions into 20 quantiles. Therefore, X contains fixed effects separating the firms into 20 size bin classes for econometric specification 1.7; and fixed effects for 20 age bin classes for econometric specification 1.8.

sampling biases Olley and Pakes (1996).

Following the work of Duygan-Bump et al. (2015), we can quantify the differential crisis effect on young relative to mature firms and on small relative to large firms by computing the following double-differences:

$$\hat{\theta}_{age}^{Cr} = (\hat{\theta}_{yng} - \hat{\theta}_{mtr})^{Cr} - (\hat{\theta}_{yng} - \hat{\theta}_{mtr})^{Bm} \tag{1.9}$$

$$\hat{\theta}_{size}^{Cr} = (\hat{\theta}_{sml} - \hat{\theta}_{lrg})^{Cr} - (\hat{\theta}_{sml} - \hat{\theta}_{lrg})^{Bm} \tag{1.10}$$

where $\hat{\theta}_j^T$ denotes the predicted mean growth rate (i.e. the MEM) of firms that belong in group j∈{young, mature, small, large} during the period T∈{pre-crisis,crisis} as it is produced by the estimation of models 1.7 and 1.8. Expressions 1.9 and 1.10 give us the impact of the Greek financial crisis on the growth rates of Greek firms with respect to their size and age. A negative outcome implies that the fall of growth rate due to crisis was more severe in small (young) than large (mature) firms. In Table 1.3 we present the estimates for the two expressions. Column (a) presents the estimates for $\hat{\theta}_{age}^{Cr}$ and $\hat{\theta}_{size}^{Cr}$ using the MEMs as they produced by the estimation of econometric specifications 1.7 and 1.8. Moreover, we re-estimate econometric specifications 1.7 and 1.8 using the DHS growth rates on the one hand to investigate the role of the extensive margin and on the other to deal with potential "regression-to-the-mean" effects. The relevant estimates for $\hat{\theta}_{age}^{Cr}$ and $\hat{\theta}_{size}^{Cr}$ are presented in column (b). Finally, we re-estimate models 1.7 and 1.8 only for continuers, using the DHS definition, for further robustness. The relevant estimates for $\hat{\theta}_{age}^{Cr}$ and $\hat{\theta}_{size}^{Cr}$ are presented in column (c).

The decline in sales growth rate of Greek firms due to crisis was about 16.5 to 21 percentage points larger in young firms than in their matures

	(a)	(b)	(c)
	$\Delta lnS_{i,t}$	DHS-Continuers	DHS-All Firms
$\hat{\theta}^{Cr}_{age}$	-0.208***	-0.165***	-0.210***
	(0.010)	(0.011)	(0.011)
$\hat{\theta}^{Cr}_{size}$	-0.221***	-0.150***	-0.154***
	(0.010)	(0.009)	(0.007)

Notes: In this table, we investigate the differential effect of the Greek financial crisis on young relative to mature firms and on small relative to large firms. To do so, we compute the double difference between the marginal effects of mature and young (or large and small) firms on firm growth, between the boom and the crisis periods, based on the estimation results of econometric specifications 1.7 and 1.8. A firm is "mature" if its age is larger than 5 years and "young" otherwise. A firm is "small" if it is size is below the 6th decile of the size distribution, "medium" if its size is between the 6th and the 9th deciles and "large" if its size belongs to the 10th decile of the size distribution. *, **, *** denote statistical significance at the 10, 5 and 1 percent level respectively. Standard errors are in parentheses. "Logarithmic" and "DHS" denote the logarithmic ($\Delta lnS_{i,t}$) and the David, Haltiwanger and Schuch's ($(S_{i,t} - S_{i,t-1})0.5(S_{i,t} + S_{i,t-1})$) definitions of firm growth respectively. $S_{i,t}$ denotes the gross sales of firm "i" in year "t", deflated by the Producer Price Index (collected from the OECD Database).

Table 1.3: Differential Effect of Greek Financial Crisis

counterparts and between 15 to 22 percentage points larger in small firms than in their large counterparts. When we employ the DHS growth rates, the differential crisis effect with respect to firm size is smaller but still quite high, implying that our results are robust to "regression-to-the-mean" effects.

Therefore, Greek depression was exceedingly disruptive for both young and small firms. These findings are highly relevant to the ongoing and sparkling policy debate on appropriate governmental and EU actions for the support of enterprises during economic recessions. The design of an efficient policy has become urgent and imperative in the aftermath of the global financial crisis that erupted in 2008. Until now such public policies have targeted businesses of a certain size (SMEs in particular), ignoring the role of age[25]. However, our findings advocate that age should not be ignored by policymakers anymore.

1.5 The Role of Financing Constraints during the Crisis

As mentioned in the introduction, both the theoretical and the empirical literature (see for instance: Gertler and Gilchrist, 1994; Rajan and Zingales, 1995; Whited and Wu, 2006; Chodorow-Reich, 2014; Duygan-Bump et al., 2015; and Siemer, 2019) emphasized a variety of mechanisms whereby recessions, including ones not originating in the financial sector, could be worsened due to the presence of financial frictions. In this section, we investigate whether the size and age asymmetry, we have documented in the previous section, is driven by such credit constraints.

We use two alternative measures for financing constraints (FCs hereafter), one at the firm-level and one at the industry-level. In particular, following Giroud and Mueller (2016) and Fakos et al. (2019) we use financial leverage (measured by the debt-to-assets ratio) at firm level as a proxy for credit constraints. Moreover, we construct an industry-level measure for external financial dependence, which was originally proposed by Rajan and Zingales (1998)[26], following the procedures described in Cetorelli and Strahan (2006). The accurate definition of both measures can be found in subsection 1.2.1.

[25] See for instance the "Enterprise Europe Network" (EEN) program for EU and the "Roots" program for the case of Greece in particular.

[26] They attributed the heterogeneity in external financing needs across sectors to technological factors.

In order to disentangle the role of the financing constraints in the differential crisis effect we documented in Section 1.4, we extend the analysis of the previous Section to include not only the difference between small and large firms (or young and mature) in the "pre-crisis" (1998-2009) and the "crisis" (2010-2014) periods but also the difference between the high- and low- financially constrained sectors/firms. That is, for each regression equation 1.7 and 1.8 we include as extra regressors the dummy variable high-EFD (or high-leverage) and its interactions with the other regressors of the each econometric specification. The idea is that the differential effect of the Greek financial crisis was more severe in high-EFD sectors/firms. Or in other words, that FCs constitute an important contributor to the differential crisis effect we documented in previous Section.

For the estimation of the augmented econometric specifications 1.7 and 1.8, we follow the same estimation strategy as in the previous sections[27].

As in the previous section, we can quantify the contribution of FCs in differential crisis effect on young and mature firms by computing the following triple-differences using the MEMs form the estimation results of augmented models 1.7 and 1.8:

$$\hat{\theta}^{FC}_{age} = [(\hat{\theta}_{yng} - \hat{\theta}_{mtr})^{Cr} - (\hat{\theta}_{yng} - \hat{\theta}_{mtr})^{Bm}]^{High} - [(\hat{\theta}_{yng} - \hat{\theta}_{mtr})^{Cr} - (\hat{\theta}_{yng} - \hat{\theta}_{mtr})^{Bm}]^{Low} \tag{1.11}$$

$$\hat{\theta}^{FC}_{size} = [(\hat{\theta}_{sml} - \hat{\theta}_{lrg})^{Cr} - (\hat{\theta}_{sml} - \hat{\theta}_{lrg})^{Bm}]^{High} - [(\hat{\theta}_{sml} - \hat{\theta}_{lrg})^{Cr} - (\hat{\theta}_{sml} - \hat{\theta}_{lrg})^{Bm}]^{Low} \tag{1.12}$$

where $\hat{\theta}'s$ denote the MEMs and superscripts "High" and "Low" the high- and low- EFD sectors or the high- and low- leverage firms depending on the

[27] Of course, in order our estimation process to be consistent we modify both the first-stage survival equation and the moment conditions to include the high-EFD variable and its relevant interaction terms.

assumption we make.

The above triple difference exploits variation in sales growth across three dimensions: time (before and during the crisis), firm age (young and mature) or size (small and large), and external financial dependence (high and low). The third dimension is especially useful because it helps isolate factors that have a differential impact on sales growth by firm age or size.

	Razan & Zingales Index			**Leverage**		
	$\Delta lnS_{i,t}$	DHS-Continuers	DHS-All Firms	$\Delta lnS_{i,t}$	DHS-Continuers	DHS-All Firms
$\hat{\theta}^{FC}_{age}$	-0.054***	-0.025**	-0.030***	-0.100***	-0.029**	-0.054***
	(0.013)	(0.013)	(0.012)	(0.016)	(0.015)	(0.016)
$\hat{\theta}^{FC}_{size}$	-0.059***	-0.019**	-0.032**	-0.030***	-0.031***	-0.025**
	(0.018)	(0.010)	(0.011)	(0.014)	(0.011)	(0.012)

Notes: In this table, we investigate the the role of the financing constraints in the differential effect of the Greek financial crisis on young relative to mature firms and on small relative to large firms. To do so, we compute the triple difference between the marginal effects of mature and young (or large and small) firms on firm growth, between the boom and the crisis periods, between the highly and lowly financially constraints sectors/firms based on the estimation results of augmented econometric specifications 1.7 and 1.8. We use two alternative measures of financial constraints, the industry-level index of Rajan and Zingales (1998) and the financial leverage at the firm-level (proxied by debt-to-assets ratio). A firm is "mature" if its age is larger than 5 years and "young" otherwise. A firm is "small" if it is size is below the 6th decile of the size distribution, "medium" if its size is between the 6th and the 9th deciles and "large" if its size belongs to the 10th decile of the size distribution. We estimated three alternative versions of models 1.7 and 1.8. First, we estimated it using the logarithmic difference of deflated sales ($\Delta lnS_{i,t}$) as a measure of firm growth. Second, we estimated them by employing the Davis, Haltiwanger and Schuh's (1996) definition $((S_{i,t} - S_{i,t-1})0.5(S_{i,t} + S_{i,t-1}))$ of firm growth. Finally, we estimated using using the latter definition and also restricting the sample only for continuing firms. $S_{i,t}$ denotes the gross sales of firm "i" in year "t", deflated by the Producer Price Index (collected from the OECD Database). *, **, *** denote statistical significance at the 10, 5 and 1 percent level respectively. Standard errors are in parentheses. Standard errors are clustered by firm and calculated according to Delta Method (Dorfman, 1938).

Table 1.4: The role of the FCs in the Differential Effect of Greek Financial Crisis

In Table 1.4 we present the estimates for the two expressions. As in the previous section, we also estimate these differentials using the DHS growth rates to explore both the role of extensive margin and the potential impact of "regression-to-the-mean" effects. $\hat{\theta}^{FC}_{age}$ implies that the relative (young versus mature) impact of the crisis on sales growth is between 2.5 to 5.4 percentage points larger in industries with high financing needs or between 3 to 10 percentage points large in high-leveraged firms. Similarly, $\hat{\theta}^{FC}_{size}$ shows that the relative (small versus large) impact of the crisis on sales growth is between 2 to 5.9 percentage points larger in industries with high external financial dependence or between 2.5 to 3 percentage points large in high-leveraged firms. Both triple differences are statistically significant and economically large. Therefore, financing constraints played an important role in explaining changes in sales growth during the the financial crisis either in firm- (proxied by leverage) or in sector- (proxied by Rajan and Zingales' (1998) index) level.

Comparing the above growth differentials with those in Table 1.3 we can see that the financing constraints account for between 15% and 48% of the estimated age-growth differential due to the crisis ($\hat{\theta}^{FC}_{age}/\hat{\theta}^{Cr}_{age}$) and for between 13% to 27% of the estimated size-growth differential due to the crisis ($\hat{\theta}^{FC}_{size}/\hat{\theta}^{Cr}_{size}$). Therefore, credit constraints constitute an important contributor to the documented decline of young (small) firms' sales growth due to the crisis. These findings suggest that public policies aimed at supporting firm activity should focus primarily on young firms and start-ups, adopting credit-strengthening measures either through the banking system or through capital markets.

1.6 Aggregate implications of firm sales growth and financing constraints

Following the approach of Chodorow-Reich (2014) and Siemer (2019), we can use the estimates in sections 1.4 and 1.5 in order to obtain the aggregate implications of the firm sales dynamics and the financial constraints, respectively.

1.6.1 Aggregate Implications of Firm Sales Dynamics

In order to estimate the aggregate impact of firm sales dynamics on the Greek economy in this counterfactual exercise, the following assumptions is necessary:

> Assumption (Partial equilibrium). The overall effect on gross output is the sum of the direct sales effects on each firm.

The above Assumption rules out any general equilibrium effects through price adjustments. Taking such effects into account would require a general equilibrium model.

Given the assumption above, we can proceed to the computation of the aggregate implications of the estimates in section 1.4. This study argued that the estimates in the aforementioned section can identify the differential effect of the Greek financial crisis on small relative to large and on young relative to mature firms. Consequently, the aggregate implications of the financial crisis can then be calculated by comparing the sales evolution in the (fitted) data with the sales evolution in a counterfactual in which we assume that the crisis affected small firms in the same way as large firms, i.e. the differential crisis effect is zero (and similar for young and mature).

Define the counterfactual growth rate of a firm i of group j, j∈{small during crisis, young during crisis}, as:

$$\tilde{g}_{i,j} = \bar{\hat{g}}_{i,j} + \left|\hat{\theta}_j^{Cr}\right| \tag{1.13}$$

where $\bar{\hat{g}}_{i,j}$ denotes the mean predicted value of firm growth from the regression of firm type j, and $\widehat{\theta}_j$ is the corresponding point estimate of the differential crisis effect. During the pre-crisis (1998-2009) period the counterfactual growth rate equals the fitted growth rate.

After the construction of the counterfactual growth rate, we can create the counterfactual end-period level of sales as follows:

$$\tilde{s}_{i,2014} = M(\tilde{g}_i) \tag{1.14}$$

where, as in Chodorow-Reich (2014), M denotes the mapping from symmetric growth rates to the end-period level, T=2014, holding the initial (pre-crisis) level, t=2009, fixed[28]:

$$M[x] = e^x s_{i,2009} \tag{1.15}$$

In the same spirit, the fitted value end-period sales level can be computed as: $\hat{s}_{i,2014} = M(\hat{g}_i)$.

The aggregate crisis effect can be calculated as follows:

$$\frac{\sum_{i\epsilon j}(\tilde{s}_{i,2014} - \hat{s}_{i,2014})}{\sum_i(s_{i,2009} - s_{i,2014})} \tag{1.16}$$

[28]For the Davis, Haltiwanger and Schuh's (1996) definition for firm growth, the analogous mapping function is the following one:

$$M[x] = \frac{1 + 0.5x}{1 - 0.5x} s_{i,2009}$$

Gross Output Losses: 2009-2014	
Total gross output decline (aggregate data)	23%
Total gross output decline (aggregated firm-level data)	22%
Share due to differential effect on young firms ($\Delta lnS-$continuers)	12.5 p.p.
Share due to differential effect on young firms (DHS - continuers)	11.1 p.p.
Share due to differential effect on young firms (DHS - all firms)	14.4 p.p.
Share due to differential effect on small firms ($\Delta lnS-$continuers)	8.5 p.p.
Share due to differential effect on small firms (DHS - continuers)	4.2 p.p.
Share due to differential effect on small firms (DHS - all firms)	4.1 p.p.

Notes: The table reports the fraction of total gross output losses due to the differential effect of the financial crisis on small and young firms. Aggregate data has been obtained from OECD. By defining firm growth as the logarithmic difference of firm size ($\Delta lnS_{i,t}$) we restrict our sample to only continuing firms. By employing the David, Haltiwanger and Schuch's ($(S_{i,t} - S_{i,t-1})0.5(S_{i,t} + S_{i,t-1})$) definition for firm growth we include in our analysis both the entering and the exiting firms.

Table 1.5: Aggregate Implications of Firm Sales Dynamics during the Greek Financial Crisis

For the computation of the above aggregate differential crisis effect we discrete three cases. First, we compute it using as a measure of firm growth the logarithmic difference of sales. Second, we compute it using the Davis, Haltiwanger and Schuh's (1996) definition for firm growth, which allow us to include entering and exiting firms in our analysis. Finally, we compute the effect using the DHS definition but restricting our sample to only continuing firms. Table 1.5 reports the relevant results.

First of all, our sample gives almost the same quantitative reduction in gross output as the data in aggregate-level, a fact that implies that our firm-level dataset resembles at a large extent the aggregate Greek economy. The aggregate effect of the differential impact of the Greek financial crisis on small relative to large and especially on young relative to mature firms is, quantitatively, important. The differential effect on small firms account for about 4.1 to 8.5 percentage points of the decline in gross output due to the crisis. Meanwhile the effect on young firms accounts for about 11.1 to 14.4 percentage points of the overall gross output decline. It is important to note that these estimates can not be simply added up to account for the total effect of financial crisis on small and young firms as firms can be included in both categories. It is notable, that when we include entering and exiting firms in our analysis the aggregate differential crisis effect with respect to age is significantly higher. Therefore, the crisis affected sales growth in young firms strongly through the entry and exit of firms.

1.6.2 Aggregate Implications of Financial Constraints during the Greek Financial Crisis

In the same spirit, for the computation of the contribution of financial constraints to the aggregate differential crisis effect, we documented above, we have to make some extra assumptions:

> Assumption 1 (Low-EFD firms are unconstrained): Firms in low-EFD sectors are unconstrained and financial constraints affect firms only through high-EFD.

In order to compute aggregate implications of a credit supply shock, as it captured by the financial constraints, one needs to assume the existence of an unconstrained category of firms, as in Chodorow-Reich (2014), or have a good measure of the credit supply shock for the least constrained category. In the context of this study, the unconstrained category has to be low-EFD firms. Assumption 1 is quite conservative. If low-EFD firms were also hit by a credit supply shock then the estimates will understate the true effect of the credit supply shock. Due to the presence of entry and exit in the

ICAP data, we make the following additional assumption for calculation of aggregate implications, following Siemer (2019):

> Assumption 2 (No credit supply effect on start-ups). The credit supply shock did not affect start-ups or potential start-ups.

Assumption 2 is required for two reasons: (a) potential entrants are not observed and any effect of financial constraint on changes in the decisions of entrants can not be taken into account to compute aggregate implication, and (b) we cannot define a growth rate for either entrants or exiters[29]. Assumptions 1 and 2 mean that the partial equilibrium aggregate effects of a credit supply shock are likely understated: First, it is unlikely that low-EFD firms were entirely unconstrained. To the extent that the credit supply shock reduced sales growth in low-EFD firms, the aggregate implications in this study will understate the aggregate effect. Second, the credit supply shock possibly affected entrants as well as potential entrants, which, in turn, would increase the aggregate effect of a credit supply shock.

As before, the counterfactual growth rate can be defined as:

$$\tilde{g}_{i,j} = \bar{\hat{g}}_{i,j} + \left|\hat{\theta}_j^{FC}\right| \tag{1.17}$$

where $\bar{\hat{g}}_{i,j}$ denotes the mean predicted growth rate from the regression of firm type j∈{small high-EFD during crisis, young high-EFD during crisis} and $\hat{\theta}_j^{FC}$ is the corresponding point estimate of the differential response of small/young firms to crisis due to financial constraints.

[29] By using the Davis, Haltiwanger and Schuch's definition for firm growth, we will be able to assign values for the firm growth of both entrants and exiters. However, entrants (exiters) will be, by construction, at the upper (lower) bound of the DHS growth rate and thus cannot be assigned a higher (lower) growth rate in a counterfactual. Therefore, the DHS definitions will not add any additional information in our analysis. See Siemer (2019) for more details about the issue.

Assuming the same mapping function as before, the aggregate differential effect can be calculated as follows:

$$\frac{\sum_{i\epsilon j}\big(\widetilde{s}_{i,2014} - \widehat{s}_{i,2014}\big)}{\sum_{i}\big(s_{i,2010} - s_{i,2014}\big)} \tag{1.18}$$

For the computation of the above aggregate differential crisis effect we discrete three cases. First, we compute it using as a measure of firm growth the logarithmic difference of sales. Second, we compute it using the Davis, Haltiwanger and Schuh's (1996) definition for firm growth, which allow us to include entering and exiting firms in our analysis. Finally, we compute the effect using the DHS definition but restricting our sample to only continuing firms. Table 1.6 reports the relevant results.

Gross Output Losses: 2009-2014

	Rajan and Zingales' Index	Firm-level Leverage
Total gross output decline (aggregate data)	23%	
Total gross output decline (aggregated firm-level data)	22%	
Share due to differential effect on young high-FED firms ($\Delta lnS-$continuers)	2.4 p.p.	5.5 p.p.
Share due to differential effect on young high-EFD firms (DHS - continuers)	1.3 p.p.	1.6 p.p.
Share due to differential effect on young high-EFD firms (DHS - all firms)	1.4 p.p.	3.1 p.p.
Share due to differential effect on small high-EFD firms ($\Delta lnS-$continuers)	1.4 p.p.	1.0 p.p.
Share due to differential effect on small high-EFD firms (DHS - continuers)	0.5 p.p.	1.0 p.p.
Share due to differential effect on small high-EFD firms (DHS - all firms)	1.0 p.p.	1.0 p.p.

Notes: The table reports the fraction of total gross output losses due to the differential effect of financial constraints on small and young firms. We use two alternative measures of financial constraints, the industry-level index of Rajan and Zingales (1998) and the financial leverage at the firm-level (proxied by debt-to-assets ratio). Aggregate data has been obtained from OECD. By defining firm growth as the logarithmic difference of firm size ($\Delta lnS_{i,t}$) we restrict our sample to only continuing firms. By employing the David, Haltiwanger and Schuch's ($(S_{i,t} - S_{i,t-1})0.5(S_{i,t} + S_{i,t-1})$) definition for firm growth we include in our analysis both the entering and the exiting firms.

Table 1.6: Aggregate Implications of Financial Constraints

The aggregate effect of the differential impact of crisis due to financial constraints on small relative to large and on young relative to old firms is, quantitatively, important at both industry and firm level. The differential effect on small firms due to financial constraints account for about 0.5 to 1.4 percentage points of the decline in sales observed during the recession. Meanwhile the effect on young firms due to financial constraints accounts for about 1.3 to 5.5 percentage points of the overall sales decline. It is important to note that these estimates can not be simply added up to account for the total contribution of financial constraints to the differential crisis effect on small and young firms as firms can be included in both categories.

Taking into account the results of the previous subsection, we find that financial constraints constituted an important contributor to the documented decline of aggregate gross output due to the differential crisis effect either on small relative to large or on young relative to mature firms. In particular, about the 12 to 44 percent of the decline in gross output due to the differential crisis effect on young relative to mature firms and approximately the 12 to 24 percent of the observed loss of aggregate gross output due to the differential crisis effect on small relative to large firms stemmed from financial constraints either at industry or firm level.

Our findings contribute to the ongoing policy debate on appropriate EU and national policies that attempt to alleviate credit constraints faced by firms, a debate that became very vivid and sparkling in the aftermath of the global financial crisis that erupted in 2008. Until now such public policies have targeted businesses of a certain size (SMEs in particular), ignoring the role of age[30]. However, we find that, at least for the case of Greece, young

[30]See for instance the "Enterprise Europe Network" (EEN) program for EU and the "Roots" program for the case of Greece in particular.

firms were hit more than small firms and surely credit constraints played an important role on this disruption. We also find that young firms are more important than small firms for the aggregate fluctuations. Therefore, age should not be ignored by policymakers anymore. Public policies should focus primarily on young firms and start-ups, adopting both credit-enhancing measures and advisory support.

1.7 Small VS. Large Shocks

This study contributes to the literature on firm life-cycle dynamics and aggregate fluctuations by studying the Greek financial crisis as an example of a severe large aggregate shock, that, to best of our knowledge, has not been examined before. The previous literature (e.g. Clementi and Palazzo, 2016; Sedlacek and Sterk, 2017; Pugsley and Sahin, 2019) has focused on small aggregate shocks and particularly on business cycle downturns. A natural question that might arise here, is whether our findings for a large aggregate shock are analogous with those for a small one and what the benefit of studying the Greek case is.

To answer to these questions, we compare our work with that of Pugsley and Sahin (2019). By using annual state-level US data for the period 1998-2012, they analyzed the effect of the secular decline in the share of startups and its delayed effects on the firm age distribution on the aggregate economy. They found that the employment growth rates of startups and young firms are significantly more cyclical than those of mature firms.

To do this, we estimate the following model (it is equation 4 on p. 119

at Pugsley and Sahin's paper):

$$g_t^a = \bar{g}_t^a + \beta^a Z_t + \varepsilon_t^a \tag{1.19}$$

where a ={young, mature}, g_t^adenotes the growth rate of firms that belong to the age group α and Z_ta business-cycle shock.

Pugsley and Sahin used log differences in annual personal income as a proxy for Z_t. We estimate two alternative versions of this model. In the first version (model 1 hereafter), we replace Z_t with the crisis dummy (defined in section 1.3) to capture the precise non-linear differential impact of the Greek depression which represents a large aggregate shock. In the second version(model 2 hereafter), we employ log differences in annual aggregate sales as a proxy for Z_t to capture the differential impact of business cycle upturns and downturns. The second version allow us to have some directly comparable results with those of Pugsley and Sahin. In order to keep up with Pugsley and Sahin's work we changed the threshold in the young/mature dummy from 5 to 10 years, we used a pooled OLS estimator and finally we included time, location, industry and size fixed effects in the above equation.

Table 1.7 presents our estimation results together with the corresponding estimates from Pugsley and Sahin (results from Table 7, p. 1131). Beginning with the results for model 2, we can see that the growth rates of young firms are significantly more cyclical than those of mature firms (since $|\beta^{yng}| > |\beta^{mtr}|$), as in Pugsley and Sahin's paper. In other words, business cycle downturns, have a significantly larger effect on young firms than on their mature counterparts. Although, our estimates for cyclical elasticities for both young and mature enterprises are quite larger than those of Pugs-

	Our Estimates			**Pugsley & Sahin (2019)**
	Model 1		Model 2	Equation 4 (p. 1119) (Results from Table 7, p. 1131)
	Coefficient	Elasticity	Elasticity	Elasticity
Young	-0.133***	1.511	0.531***	0.258***
	(0.032)		(0.130)	(0.040)
Mature	-0.055***	0.625	0.387***	0.158***
	(0.016)		(0.012)	(0.040)

Notes: In this table we compare our work, which focuses on the differential impact of a large aggregate shock (Greek Depression) on young relative to mature firms, with that of Pugsley and Sahin (2019), which refers to the differential impact of small aggregate shocks (business cycle downturns) on young relative to mature firms. To do this, we estimate the following model (it is model 4 on p. 119 at Pugsley and Sahin's paper): $g_t^a = \bar{g}_t^a + \beta^a Z_t + \varepsilon_t^a, a =$ {young, mature}, where g_t^adenotes the growth rate of firms that belong to age group α and Z_ta business-cycle shock (Pugley and Sahin use log differences in annual personal income as a proxy for Z_t). We estimate two alternative versions of this model. In the first version, we replace $Z_t$with the crisis dummy (defined in section 1.3) to capture the differential impact of Greek depression which represents a large aggregate shock. In the second version, we employ log differences in annual aggregate sales as a proxy for Z_t to capture the differential impact of a small aggregate shock, i.e. business cycle upturns and downturns. For model 1, the elasticity is calculated by dividing each regression coefficient with the decline in the average growth rate due to crisis in our sample (it is equal to 11.1 percentage points). In order to keep up with Pugsley and Sahin's work a) we changed the threshold in the young/mature dummy from 5 to 10 years, b) we used a pooled OLS estimator, c) we included time, location, industry and size fixed effects. *, **, *** denote statistical significance at the 10, 5 and 1 percent level respectively. Standard errors are in parentheses.

Table 1.7: Comparison of our results with those of Pugsley and Sahin (2019)

ley and Sahin, the difference between the elasticities of the two age groups we find is analogous with the one in the Pugsley and Sahin.

When we focus our analysis on the eruption of the Greek depression (model 1), the estimates for the cyclical elasticities are even larger (and so is their difference), a fact that unveils the severity of this crisis. Crises are exceptionally large shocks and they seem to have a non-linear effect that cannot be captured by examining normal business cycles. Especially for the case of the Greek financial crisis, this non-linear effect was amplified by a credit supply shock as we have shown in the previous sections: financing constraints worked as a nonlinear propagator of the crisis in the sense that the latter had a stronger negative effect on firm growth in the industries (or firms) with higher financial distress.

To sum up, our findings lay in accordance with the previous literature on firm life-cycle dynamics and aggregate fluctuations: business cycle downturns, have a significantly larger effect on young firms than on their mature counterparts. Moreover, the case of the Greek Depression, which represents a large aggregate shock, offers the opportunity to examine the non-linear effect that crises exert on an economy, that normal business cycles fail to capture.

1.8 Conclusions

Using the Greek Depression as a laboratory, we bring new evidence to bear on the question of whether, and how, the response of firms to financial crises might be related to firm size and age. First, we find that although small and especially young firms are achieving more rapid sales growth rates during normal and even recessionary times, both age and size act as a business shield against severe sales declines and eventually bankruptcy during a downturn. Then, we quantify the differences in the impact of the financial crisis on the sales growth of Greek firms by age and size. We find that the decline in the firm growth rate due to Greek financial crisis was about 21 percentage points larger in young firms than in their mature counterparts and 22 percentage points larger in small firms than in their large counterparts. These results have important aggregate implications, too. We calculate that between 11.1 to 14.4 percent of the 23 percent drop in aggregate gross output during the crisis was due to the differential impact of the crisis on young firms and that between 4 to 8.5 percent was due to the differential impact of the crisis on small firms.

This study also highlights the role of credit constraints in explaining these firm dynamics around the Greek financial crisis. We find that financing constraints reduced sales growth in small and young firms significantly during the Greek Depression. We also find that young firms are more important than small firms for the aggregate fluctuations. In particular, about the 44 percent of the decline in gross output due to the differential crisis effect on young relative to mature firms and approximately the 24 percent of the observed loss of aggregate gross output due to the differential crisis effect on small relative to large firms stemmed from financing constraints either at industry or firm level.

EU and governmental policies that attempt to alleviate credit constraints faced by firms, especially during economic recessions, are widely adopted across countries. Until now such public policies have targeted businesses of a certain size, ignoring the role of age. Our findings suggest that it is important for policymakers to seriously consider the business conditions not only for small firms, but particularly for young firms, in policy design.

Appendix

A Additional Stylized Facts and Descriptive Statistics

This section provides additional stylized facts on the changes in firm growth, firm turnover and credit constraints during the Greek Depression.

A.1 Firm Turnover and Crisis

In this section we provide information about the actual patterns of firm entry and exit in the Greek economy over the period 1998-2014.

In Figure A.1, we depict the evolution of firm entry according to both the official public administrative records (General Commercial Registry - GCR or G.E.MI.) and our firm-level sample from ICAP. Recall that ICAP collects entry data from the same administrative records. In general lines, our sample resembles satisfactorily the course of firm creation of the Greek economy. The eruption of the 2008 global financial crisis and the Greek Depression that followed led to a notable decline in firm entry.

Figure A.2 presents the trajectory of firm exits according to General Commercial Registry. The outburst of the Greek crisis in 2010 triggered a tremendously destructive period for Greek firms which culminated in 2011. In particular, the exit rate increased by 5,350 percent from 2009 to 2011. However, the financial aid that the Greek state received under the first (May, 2010) and the second (March, 2012) Economic Adjustment Programmes[31] gave an immediate relief to the economy and stopped the rapid destruction.

[31] Of course, in exchange for harsh austerity measures.

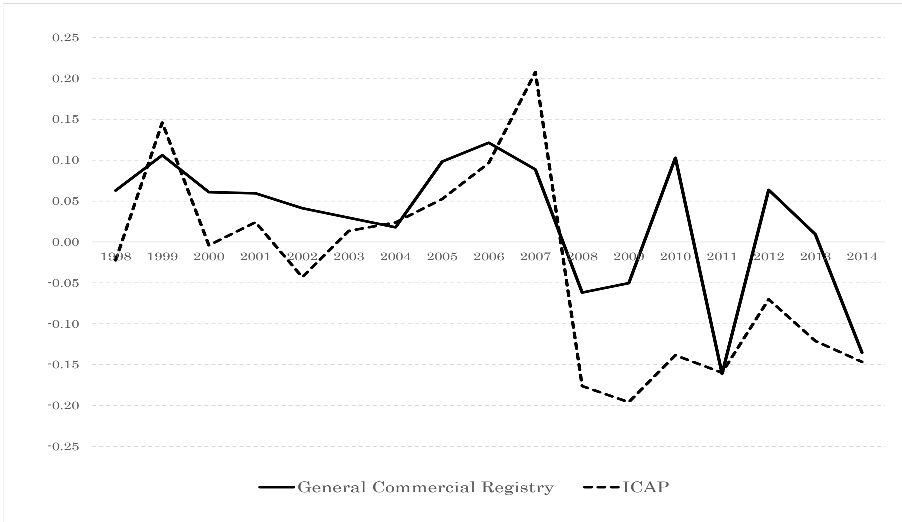


Figure A.1: Firm entry over the period 1998-2014

Notes: This figure presents the evolution of firm entry according to both the official public administrative records (General Commercial Registry - GCR or G.E.MI.) and our firm-level sample from ICAP.

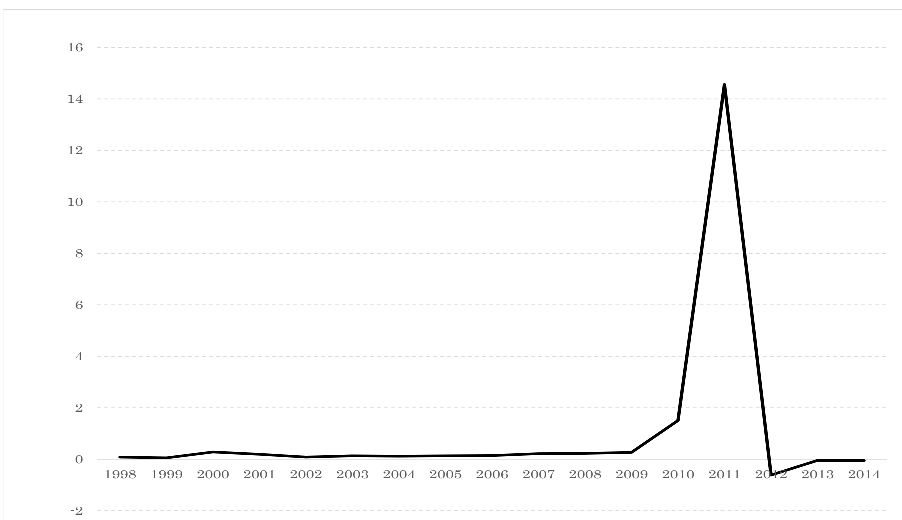


Figure A.2: Firm exit over the period 1998-2014

Notes: This figure presents the evolution of firm exit according to the Greek official public administrative records (General Commercial Registry - GCR or G.E.MI.).

A.2 Firm Growth and Crisis

In this section, we focus on the repercussion of the financial crisis on the evolution of Greek firms. We examine the impact of both age and size on the firm growth and whether it changed after the outburst of the crisis. Furthermore, in order to investigate the role of endogenous selection on the evolution of firm growth we examine the impact of age and size on both the unconditional and conditional firm growth rates, with the latter to imply the growth rate of the firms which survived until 2014 (i.e. the last available year in our sample).

Figure A.3 shows the average unconditional and conditional growth rates for the Greek firms before and during the crisis era. It is apparent that crisis reversed the positive growth rates that Greek firms achieved in the pre-crisis era. In addition, selection seems to play a very interesting role in the firm growth patterns: the growth rate of survivors is much more intensive in the “boom” period (i.e. 1998-2009) and much less contractive during the crisis (2010-2014). Thus, it is very important for our analysis to treat efficiently the problem of selectivity.

In Figure A.4 we show both the unconditional and conditional average growth rates for the “young” and the “mature” firms as well[32]. We cite them for both the “boom” and the “crisis” eras. Three interesting remarks can be made. First, selection matters: during the “boom” period mature firms have negative unconditional but positive conditional growth rates. Second, crisis reserved the pattern of firm growth as in the case of the full sample. Third, age has a clear impact on firm growth: “young” firms have much more intensive growth rates (either positive in “boom” period or negative

[32] A firm is defined as "mature" if its age is larger than 5 years and "young" otherwise.

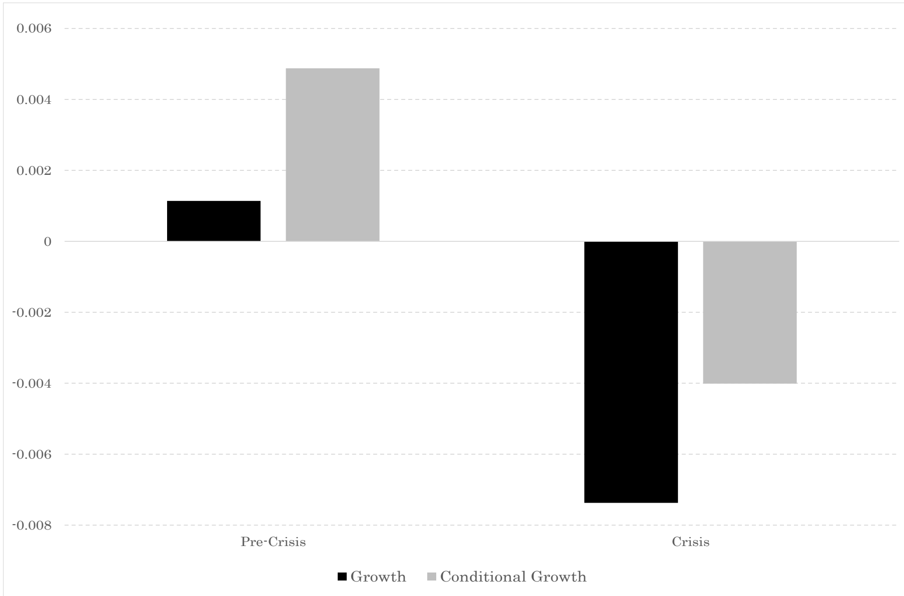


Figure A.3: Firm Growth before and during the Greek Depression

Notes: This figure presents the average unconditional and conditional growth rates for the Greek firms before and during the crisis era. The term "conditional" implies the growth rate of the firms that survived until 2014 (i.e. the last available year in our sample).

in the “crisis” period) than their “mature” counterparts.

Figure A.5 presents both the unconditional and conditional average growth rates for the “small” and the “large” firms as well[33]. Two interesting remarks can be made. First, crisis reserved the pattern of firm growth as in the case of the full sample. Third, size has a clear negative impact on firm growth: “small” firms have much more intensive growth rates (either positive in “boom” period or negative in the “crisis” period) than their “large” counterparts. It is notable that large firms continued to develop even after the eruption of the crisis.

[33]A firm is defined as "small" if it is size is below the 60th percentile of the size distribution and "large" if its size is larger than the 90th percentile of the size distribution.

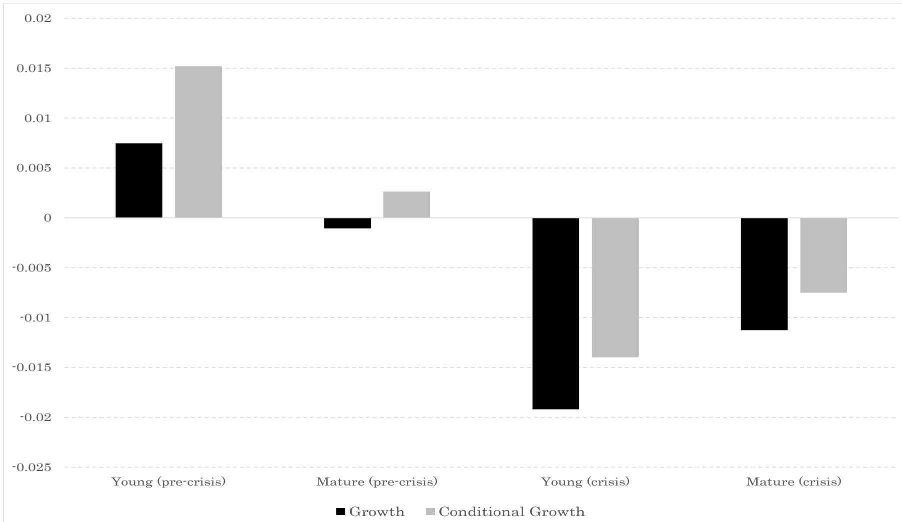


Figure A.4: Firm growth by age group over the period 1998-2014

Notes: This figure presents the average sales growth rates by age groups. A firm is "mature" if its age is larger than 5 years and "young" otherwise.

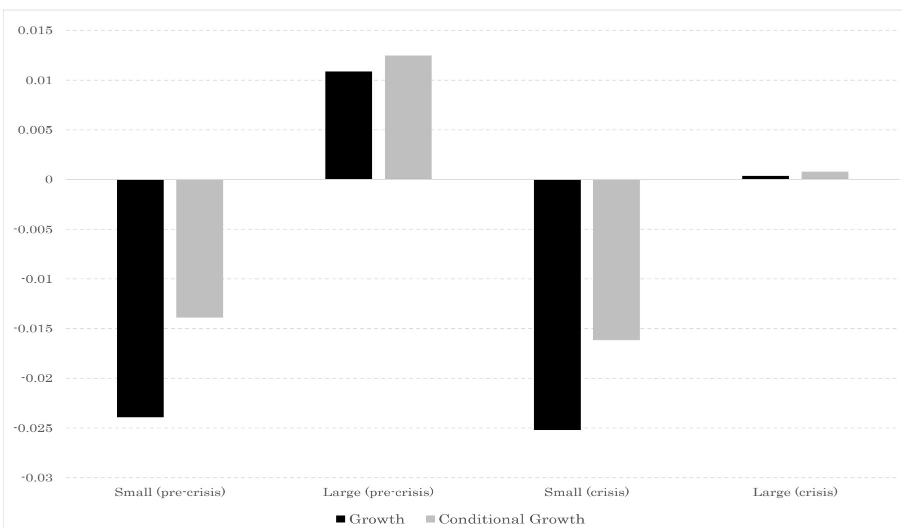


Figure A.5: Firm growth by size group over the period 1998-2014

Notes: This figure presents the average sales growth rates by size groups. A firm is dened as "small" if it is size is below the 60th percentile of the size distribution and "large" if its size is larger than the 90th percentile of the size distribution.

A.3 Facts on Lending from 1998 to 2014

Seeking to examine the role of credit constraints in the impact of crisis on Greek firms it would be very useful to have a look at the course of loan supply before and during the Greek Depression. Two important facts happened on loan supply during the 1998-2014 era. The first fact is that the Greek crisis was preceded by a credit boom during the period 1998-2009[34]. In figure A.6 we depict the evolution of loan supply to non-financial corporations in Greece over the period 1998-2014[35]. The Greek economy was characterized by a splurge in which credit to the private economy rose by 239 percent in the years 1998 - 2009. This credit flood is likely to have rendered many firms vulnerable to financial shocks. The over-accumulation of corporate debt during a boom period may bring firms closer to their collateral constraint and thus make debt servicing more burdensome in a case of a recession.

The second fact is a that Greek crisis presents a negative shock to the supply of credit to non-financial firms. A weighty decline in loan supply started in 2010 and continuous until today[36]. In Figure A.6 we can see that the fall of loan supply was 18 percent from 2010 to 2014.

We contribute to the literature being the first to quantify the role of credit supply in the firm growth trajectories.

[34] This fact on lending was also documented in the work of Schularick and Taylor (2012) for the period 2002-2014.

[35] Data have been obtained from the Bank of Greece.

[36] August, 2019

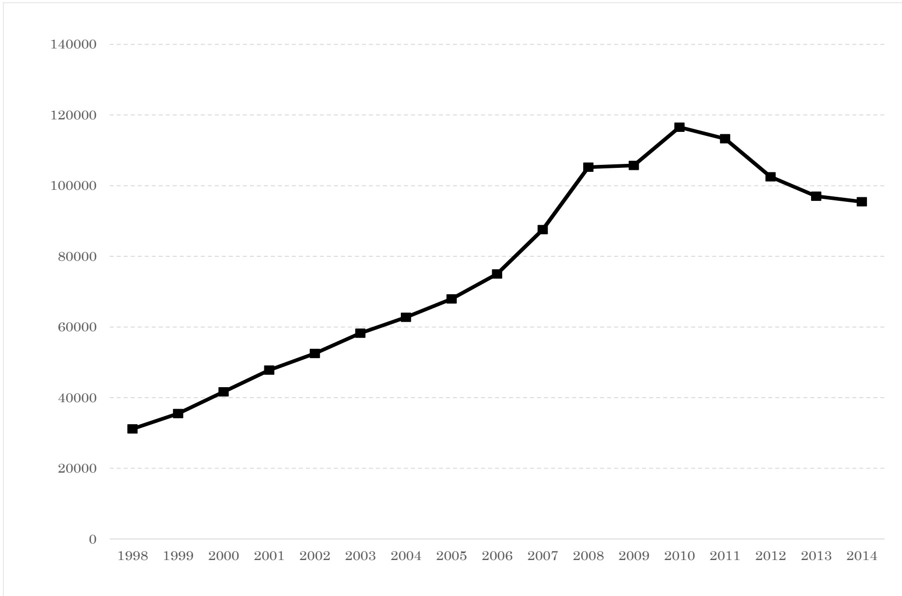


Figure A.6: Evolution of Loan Supply over the period 1998-2014

B Data

The firm-level data are proprietary and they have been obtained from the ICAP Group SA, a private research company which collects detailed balance sheet and income statement data for SA and Ltd companies in Greece, together with their establishment date, location and ownership status, for credit risk evaluation and management consulting. Because ICAP database is used for credit decisions, the data are carefully controlled. Our dataset contains firm-level information for approximately 53,000 Greek firms operating in all sectors, except for banks and insurance companies, for the time period 1998 - 2014. For this study we use information on gross sales, gross output/revenue, total balance-sheet assets, long-term liabilities, short-term liabilities, year of establishment, NACE2 codes, firm location and accounting depreciation flow. The aggregate data and deflators for Greece are collected from two publicly available sources: the Eurostat and the Organization for Economic Cooperation and Development.

B.1 Data Cleaning

We prepare the data for estimation in two stages. First, we clean the data from basic reporting mistakes. Second, we trace and deal with gaps in the data[37]. In particular, we implement the following steps to clean the data:

1. We set to missing firm-year observations of gross sales that are negative.

2. We drop firm-year observations that have missing information on gross sales, total assets or establishment date.

3. We audit for duplicates in our data.

[37] By the term gap we mean a set of missing consecutive firm-year observations.

4. We deal with potential gaps in the data. Due to the high number of missing observations in our sample, in order to ensure the internal consistency of our dataset, we delete the information either of the firms whose sales data has 4 or more gaps, or of the firms with 2 or 3 gaps if the maximum length of a gap is at least 5 consecutive years.

Table B.1 summarizes the coverage in our data for the aggregate economy and for the two largest industries (Manufacturing and Trade). The columns in the table represent the ratio of aggregate gross output[38] recorded in our sample relative to the same object in national level. Gross output collected from Eurostat, as reported by its Structural Business Statistics (SBS). The data in Eurostat are from Census sources and represent the universe of firms. The coverage statistics we report are conservative because we have dropped observations with missing, zero, or negative values for gross sales. As Table B.1 shows the coverage in our sample averages roughly 58 percent for the aggregate economy. In addition, the coverage for the two largest industries of Greek economy are consistently high. In particular, it averages roughly 82 and 65 percent for the manufacturing and trade industries, respectively.

B.2 Data Issues

A major concern that arises about the firm-level data is sampling bias. Four are the main sources of this problem. First, not the entire population of Greek SA and Ltd companies is available in ICAP database. Second, some companies may have been included in ICAP database some years after of their establishment. Third, some companies may have been removed from

[38] Gross output is defined by the Bureau of Economic Analysis (BEA) as: “a measure of an industry’s sales or receipts, which can include sales to final users in the economy (GDP) or sales to other industries (intermediate inputs). At the firm-level, gross output was measured by aggregate gross sales.

Year	**Overall Economy**	**Manufacturing**	**Trade**
1998	0.47	0.66	0.48
1999	0.52	0.68	0.48
2000	0.58	0.77	0.51
2001	0.56	0.76	0.62
2002	0.57	0.79	0.53
2003	0.56	0.81	0.54
2004	0.55	0.83	0.60
2005	056	0.83	0.70
2006	0.57	0.86	0.84
2007	0.61	0.90	0.82
2008	0.65	0.90	0.78
2009	0.60	0.84	0.72
2010	0.61	0.85	0.73
2011	0.66	0.89	0.85
2012	0.63	0.88	0.85
2013	0.61	0.87	0.95
2014	0.60	0.85	0.89
Average	0.58	0.82	0.65

Notes: Coverage is defined as the ratio of the firm-level to the macro-level gross output. The data for macro-level gross output have been obtained by Eurostat. At the firm-level, gross output was measured by aggregate gross sales.

Table B.1: Coverage in ICAP Relative to Eurostat the sample without being actually closed or bankrupt. However, the most important driver of the sampling bias in the dataset is the fact that ICAP database was heavily updated in 2005: 5,055 companies were added in the database and only the half of them were really newborns (the rest had been established before 2005).

In Table B.2 we cite the per year entries, exits and the number of firms in our dataset. We define “entry/exit” as the first/last year for which a firm has valid financial data. ICAP database also provides data about the firms’ year of establishment, i.e. the year of their “birth”, obtained by administrative records. This data allows the accurate calculation of firm age, a variable which plays a crucial role in our analysis. Obviously, firm age due to its construction, was not affected by the 2005 data update. The difference between the sample entries and the firm births indicates the presence of the sampling bias.

Now, we focus on the consequences of the 2005 update of ICAP database in the structure of our dataset. In Table B.3 we examine the distribution of firms regarding their age and size before and after the data update. As we can see the distribution of firms with respect to both age and size remained almost unchangeable after the 2005 data update. Moreover, the majority of both the 2004 exiters and the 2005 entrants were “small-sized” firms whilst a very small proportion of firms was “large-sized”. In addition, the 25% of the 2005 entrants were “mature” firms, i.e. they have been established before 2005, a fact which implies that the entry rate of 2005 cannot be reliable in our dataset. In Table B.4 we present the firm size distribution (FSD hereafter) before and after the 2005 data update and for the 2005 entrants and the 2004 exiters as well. As we can see the FSD remained almost unchangeable after the update, whilst the FSD of the firms which excluded from the dataset is very similar with the distribution of those which were inserted in it. Hence, the 2005 data update had a minor impact on the general structure of our dataset.

In any case, the econometric methodology we follow, based on Olley and Pakes's (1996) approach, allows us to correct for both the endogenous selection due to exit and the sampling bias.

Year	Entries	Exits	Firms	Births
1998	25,743	1,788	25,743	934
1999	3,633	1,654	26,802	2,034
2000	3,651	2,031	28,561	2,707
2001	3,261	2,294	29,552	2,610
2002	2,836	2,116	29,871	2,311
2003	2,871	2,182	30,558	2,383
2004	2,639	1,987	31,042	2,274
2005	5,055	2,131	31,892	2,571
2006	4,144	2,260	35,221	3,162
2007	5,358	3,402	37,449	4,009
2008	3,105	2,783	34,726	2,600
2009	3,175	3,435	35,717	2,659
2010	5,488	4,973	38,975	4,624
2011	4,850	6,586	39,564	4,182
2012	2,630	4,215	34,618	2,398
2013	2,671	7,277	35,096	2,477
2014	2,870	32,866	32,866	2,696
Total	83,980	83,980	-	9,182

Notes: " Entry/Exit" is defined as the first/last year for which a firm has valid financial data in ICAP dataset. "Birth" denotes the number of firms which established yearly according to public administrative authorities.

Table B.2: Firm Entries and Exits in ICAP Dataset

	2004 - All Firms	**2004 - Exiters**	**2005 - All Firms**	**2005 - Entrants**
Small	46.45	59.58	47.22	47.62
Medium	42.14	33.58	41.91	46.24
Large	11.41	6.84	10.87	6.14
Young	29.52	46.36	30.07	75.06
Mature	70.48	53.64	69.63	24.94

Notes: This Table presents the proportion of firms in the sample by age and by size groups. A firm is defined as "small" if it is size is below the 60th percentile of the size distribution, "medium" if its size is between the 51th and the 90th percentiles and "large" if its size is larger than the 90th percentile of the size distribution. A firm is defined as "mature" if its age is larger than 5 years and "young" otherwise. Firm size is defined as the logarithm of gross sales in period t-1, deflated by the Producer Price Index - PPI. Firm age is defined as the difference between the current year of operation and the year of establishment for each firm. For startups firms, age is set equal to zero.

Table B.3: Distribution of Greek Firms by Age and Size Classes

Statistics	**Before Update**	**After Update**	**2004 Exiters**	**2005 Entrants**
Mean	13.746	13.552	13.310	13.515
Stand. Dev.	1.931	1.931	1.976	1.313
Variance	3.730	3.762	3.906	2.602
Min	0.295	-0.119	4.431	2.631
Max	22.910	22.947	20.801	22.172
Skewness	-0.294	-0.272	-0.308	-0.565
Kurtosis	4.108	4.170	3.842	5.106
p25	12.604	12.401	12.169	12.653
p50	13.869	13.649	13.389	13.640
p75	14.952	14.765	14.590	14.511

Notes: This table presents the firm size distribution before and after the 2005 data update for all firms, for the 2005 entrants and for the 2004 exiters as well.

Table B.4: Firm Size Distribution before and after the 2005 data update

C Additional Estimation Results

C.1 Estimation Results for Econometric Specification (1)

Table C.1 presents the estimation results for the econometric specification (1). Since this model is constituted by categorical variables and much more since these variables are interacted together, citing the regression coefficients would be misleading since they fail to capture efficiently the partial effect of firm age or size on firm growth (Williams, 2012). Moreover, the dynamic nature of our model comprises the first lags of all regressors (as a residual of the quasi-differencing process), creating some "lagged effects"[39], wherein, in contrast to regression coefficients, marginal effects at means (MEMs hereafter) can capture. Therefore following Haltiwanger et al. (2013), we present the MEMs instead of the regression coefficients in order to compute properly the partial effects of age and size and take into account the "lagged effects" as well. We estimated three alternative versions of model (1). First, we estimated it using the logarithmic difference of deflated sales ($\Delta lnS_{i,t}$) as a measure of firm growth. Second, we estimated it by employing the Davis, Haltiwanger and Schuh's (1996)($(S_{i,t} - S_{i,t-1})0.5(S_{i,t} + S_{i,t-1})$) definition (DHS hereafter) of firm growth in order to include in our analysis both entrants and exiting firms. Finally, we estimated model (1) using the latter definition and also restricting the sample only for continuing firms. In order to use properly the DHS growth rates we use the "average" definition for firm size (Haltiwanger et al., 2013). "Average" size is defined as the logarithm of average gross sales (deflated by the Producer Price Index) in years t -1 and t.

[39] A meticulous analysis of this issue can be found in Greene (2002), ch. 19, pp. 560-562.

	Logarithmic Growth		DHS Growth (Continuers)		DHS (All firms)	
	Boom	**Crisis**	**Boom**	**Crisis**	**Boom**	**Crisis**
Growth Persistence	0.089***		-0.021**		-0.074***	
	(0.017)		(0.009)		(0.005)	
Age Class						
1 to 3	0.048***	-0.084***	-0.037***	-0.099***	0.008*	-0.099***
	(0.005)	(0.012)	(0.006)	(0.012)	(0.004)	(0.011)
4 to 6	0.014***	-0.128***	-0.009***	-0.053***	0.001	-0.087***
	(0.003)	(0.008)	(0.002)	(0.007)	(0.003)	(0.007)
7 to 10	-0.024***	-0.125***	-0.031***	-0.066***	-0.025***	-0.109***
	(0.003)	(0.007)	(0.002)	(0.006)	(0.002)	(0.006)
11 to 15	-0.028***	-0.146***	-0.037***	-0.084***	-0.030***	-0.134***
	(0.003)	(0.006)	(0.002)	(0.005)	(0.002)	(0.005)
16 to 20	-0.034***	-0.168***	-0.047***	-0.090***	-0.044***	-0.143***
	(0.003)	(0.006)	(0.002)	(0.005)	(0.002)	(0.005)
21^{+}	-0.037***	-0.146***	-0.051***	-0.090***	-0.048***	-0.147***
	(0.002)	(0.005)	(0.002)	(0.004)	(0.002)	(0.004)
Size Class						
1 to 30	0.053***	-0.081***	-0.015***	-0.074***	0.007***	-0.100***
	(0.003)	(0.006)	(0.002)	(0.005)	(0.002)	(0.006)
31 to 60	-0.015***	-0.131***	-0.054***	-0.098***	-0.051***	-0.150***
	(0.002)	(0.006)	(0.001)	(0.004)	(0.001)	(0.004)
61 to 70	-0.043***	-0.162***	-0.070***	-0.064***	-0.072***	-0.116***
	(0.003)	(0.007)	(0.002)	(0.006)	(0.002)	(0.006)
71 to 80	-0.054***	-0.165***	-0.076***	-0.090***	-0.079***	-0.146***
	(0.003)	(0.007)	(0.002)	(0.006)	(0.002)	(0.006)
81 to 90	-0.072***	-0.181***	-0.067***	-0.102***	-0.073***	-0.163***
	(0.003)	(0.007)	(0.002)	(0.006)	(0.002)	(0.006)
91 to 100	-0.076***	-0.196***	-0.027***	-0.119***	-0.033***	-0.183***
	(0.004)	(0.007)	(0.002)	(0.008)	(0.002)	(0.008)
Observations	342,412		342,412		374,896	

Notes: In this table, we investigate the role of firm age and firm size in firm growth before and during crisis. The cited average marginal effects were obtained by the estimation of econometric specification $g_{i,t} = \beta_0 + \beta_{1,j} S^j_{i,t} + \beta_{2,k} A^k_{i,t} + \beta_{3,j,k}(S^j \times A^k)_{i,t} + \varepsilon_{i,t}$. To capture the effect of 2010 Greek financial crisis on the firm growth, we include in the model a crisis dummy and its interaction with all the regressors of econometric specification. The crisis dummy receives the value 1 for the crisis period (2010-2014) and the value 0 for the pre-crisis period (1998 - 2010). We compute marginal effects of firm size (age) from that model holding the age (size) distribution of sales constant at the sample mean. We included time, industry and prefecture fixed effects in all cases. We assumed first-order Markovian disturbances. We estimated three alternative versions of model (1). First, we estimated it using the logarithmic difference of deflated sales ($\Delta ln S_{i,t}$) as a measure of firm growth. Second, we estimated it by employing the Davis, Haltiwanger and Schuh's (1996) definition ($(S_{i,t} - S_{i,t-1})0.5(S_{i,t} + S_{i,t-1})$) of firm growth. Finally, we estimated model (1) using the latter definition and also restricting the sample only for continuing firms. $S_{i,t}$ denotes the gross sales of firm "i" in year "t", deflated by the Producer Price Index (collected from the OECD Database). Age categories are defined in years, whilst size categories are defined in percentiles of the size distribution. *, **, *** denote statistical significance at the 10, 5 and 1 percent level respectively. Standard errors are in parentheses. Standard errors are clustered by firm and calculated according to Delta Method (Dorfman, 1938).

Table C.1: Marginal Effects at Means of Age and Size on Firm Growth

C.2 Changing Size/ Age Cut-offs

In this section we examine the role of age and size cut-offs in our analysis. We consider the following experiment: First, we change the age-cutoff to correspond to the one used by Rajan and Zingales (1998) and Cetorelli and Strahan (2006). In their age definition, a firm is "mature" if its age is larger than 10 years and "young" otherwise. Second, we consider strictly balanced size cut-offs. More specifically, we separate the sales distribution in terciles and we assign each of them to a size group (small, medium or large).

	(a)	(b)	(c)
	$\Delta lnS_{i,t}$	DHS-Continuers	DHS-All Firms
$\hat{\theta}^{Cr}_{age}$	-0.167***	-0.269***	-0.213***
	(0.007)	(0.009)	(0.008)
$\hat{\theta}^{Cr}_{size}$	-0.152***	-0.078***	-0.082***
	(0.006)	(0.005)	(0.005)

Notes: In this table, we investigate role of age and size cut-offs in our analysis. To do so, we change the age-cutoff to correspond to the one used by Rajan and Zingales (1998) and Cetorelli and Strahan (2006). In their age definition, a firm is "mature" if its age is larger than 10 years and "young" otherwise. Second, we consider strictly balanced size cut-offs. More specifically, we separate the sales distribution in terciles and we assign each of them to a size group (small, medium or large). Using the aforementioned age and size cut-offs we re-estimate econometric specifications (4) and (5) and subsequently we compute the differentials (6) and (7). *, **, *** denote statistical significance at the 10, 5 and 1 percent level respectively. Standard errors are in parentheses. "Logarithmic" and "DHS" denote the logarithmic ($\Delta lnS_{i,t}$) and the Davis, Haltiwanger and Schuh's (1996) ($(S_{i,t} - S_{i,t-1})0.5(S_{i,t} + S_{i,t-1})$) definitions of firm growth respectively. $S_{i,t}$ denotes the gross sales of firm "i" in year "t", deflated by the Producer Price Index (collected from the OECD Database).

Table C.2: Alternative Size/Age Cut-offs

Using the aforementioned age and size cut-offs we re-estimate econometric specifications (4) and (5) and subsequently we compute the differentials (6) and (7). Table C.2 presents the correspoding results. As we can see, these findings are qualitatively similar with our main ones: the decline in sales growth rate of Greek firms due to crisis was significantly larger in young firms than in their matures counterparts and in small firms than in their large counterparts.

Bibliography

[1] Ackerberg, D. A., K. Caves and G. Frazer, 2015, "Identification Properties of Recent Production Function Estimators", Econometrica, Vol. 83, No. 6, pp. 2411–2451. Anderson, T.W. and C. Hsiao, 1982, "Formulation and Estimation of Dynamic Models using Panel Data", Journal of Econometrics, Vol. 18, pp. 47-82.

[2] Arellano, M. and O. Bover, 1995, "Another Look at the Instrumental Variable Estimation of Error-components Models", Journal of Econometrics, Vol. 68, pp. 29-51.

[3] Arellano, M. and S. Bond, 1991, "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations", Review of Economic Studies, Vol. 58, pp. 277-298.

[4] Arkolakis, C., 2016, "A Unified Theory of Firm Selection and Growth", Quarterly Journal of Economics, Vol. 131, No. 1, pp. 89- 155.

[5] Barron, D.N., E. West, M.T. Hannan, 1994, "A Time to Grow and a Time to Die: Growth and Mortality of Credit Unions in New York, 1914-1990", American Journal of Sociology, Vol. 100, No. 2, pp. 381-421.

[6] Benmelech, E., N.K. Bergman, and A. Seru, 2011, “Financing Labor”, NBER Working Paper.

[7] Bentzen, J., E.S. Madsen and V. Smith, 2012, “Do Firms’ Growth Rates Depend on Firm Size?”, Small Business Economics, Vol. 39, No. 4, pp. 937–947.

[8] Bliss, C.I., 1935, "The Calculation of the Dosage-mortality Curve", Annals of Applied Biology, pp. 134–167.

[9] Blundell, R. and S. Bond, 1998, “Initial Conditions and Moment Restrictions in Dynamic Panel Data Models”, Journal of Econometrics, Vol. 87, pp. 115-43.

[10] Brunnermeier, M.K. and M. Oehmke, 2013, “Bubbles, Financial Crises, and Systemic Risk”, in: Constantinides, G.M., M. Harris, and R.M. Stulz (Eds.), Handbook of the Economics of Finance, Vol. 2, Elsevier, pp. 1221–1288.

[11] Castellani, D., G.B. Navaretti and F. Pieri, 2014, "Age and Firm Growth: Evidence from three European Countries", Small Business Economics, Vol .43, No. 4, pp. 823-837.

[12] Cetorelli, N. and P. E. Strahan, 2006, “Finance as a Barrier to Entry: Bank Competition and Industry Structure in Local US Markets”, The Journal of Finance, Vol. 61, No. 1, pp. 437-461.

[13] Champernowne, D.G., 1973, “The Distribution of Income between Persons”, Cambridge, Cambridge University Press.

[14] Chari, V.V., L. Christiano and P. Kehoe, 2007, “The Gertler-Gilchrist Evidence on Small and Large Firm Sales,” mimeo.

[15] Chodorow-Reich, G., 2014, “The Employment Effects of Credit Market Disruptions: Firm-level Evidence from the 2008-09 Financial Crisis," The Quarterly Journal of Economics, Vol. 129, No. 1, pp. 1-59.

[16] Clementi, G.L., and B. Palazzo, 2016, “Entry, Exit, Firm Dynamics, and Aggregate Fluctuations”, American Economic Journal: Macroeconomics, Vol. 8, No. 3, pp. 1-41.

[17] Coad, A., 2007, “Firm Growth: A Survey”, Papers on Economics and Evolution 2007-03, Max Planck Institute of Economics, Evolutionary Economics Group, Jena, Germany.

[18] Coad, A., S.O. Daunfeldt and D. Halvarsson, 2018, “Bursting into Life: Firm Growth and Growth Persistence by Age”, Small Business Economics, Vol. 50, No. 1, pp. 55-75

[19] Coad, A. and W. Hölzl, 2010, “Firm Growth: Empirical Analysis”, Handbook on the Economics and Theory of the Firm, Edward Elgar Publishing, pp. 324-338.

[20] Clementi, G.L. and H. Hopenhayn, 2006, “A Theory of Financing Constraints and Firm Dynamics”, Journal of Economics, Vol. 121, No. 1, pp. 229-265.

[21] Cooley, T. and V. Quandrini, 2001, “Financial Markets and Firm Dynamics”, American Economic Review, Vol. 91, No 5, pp. 1286-1310.

[22] Crouzet, N. and N.R. Mehrotra, 2017, "Small and Large Firms over the Business Cycle”, Meeting Papers 600, Society for Economic Dynamics.

[23] Das, S., 1995, “Size, Age and Firm growth in an Infant Industry: The

Computer Hardware Industry in India”, International Journal of Industrial Organization, Vol. 13, pp. 111-126.

[24] Davis, S.J., J. Haltiwanger and S. Schuh, 1996, “Small Business and Job Creation: Dissecting the myth and Reassessing the Facts”, Small Business Economics, Vol. 8, No.4, pp. 297-315.

[25] Decker, R., J. Haltiwanger, R. Jarmin and J. Miranda, 2013, “The Secular Decline in Business Dynamism in the U.S.”, mimeo.

[26] Hart, P. E. and N.Oulton, 1996, ‘The Growth and Size of Firms”’, Economic Journal, Vol. 106, No. 3, pp. 1242-1252.

[27] Decker, R., J. Haltiwanger, R. Jarmin, and J. Miranda, 2014, "The Role of Entrepreneurship in US Job Creation and Economic Dynamism", Journal of Economic Perspectives, Vol. 28, No. 3, pp. 3-24.

[28] Delmar, F. and P. Davidsson, P. and W. Gartner, 2003, “Arriving at the High Growth Firm”, Journal of Business Venturing, Vol. 18, No. 2, pp. 189-216.

[29] Duygan-Bump, B., A. Levkov, and J. Montoriol-Garriga, 2015, “Financing Constraints and Unemployment: Evidence from the Great Recession”, Journal of Monetary Economics, Vol.75, pp. 89-105.

[30] Ericson, R., and A. Pakes, 1995, “Markov-Perfect Industry Dynamics: A Framework for Empirical Work”, Review of Economic Studies, Vol. 62, pp. 53–82.

[31] Evans, D. S., 1987a, “The Relationship between Firm Growth, Size, and Age: Estimates for 100 Manufacturing Industries”, Journal of Industrial Economics, Vol. 35, No. 4, pp. 567-581.

[32] Evans, D., and B. Jovanovic, 1989, “An Estimated Model of Entrepreneurial Choice under Liquidity Constraints”, Journal of Political Economy, Vol. 97, No. 4, pp. 808–827.

[33] Fakos, A., P. Sakellaris and T. Tavares, 2018, “Investment Slumps during Financial Crises: The Role of Credit Constraints”, Working paper.

[34] Fort, T.C., J. Haltiwanger, R.S. Jarmin and J. Miranda, 2013, “How Firms Respond to Business Cycles: The Role of Firm Age and Firm Size”, IMF Economic Review, Vol. 61, No. 3, pp 520–559.

[35] Foster, L., J. Haltiwanger, and C. Syverson, 2012, “The Slow Growth of New Plants: Learning about Demand,” NBER Working Paper No. 17853.

[36] Gertler, M. and S. Gilchrist, 1994, “Monetary Policy, Business Cycles, and the Behavior of Small Manufacturing Firms”, Quarterly Journal of Economics, Vol. 109, No. 2, pp. 309-340.

[37] Giroud, X., H.M. Mueller, 2016, “Firm Leverage, Consumer Demand, and Employment Losses During the Great Recession”, The Quarterly Journal of Economics, Vol. 132, No. 1, pp. 271–316.

[38] Greene, W., 2012, Econometric Analysis, 7th Edition, Prentice Hall, Upper Saddle River.

[39] Grieser, W.D., and C.J. Harlock, 2019, “Panel-Data Estimation in Finance: Testable Assumptions and Parameter (In)Consistency”, Journal of Financial and Quantitative Analysis”, Vol. 54, No. 1, pp. 1-29.

[40] Gourinchas, P.O., T. Philippon and D. Vayanos, 2017, “The Analytics

of the Greek Crisis”, NBER Macroeconomics Annual, Vol. 31, No. 1, pp. 1–81.

[41] Hall, B. H., 1987, ‘The Relationship between Firm Size and Firm Growth in the U.S. Manufacturing Sector”, Journal of Industrial Economics, Vol. 35, No. 4, pp. 583-600.

[42] Haltiwanger, J., R.S. Jarmin and J. Miranda, 2013, “Who Creates Jobs? Small Versus Large Versus Young”, The Review of Economics and Statistics, Vol. 95 No. 2, pp. 347-361.

[43] Hopenhayn, H, 1992, “Entry, Exit, and Firm Dynamics in Long Run Equilibrium”, Econometrica, Vol. 60, No. 5, pp. 1127–1150.

[44] Ijiri, Y., and H.A. Simon, 1967, “A Model of Business Firm Growth”, Econometrica, Vol. 35, No. 2, pp. 348-355.

[45] Jovanovic, B., 1982, “Selection and Evolution of Industry”, Econometrica, Vol. 50, No. 3, pp. 649-670.

[46] Kalemli-Ozcan, S., L. Laeven and D. Moreno, 2018, “Debt Overhang, Rollover Risk, and Corporate Investment: Evidence from the European Crisis”, National Bureau of Economic Research, Working Paper 24555.

[47] Kudlyak, M., and J.M. Sanchez, 2017, “Revisiting Gertler-Gilchrist Evidence on the Behavior of Small and Large Firms", Journal of Economic Dynamics and Control, Vol. 77, pp. 48-69.

[48] Luttmer, E., 2007, "Selection, Growth, and the Size Distribution of Firms", Quarterly Journal of Economics, Vol. 122, No. 3, pp.1103-1144.

[49] Mansfield, E., 1962, "Entry, Gibrat's Law, Innovation and the Growth of Firms", American Economic Review", Vol. 52, pp. 1023-1051.

[50] Olley, G.S. and A. Pakes, 1996, "The Dynamics of Productivity in the Telecommunication Equipment Industry", Econometrica, Vol. 69, No. 2, pp. 307-342.

[51] Pugsley, B., P. Sedlacek, and V. Sterk, 2018, "The Nature of Firm Growth," CEPR Discussion Papers 12670, C.E.P.R. Discussion Papers January 2018.

[52] Pugsley, B., and A. Sahin, 2019, "Grown-up Business Cycles", The Review of Financial Studies, Vol. 32, No. 3, pp. 1102–1147.

[53] Rajan, R.G. and L. Zingales, 1998, "Financial Dependence and Growth," American Economic Review, Vol. 88, No. 3, pp. 559-586.

[54] Rivers, D., and Q.H. Vuong, 1988, "Limited Information Estimators and Exogeneity Tests for Simultaneous Probit Models", Journal of Econometrics, Vol. 39, pp. 347–366.

[55] Roodman, D. M., 2009, "A Note on the Theme of Too Many Instruments", Oxford Bulletin of Economics and Statistics, Vol. 71, pp.135–158.

[56] Sedl*áč*ek, P., 2019, "Lost Generations of Firms and Aggregate Labor Market Dynamics", Journal of Monetary Economics, forthcoming

[57] Sedl*áč*ek, P., and V. Sterk, 2017, "The Growth Potential of Startups over the Business Cycle", American Economic Review, Vol.107, No.10, pp. 3182-3210.

[58] Schularick, M. and A.M. Taylor, 2012, “Credit Booms Gone Bust: Monetary Policy, Leverage Cycles, and Financial Crises, 1870-2008”, American Economic Review, Vol. 102, No. 2, pp. 1029–61.

[59] Siemer, M., 2019, “Employment Effects of Financial Constraints during the Great Recession”, Journal of Economics and Statistics (forthcoming).

[60] Sutton, J., 1997, “Gibrat’s Legacy”, Journal of Economic Literature, Vol. 35, pp. 40-59.

[61] Tornqvist, L., P. Vartia, and Y. Vartia, 1985, “How Should Relative Changes Be Measured?”, The American Statistician, Vol. 39, No. 1, pp. 43-46.

[62] Whited, T.M. and G. Wu, 2006, “Financial Constraints Risk”, Review of Financial Studies, Vol. 19, No. 2, pp. 531-559.

[63] Williams, R., 2012, “Using the Margins Command to Estimate and Interpret Adjusted Predictions and Marginal Effects”, The Stata Journal, Vol. 12, No. 2, pp. 308–331.

[64] Windmeijer, F., 2005, “A Finite Sample Correction for the Variance of Linear Efficient Two-step GMM Estimators”, Journal of Econometrics, Vol. 126, pp. 25–51.

[65] Wooldridge, J., 2004, “On Estimating Firm-level Production Functions using Proxy Variables to Control for Unobservables”, Mimeo, Michigan State University.

[66] Yasuda, T., 2005, “Firm Growth, Size, Age and Behavior in Japanese Manufacturing”, Small Business Economics, Vol. 24, pp. 1-15

Chapter 2

Financial crises, firm-level shocks, and large downturns: Evidence from Greece

Abstract

How do firm-specific shocks contribute to large economic downturns associated with financial crises? Using a large and representative dataset on Greek firms covering all sectors of the economy over the period 2000-2014, we find that the contribution of firm-specific shocks to the volatility of aggregate sales growth increased substantially (about 30%) during the Greek financial crisis and dominated the contribution of macroeconomic and sectoral shocks. We also find that, throughout the sample period, inter-firm linkages are two and a half times as important as the direct effect of firm shocks in driving aggregate fluctuations. However, during the financial crisis, the Greek economy became more granular and the direct effect of firm-specific shocks had increased importance in driving aggregate volatility.

2.1 Introduction

The origins of business cycle fluctuations is a long-standing question in macroeconomics. The traditional macroeconomic theory has long assumed that business–cycle fluctuations are the results of aggregate macroeconomic changes. The conventional assumption is that firm-specific or idiosyncratic shocks average out in the aggregate and thus they have a negligible effect at the aggregate level (Lucas, 1977). However, a seminal paper by Gabaix (2011) showed that firm-level idiosyncratic shocks may translate into fluctuations at the aggregate level if the firm size distribution is sufficiently heavy-tailed (in the sense that largest firms contribute disproportionally to aggregate output). Gabaix called this view as the "granular hypothesis". A growing empirical literature has been flourished in the last decade supporting and extending this idea (e.g. Foerster et al., 2011; Acemoglu et al., 2012; Acemoglu et al., 2013; di Giovanni et al., 2014; Karasik et al., 2016; Friberg and Sanctuary, 2016; Acemoglu et al., 2016; Barrot and Sauvagnat, 2016; Caliendo et al. 2018; Popova, 2019; Giroud and Muller, 2019).

This study contributes to this literature by examining specifically the changing sources of aggregate volatility in a country undergoing a financial crisis, Greece. It has two objectives. The first is to examine whether and how much firm-specific shocks contribute to large economic downturns associated with financial crises, using the Greek Depression as an economic laboratory. The second objective of this study is to bring additional evidence on the role that inter-firm linkages play in the propagation of firm-level idiosyncratic shocks in the aggregate economy, especially after a large shock.

Using a novel and large firm-level dataset representative of the entire

Greek economy over the period 200-2014 and following very closely the methodology formulated in di Giovanni et al. (2014), we decompose firm sales growth into a "macro-sectoral" (capturing both sectoral and aggregate shocks) and a firm-specific component. By using these results, properly weighted, we obtain an estimate of the relative importance of firm-level idiosyncratic shocks in aggregate sales volatility, as the ratio of the standard deviation of the aggregated firm-specific shocks to the standard deviation of aggregate sales growth. We find that the firm-specific and macro-sectoral components each contributed roughly equally to aggregate sales volatility during the entire period. However, during the financial crisis, the volatility of firm-specific shocks rose five times more than that of macro-sectoral shocks. These results are robust to allowing for firm sales growth to respond heterogeneously to macroeconomic and sectoral shocks with respect to 3 observable characteristics: firm age, firm size and financing constraints. Therefore, idiosyncratic shocks to firms constitute an important contributor to large economic downturns.

Having sufficient evidence for the granularity of the Greek economy we go deeper and we investigate the potential role that inter-firm linkages play in this. Relying on a model based on the approach proposed by Carvalho and Gabaix (2013) and di Giovanni et al. (2014) we find that, throughout the sample period, inter-firm linkages are two and a half times as important as the direct effect of idiosyncratic shocks in driving aggregate fluctuations. We also find that during the financial crisis, the direct effect of firm-specific shocks had increased importance in driving aggregate volatility. These linkages among firms can be attributed either to production or financial networks. The explanation for the first is simple. Firms build a network with other firms in order to obtain inputs and to sell their products. A shock to a single firm could have much larger repercussions on the macroeconomy if it diminishes the output of not only this firm, but also of others that are associated with it through a network of input-output linkages (Acemoglu et al., 2012). Financial networks arise from mutual lending and borrowing relationships among firms. Therefore, a financial shock on one firm can be dispersed into the firms that are connected with that via these lending or borrowing interconnections (Cabrales et al., 2015). A second element of inter-firm financial linkages is the confidence in the credit quality of particular firms. If a firm's perceived ability to pay declines for whatever reason, then so does the market value of its liabilities. In a mark-to-market regime this reduction in value can spread to other firms that hold these liabilities among their assets (Glasserman and Young, 2015).

Our evidence comes from proprietary firm-level data obtained from ICAP Group, S.A., a private research company that collects detailed balance sheet and income statement information for SA and Ltd companies in Greece. Our dataset is ideal for studying the granular nature of financial crises because it contains detailed information on gross sales of private firms in contrast with other widespread datasets from publicly listed firms such as Compustat. The time dimension of the dataset allows us to capture fluctuations of the business cycles of the Greek economy since it covers the Greek Depression (2009-2014) and the boom period that preceded.

Several features of the Greek Depression make Greece the appropriate laboratory to investigate whether or not idiosyncratic shocks to firms contribute to aggregate fluctuations and especially to severe financial crises. First, it is the largest economic crisis an advanced economy has ever faced, both in magnitude and duration: four years after the eruption of the crisis, Greek economy had lost almost a quarter of its gross output[1]. Second, the banking sector almost collapsed during the crisis. Therefore, Greek Depression affected firms through both the demand-supply and financial channel, a fact that constitutes Greece a very interesting case for examining the role of firm-specific shocks in the eruption and contagion of a financial crisis, and the role that both production and financial networks across firms play as well. Third, the crisis was preceded by a period of economic boom and rapid leveraging.

Our study is closely related to the growing literature in finance and macroeconomics that analyzes how idiosyncratic shocks to firms propagate in the economy through inter-firm linkages. This literature focuses mainly on production and financial networks among firms or sectors. Particularly relevant empirical papers on production networks are those of Foerster et al. (2011), Acemoglu et al. (2012), Acemoglu et al. (2013), di Giovanni et al. (2014), Friberg and Sanctuary (2016), Acemoglu et al. (2016), Caliendo et al. (2018) and Popova (2019) that feature mechanisms through which input-output linkages lead to business-cycle fluctuations. Moreover, a theoretical framework for the analysis of the contribution of production networks in the aggregate fluctuations was developed by Carvalho (2008), Acemoglu et al. (2012), Acemoglu et al. (2014), Baqaee (2015) and Obereld (2018). In particular, the aforementioned authors developed a multi-sector framework, based on the pioneering work of Long and Plosser (1983), to analyze how input-output linkages can lead to aggregate fluctuations showing that shocks hitting sectors that are highly significant as suppliers to other sectors are not average out in aggregate. The literature on financial networks is more

[1]The crisis erupted in 2009. Five years later, the Greek economy had lost 22% of gross output. See Gourinchas et al. (2016) and Giannoulakis and Sakellaris (2020) for a more meticulous presentation of the Greek Depression.

limited. A consign presentation of the theoretical background of financial networks can be find in Cabrales et al. (2015), whilst an extensive literature review on this issue is provided in Glasserman and Young (2016).

Despite the rich empirical evidence on the role of inter-firm linkages in the propagation of the firm-level idiosyncratic shocks in the aggregate economy, many models that try to explain the origins and the internal mechanics of the 2007-09 global financial crisis or of other recessions or crises do not take into consideration these production and financial networks [2]. Our findings indicate that for a deeper insight of the 2007-09 financial crisis there is a need for theoretical models that capture these production and financial networks propagation mechanisms of idiosyncratic shocks to firms [3].

The remainder of the chapter is organized as follows. Section 2.2 provides a description of the data. Section 2.3 presents the empirical methodology we follow, while Section 2.4 includes the estimation results. Finally, Section 2.6 concludes.

[2]There is an important and large class of theoretical models that incorporate firm-specific shocks in their analysis to explain business cycle fluctuations, but they only capture the direct effect of the these shocks and not the input-output and financial linkage effects (some recent examples are those of Bloom (2009), Bloom et al. (2012), Gilchrist et al. (2014) and Christiano et al. (2014)). In addition, the sparse theoretical literature on the Greek Depression (Gourinchas et al. (2016), Economides et al. (2017) and Chodorow-Reich et al. (2019)) has completely ignored the role of firm heterogeneity in the eruption and the expansion of the crisis.

[3]Two notable papers with general equilibrium models that incorporate the production network propagation mechanism of microeconomic shocks in the macroeconomy is that of Barrot and Sauvagnat, 2016 and Huneeus (2018), with the former to examining how idiosyncratic firm-level shocks, identified with the occurrence of natural disasters propagate across U.S. economy through firms' production networks and the later to evaluating how international trade shocks during the Great Recession propagated in Chile. Also, two interesting theoretical models that analyze the contagion, via transmission of idiosyncratic shocks to firms, in financial networks are those of Acemoglu, Ozdaglar, and Tahbaz-Salehi (2014) and Glasserman and Young (2015) in which the authors consider linkages among both assets and liabilities of firms, arising from mutual lending and borrowing relationships among them, via standard debt contracts.

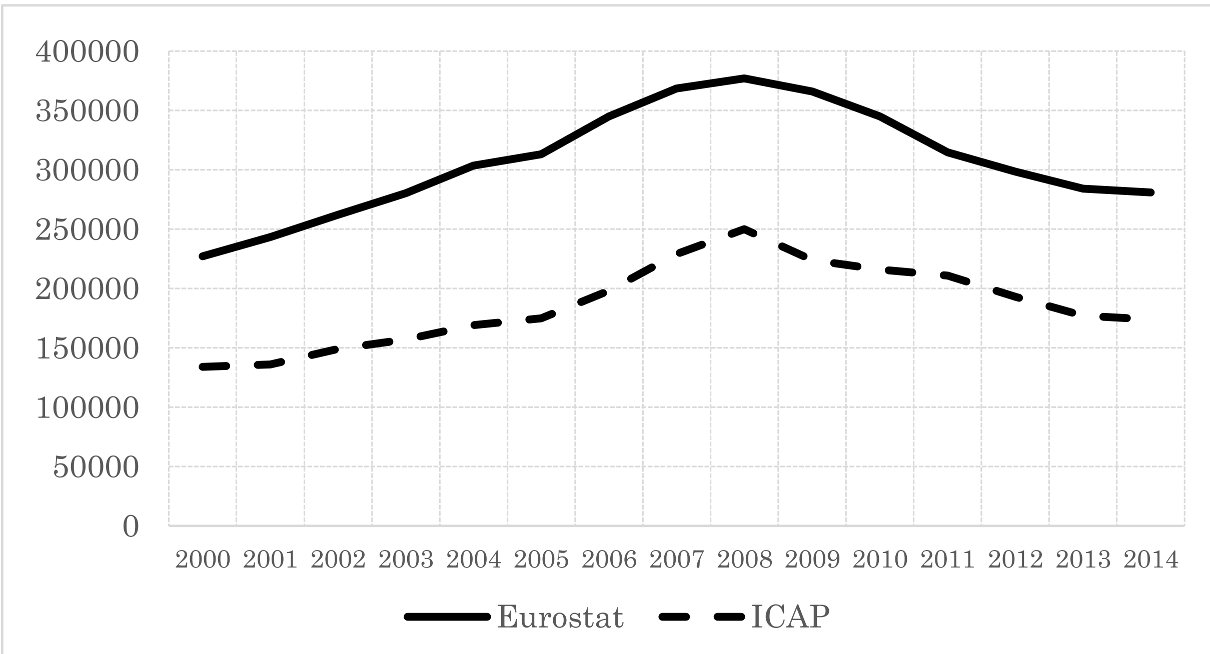
2.2 Data and Descriptive Statistics

We employ a proprietary firm-level dataset obtained from ICAP Group, S.A., a private research company that collects detailed accounting information for S.A. and Limited-liability companies in Greece. All companies are legally required to publish their accounts annually and ICAP strives to cover the universe of Greek firms. ICAP data is used by commercial banks for credit decisions and by the central bank for credit rating information. Thus, the data are carefully controlled. Our dataset contains firm-level information for approximately 50,000 Greek firms operating in all sectors, except for banks and insurance companies, for the years 200 - 2014. The time dimension of the dataset allows us to capture fluctuations of the business cycles of the Greek economy since it covers the Greek Depression (2009-2014) and the boom period that preceded.To our knowledge, this study is the first to use so large and representative a firm-level dataset for the Greek economy. A natural question that might arise here is whether our firm-level dataset resembles the aggregate Greek economy. Our sample covers roughly 60 percent of the gross output in the Greek economy over the period 2000-2014 [4].

In Figures 2.1 and 2.2 we compare the evolution of aggregate firm sales in our ICAP dataset with that of gross output as it recorded by Eurostat. As we can see, total sales in our sample of firms mimics aggregate activity well: the growth rate of total sales tracks the growth rate of Gross Output.

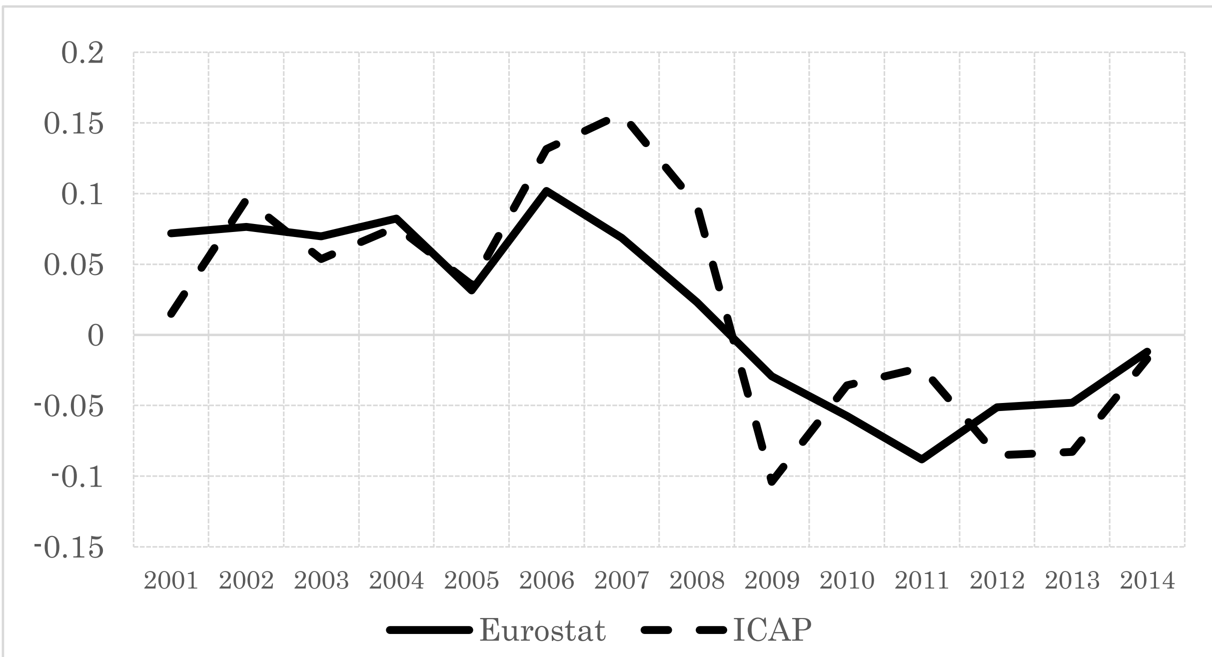
Table 2.1 presents descriptive statistics for firm-level growth rates for the pre-crisis (2000-2008) and the crisis (2009-2014) periods. The average

[4] Gross output is defined by the Bureau of Economic Analysis (BEA) as: “a measure of an industry’s sales or receipts, which can include sales to final users in the economy (GDP) or sales to other industries (intermediate inputs). In firm-level, gross output was measured by aggregate gross sales.



Notes: In this Figure, we compare the evolution of the aggregate gross output in our ICAP dataset with the same aggregate as recorded by Eurostat. Gross output is defined by the Bureau of Economic Analysis (BEA) as: "a measure of an industry's sales or receipts, which can include sales to final users in the economy (GDP) or sales to other industries (intermediate inputs)". At the firm-level, gross output was measured by aggregate gross sales.

Figure 2.1: Aggregate Gross Output in ICAP and Eurostat databases



Notes: In this Figure, we compare the evolution of the growth of total sales in ICAP dataset with the same aggregate as recorded by Eurostat. Gross output is defined by the Bureau of Economic Analysis (BEA) as: "a measure of an industry's sales or receipts, which can include sales to final users in the economy (GDP) or sales to other industries (intermediate inputs)". At firm-level, gross output was measured by aggregate gross sales.

Figure 2.2: Growth of Total Sales in ICAP VS Growth of Gross Output in Eurostat databases

growth rate of aggregate sales, for both time periods, is lower than the (unweighted) average growth rate of individual firm-level sales. This is to be expected, as the unweighted metrics are dominated by small firms. Firm-level volatility increased during the crisis era. Therefore, we expect that the contribution of firm-specific shocks to aggregate fluctuations would increase. Finally, the table also reports the square root of the Herfindahl index of firm sales shares. The concentration ratio is higher for Greece than for both France (Gabaix, 2011) and Sweden (Friberg and Sanctuary, 2016), suggesting that firm-specific volatility for the Greek economy should be important. Overall the summary statistics indicate that the Greek economy is more volatile and more "granular" than both the French and the Swedish economies.

	Pre-crisis Period	**Crisis Period**
	2000-2008	2009-2014
Average aggregate growth rate	0.034	-0.058
Mean of individual growth rates	0.047	-0.095
Standard deviations of sales growth rate	0.593	0.639
Average $\sqrt{Herf(f)}$	0.065	0.086

Notes: This table presents the basic summary statistics for our sample. $Herf(f)$ denotes the Hirschmann–Herfindahl index of firm sales shares

Table 2.1: Summary Statistics

2.3 Methodology

To identify firm-level idiosyncratic shocks and quantify their contribution to aggregate fluctuations we follow the well-established methodology of di Giovanni et al. (2014)[5].

Consider an economy with n firms. Firm's growth rate is defined as $g_{i,t} = \Delta \ln S_{i,t}$, where $S_{i,t}$ denotes the gross sales of firm i at period t, deflated by the relevant producer price index. The growth rate of a firm consists of two components: one common to all firms in the industry (i.e. a macroeconomic shock) and one specific to the firm. In other words, the firm-specific shock is the portion of the growth rate $g_{i,t}$ that is not generated by a common, industry-wide shock. Hence, the idiosyncratic shock is defined as:

$$\varepsilon_{i,t} = g_{i,t} - \delta_{j,t} \tag{2.1}$$

The general component $\delta_{j,t}$ can be considered as the average growth rate of sales for sector j over a period t[6].

The impact of a firm-specific shock is proportional to the size of the firm. The simplest measure of the size of a firm is its market share in the previous period, which is denoted by $s_{i,t-1} = S_{i,t-1}/S_{t-1}$, where S_{t-1} stands for the aggregate sales at period $t-1$. According to Gabaix (2011), the overall impact of firm-specific shocks on the aggregate economy constitutes the granular shock which is given by the weighted average of the firm-specific

[5]Due to the limited time span of our sample, Gabaix's (2011) original methodology would not be the most appropriate in our case. Nevertheless, we provide an application of this methodology in Appendix B. The relevant results under Gabaix's (2011) methodology are very close to the main results of this study

[6]Technically, we estimate these idiosyncratic shocks by regressing the sales growth rates on a number of sectoral dummy variables, following di Giovanni et al. (2014).

deviations from the average growth rate:

$$G_t = \sum_{i \in M} s_{i,t-1} \varepsilon_{i,t} \tag{2.2}$$

where M is the number of firms for which we calculate the granular shock[7]. Following di Giovanni et al. (2014), we calculate the granular shock using data from all firms in the dataset independently of their size.

Following di Giovanni et al. (2014) , we can represent the aggregate growth rate as follows [8]:

$$g_{A,t} = \sum_{j=1}^{J} w_{j,t-1} \delta_{j,t} + \sum_{i=1}^{M} w_{i,t-1} \varepsilon_{i,t} \tag{2.3}$$

where $w_{j,t-1}$ is the share of sector j's sales in the total output of Greek firms, and $w_{i,t-1}$ is the share of a firm i's sales in the total output. The second term in (2.3) $\sum_i w_{i,t-1} \varepsilon_{i,t}$ is none other than Gabaix's (2011) "granular residual" (2.2). In order to ensure the compatibility of our analysis with the work of di Giovanni et al. (2014), we restrict our sample to the intensive margin of aggregate sales growth by excluding firm-year observations where a firm is an entrant or an exiter.

Let $\sigma^2_{A,t}$ be the aggregate volatility of aggregate growth rate $g_{A,t}$. We can

[7] The definition of M varies in the literature. Gabaix (2011) restricted M to the 100 largest firms in US, implying that only large firms affect business cycles. In contrast, di Giovanni et al. (2014) estimated macroeconomic and idiosyncratic shocks using data from the universe of French firms independently of their size. Karasik et al. (2016) combined these approaches by examining two cases: the case of 10 largest Canadian companies and the case of all companies. In Appendix B, we apply Gabaix's (2011) original methodology for both the whole sample and for only the top 1% largest firms. We find that small and medium firms are also important for the granularity of the Greek economy.

[8] We do not have exports data, so we cannot differentiate by the destination of firm sales, as di Giovanni et al. (2014) do. This should not affect the estimates much as Greece has a low exports-to-GDP ratio (23% versus 38% for the European Union over 2000-2014 - see Appendix C for more details). In section 2.5.2 we provide some more arguments for robustness.

decompose it as follows:

$$\sigma^2_{A,t} = \sigma^2_{J,t} + \sigma^2_{F,t} + COV_t \tag{2.4}$$

where:

$\sigma^2_{J,t} = Var\left(\sum_{j=1}^{J} w_{j,t-1}\delta_{j,t}\right)$, macro-sectoral volatility

$\sigma^2_{F,t} = Var\left(\sum_{i=1}^{M} w_{i,t-1}\varepsilon_{i,t}\right)$, firm-specific volatility

$COV_t = Cov\Big(\sum_{j=1}^{J} w_{j,t-1}\delta_{j,t}, \sum_{i=1}^{M} w_{i,t-1}\varepsilon_{i,t}\Big)$, covariance of the shocks from different levels of aggregation.

Specification (2.4) allows as to quantify the contribution of individual shocks to aggregate fluctuations. For a deeper insight into the channels through which firm-specific shocks affect aggregate volatility we further decompose idiosyncratic volatility into the contribution of individuals variances and comovements between firms (Carvalho and Gabaix, 2013; di Giovanni et al., 2014):

$$\sigma^2_{F,t} = \underbrace{\sum_{i=1}^{M} w^2_{i,t-1} Var\left(\varepsilon_{i,t}\right)}_{Direct_t} + \underbrace{\sum_{k \neq i} w_{k,t-1} w_{i,t-1} Cov\left(\varepsilon_{k,t}, \varepsilon_{i,t}\right)}_{Link_t} \tag{2.5}$$

The first term in equation (2.5) captures the direct effect of idiosyncratic shocks to firms on aggregate volatility in the absence of inter-firm linkages. This "direct" effect should be inappreciable according to the conventional assumption of many macroeconomic models that idiosyncratic shocks vanish at the aggregate level.

The second term in equation (2.5) designates comovements between firms' outputs, i.e. covariances of idiosyncratic shocks across firms. This correlation emerges from existing linkages through the input-output structure and intermediary consumption or through the constants in the common labor market or through financial networks across firms. In this case, the shocks to one firm will merely drive the output dynamics of other firms related with the first one. Despite the significant of this "link" effect, its role has been ignored by the majority of the literature in macroeconomics based on the argument that covariances between firms are repercussions of macroeconomic shocks that firm faced (Acemoglu et al., 2012).

We estimate econometric specifications (2.3), (2.4) and (2.5)[9] following the algorithms provided by di Giovanni et al. (2014)[10].

2.4 Estimation Results

Table 2.2 presents descriptive statistics of the actual growth rates of firms' sales and its components resulting from decomposition (2.3), described in the main text. It is clear that the volatility of actual sales growth is dominated by its firm-specific component, rather than the macro-sectoral shocks. The standard deviation of the firm-specific component is almost the same as the standard deviation of actual sales growth and the correlation is almost perfect. To the contrary, the macro-sectoral component is much less volatile and has lower correlation with actual sales growth. These results lie in accordance with the widely accepted line of thinking that most shocks hitting firms are idiosyncratic (Haltiwanger, 1997). In addition, the standard de-

[9] We have also estimated these three specifications using fixed weights, in line with di Giovanni et al. (2014). These alternative specifications yields very similar results and hence they are not reported.

[10] Retrieved on December, 2019, from here.

viation we find (either the actual or the firm-specific or macro-sectoral) is much larger than that of Gabaix (2011) and Friberg and Sanctuary (2016) who studied the cases of France and Sweden respectively. The reason for that is that our sample, in contrast with theirs, covers the period of the global financial crisis which for Greece was prolonged by both the sovereign debt and banking crises.

Figure 2.3 and Table 2.3 report the estimates for the aggregate volatility and its components according to equation (2.4). In particular, Figure 2.3 depicts the estimates of aggregate volatility $\sigma_{A,t}$ and its components $\sigma_{j,t}$ (firm-specific) and $\sigma_{F,t}$ (macro-sectoral) for the Greek economy during the period 2001-2014, together with two kinds of 95% confidence intervals: analytical and bootstrapped. Table 4 cites the averages of our estimates of $\sigma_{A\tau}$, $\sigma_{j,t}$ and $\sigma_{F,t}$, as well as their ratios, over the whole sample period and over the pre-crisis (2000-2014) and crisis (2009-2014) period separately.

From Table 2.3 we can see that macro-sectoral and firm-specific shocks contributed roughly equally to aggregate sales volatility over the entire period - roughly 70% each[11]. However, there is a marked difference between the boom and crisis periods. The financial crisis did not increase aggregate volatility much but brought a substantial increase in the importance for aggregate fluctuations of firm-specific relative to macro-sectoral shocks. From Figure 2.3 it is apparent that although the contribution of both macro-specific and firm-specific component increased during the crisis, the contribution of the latter was rose five times more than that of the former (increases of 39% and 8% respectively) [12]. Therefore as in the case of Gabaix's

[11]These numbers add up to more than 1 because they have been converted to standard deviations and the existence of non-zero covariance terms.More specifically, since the aggregate variance is additive in the firm-specific and macro-sectoral variance components, the aggregate standard deviation is smaller than the sum of the standard deviations of the two components.

[12]These results are robust to allowing for

(2011) methodology firm-specific shocks contribute much more to economic downturns - or more precisely to financial crises (as the Greek Depression was) - than to business cycle upturns.

Using equation (2.5), we further decompose the idiosyncratic component into two terms: the direct channel (variation in individual shocks - DIRECT) and the effect of inter-firm linkages (covariance of shocks between firms - LINK). Figure 2.4 depicts the estimates for the DIRECT and the LINK effects of the firm-specific component. It is apparent from the figure that LINK component explains most of total firm-specific volatility (specifically 93% over the time period 2001-2014). Nevertheless, the DIRECT component is not inappreciable (explaining 35% over the time period 1998-2014). During the financial crisis, the Greek economy became more granular. The contribution of the direct effect of firm-specific shocks in driving aggregate volatility increased by 75%.

The preponderance of inter-firm linkages in driving aggregate fluctuations is likely due to important production and financial networks across firms. The explanation for the input-output linkages is simple. Firms build a network with other firms in order to obtain inputs and to sell their products. A shock to a single firm could have much larger repercussions on the macroeconomy if it diminishes the output of not only this firm, but also of others that are associated with it through a network of input-output linkages (Acemoglu et al., 2012). Financial networks arise from mutual lending and borrowing relationships among firms. Therefore, a financial shock on one firm can be dispersed into the firms that are connected with that via these lending or borrowing interconnections (Cabrales et al., 2015). A sec-

rm sales growth to respond heterogeneously to macroeconomic and sectoral shocks with respect to three observable firm characteristics: firm age, firm size, and various measures of financing constraints. See section 2.5.1 for more details

	Obs	Mean	St. Dev.	Correlation
Actual	406,670	-0.017	0.653	1.000
Firm-specific	406,670	0.000	0.637	0.987
Macro-sectoral	1,377	-0.012	0.173	0.065

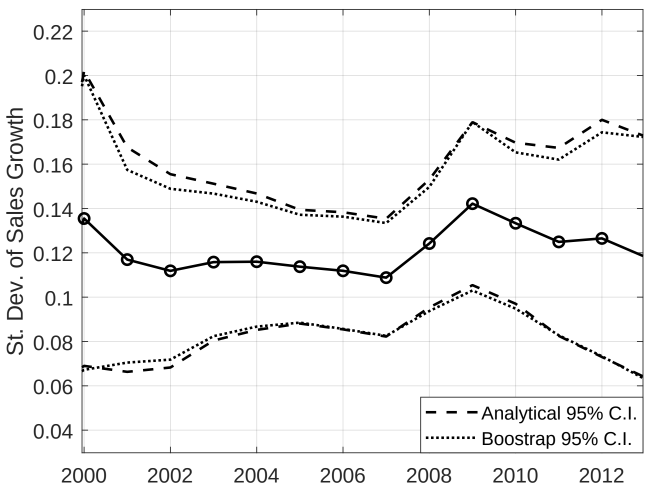
Notes: "Actual" refers to $g_{i,t}$, "Firm-specific" to $\varepsilon_{i,t}$, and "Macro-sectoral" to $\delta_{j,t}$ (equation (2.1)). Column (2) reports the average $g_{i,t}$, $\varepsilon_{i,t}$, and $\delta_{j,t}$ in the sample of firms and years. Column (3) reports the average sample standard deviation of $g_{i,t}$, $\varepsilon_{i,t}$, and $\delta_{j,t}$. Column (4) presents the correlation between $g_{i,t}$, $\varepsilon_{i,t}$, and $\delta_{j,t}$.

Table 2.2: Summary Statistics and Correlations of Actual Firm-level Growth and Firm-specific VS Sector-specific Components

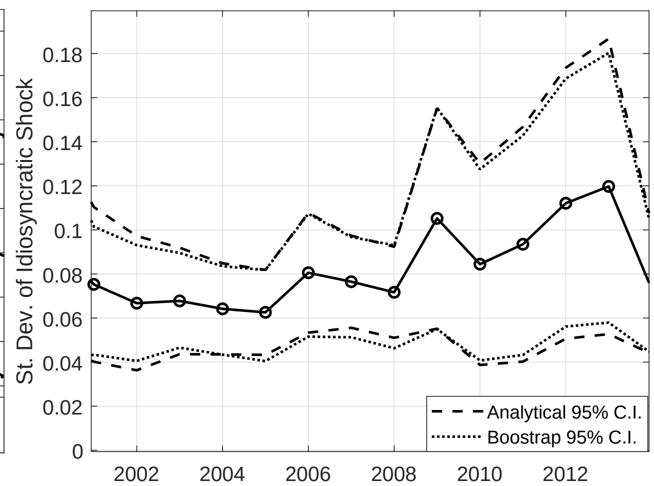
	St. Dev.		
	Whole Period	Pre-crisis	Crisis
Actual	0.1176	0.1149	0.1211
Firm-specific	0.0824	0.0707	0.0980
Macro-sectoral	0.0838	0.0811	0.0875
	Relative St. Dev		
	Whole Period	Pre-crisis	Crisis
Actual	1.0000	1.0000	1.0000
Firm-specific	0.7008	0.6150	0.8094
Macro-sectoral	0.7129	0.7056	0.7222

Notes: The table displays the decomposition of aggregate volatility $\sigma_{A,t}$ of sales growth into firm-specific $\sigma_{F,t}$ and macro-sectoral $\sigma_{J,t}$ components, averaged over the period 2001-2014, the pre-crisis period 2001-2008, and the crisis period 2009-2014.

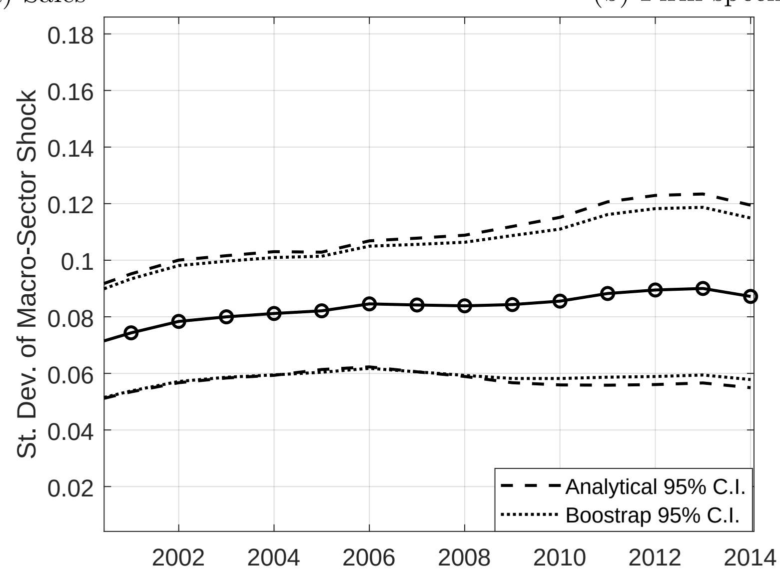
Table 2.3: The Impact of Firm-specific and Macro-Sectoral Shocks on Aggregate Volatility



(a) Sales



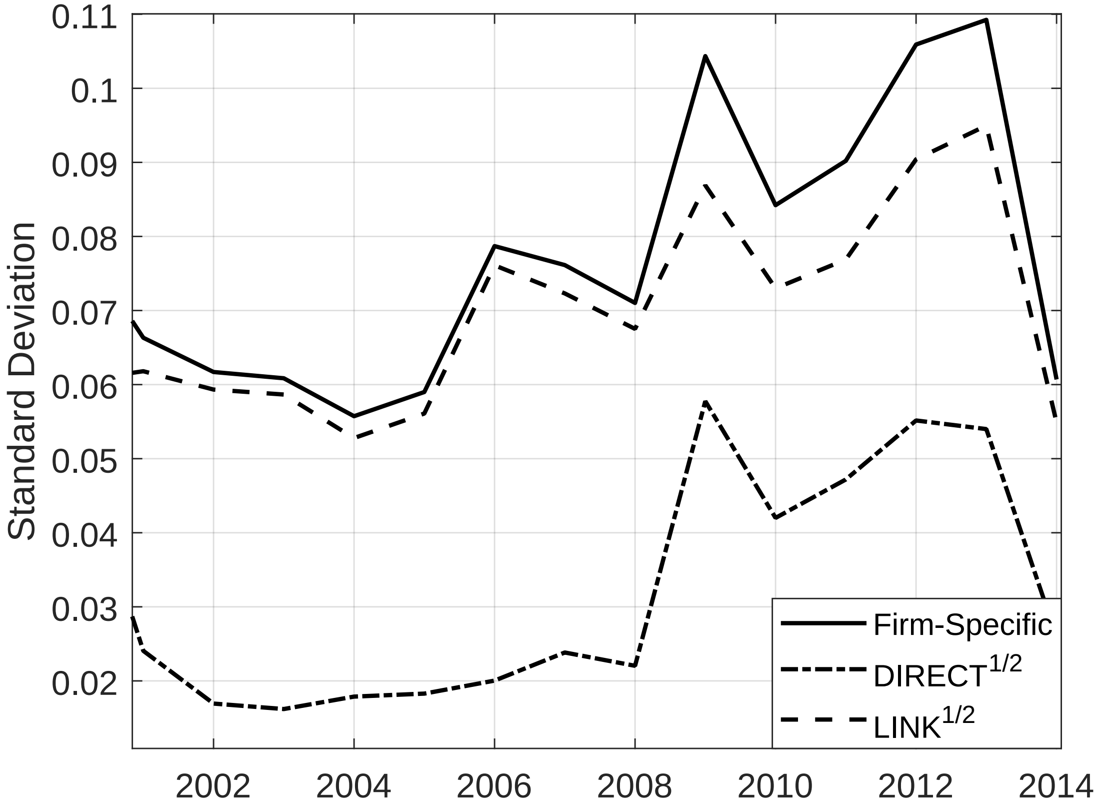
(b) Firm-specific



(c) Macro-Sectoral

Notes: This figure presents the estimates of aggregate shocks $\sigma_{A,t}$ into firm-specific $\sigma_{j,t}$ and sector-specific $\sigma_{F,t}$ components from the Greek economy over the period 2001-2014, along with both analytical and bootstrap 95% confidence intervals, according to the variance decomposition (3.4).

Figure 2.3: Volatility of sales growth and its components



Notes: This figure presents a decomposition of the firm-specific aggregate variance into two components that measure the contribution of firm-specific variances ($\sqrt{DIRECT_t}$) and of covariances across firms ($\sqrt{LINK_t}$). The decomposition is based on equation (3.5).

Figure 2.4: Contribution of individual volatilities and covariance terms to firm-specific fluctuations

ond element of inter-firm financial linkages is the confidence in the credit quality of particular firms. If a firm's perceived ability to pay declines for whatever reason, then so does the market value of its liabilities. In a mark-to-market regime this reduction in value can spread to other firms that hold these liabilities among their assets (Glasserman and Young, 2015).

Percentiles of Sales Distribution	Firm exits during Crisis	Exits as percentage of Number of Firms
0-20	4,752	70%
21-40	3,185	47%
41-60	3,126	46%
61-80	1,966	29%
81-100	1,241	18%
Top 100 firms	0	0

Notes: In this table we analyze the exit behavior during the crisis (2009-2014) of firms that existed in 2008. We do this by size groups. We define size categories using percentiles of the 2008 sales distribution. In the third column we present the ratio of firm exits that occurred during the crisis as a share of the number of firms in 2008. There is a clear negative relationship between hazard and firm size. This finding lies in accordance with the results of Giannoulakis and Sakellaris (2020). These authors found that the survival probability of Greek firms during the period 2001-2014 is negatively correlated with firm size.

Table 2.4: Firm Exits by Size during the crisis

Finally, the increased importance of the direct component during the financial crisis seems to be due to differential firm exit rates by size category. Table 2.4 presents the exit behavior during the crisis (2009-2014) of firms that existed in 2008 (i.e. the last year before the eruption of the crisis). As we can observe exit rates during the crisis were higher for small firms.

As a result the Herfindahl index of firm sales shares rose from 0.065 in the pre-crisis period to 0.081 during the crisis.

2.5 Sensitivity Analysis

2.5.1 The Role of Firm-specific Factors

There is a growing literature in macroeconomics and corporate finance that has strived to document heterogeneous responses of firms to aggregate fluctuations. This literature has attributed these heterogeneous responses of firms to various firm-specific factors such as: firm age and firm size (Fort et al., 2013; Siemer 2019), access to capital markets (Gertler and Gilchrist, 1994; Chodorow-Reich, 2014), intensity of research and development (Comín and Philippon, 2005), and export intensity (Blum et al., 2013). For Greece, Giannoulakis and Sakellaris (2020) examined the heterogeneous responses of Greek firms to the 2009 financial crisis with respect to their age, size and the financing constraints they face.

Therefore, it is quite possible that firms will react differently to sector- and macro-level shocks due to firm-specific factors and not due to idiosyncratic shocks. If this is the case, the estimated values of $\varepsilon_{i,t}$ from growth decomposition (2.3) will reflect not only idiosyncratic shocks to firms, but also the heterogeneous responses of firms to the aggregate and sectoral shocks.

In order to disentangle the role of heterogeneous firm responses, due to observable firm-specific factors, in the impact of firm-specific shocks on aggregate fluctuations, we estimate the following augmented version of growth decomposition (2.1):

$$g_{i,t} = \delta_{j,t} + \delta_{j,t} \times SF_{i,t} + \beta SF_{i,t} + \varepsilon_{i,t} \tag{2.6}$$

where $SF_{i,t}$ is a particular observable firm-specific factor. This augmented econometric specification allows heterogeneity of firm responses to country- and sector-level shocks to be systematically related to observable firm characteristics, apart from idiosyncratic shocks. We use three firm characteristics that they have been widely adopted in the literature (di Giovanni et al., 2014): (i) firm age[13], (ii) firm size (sales quintile dummy), (iii) financial leverage (quintile dummy for the firm's debt-to-assets ratio[14]). We also examine the case in which all of the aforementioned firm-specific characteristics are included together.

In Table 2.5 we present the results for econometric specification (2.6). Clearly, firm age and size have a negative impact on firm sales growth whilst leverage has a positive one. These results are in accordance with the findings of Giannoulakis and Sakellaris (2020). In this paper, the authors documented that young and small firms exhibited higher sensitivity, in terms of sales growth, to the Greek crisis than their large and mature counterparts. They found also that a large part of this differential impact of the Greek crisis on firm growth stemmed from financing constraints that young and small firms face.

Although the three firm characteristics have a significant impact on firm growth, the question is whether or not they affect the volatility of the latter, or in other words which is the role of these factors in business cycle fluctu-

[13] Following Haltiwanger et al. (2013) and Giannoulakis and Sakellaris (2020) we use a dummy variable that receives the value 1 if firms are young (less than 5 years old) and the value 0 otherwise.

[14] As an alternative measure of financial leverage we use the debt-to-sales ratio. The results are very similar

	Whole Period	**Pre-crisis Period**	**Crisis Period**
	Controlling for Age Effects		
Age coefficient	-0.516***	-0.452***	-0.617***
	(0.021)	(0.026)	(0.035)
	Controlling for Size Effects		
Size coefficient	-0.137***	-0.141***	-0.131***
	(0.007)	(0.008)	(0.010)
	Controlling for Financial Effects		
Leverage coefficient	0.114***	0.154***	0.096***
	(0.011)	(0.017)	(0.013)
	Controlling for All the Effects		
Age coefficient	-0.426***	-0.373***	-0.514***
	(0.021)	(0.026)	(0.036)
Size coefficient	-0.103***	-0.117***	-0.088***
	(0.007)	(0.008)	(0.010)
Leverage coefficient	0.087***	0.165***	0.043***
	(0.010)	(0.016)	(0.013)

Notes: In this table we investigate the impact of firm age, firm size and financial leverage on firm sales growth by estimating the econometric specification (2.6). We report the estimation results for the whole time period 2001-2014, and the pre-crisis (2001-2008) and crisis (2009-2014) periods as well. *, **, *** denote statistical significance at the 10, 5 and 1 percent level respectively. Standard errors are in parentheses.

Table 2.5: The Impact of Firm-specific Factors on Firm Growth

ations. To answer this question, we re-estimate the variance decomposition (2.4) using equation (2.6).

Table 2.6 presents the results. Allowing firms to exhibit heterogeneous responses to macro-sectoral shocks according to the three aforementioned firm-specific factors had an almost imperceptible impact on the firm-specific component of the aggregate volatility either focusing on the whole sample period or on the pre-crisis and crisis period separately. To be more precise, allowing firm sensitivity to differ by firm age or access to finance led to a very small fall of the contribution of firm-specific shocks in the aggregate volatility whilst allowing heterogeneous firm responses across firm size distribution had led to a very small increase. Also we observe a tiny fall in the relative standard deviation of the idiosyncratic component in the case of the inclusion of all firm characteristics in model (2.6). In any case, these changes were extremely small and cannot bring our conclusions about the role of idiosyncratic shocks in aggregate fluctuations into question. This is clear even when we examine the two effects (the "direct" and the "linkage") of the idiosyncratic component separately.

It is noteworthy that in all different versions of econometric specification (2.6), independently of which control we include, the contribution of idiosyncratic component to aggregate fluctuations became significantly larger during the crisis. This result verifies our conclusion that firm-specific shocks contribute much more to economic downturns - or more precisely to financial crises (as the Greek Depression was) - than to business cycle upturns.

In summary, our results are robust to allowing for firm sales growth to respond heterogeneously to macroeconomic and sectoral shocks according to systematic firm-specific factors. Thus, a large part of the heterogeneous response of firms to business cycle fluctuations can be attributed to idiosyn-

	Whole Period		Pre-crisis Period		Crisis Period	
	St. Dev	Relative SD	St. Dev	Relative SD	St. Dev	Relative SD
Actual	0.1176	1.0000	0.1149	1.0000	0.1211	1.0000
Differing Firm Sensitivity by Age						
Firm-specific	0.0802	0.6821	0.0684	0.5956	0.0959	0.7915
Direct	0.0308	0.3650	0.0193	0.2810	0.0462	0.4770
Linkage	0.0734	0.9237	0.0656	0.9591	0.0838	0.8763
Differing Firm Sensitivity by Size						
Firm-specific	0.0864	0.7346	0.0769	0.6694	0.0990	0.8171
Direct	0.0305	0.3387	0.0189	0.2481	0.0460	0.4596
Linkage	0.0800	0.9322	0.0745	0.9675	0.0874	0.8851
Differing Firm Sensitivity by Finance (Debt-to-assets)						
Firm-specific	0.0777	0.6610	0.0660	0.5746	0.0933	0.7702
Direct	0.0305	0.3732	0.0190	0.2871	0.0459	0.4880
Linkage	0.0708	0.9197	0.0632	0.9572	0.0810	0.8698
Differing Firm Sensitivity by Age, Size and Finance						
Firm-specific	0.0794	0.6753	0.0703	0.6120	0.0915	0.7553
Direct	0.0303	0.3660	0.0191	0.2734	0.0452	0.4894
Linkage	0.0726	0.9211	0.0676	0.9604	0.0793	0.8687

Notes: This Table reports the estimated firm-specific component of aggregate volatility under the augmented model (2.6) in which firms are allowed to exhibit heterogeneous sensitivity to sectoral shocks according to 3 observable firm-specific characteristics: firm age, firm size and access to finance. We report these results for the whole time period 2001-2014, and the pre-crisis (2001-2008) and crisis (2009-2014) periods as well. The word "Actual" denotes the average standard deviation of actual aggregate sales growth over 2001 - 2014 which is given by $\frac{1}{T}\sum_{t=2001}^{2014}\sigma_{A,t}$. The term "Firm-specific" stands for the average standard deviation of the firm-specific component, $\frac{1}{T}\sum_{t=2001}^{2014}\sigma_{F,t}$, and its average value relative to the actual, $\frac{1}{T}\sum_{t=2001}^{2014}\frac{\sigma_{F,t}}{\sigma_{A,t}}$. The words "Direct" and "Linkage" denote the direct $\left(\sqrt{\sum_{i=1}^{M} w_{i,t-1}^2 Var\left(\varepsilon_{i,t}\right)}\right)$ and the linkage $\left(\sqrt{\sum_{k\neq i} w_{k,t-1}w_{i,t-1}Cov\left(\varepsilon_{k,t},\varepsilon_{i,t}\right)}\right)$ effect of the idiosyncratic component, respectively. "Size" is the dummy for the firm's quintile in the sales distribution. "Age" is the dummy for whether the firm is more than 5 years old. "Finance" is the quintile dummy for the firm's debt-to-assets ratio which constitutes a proxy for the financing constraints that a firm faces.

Table 2.6: Systematic firm heterogeneity VS firm-specific shocks

cratic shocks.

2.5.2 Results for the Manufacturing Sector: an exporting sector

Unlike di Giovanni et al. (2014) our dataset does not contain export data. Thus, we cannot distinguish differentiation of sales shocks by destination of exports and we concentrate on decomposing total firms sales into aggregate and firm-level components. To check whether this affects our results much we study a single sector that has more exporting activity than the rest of the economy, manufacturing, and contrast it to the whole economy, that contains many non-tradeable sectors. If export-destination demand shocks are not accounted for by a macro-sector-destination component, they will show up as firm-specific shocks. Furthermore, they will show up as higher covariance terms (LINK) in the decomposition of firm-specific shock volatility to DIRECT and LINK. If export-destination demand shocks are important for Greece, we would expect to find that in manufacturing the contribution of firm-specific shocks to aggregate fluctuations is higher than it is in the whole economy. Furthermore, we would expect to find that in manufacturing the contribution of LINK to firm-specific shock volatility is higher than it is in the whole economy.

In fact we find the opposite. The contribution of both shocks to aggregate fluctuations was higher than that of idiosyncratic shocks both before and during the crisis. Despite the fact that the contribution of firm-specific shocks increased (about 23 %) after 2009, it did not dominate the contribution of macro-sectoral shocks (which also increased by 15 %).

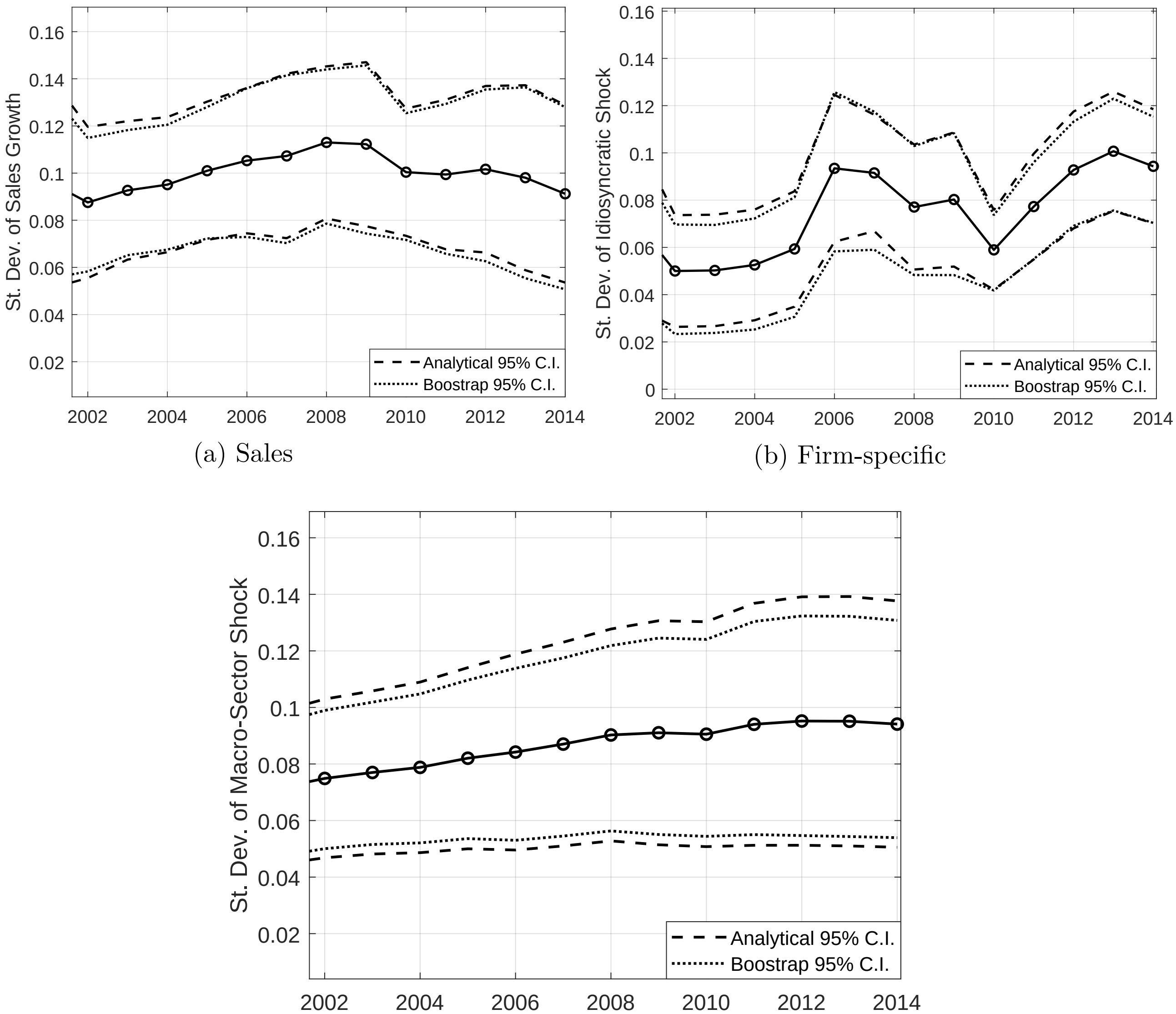
Moreover, we find that the direct component of the idiosyncratic volatility is larger in the manufacturing sector than in the entire economy, especially after the start of the Greek financial crisis.

These results, and the fact that Greece is a low-exporting economy, lead us to believe that the absence of firm export-destination data do not affect much our results.

	St. Dev.		
	Whole Period	Pre-crisis	Crisis
Actual	0.1001	0.0998	0.1005
Firm-specific	0.0750	0.0682	0.0841
Macro-sectoral	0.0861	0.0807	0.0933
	Relative St. Dev		
	Whole Period	Pre-crisis	Crisis
Actual	1.0000	1.0000	1.0000
Firm-specific	0.7490	0.6830	0.8364
Macro-sectoral	0.8603	0.8086	0.9288

Notes: The rows of the table refer to the decomposition of aggregate shocks $\sigma_{A\tau}$ into firm-specific $\sigma_{F\tau}$ and sector-specific $\sigma_{j\tau}$ components for the sector of Manufacturing, averaged over the period 2001-2014, the pre-crisis period 2001-2008 and the crisis period 2009-2014.

Table 2.7: The Aggregate Impact of Firm-specific Shocks on Aggregate Volatility in the Manufacturing Sector

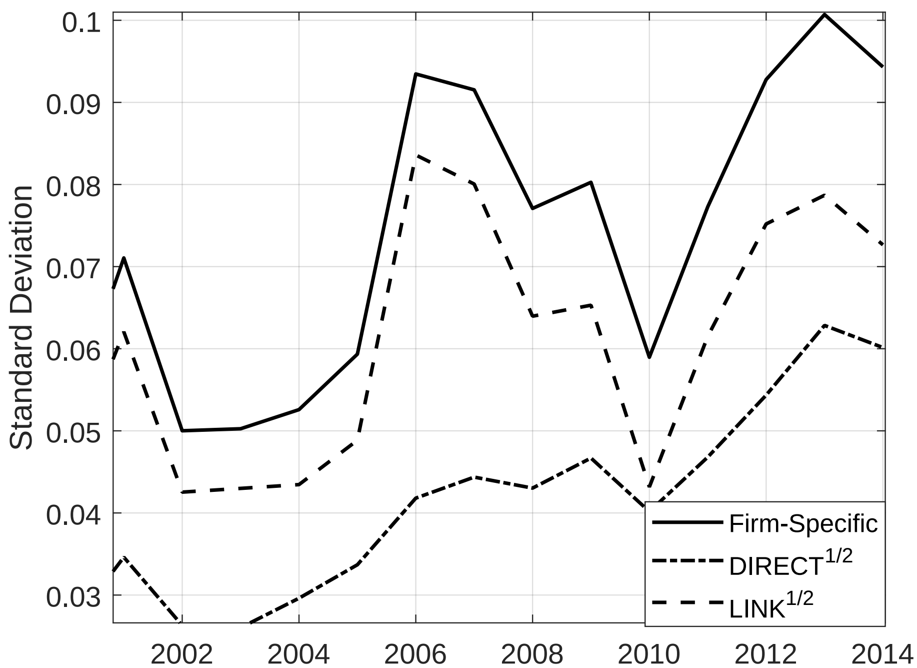


(a) Sales (b) Firm-specific

(c) Macro-Sectoral

Notes: This figure presents the estimates for the volatility of aggregate shocks $\sigma_{A\tau}$and for its firm-specific $\sigma_{F\tau}$ and sector-specific $\sigma_{j\tau}$ components from the manufacturing sector over the period 2001-2014, along with both analytical and bootstrap 95% confidence intervals, according to the variance decomposition (2), described in the main text.

Figure 2.5: Volatility of sales growth and its components in the Manufacturing Sector



Notes: This figure presents a decomposition of the firm-specific aggregate variance into two components that measure the contribution of firm-specific variances ($\sqrt{DIRECT_\tau}$) and of covariances across firms ($\sqrt{LINK_\tau}$). The decomposition is based on equation (2.5) of the main text.

Figure 2.6: Contribution of individual volatilities and covariance terms to firm-specific fluctuations

2.6 Conclusions

Using the Greek economy as a laboratory, we bring new evidence on microeconomic sources of aggregate fluctuations and, particularly, of large economic downturns caused by financial crises. We find that firm-specific shocks contributed substantially to the volatility of aggregate sales growth.This contribution became substantially larger during the crisis.

This study also highlights the role of inter-firm networks in amplifying and propagating these firm-level idiosyncratic shocks through the aggregate economy. Throughout the sample period, firm linkages are two and a half times as important as the direct effect of firm-specific shocks in driving aggregate fluctuations. During the financial crisis, the Greek economy became more granular and the direct effect of firm-specific shocks had increased importance in driving aggregate volatility.

Our findings indicate that for a deep insight into the mechanics of large downturns associated with financial crises, it is important to model firm heterogeneity. In addition, it is important to study models that capture inter-firm network propagation mechanisms of idiosyncratic shocks to firms.

Appendix

A Data

The firm-level data are proprietary and they have been obtained from the ICAP Group, S.A., a private research company which collects detailed balance sheet and income statement data for SA and Ltd companies in Greece, together with their establishment date, location and ownership status, for credit risk evaluation and management consulting. ICAP data is used by commercial banks for credit decisions and by the central bank for credit rating information. Thus, the data are carefully controlled. Our dataset contains firm-level information for approximately 50,000 Greek firms operating in all sectors, except for banks and insurance companies, for the time period 2000 - 2014. For this chapter we use information on gross sales, total balance-sheet assets, long-term and sort-term liabilities, year of establishment, and NACE rev. 2 codes.

We prepare the data for estimation in two stages. First, we clean the data from basic reporting mistakes. Second, we transform our dataset in order to be compatible with the methodology of di Giovanni et al. (2014).

In particular, we implement the following steps to clean the data:

1. We set to missing firm-year observations of gross sales that are negative.

2. We drop firm-year observations that have missing information on gross sales.

3. We audit for duplicates in our data.

4. We trimmed bottom and top 1% of the sales growth rates series to exclude extreme values from our analysis[15].

[15] di Giovanni et al. (2014) dropped observations where the annual firm sales growth rate was less than

5. Following the methodology of di Giovanni et al. (2014), we restrict our sample to the intensive margin of aggregate sales growth by excluding firm-year observations where a firm is an entrant or an exiter.

To our knowledge, this is the first study to use so large and representative a firm-level dataset for the Greek economy. A natural question that might arise here is whether our firm-level dataset resembles the aggregate Greek economy. The coverage in our sample is consistently high. In particular, the ratio of aggregate gross output[16] recorded in our sample relative to the same variable in national level averages roughly 58 percent for the aggregate economy. This percentage is conservative because we have dropped observations with missing, zero, or negative values for gross sales. Gross output is taken from Eurostat, as reported by its Structural Business Statistics (SBS). The data in Eurostat are from Census sources and represent the universe of firms.

B Test of the Granular Hypothesis (Gabaix, 2011)

In this section, we employ the standard approach of Gabaix (2011) to identify firm-level idiosyncratic shocks and quantify their impact on the aggregate economy. In other words, we test the granular hypothesis for Greece.

Gabaix (2011) demonstrated that if the granular hypothesis (GH hereafter) holds, then a regression of the growth rate of any economic aggregate on the granular residual (2.2) should yield a R-squared value significantly larger than zero, since the R-squared identifies the part of the volatility

−50% and greater than 200%. Since our datset covers the crisis era, i.e. a period of extremely negative growth rates, we cannot use the aforementioned cut-offs. Therefore, to exclude extreme values from our dataset we trimmed the bottom and top 1% of the observations of sales growths rates.

[16]Gross output is defined by the Bureau of Economic Analysis (BEA) as: "a measure of an industry's sales or receipts, which can include sales to final users in the economy (GDP) or sales to other industries (intermediate inputs). At the firm-level, gross output was measured by aggregate gross sales.

of the economic aggregate that is explained by variations in the granular shock. Let Y_t denote a national-level aggregate. To test the validity of the GH we use the following econometric specification:

$$\Delta \ln Y_t = \beta_0 + \beta_1 G_t + u_t \tag{B1}$$

The economic aggregate Y_t is vital for our analysis. Since we do not have the universe of the Greek firms it would not be appropriate to employ a macro variable as a proxy for Y_t, as the majority of the literature does (Gabaix, 2011; Foster et al., 2011; and Popova, 2019). Therefore, we define Y_t as the aggregate sales from our firm-level dataset. Nevertheless, we use the gross output (received by the Eurostat Database) and the GDP (received by the OECD Database) at national level to audit the robustness of our results.

In order to investigate whether the eruption of the Greek crisis affected the granularity of the Greek economy we also estimate equation (B1) for two sub-periods: the "pre-crisis" (2000-2008) and the "crisis" (2009-2014).

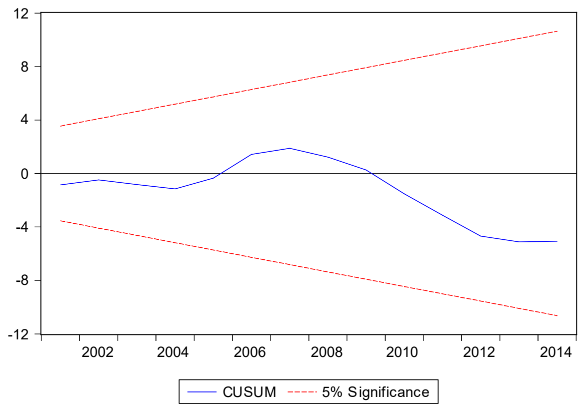
We estimate econometric specification B1 using OLS with heteroskedasticity and autocorrelation consistent (HAC) standard errors. Many statistical concerns arise from the very small sample size. In order to examine, to the extent possible, the validity of our estimates we perform a variety of tests. First, we examine whether residuals are uncorrelated (using the Breusch-Godfrey LM test for 1st order autocorrelation) and normally distributed (using the Jarque-Bera normality test). The tests for all estimated equations reveal that there is no serial correlation in the residuals and that the latter follow the normal distribution (see Tables B1 and B2). Second, we test for the dynamic stability of the estimated parameters using the cumulative sum test (CUSUM). Figure B1 shows that the estimated parameters of the basic econometric specification are stable over time. We also find stable parameters for all the alternative specifications[17].

Tables B1 and B2 present the estimation results for econometric specification (B1). All the regressions are supportive of the granular hypothesis. Starting with the basic specification, we can see that the Greek economy is highly granular: firm-specific shocks accounted for the 62% of the aggregate fluctuations during the period 2000-2014. It is also noteworthy that the economy became even more granular during the depression, a fact that reveals the vital role that firms played in the intensity of the Greek crisis. The restriction of the granular shock only to the 1% of the largest firms reduces the R^2 value by 0.11. Although, the largest part of the granularity is driven by the top 1% firms, the rest 99% has also a considerable impact on aggregate fluctuations and should not be ignored.

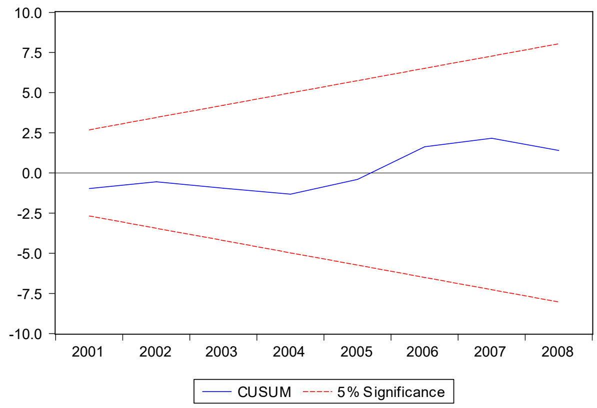
The contribution of the idiosyncratic shocks to the business cycles is smaller when we use the macro variables. However, this finding should not surprise us. Our dataset does not cover the universe of the Greek firms (it covers approximately the 58% of it). Therefore, it is reasonable to find a smaller contribution of the firm-specific shocks to the volatility of the macroeconomic variables.

In any case, if only aggregate shocks were important and not idiosyncratic, then the R^2 of all the regressions in Table 2 would be zero. Hence, the good explanatory power of the granular residual is inconsistent with the assumption of many macroeconomic models that shocks to individual firms cancel out in the aggregate. In other words, the granular hypothesis is valid for the case of Greece. Also the sensitivity of aggregate fluctuations

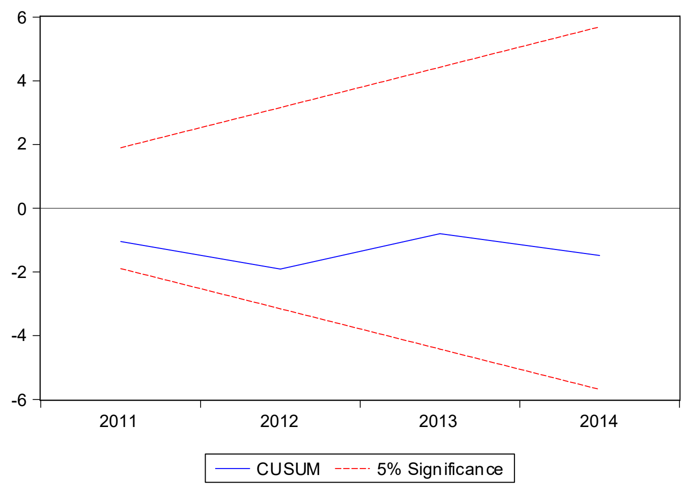
[17] We do not present here the relevant CUSUM graphs, however they are available upon request.



(a) Whole Sample



(b) Pre-crisis Period



(c) Crisis Period

Notes: This figure presents the CUSUMs (cumulative sum control charts) for the estimated model B1. The CUSUM test is based on the cumulative sum of the recursive residuals. We plot the cumulative sum together with the 5% critical lines. The test indicates parameter stability if the cumulative sum goes inside the area between the two critical lines.

Figure B1: CUSUM tests for Parameter Stability

	All firms				Top 1% Largest Firms	
	Whole-sample		Pre-crisis	Crisis	(Whole sample)	
G_t	0.939***	0.981**	0.600**	1.468***	0.393***	1.542***
	(0.260)	(0.257)	(0.102)	(0.094)	(0.334)	(0.219)
$G_{t\text{-}1}$		-0.091				0.008
		(0.221)				(0.460)
Intercept	0.127***	0.121***	0.113***	0.179***	0.234***	0.112***
	(0.020)	(0.031)	(0.011)	(0.014)	(0.051)	(0.036)
R^2	0.65	0.65	0.58	0.92	0.54	0.49
Adj.R^2	0.62	0.60	0.53	0.90	0.51	0.41
Breush-Godfrey LM Test	0.092	0.067	0.778	0.583	0.163	0.186
Jarque-Bera Test	0.223	0.496	0.593	0.759	0.548	0.577
Parameter Stability	yes	yes	yes	yes	yes	yes

Notes: For the year t = 2000 to 2014, aggregated firm-sales growth is regressed on the granular residual G_t. The firms are the largest by sales of the previous year. Robust standard errors are given in parentheses. The null hypothesis for the Breusch-Godfrey LM test for 1st order autocorrelation is that there is no serial correlation. The null hypothesis for the Jarque-Bera normality test is that the residuals are normally distributed. Parameter stability has been examined through the CUSUM (cumulative sum control chart) test.

Table B1: Test of Granular Hypothesis

	Gross Output			Gross Domestic Product		
	Whole-sample	Pre-crisis	Crisis	Whole-sample	Pre-crisis	Crisis
G_t	0.357*	0.143	0.426**	0.319*	0.009	0.642*
	(0.176)	(0.089)	(0.058)	(0.162)	(0.126)	(0.235)
Intercept	0.065**	0.097***	0.024**	0.068***	0.060**	0.082**
	(0.025)	(0.020)	(0.008)	(0.023)	(0.016)	(0.027)
R^2	0.21	0.00	0.53	0.21	0.000	0.42
Adj.R^2	0.16	-0.11	0.41	0.15	-0.011	0.27
Breush-Godfrey LM Test	0.069	0.581	0.658	0.198	0.315	0.134
Jarque-Bera Test	0.693	0.728	0.358	0.937	0.934	0.653
Parameter Stability	yes	yes	yes	yes	yes	yes

Notes: For the year t = 2000 to 2014, gross output and gross domestic product are regressed on the granular residual G_t. Robust standard errors are given in parentheses. The null hypothesis for the Breusch-Godfrey LM test for 1st order autocorrelation is that there is no serial correlation. The null hypothesis for the Jarque-Bera normality test is that the residuals are normally distributed. Parameter stability has been examined through the CUSUM (cumulative sum control chart) test.

Table B2: Robustness Checks

in firm-specific shocks was amplified during the Greek Depression, implying that individual shocks to firms constitute an important contributor to large economic downturns associated to financial crises.

C Exporting Activity

	Greece	France	Sweden	EU
1998-2014	22.81	27.55	44.33	37.48
1998-2009	20.73	27.08	43.62	35.58
2010-2014	27.81	28.69	44.34	42.05

Table C1: Exports as percentage of GDP

Source: World Bank

Bibliography

[1] Acemoglu, D., V.M. Carvahlo, A. Ozdaglar, and A. Tahbaz-Salehi, 2012, "The Network Origins of Aggregate Fluctuations", Econometrica, Vol. 80, No. 5, pp. 1977–2016.

[2] Acemoglu, D., A. Ozdaglar, and A. Tahbaz-Salehi, 2013, "The Network Origins of Large Economic Downturns", NBER Working Paper No. 19230.

[3] Acemoglu, D., A. Ozdaglar and A. Tahbaz-Salehi, 2014, "Microeconomic Origins of Macroeconomic Tail Risks", NBER Working Paper No. 20865.

[4] Acemoglu, D., A. Ozdaglar, and A. Tahbaz-Salehi, 2014, "Systemic risk andstability in financial networks" American Economic Review, Vol. 105, No. 2, pp. 564–608.

[5] Acemoglu, D., U. Akcigit, and W. Kerr, 2016, "Networks and the Macroeconomy: An Empirical Exploration", NBER Macroeconomics Annual, Vol. 30, No. 1, pp. 276—335.

[6] Baqaee, D., 2015, "Labor Intensity in an Interconnected Economy", Harvard Working Paper.

[7] Barrot, J.N. and J. Sauvagnat, 2016, "Input Specificity and the Propagation of Idiosyncratic Shocks in Production Networks", Quarterly Journal of Economics, Vol. 131, No. 3, pp. 1543—1592.

[8] Bloom, N., 2009, "The Impact of Uncertainty Shocks", Econometrica, Vol. 77, No. 3, pp. 623–685.

[9] Blum, B.S., S. Claro, and I. Horstmann, 2013, "Occasional and Perennial Exporters", Journal of International Economics, Vol. 90, No. 1, pp. 65–74.

[10] Bloom, N., M. Floetotto, N. Jaimovich, I. Saporta-Eksten, and S.J. Terry, 2012, "Really Uncertain Business Cycles", NBER Working Paper No. 18245.

[11] Cabrales, A., D. Gale, and P. Gottardi, 2016, "Financial Contagion in Networks", In Oxford Handbook of the Economics of Networks, edited by Yann Bramoulle, Andrea Galeotti, and Brian Rogers, pp. 543–68. Oxford and New York: Oxford University Press.

[12] Caliendo, L., F. Parro, E. Rossi-Hansberg, and P.D. Sarte, 2018, "The Impact of Regional and Sectoral Productivity Changes on the U.S. Economy", Review of Economic Studies, Vol. 85, No. 4, pp. 2042—2096.

[13] Carvalho, V., 2008, "Aggregate Fluctuations and the Network Structure of Intersectoral Trade", CREI Working Paper.

[14] Carvalho, V. M., and X. Gabaix, 2013, "The Great Diversification and Its Undoing", American Economic Review, Vol. 103, No. 5, pp. 1697–1727.

[15] Chang, M., X. Chen and F. Schorfheide, 2018, "Heterogeneity and Aggregate Fluctuations", Manuscript, University of Pennsylvania

[16] Chodorow-Reich, G., 2014, "The Employment Effects of Credit Market Disruptions: Firm-level Evidence from the 2008-9 Financial Crisis," The Quarterly Journal of Economics, Vol. 129, No. 1, pp. 1-59.

[17] Chodorow-Reich, G., L. Karabarbounis and R. Kekre, 2019, "The Macroeconomics of the the Greek Depression", NBER Working Paper No. 25900.

[18] Christiano, L.J., R. Motto, and M. Rostagno, "Risk shocks", American Economic Review, Vol. 104, No. 1, pp. 27–65.

[19] Comin, D., and T. Phillippon, 2006, "The Rise in Firm-Level Volatility: Causes and Consequences", in NBER Macroeconomics Annual 2005, Vol. 20, ed. by M. Gertler and K. S. Rogoff. Cambridge, MA: MIT Press, Chapter 1, pp. 167–201. [1307,1333

[20] Di Giovanni, J., A.A. Levchenko and I. Méjean, 2014, "Firms, destinations, and aggregate fluctuations", Econometrica, Vol. 82, No. 4, p. 1303–1340.

[21] Economides, G., Dimitris Papageorgiou and A. Philippopoulos, 2017, "The Greek Great Depression: A General Equilibrium Study of its Drivers", in Political Economy Perspectives on the Greek Crisis, ed. by D. C. I Bournakis, C Tsoukis, and T. Palivos, pp. 205-221, Palgrave Macmillan.

[22] Foerster, A.T., P.D.G. Sarte and M.W. Watson, 2011, "Sectoral versus

aggregate shocks: A structural factor analysis of industrial production", Journal of Political Economy, Vol. 119, No. 1, p. 1–38.

[23] Fort, T.C., J. Haltiwanger, R.S. Jarmin and J. Miranda, 2013, "How Firms Respond to Business Cycles: The Role of Firm Age and Firm Size", IMF Economic Review, Vol. 61, No. 3, pp 520–559.

[24] Friberg, R., and M. Sanctuary, "The contribution of firm-level shocks to aggregate fluctuations: The case of Sweden", Economics Letters, Vol. 147, pp. 8–11.

[25] Gabaix, X., 2011, "The granular origins of aggregate fluctuations", Econometrica, Vol. 79, No. 3, pp. 733–772.

[26] Gertler, M. and S. Gilchrist, 1994, "Monetary Policy, Business Cycles, and the Behavior of Small Manufacturing Firms", Quarterly Journal of Economics, Vol. 109, No. 2, pp. 309-340.

[27] Giannoulakis, S. and P. Sakellaris, 2020, "Firm Growth Dynamics after Large Shocks: Evidence from the Greek Depression", Working Paper.

[28] Gilchrist, S., J.W. Sim, and E. Zakrajšek, 2014, "Uncertainty, financial frictions, and investment dynamics", NBER Working Paper No. 20038.

[29] Giroud, Xavier, and Holger M. Mueller. 2019. "Firms' Internal Networks and Local Economic Shocks." American Economic Review, Vol. 09, No. 10, No. 3617-49.

[30] Glasserman, P., and H.P. Young, 2015, "How likely is contagion in financial networks?", Journal of Banking and Finance, Vol. 50, pp. 383–399.

[31] Glasserman, P., and H.P. Young, 2016, "Contagion in Financial Networks", Journal of Economic Literature, Vol. 54, No. 3, pp. 779-831.

[32] Gourinchas P.O., T. Philippon and D. Vayanos, 2016, "The Analytics of the Greek Crisis", NBER Working Paper No. 22370.

[33] Haltiwanger, J.C., 1997, "Measuring and Analyzing Aggregate Fluctuations: The Importance of Building From Microeconomic Evidence", Federal Reserve Bank of St. Louis Review, Vol. 79, No. 3, pp. 55–77.

[34] Haltiwanger, J., R.S. Jarmin and J. Miranda, 2013, "Who Creates Jobs? Small Versus Large Versus Young", The Review of Economics and Statistics, Vol. 95 No. 2, pp. 347-361.

[35] Huneeus, F., "Production Network Dynamics and the Propagation of Micro Shocks", Working Paper, 2018.

[36] Karasik, L., D. Leung D. and B. Tomlin, 2016, "Firm-specific shocks and aggregate fluctuations", Bank of Canada Staff Working Paper, No. 2016–51.

[37] Long, J. and C. Plosser, 1983, "Real Business Cycles", Journal of Political Economy, Vol. 91, No. 1, pp. 39-69.

[38] Lucas, R.E., 1977, "Understanding Business Cycles", Carnegie-Rochester Conference Series on Public Policy, Vol. 5, No. 1, pp. 7-29.

[39] Obereld, E., 2018, "A theory of input-output architecture", Econometrica, Vol. 86, No. 2, pp. 559-589.

[40] Popova, S., 2019, "Idiosyncratic shocks: estimation and impact on aggregate fluctuations", Bank of Russia Staff Working Paper, No. 2019-46.

[41] Siemer, M., 2019, "Employment effects of financial constraints during the Great Recession", Journal of Economics and Statistics (forthcoming).

Chapter 3

Effects of Fiscal Stimulus on Credit Constraints and the Role of Firm Dynamics

Abstract

During the 2007-09 contraction, the credit crunch in the U.S. economy co-evolved with a dramatic and persistent decline (27%) in firm entry. The massive monetary expansion pursued by the U.S. Federal Reserve during the crisis had limited success in tackling these two phenomena. This study examines whether and to what extent fiscal policy can deal with them. First, a VAR model, covering the period 1993Q3-2019Q4, documents empirically that the expansionary fiscal policy can stimulate both the credit supply and the new business formation. Second, we develop a New Keynesian DSGE model combining endogenous firm entry and firm-level financial constraints to explain this finding. The model implies that a fiscal expansion can relax credit constraints faced by firms, leading to a gradual and persistent rise in firm numbers. We also demonstrate that firm entry dynamics are a crucial

dimension for fiscal policy analysis in the presence of financial frictions. We find that firm entry substantially affects the persistence of the impact of fiscal shocks on the aggregate economy and the size of fiscal multipliers, especially in the long run.

3.1 Introduction

The credit crunch that was driven by a sharp rise in defaults on sub-prime mortgages had a prominent role in the 2007-09 contraction of the U.S. economy. Policymakers in the U.S. primarily focused on expansionary monetary tools (both conventional and unconventional) to alleviate the adverse repercussions of this credit crisis, by amplifying liquidity[1]. According to the so-called credit channel of monetary policy (Bernanke and Gertler, 1995), a monetary expansion should lead to an increase in banking credit. Surprisingly, the intensively expansionary monetary policy pursued by the U.S. Federal Reserve during the recent recession led to a contraction of bank credit (Orlowski, 2016).

The credit crisis co-evolved with a significant and persistent decline in the number of startups. Recent literature documented the interlinkage between these two phenomena[2]. Although there is an important and large literature suggesting that expansionary monetary policy can stimulate new business formation (Bilbiie et al., 2007b; Bergin and Corsetti, 2008; Lewis, 2009;

[1]U.S. Federal Reserve conducted massive and unpreceded liquidity injections on banks during the crisis and its aftermath. The monetary base expanded from $827 billion in 2007 to $3927 billion by the end of 2014 (an increase equal to 375%).

[2]Bergin et al. (2018) showed that a fall in firm entry can be an important part of the transmission of financial shocks to the real economy. Sedlacek (2019) attributed the slow recovery of the U.S. economy from the recent financial crisis to the persistent decline in the firm entry, caused by a worsening in financial conditions (under the presumption that the entry cost faced by potential entrants captures the effects of financial frictions).

Lewis and Poilly, 2012), the decline in new firm entry in the U.S. was quite persistent (firm entry was below its pre-crisis level until late 2014), despite the unprecedented monetary expansion utilized by the U.S. Federal Reserve during the crisis[3].

In light of the limited success of the monetary policy to boost bank credit and support new business formation, and given the interdependence between the two, there is an urgent need to examine alternative corrective policy tools for supporting both credit markets and new firm entry, especially during and after economic downturns. This study asks to what extent fiscal policy can be utilized to both alleviate credit constraints and stimulate firm entry.

As a first step, we employ U.S. quarterly data from the Business Dynamics Statistics (BDS) database spanning the period 1993Q3-2019Q4, aiming at the empirical examination of the dynamic relationship between drops in firm entry and credit supply. By using a vector autoregressive (VAR) model, we document that expansionary fiscal policy can stimulate both the credit supply and the new business formation, leading to a significant expansion of aggregate output.

We develop a New Keynesian model with endogenous firm entry, firm-level collateral constraints and rich specifications of fiscal rules to interpret and further analyze this empirical finding. We build on the pioneer model of endogenous entry of Bilbiie et al. (2007a; 2012). New firms enter after paying a one-time sunk cost, and each firm produces a differentiated good, under conditions of monopolistic competition. We extent this setup in three directions. First, following Bergin et al. (2018), we assume that firms fi-

[3]Lewis (2009) and Lewis and Poilly (2012) empirically demonstrate that net firm entry increases only with a significant lag after a monetary expansion.

nance entry and production (working capital) through an endogenous mix of debt and equity. Debt is created by an intra-period loan that is subject to an enforcement constraint. Second, following Bilbiie et al. (2007b), we assume that both incumbents and entrants face a nominal rigidity in the form of a quadratic cost of adjusting prices over time. Third, we incorporate a rich description of fiscal policy, based on three fiscal instruments: government spending, a tax on labor income, and a tax on firm revenue. We use detailed specifications for fiscal rules according to which all fiscal policy instruments respond to both the level of public debt and the state of economic activity, leading to a procyclical fiscal policy and non-trivial debt dynamics (Leeper et al., 2010).

Firms' endogenous decision on the means of financing between equity and debt connects credit constraints with firm entry dynamics. Moreover, the rich description of fiscal policy in our model allows us to carefully layout the effects of fiscal policy on credit conditions and firm dynamics. Our approach consists of two steps. First, we analyze the dynamic effects of fiscal stimulus in the short-run. Fiscal stimulus takes the usual form of an increase in government spending or a decrease in taxes (on either labor income or firm revenue). Fiscal expansion spurs aggregate demand, which raises firm production and profits (dividends). The rise in current dividends attracts investors, making them more willing to invest either to incumbent or new firms. As a result, equity prices rise. Since equity is used as collateral, the financing constraints faced by firms are easing, and thus the credit conditions are improving. The business environment becomes temporarily more attractive, drawing a higher number of entrants which translates into a gradual increase in the total mass of firms in the economy. Hence, firm entry is post-cyclical. The gradual adjustment in firm numbers smooths the boost of the real economy created by the fiscal stimulus. We also find that this gradual adjustment substantially increases the persistence of the impact of fiscal shocks on the real economy. So, the model implies that expansionary fiscal policy can both alleviate credit constraints and facilitate firm entry, stimulating the real economy.

Next, we quantify the dynamic effects of fiscal shocks in the medium and long runs calculating the present-value multipliers (Moutford and Uhlig, 2009) for output from changes in government spending, labor tax rates, and firm revenue tax rates. We find that present-value multipliers change substantially when the firm entry dimension is taken into consideration in a context with financial frictions. Adjustments in firm numbers lead to higher government spending multipliers at shorter horizons but at the cost of smaller multipliers over longer horizons. Moreover, firm entry dynamics lead to persistently higher multipliers for both labor and firm revenue tax rates in the medium and long runs.

This study contributes to the recent literature on the credit effects of fiscal policy. Although fiscal expansion has traditionally been considered as a counterproductive policy tool for spurring bank credit[4], there is a growing body of evidence from the U.S. and other advanced economies suggesting that fiscal stimuli can increase bank credit (see for instance Miranda-Pinto et al., 2019; Auerbach et al., 2020). A common feature of the theoretical frameworks in the above papers is that fiscal stimuli can spur credit supply through a reduction in interest rates. Our model presents an alternative, micro-oriented, channel though which fiscal policy can mitigate the adverse effects of credit constraints. This channel is the firm equity. Fis-

[4]The standard prediction of both neoclassical and Keynesian theories is that fiscal expansion reduces private investment by raising interest rates. However, recent empirical evidence contradicts the conception that fiscal expansion deteriorates credit conditions. See Murphy and Walsh (2018) for a review.

cal expansion causes an increase in aggregate demand which in turn raises firm production and profits, and as a result equity prices rise. Since equity is used as collateral, financing constraints faced by firms relax, improving credit conditions.

Our study is also part of the literature on the design of fiscal policy when firm entry is endogenous. Lewis (2009) extended the Bilbiie et al.'s (2007a; 2012) framework for fiscal and monetary policy analysis. He found that firm entry reacts positively to expansionary government spending and monetary shocks. Chugh and Ghironi (2011) used an extended version of the same model to study the implications of both exogenous and Ramsey-optimal fiscal policy. Cooke and Damjanovic (2020) developed a model of firm entry and fluctuations in the volatility of firm-level demand shocks to study dividend and labor-income taxation. We extend this literature in two directions. First, in contrast to the above theoretical frameworks - which typically examine the implications of firm entry in frictionless contexts - we incorporate financial frictions in our analysis conforming to the recent evidence on the interrelationship between credit constraints and firm entry (Bergin et al., 2018). Second, we are the first to examine the quantitative effects of firm entry in fiscal multipliers in both the short- and the long- runs. Our findings suggest that firm entry dynamics can be a critical determinant of fiscal policy, since they affect substantially both the persistence and the size of the impact of fiscal shocks on aggregate economy.

The remainder of this chapter is organized as follows. The next section provides empirical evidence on the linkage between firm entry and financial shocks and the role of fiscal policy in it. Section 3.3 introduces a DSGE model with endogenous entry, firm-level financial constraints and detailed fiscal policy aspects. Section 3.4 presents its calibration and quantitative results. Section 3.5 concludes.

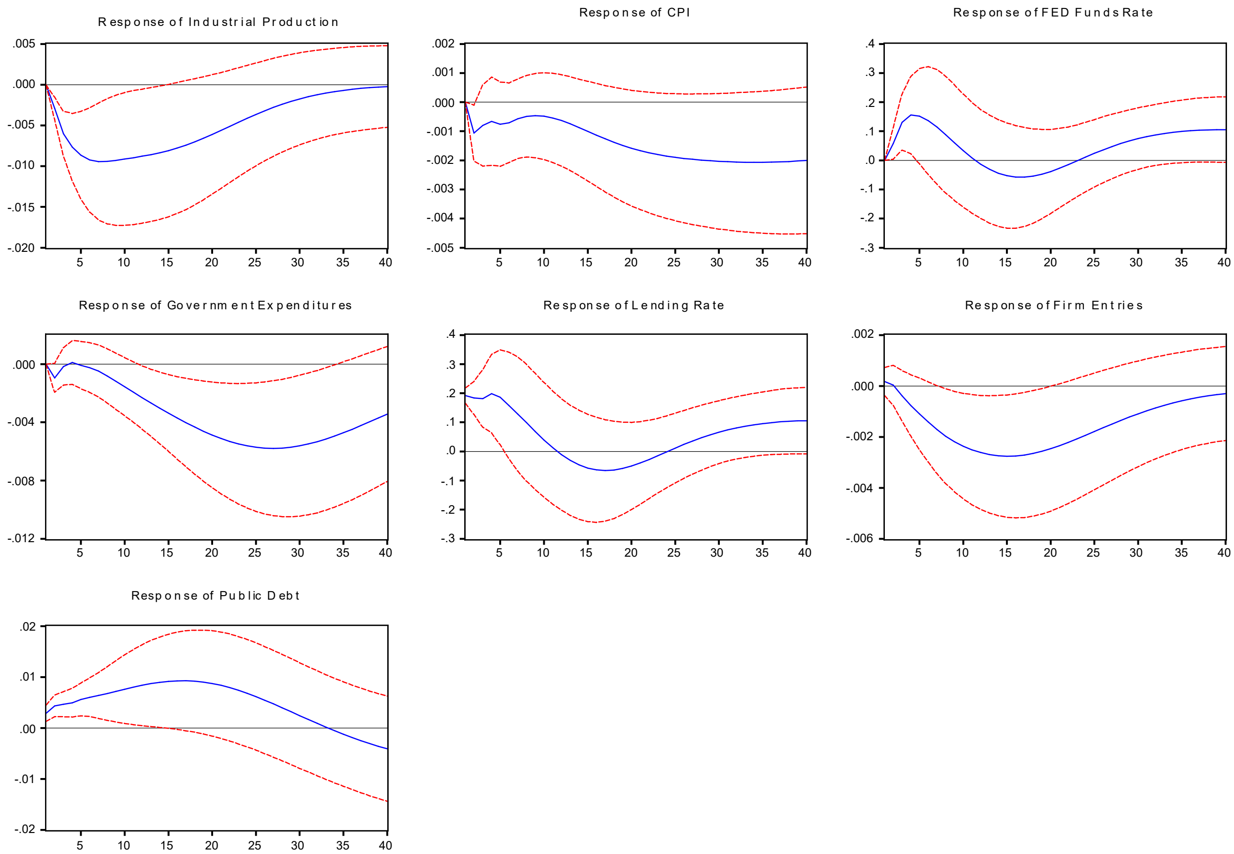
3.2 Motivation and Empirical Evidence

We use a vector autoregression to estimate the dynamic response of firm entry to financial shocks in the US economy, and the response of both firm entry and financial conditions to fiscal policy. The establishment births data series of the US Bureau of Labor Statistics (BLS) are used as a measure of firm entry. Following Chor and Manova (2012) and Bergin et al. (2018), we employ the 3-month interbank lending rate as a measure of the tightness of financial conditions over time, as it is a broad measure of overall financial liquidity. Our sample covers the period 1993q3-2019q4 for the US economy and thus the 2007-08 financial crisis. The data for all variables, apart from the series for firm entry, obtained from Federal Reserves Economic Database (FRED).

A 7-variable VAR model is estimated at a quarterly frequency, with variables in the following order: the logarithm of industrial production, the logarithm of consumer price index (CPI hereafter), the FED funds ratio, the logarithm of real government consumption expenditures and gross investment, the 3-month interbank lending rate, the logarithm of new firms, and the logarithm of public debt. We represent an exogenous fiscal shock as an innovation to real government consumption expenditures and gross investment orthogonal to contemporaneous movements in other macroeconomic variables, including the FED funds rate. The latter variable is included to help disentangle the effects of monetary policy from the effects of an exogenous fiscal shock. Similarly, we represent an exogenous financial shock as an innovation to the interbank lending rate orthogonal to contemporaneous movements in other macroeconomic variables, including public expenditures and the FED funds rate. Following Eichenbaum and Evan (1995) and Bernanke and Mihov (1998), we assume that output and consumer prices are not contemporaneously affected by monetary policy shocks, and thus specify a VAR ordering the FED funds rate after industrial production and CPI. We order firm entry after the variables representing shocks discussed above, allowing the data to reveal whether this variable responds on the impact of shocks or with a lag (Bergin and Corsetti, 2008). Finally, we include the logarithm of public debt to examine the role of credit constraints to debt dynamics.

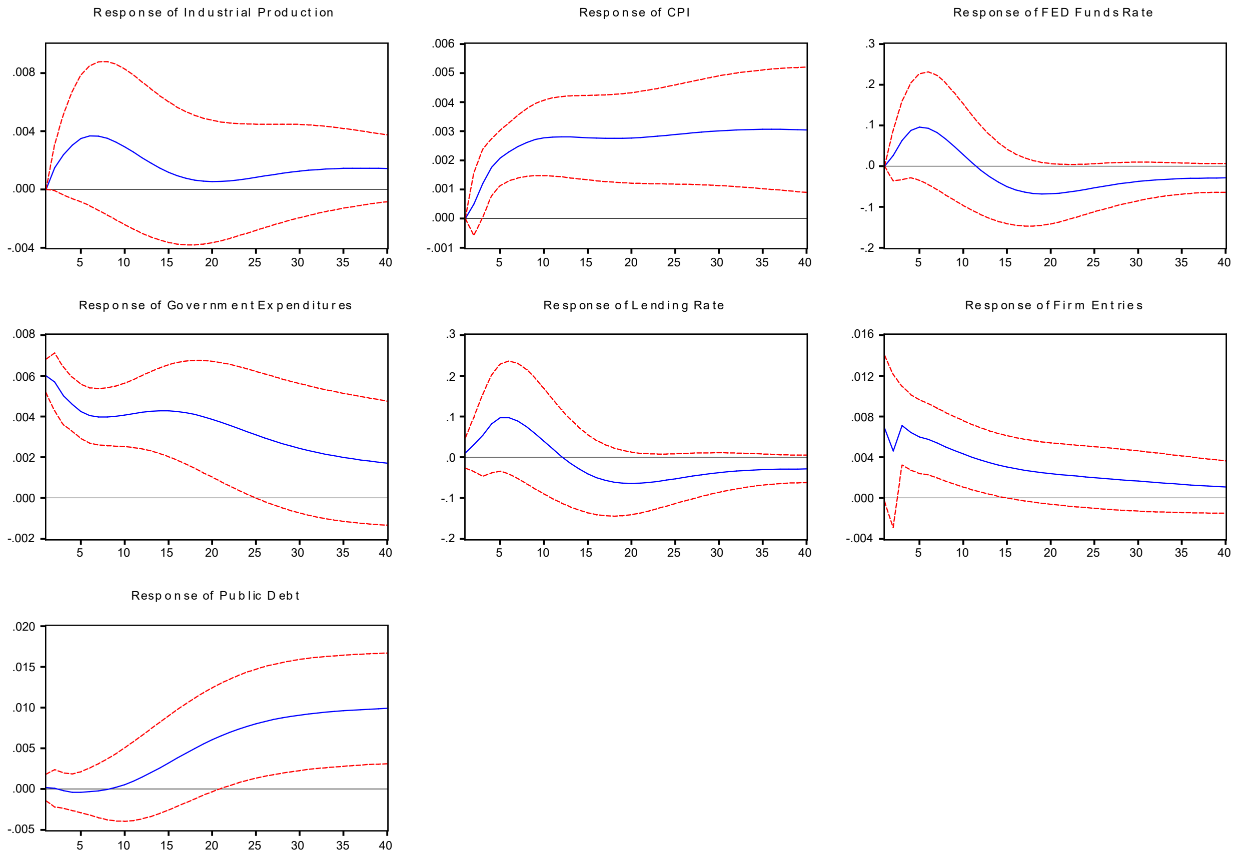
Figure 3.1 reports impulse responses for the system to an adverse financial shock, i.e. an increase in the 3-month interbank lending rate. Error bands indicate plus and minus two standard deviations. It shows that firm entries respond negatively and persistently to a credit tightening shock. However, the responses of firm entries to the financial shock require 6 quarters before becoming significant and the negative effect lasts 18 quarters. The maximal drop occurs 15 quarters after the shock. An adverse financial shock also leads to an immediate and persistent fall in output (it lasts 19 quarters). Regarding the fiscal variables, government spending responds negatively and persistently to a credit tightening shock, but also tardily: it requires 11 quarters before becoming significant and the negative effect lasts 27 quarters. In contrast, public debt responds instantly to a credit tightening shock and its negative responses last for around 19 quarters. The responses of the FED funds rate are positive during the first 5 and the last 5 quarters, but insignificant in the meantime. Finally, the responses of CPI are not significant to an adverse financial shock.

Figure 3.2 reports impulse responses for the system to an expansionary



Notes: Impulse responses generated from a 7-variable VAR model at quarterly frequency from 1993q3 to 2019q4 for the US economy, with variables in the following order: the logarithm of industrial production, logarithm of CPI, FED funds rate, real government expenditures and gross investment, 3-month interbank lending rate, logarithm of new firms, and logarithm of public debt.

Figure 3.1: Estimated Impulses Responses to an Adverse Financial Shock



Notes: Impulse responses generated from a 7-variable VAR model at quarterly frequency from 1993q3 to 2019q4 for the US economy, with variables in the following order: the logarithm of industrial production, logarithm of CPI, FED funds rate, real government expenditures and gross investment, 3-month interbank lending rate, logarithm of new firms, and logarithm of public debt.

Figure 3.2: Estimated Impulses Responses to an Expansionary Fiscal Shock

fiscal shock, i.e. an increase in government expenditures. It shows that firm entry responds positively, instantly and persistently to an increase in government spending: it is significant from the first quarter and its positive effect lasts 20 quarters. To the contrary, the lending rate reacts negatively to the fiscal shock but quite belatedly: it requires 20 quarters before becoming significant and the negative effect lasts only 7 quarters. Notably, the effects of fiscal policy on the credit constraints emerge around the time that the effect on entry fades, a fact that implies the interlinkage between these two variables. An expansionary fiscal shock also leads to an immediate but short-lived invigoration of output (it lasts only 3 quarters). Moreover, public debt responds positively and persistently to an expansionary fiscal shock. However, the responses of government debt to the fiscal shock require 19 quarters before becoming significant but it remains so until the last quarter. The responses of the CPI are positive and persistent. Finally, the responses of the FED funds rate are not significant to an expansionary fiscal shock.

We conclude that recessionary financial shocks exert a negative impact on firm entry. However, we find that expansionary fiscal policy can alleviate both the fall in firm entry and the adverse financial conditions but that the effects on financial conditions emerge around the time that the effect on entry disappears. In the next section, we turn to a theoretical model to provide an explanation for this pattern of empirical findings.

3.3 The Model: The role of firm entry in a small-medium new Keynesian model

The model considers a closed economy with six different types of agents:

(i) a perfectly competitive final goods sector that combines all available intermediate goods with a CES aggregator;

(ii) a monopolistically competitive intermediate goods sector with endogenous firm entry;

(iii) a representative household who supplies labor to the intermediate firms and purchases bonds from these firms and from the government;

(iv) a representative investor who finances new and existing intermediate firms through equity purchase;

(v) the government that conducts the fiscal policy: it finances its needs by borrowing from households and by imposing distortionary taxes in labor income and firm revenue,

(vi) an independent monetary authority that conducts the monetary policy through a Taylor-type interest rate rule.

The final goods are consumed by both the investors and the households. Following Perri and Quadrini (2011), we assume that households are more patient than investors[5]. Because investors are the owners of the firms, this assumption generates a borrowing incentive for intermediate firms: the lower discount factor of investors implies that in equilibrium firms prefer borrowing from the households. The investors' income is from the equity investment in the intermediate firms, while the worker finances his consumption through labor income and bond investment in the government and the intermediate firms.

We assume that output is produced by a set of monopolistically competitive firms, each producing a different variety of a good j defined in the interval $[0, N]$, where N is the number of firms in the economy which is endogenously determined in the model. They hire labor from the households and issue equities and corporate bonds, which are purchased by investors

[5]This implies that investors have a smaller discount factor than households.

and households, respectively. To finance production (working capital), they must also borrow an intra-period loan. Following the standard literature on collateral constraints, we assume that this borrowing is subject to an enforcement constraint[6].

Prior to entry, potential entrants face an one-time sunk cost. They can finance this entry cost with a mixture of debt and equity. Following Bergin et al. (2018), we assume that firms are permitted to begin production immediately in the period of entry. This assumption leads to identical financial constraints for all firms, both incumbents and entrants, implying identical debt-equity decisions among all firms.

Following Bilbiie et al. (2007b), we assume that both incumbents and entrants face nominal rigidity in the form of a quadratic cost of adjusting prices over time (Rotemberg, 1982).

Government consumes and imposes proportional taxes on both labor income and firm revenue. Also, it borrows from households through one-period sovereign bonds. We use detailed specifications for fiscal rules according to which all fiscal policy instruments respond to both the level of public debt and the state of economic activity, leading to a procyclical fiscal policy and non-trivial debt dynamics (Leeper et al., 2010).

Finally, the monetary policy is conducted by an independent central bank through a Taylor-type feedback interest rate rule (Taylor, 1993).

[6]This kind of financial friction dates back to Kiyotaki and Moore (1997). In our model's setup, we follow the recent work of Jermann and Quadrini (2012) and Bergin et al. (2018) in which a firm's borrowing capability is restricted by its asset value

3.3.1 Final Good Producer

Production is split into two parts: the final goods producer and the intermediate goods producers. There is a representative competitive final goods firm which aggregates intermediate inputs according to a CES technology. To the extent to which the intermediates are imperfect substitutes in the CES aggregator, this generates a downward - sloping demand for each intermediate variety, which gives these intermediate producers pricing power. There are a continuum $[0, N_t]$ of monopolistically competitive intermediate These firms produce output using labor and are subject to an aggregate productivity shock. They cannot not freely adjust their prices in each period, in a way that we will discuss in more depth below.

The final good is a CES aggregate of all existing varieties $\widetilde{N}_t$:

$$Y_t = [\int_0^{\widetilde{N}_t} y_t(j)^{\frac{\varepsilon-1}{\varepsilon}} dj]^{\frac{\varepsilon}{\varepsilon-1}} \tag{3.1}$$

where $\widetilde{N}_t = N_{t-1} + N_t^E$ is the number of all existing varieties at period t, i.e. those from existing firms (N_{t-1}) and those from new firms (N_t^E).

Let $p_t(j)$ denote the nominal (production-based) price of an intermediate good $j \in [0, \widetilde{N}_t]$ and P_t the aggregate (consumption-based) price of the final good.

The profit maximization problem of the final good firm is:

$$\max_{y_t(j)} P_t[\int_0^{\widetilde{N}_t} y_t(j)^{\frac{\varepsilon-1}{\varepsilon}} dj]^{\frac{\varepsilon}{\varepsilon-1}} - \int_0^{\widetilde{N}_t} p_t(j) y_t(j) dj$$

The first order decision is given by,

$$y_t(j) = (\frac{p_{t(j)}}{P_t})^{-\varepsilon} Y_t \tag{3.2}$$

Equation (3.2) is the relative demand that the j^{th} intermediate firm faces. It is a function of the relative price of product "j", of the price elasticity of demand ε, and it is proportional to aggregate output, Y_t.

Combining (3.1) with (3.2) we get an expression for the aggregate consumption-based price level:

$$P_t = [\int_0^{\widetilde{N}_t} p_t(j)^{1-\varepsilon} dj]^{\frac{1}{1-\varepsilon}} \tag{3.3}$$

3.3.2 Intermediate Goods Firms

The timeline of the production by the intermediate goods firms is as follows. Each period starts with two aggregate state variables: the technology shock (A_t), and the financial shock (ξ_t). We will describe the financial shock (ξ_t) in more detail in the next Section. At the beginning of each period, the economy consists of N_{t-1} incumbent firms, each of which has a matured debt repayment b_{t-1}. There are also N_t^E new entrants who enter the market, hire labor and produce as the existing incumbents do, except that these new entrants do not have a matured debt repayment from last period. The final goods are constructed over the $\widetilde{N}_t = N_{t-1} + N_t^E$.

Then, the incumbents and the new entrants hire labor, issue corporate bonds and stocks and produce goods, households supply labor and make consumption and corporate bond investment decision over the $\widetilde{N}_t$ firms, investors purchase goods for consumption as well as corporate equities of the $\widetilde{N}_t$ firms, and goods and labor markets clear.

At the end of each period after all markets have cleared, there is an exogenous death shock which applies to all incumbents and new entrants and which occurs with a probability of $\delta \in (0, 1)$. Because death shock occurs at the end of each period, only N_t firms remain in the market after the death shock:

$$N_t = (1-\delta)\left(N_{t-1} + N_t^E\right) \tag{3.4}$$

3.3.2.1 Enforcement constraint

Following Bergin et al. (2018), we assume that firms finance their production through equities or corporate bonds which are purchased by investors and households, respectively. Moreover, firms must also borrow an intra-period loan to cover labor expenses. As in Jermann and Quadrini (2012), this borrowing is subject to an enforcement constraint.

More specifically, a firm must pay the workers at the beginning of each period and before the realization of its revenue. To cover its labor expenses $w_t l_t(j)$, firm j borrows an intra-period loan (w_t and $l_t(j)$ denote the real wage rate and the labor input, respectively). The intra-period loan is repaid at the end of each period and there is no interest. The end-of-period firm value, $E_t\left[m_{t+1}V_{t+1}(j)\right]$[7], is used as collateral for this loan, with m_{t+1} to denote the discount factor of investors who are the owners of the firms. As a firm may default on its debt repayments, its borrowing ability is restricted by the following enforcement constraint (Bergin et al., 2018):

$$E_t\left[m_{t+1}V_{t+1}(j)\right] \geq \xi_t w_t l_t(j) \tag{3.5}$$

The above enforcement constraint implies that households are willing to lend to firms only if the liquidation value in case of default is at least sufficient to cover the loaned amount. Households can liquidate the firms' end-

[7]Since the firm's equity value (q_t) is the expected discounted value of dividend payments starting from period $t+1$, it is equal to the end-of-period firm value.

of-period value $E_t\left[m_{t+1}V_{t+1}(j)\right]$ suffering a liquidation loss ($\xi_t < 1$). The stochastic innovation ξ_t is defined as 'a financial shock', which captures the "liquidity" of firm assets. Adverse credit conditions can be translated into a lack of liquidity that makes lenders impose tighter collateral constraints on firms.

3.3.2.2 Production and Pricing Decisions

Each firm produces a differentiated product under conditions of monopolistic competition. All firms have access to the same production technology, denoted by the production function,

$$y_t(j) = A_t l_t(j) \tag{3.6}$$

The variable A_t denotes aggregate labor productivity, common to all firms and subject to temporary shifts ε_t^a.

Firm dividends are given by the following expression,

$$d_t(j) = \pi_t(j) - \left[b_{t-1}(j) - \frac{b_t(j)}{1+r_t}\right] \tag{3.7}$$

where $\pi_t(j)$ and $b_t(j)$ denote firm's operational profits and debt (in corporate bonds), respectively.

Operational profits are defined as,

$$\pi_t(j) = (1-\tau_t^f)\frac{p_t(j)}{P_t}y_t(j) - w_t l_t(j) - \frac{\kappa}{2}\left[\frac{p_t(j)}{p_{t-1}(j)} - 1\right]\frac{p_t(j)}{P_t}y_t(j) \tag{3.8}$$

with the last term to capture the quadratic cost of adjusting prices over time (Rotemberg, 1982). τ_t^f stands for a tax on firm revenue.

The optimization problem is choosing the price of the individual variety, $p_t(j)$, the dividend payout, $d_t(j)$, and the new debt, $b_t(j)$, to maximize the cum-dividend market value of the firm, $V_{j,t+1}(b_{j,t+1})$; that is, the beginning-of-period firm value which includes dividend:

$$V_t(j) = \max_{p_t(j),b_{t-1}(j)} \{d_t(j) + E_t [m_{t+1} V_{j,t+1}(b_{j,t+1})]\} \tag{3.9}$$

subject to the dividend equation (3.7), the enforcement constraint (3.5), the demand for individual variety (3.1) and the production technology (3.6). The optimization implies the following pricing rule and the multiplier associated with the enforcement constraint:

$$\frac{p_t(j)}{P_t} = \lambda_t(j)(1 + \mu_t)\frac{w_t}{A_t} \tag{3.10}$$

$$\mu_t = \frac{1/(1 + r_t) - E_t m_{t+1}}{\xi_t E_t m_{t+1}} \tag{3.11}$$

where μ_t is the Lagrange multiplier associated with the enforcement constraint. It is the shadow price of the intra-period loan on firm value, and measures the relative cost of bond financing $(1 + r_t)$ to equity financing $(1/E_t m_{t+1})$ for a financially constrained firm adjusted by the financial market condition (ξ_t). Holding everything else constant, a worsening financial market condition (falling ξ_t) increases the tightness of the financial constraint (rising μ_t).

An increased tightness (i.e. a rise in μ_t) will lead to rising goods prices according to (3.11), holding all else constant.

$\lambda_t(j)$ denotes the price markup and is given by,

$$\lambda_t(j) = \frac{\varepsilon y_t(j)}{(\varepsilon - 1) y_t(j) \left\{ (1 - \tau_t^f) - \frac{\kappa}{2} \left[\frac{p_t(j)}{p_{t-1}(j)} - 1 \right]^2 \right\} + \kappa \Lambda_t} \tag{3.12}$$

where:

$$\Lambda_t = y_t(j) \left\{ \frac{p_t(j)}{p_{t-1}(j)} \left[\frac{p_t(j)}{p_{t-1}(j)} - 1 \right] - E_t m_{t+1} \frac{y_{t+1}(j)}{y_t(j)} \frac{P_t}{P_{t+1}} \left(\frac{p_{t+1}(j)}{p_t(j)} \right)^2 \left[\frac{p_{t+1}(j)}{p_t(j)} - 1 \right] \right\}$$

As expected, the markup reduces to $\varepsilon/(\varepsilon - 1)$ in the absence of nominal rigidity ($\kappa = 0$) or if the price $p_t(j)$ is constant.

Let π_t^{PPI} denotes inflation in producer prices: $\pi_t^{PPI} = \frac{p_t}{p_{t-1}} - 1$. Then, we can write the price markup as:

$$\lambda_t(j) = \frac{\varepsilon}{(\varepsilon - 1) \left[(1 - \tau_t^f) - \frac{\kappa}{2} \left(\pi_t^{PPI} \right)^2 \right] + \kappa \left\{ \left(1 + \pi_t^{PPI} \right) \pi_t^{PPI} - E_t \left[m_{t+1} \frac{Y_{t+1}}{Y_t} \frac{N_t}{N_{t+1}} (1 + \pi_{t+1}^{PPI}) \pi_{t+1}^{PPI} \right] \right\}} \tag{3.13}$$

3.3.2.3 Entry Decision

New firms are free to enter the intermediate goods market subject to a one-time sunk investment and entrants can finance this startup investment with a mix of debt and equity. Following Bergin et al. (2018), we assume that firms are permitted to begin production immediately in the period of entry. This specification allows us to assume identical financial constraints defined over working capital facing all firms, both incumbents and new entrants, implying identical capital structure decisions among all firms. This homogeneity among firms significantly simplifies the model analysis (Bergin et al., 2018).

The value of entering the market is given by,

$$V_t^{ent}(j) = \max_{p_t(j),b_{t-1}(j)} \left\{ d_t^{new}(j) + E_t \left[m_{t+1} V_{j,t+1}(b_{j,t+1}^{new}) \right] \right\} \tag{3.14}$$

This differs from the value of an incumbent firm of in (3.9) in that the new entrant begins the period with zero debt inherited from the previous period, i.e. $b_{t-1}^{new}(j) = 0$. We have that,

$$d_t^{new}(j) = \underbrace{(1-\tau_t^f)\frac{p_t^{new}(j)}{P_t}y_t^{new}(j) - w_t l_t^{new}(j) - \frac{\kappa}{2}\left[\frac{p_t^{new}(j)}{p_{t-1}^{new}(j)} - 1\right]\frac{p_t^{new}(j)}{P_t}y_t^{new}(j)}_{\pi_t^{new}} + \frac{b_t^{new}(j)}{1+r_r} - K_t^E$$

where K_t^E denotes the sunk entry cost.

As in Melitz (2003), new firms enter as long as the net value of entry ($V_t^{ent}(j)$) is positive. This directly implies the following free-entry condition:

$$\pi_t^{new} + \underbrace{\frac{b_t^{new}(j)}{1+r_r} + E_t \left[m_{t+1} V_{j,t+1}(b_{j,t+1}^{new}) \right]}_{V_t^a(j)} = K_t^E \tag{3.15}$$

where $V_t^a(j)$ defines a firm "asset value" which is the sum of bond value and equity price. In the entry condition (3.15), $V_t^a(j)$ captures the liquidity available to a new entrant from issuing financial assets, the equity $q_t = E_t \left[m_{t+1} V_{j,t+1}(b_{j,t+1}^{new}) \right]$ and the bond $b_t^{new}(j)/(1+r_t)$, which can be used towards paying the entry cost. Therefore, a firm will enter as long as it is able to raise the amount of liquidity, through operating cash and assets, required to pay the entry cost.

We now turn to the financing and pricing/production decision of the new firm. Just as for the incumbents, the new firm maximizes the beginning-of-period firm value (3.14, in this case) subject to the retained earning equation (3.7), the enforcement constraint (3.5), and the demand for individual variety (3.1). In addition to facing an entry cost, another difference in the problem of a new firm from that of an incumbent is that a new firm enters the period with no matured debt payment $b_{t-1}^{new}(j) = 0$. Because the enforcement constraint here is not affected by the initial bond position, the first-order conditions are the same as for an incumbent.

So new firms will hold the same level of firm asset value with the incumbents and therefore they will respond to an adverse financial shock in the same way as incumbent firms, by choosing a smaller level of debt issue than they otherwise would choose, as this raises end-of-period equity value and relaxes the financial constraint arising from borrowing working capital.

Following Bergin et al. (2018), we specify that the cost of new firm entry is a positive function of the total number of firms entering the market:

$$K_t^E = K_{SS}^E \left(\frac{N_t^E}{N_{t-1}^E} \right)^{\tau} \tag{3.16}$$

where K_{SS}^E is the steady state level of sunk entry costs, N_t^E describes the number of new entrants who compete with each other, and τ is an entry adjustment cost parameter. This parameter allows entry to be harder for potential entrants as the greater the number of new entrants in any given period, the larger the entry costs faced by each potential entrant. Therefore due to this "congestion externality", firm entry dynamics do not respond instantaneously to new shocks but respond gradually over time.

Using equation (3.16) we can re-write the free-entry condition (3.15) as follows:

$$q_t + \frac{b_t}{(1+r_t)} + \pi_t = K_{SS}^E \left(\frac{N_t^E}{N_{t-1}^E} \right)^\tau \tag{3.15'}$$

The left-hand side is the funding resources a potential entrant can obtain to pay the entry cost that is in the right-hand side of the above equation. (3.15') shows that the specification (3.16) for cost entry allows for a richer relationship among equity prices, firm entry and firm financing. First, the presence of the congestion externality in entry allows equity prices to comove with the level of new entry: as firm entry rises, an increase in the entry cost occurs and in turn the equilibrium equity value rises. Second, lower debt leads to higher equity prices. Finally, because production occurs in the same period as entry, current period profits also appear in the entry condition.

If we assume that no debt can be issued to pay entry cost ($b_t = 0$), that firms are required to wait one period before beginning production, so no profits are generated in the period of entry ($\pi_t = 0$), and finally that there is no congestion externality in the entry cost ($\tau = 0$), then the entry condition (3.15') is simplified to $q_t = K_{SS}^E$. This version of the entry condition is the standard used in models in the firm dynamics literature if entry costs are in goods units (Bilbiie et al. (2007b)). This version implies a constant equity price in equilibrium.

3.3.3 Households

We assume that the economy consists of a continuum of identical households i, where $i \in [0, 1]$. A typical household in the economy is both a consumer and a worker: it supplies labor services in a competitive labor market and consumes part of the goods produced in the economy. Moreover, it can save through corporate bonds.

In each period t, a typical household i derives utility from consuming a basket $C_{H,t}$ containing all the goods produced in economy while suffering disutility from labor effort, L. Households maximize the expected discounted value of flow utility U over their life horizon. Flow utility is additive-separable. The intertemporal utility is given by:

$$E_t \sum_{t=0}^{\infty} \beta^t [\frac{C_{H,t}^{1-\sigma}}{1-\sigma} - \frac{\chi}{1+\lambda} L_t^{1+\lambda}] \tag{3.17}$$

where $C_{H,t}$is the consumption, $L_t$is the labor supply, $1/\sigma$ is the intertemporal elasticity of substitution in consumption and λ the Fritch elasticity of labor supply.

The consumption is consisted by many goods, indexed by j, j$\in [0, N]$. The aggregate consumption across the individual goods is defined in the following CES form,

$$C_t = [\int_0^N c_t(j)^{\frac{\varepsilon-1}{\varepsilon}} dj]^{\frac{\varepsilon}{\varepsilon-1}} \tag{3.18}$$

where ε is the demand elasticity of substitution for the individual goods and $\varepsilon > 1$. The representative household has to deal with two problems:

Households derive income by providing labor services (L_t) at the real wage rate $(w_t = W_t/P_t)$. They can invest their wealth in a set of corporate bonds (b_{t-1}) of the N_{t-1} existing firms at price of $1/(1+r_t)$, where r_t is the gross, consumption-based, real interest rate on holdings of bonds between t − 1 and t, or in a set of government bonds (b_{t-1}^g) at price of $1/(1+r_t^g)$.

The household enters period t with corporate bonds b_{t-1} and government bonds (b_{t-1}^g). It receives income on corporate and government bonds and labor income after paying a tax to the government. The household then purchases consumption ($C_{w,t}$) and updates its corporate bond investment in the ($N_{t-1} + N_t^E$) firms (those already operating at time t and the new entrants) and its government bond investment as well.

The period budget constraint (in real terms) may thus be written as:

$$C_{H,t} + \frac{b_t^g}{1 + r_t^g} + \frac{(N_t + N_t^E)b_t}{1 + r_t} \leq (1 - \tau_t^L)w_t L_t + b_{t-1}^g + N_{t-1}b_{t-1} \tag{3.19}$$

The gross real interest rate is given by the standard Fisher equation,

$$(1 + r_t^g) = \frac{(1 + i_{t-1})}{(1 + \pi_t^{CPI})} \tag{3.20}$$

where i_t is the nominal interest rate, determined by the central bank, and $\pi_t^{CPI} = \frac{P_t}{P_{t-1}} - 1$ is the consumption-based inflation rate.

Households choose consumption, labor effort and bond purchase in period t so as to maximize utility 3.17 over their whole life horizon subject to a budget constraint as 3.19.

The first-order condition for the optimal choice of labor effort requires that the marginal disutility of labor be equal to the marginal utility from consuming the real wage received for an additional unit of labor:

$$\chi L_t^{\lambda} = (1 - \tau_t^L)w_t C_{H,t}^{-\sigma} \tag{3.21}$$

The Euler equation for corporate bond holdings is,

$$C_{H,t}^{-\sigma} = \beta(1 - \delta)E_t\left\{C_{H,t+1}^{-\sigma}(1 + r_t)\right\} \tag{3.22}$$

Finally, the Euler equation for government bond holdings is,

$$C_{H,t}^{-\sigma} = \beta E_t \left\{ C_{H,t+1}^{-\sigma} \left(1 + r_t^g\right) \right\} \tag{3.23}$$

3.3.4 Investors

The representative investor derives utility from consuming the basket of goods ($C_{I,t}$) in each period and maximizes his expected lifetime utility:

$$E_t \sum_{t=0}^{\infty} \beta_I^t [\frac{C_{I,t}^{1-\rho_I}}{1-\rho_I}] \tag{3.24}$$

where $\rho_I > 0$ is the investor's degree of risk aversion and $\beta_I \in (0,1)$ is the subjective discount factor.

Investors hold shares in a mutual fund of firms. Let s_t be the share t in the mutual fund held by the representative household entering period t. The mutual fund pays a total profit in each period equal to the total profit of all firms that produce in that period, $P_t N_{t-1} d_t$. During period t, the representative household buys s_{t+1} shares in a mutual fund of $N_{t-1} + N_t^E$ firms (those already operating at time t and the new entrants). The mutual fund covers all firms in the economy, even though only $1-\delta$ of these firms will produce and pay dividends at time $t+1$ (δ is the constant probability that a death shock hits a firm).

The investor enters period t with mutual fund share holdings s_{t-1}. It receives dividend income on mutual fund share holdings, the value of selling its initial share position, and labor income. The investor allocates these resources between purchases of shares to be carried into next period and consumption. The period budget constraint (in real terms) is:

$$C_{I,t} + (N_{t-1} + N_t^E) q_t s_t \leq N_{t-1} s_{t-1} (q_t + d_t) \tag{3.25}$$

where q_t is the stock price, in units of final goods, s_t is the equity share of the firms producing intermediate goods, held by the investor at time t, and d_t the profits of the firms.

Investors choose consumption and shares purchase in period t so as to maximize utility 3.24 over their whole life horizon subject to a budget constraint as 3.25. The Euler equation corporate share holdings is,

$$\beta_I (1-\delta) E_t \left[\frac{q_{t+1} + d_{t+1}}{q_t} \left(\frac{C_{I,t+1}}{C_{I,t}} \right)^{-\rho_I} \right] = 1 \tag{3.26}$$

As expected, forward iteration of the equation for share holdings and the absence of speculative bubbles yield the asset price solution in equation (3.9), with the stochastic discount factor:

$$m_t = \beta_I (1-\delta) \left(\frac{C_{I,t}}{C_{I,t-1}} \right)^{-\rho_I}$$

3.3.5 Government

In some period, t, the government collects real taxes for labor income and corporate revenue, consumes a quantity G_t, and issues debt of real volume $D_t = b_t^g$ which pays the predetermined gross real interest$(1 + r_t^g)$. It thereby has to restrict its activity to policies that satisfy its budget constraint, conditional on not defaulting. Thus, the budget constraint of the government is given by,

$$\frac{D_t}{1+r_t^g} - D_{t-1} + \tau_t^L w_t L_t + \tau_t^f Y_t = G_t \tag{3.27}$$

We assume rich specifications of fiscal policy rules for the three fiscal policy instruments, namely the government spending and the tax rates on labor income and firm revenue, since the have been found to fit U.S. data better (Leeper et al., 2010). In particular, the policy rules are[8]:

$$\frac{G_t}{G_{SS}} = \left(\frac{G_{t-1}}{G_{SS}}\right)^{\rho_g} \left(\frac{(D/Y)_{t-1}}{(D/Y)_{SS}}\right)^{-\gamma_{gd}} \left(\frac{Y_t}{Y_{SS}}\right)^{-\gamma_{gy}} e^{\varepsilon_t^g} \tag{3.28}$$

$$\frac{\tau_t^L}{\tau_{SS}^L} = \left(\frac{\tau_{t-1}^L}{\tau_{SS}^L}\right)^{\rho_l} \left(\frac{(D/Y)_{t-1}}{(D/Y)_{SS}}\right)^{\gamma_{ld}} \left(\frac{Y_t}{Y_{SS}}\right)^{\gamma_{ly}} e^{\varepsilon_t^L} \tag{3.29}$$

$$\frac{\tau_t^f}{\tau_{SS}^f} = \left(\frac{\tau_{t-1}^f}{\tau_{SS}^f}\right)^{\rho_f} \left(\frac{(D/Y)_{t-1}}{(D/Y)_{SS}}\right)^{\gamma_{fd}} \left(\frac{Y_t}{Y_{SS}}\right)^{\gamma_{fy}} e^{\varepsilon_t^f} \tag{3.30}$$

where G_{SS}, Y_{SS} τ_{SS}^L and τ_{SS}^f stands for the steady state levels of the GDP and fiscal variables. $(D/Y)_t$ defines the debt-to-GDP ratio. The persistence parameters ρ_g, ρ_l and ρ_f are assumed to be between 0 and 1, and ε_t^g, ε_t^f and ε_t^L are iid innovations. γ_{gd}, γ_{ld} and γ_{fd} are positive feedback fiscal policy coefficients on debt-to-GDP ratio, whilst γ_{gy}, γ_{ly} and γ_{fy} are positive feedback fiscal policy coefficients on the GDP.

The above fiscal policy rules embed two features. First, there may be some "automatic stabilizer" component to movements in fiscal variables. This is modeled as a contemporaneous response to deviations of output from the steady state (Leeper et al., 2010). Second, all instruments are permitted to respond to the state of government debt. The assumption

[8] For similar rules, see for instance Forni et al. (2009), Leeper et al. (2010) and Cantore et al. (2017) .

that fiscal instruments are set in order to keep real debt dynamics under control is consistent with the idea that debt stabilization is an important motive in the conduct of fiscal policy (Schmitt-Grohé and Uribe, 2006).

3.3.6 Monetary Authorities

We assume that the monetary policy is conducted by an independent central bank. In particular, the central bank follows a Taylor-type (1993) rule of the form,

$$\frac{i_t}{i_{SS}} = \left(\frac{i_t}{i_{SS}}\right)^{\rho_i} \left(\frac{\pi_t^{CPI}}{\pi^*}\right)^{\phi_\pi} \left(\frac{Y_t}{Y_{SS}}\right)^{\phi_y} e^{\varepsilon_t^i} \tag{3.31}$$

i_{SS} and Y_{SS} denote the steady-state values of the interest rate and output, respectively. π^*stands for the inflation target of the central bank. Parameters ϕ_π and ϕ_y are the elasticities of the nominal interest rate with respect to inflation and output, respectively. This rule implies a countercyclical monetary policy. When inflation is positive, the central bank increases nominal interest rates in order to reduce it. When output is lower than its steady state level, the central bank reduces nominal interest rates in order to increase output towards its steady state level. In addition, this feedback interest rate rule does not result in inflation and price level indeterminacy if the Taylor principle is satisfied, i.e. if the reaction of nominal interest rates to inflation is sufficiently strong (namely if ϕ_π>1).

Finally, ε_t^i is an exogenous stochastic disturbance in the nominal interest rate that follows an autoregressive process of first order.

3.3.7 Equilibrium and Aggregate Accounting

In equilibrium, all firms make identical choices. Hence,$\lambda_t(\omega) = \lambda_t$, $p_t(j) = p_t$, $p_t(j) = p_t$,$l_t(j) = l_t$,$y_t(j) = y_t$, $d_t(j) = d_t$, and $v_t(j) = v_t$. Under this symmetric equilibrium, the expression of the price index (3.3) implies that the relative price ρ_t and the number of producing firms $\widetilde{N}_t$ are tied by the following "variety effect" equation:

$$\rho_t = \frac{p_t}{P_t} = \widetilde{N}_t^{\frac{1}{\varepsilon - 1}} \tag{3.32}$$

Aggregating the budget constraint (3.19) across households, imposing the equilibrium conditions $b_t = b_{t-1} = 0$ and $s_{t+1} = s_t = 1, \forall t$, and using the budget constraint of the government (3.27) and the free-entry condition (3.15) yields,

$$C_{H,t} + C_{I,t} + G_t + N_t^E K_t^E = \frac{W_t}{P_t} L_t + \tau_t^f Y_t + \widetilde{N}_t d_t \tag{3.33}$$

The dividends received by the households are just the sum of real profits of intermediate goods firms (since the profits of the final good producer has zero profits),

$$\widetilde{N}_t d_t = \int_0^{\widetilde{N}_t} \left\{ \left(\left[1 - \tau_t^f \right] - \frac{\kappa}{2} \left[\pi_t^{PPI} \right]^2 \right) \frac{p_t(j)}{P_t} y_t(j) - \frac{W_t}{P_t} l_t(j) \right\} dj$$

or by using equation 3.32,

$$\widetilde{N}_t d_t = \left(\left[1 - \tau_t^f \right] - \frac{\kappa}{2} \left[\pi_t^{PPI} \right]^2 \right) Y_t - \frac{W_t}{P_t} L_t \tag{3.34}$$

Combining equation (3.33) with equation (3.34) we get the resource constraint of the economy,

$$Y_t = \frac{C_t + G_t + N_t^E K_t^E}{\left(1 - \frac{\kappa}{2}\left[\pi_t^{PPI}\right]^2\right)} \tag{3.35}$$

3.3.8 The New Keynesian Phillips Curve

Our model's version of the New Keynesian Phillips Curve (NKPC hereafter) follows from the log-linearized form of equation (3.13) combined with equation (3.10),

$$\pi_t^{PPI} = \beta_I(1-\delta)E_t\pi_{t+1}^{PPI} + \frac{\varepsilon - 1}{\kappa}(\hat{w}_t^r - \hat{a}_t + \hat{\mu}_t + \tilde{\tau}_t^f) - \frac{1}{\kappa}\hat{n}_t \tag{3.36}$$

where $\hat{a}_t, \hat{w}_t^r, \hat{\mu}_t$, and $\hat{n}_t$ denote percent deviations from steady state and $\tilde{\tau}_t^f$ log deviation from steady state.

Equation (3.36) is a New Keynesian Phillips curve relation that connects inflation dynamics to marginal cost in a standard fashion. Importantly, the effect of marginal cost is adjusted to reflect the number of firms that operate in the economy, the tightness of the financial constraints that firms face and the distortionary tax they pay. The number of producers is a predetermined, state variable, which introduces directly a degree of endogenous persistence in the dynamics of inflation in the Phillips curve. With a constant number of firms, not financing constraints and not tax on firm revenue, equation (3.36) reduces to the familiar New Keynesian Phillips Curve of the benchmark New Keynesian model.

Finally, using the definition of CPI-inflation, we can write the New Keynesian Phillips curve for consumption-based inflation:

$$\pi_t^{CPI} = \beta_I(1-\delta)E_t\pi_{t+1}^{PPI} + \frac{\varepsilon-1}{\kappa}(\hat{w}_t^r - \hat{a}_t + \hat{\mu}_t + \tilde{\tau}_t^f) - \frac{1}{\kappa}\hat{n}_t \\ - \frac{1}{(\varepsilon-1)}\left\{(\hat{n}_t - \hat{n}_{t-1}) - \beta_I(1-\delta)\left[E_t\hat{n}_{t+1} - \hat{n}_t\right]\right\} \quad (3.37)$$

where π_t^{CPI} now denotes the percent deviation of the gross CPI inflation rate from the steady state. Consumption-based inflation displays an additional degree of endogenous persistence relative to firm-level inflation in that it depends directly on the number of firms that produced at time $t-1$, which was determined in period $t-2$.

3.3.9 Dynamics of the Model

The dynamics of the model are represented by the following system of first order conditions for households and firms:

- Households

$$\chi L_t^{\lambda} = (1-\tau_t^L)w_t C_{H,t}^{-\sigma} \quad (3.38)$$

$$C_{H,t}^{-\sigma} = \beta(1-\delta)E_t\left\{C_{H,t+1}^{-\sigma}(1+r_t)\right\} \quad (3.39)$$

$$C_{H,t}^{-\sigma} = \beta E_t\left\{C_{H,t+1}^{-\sigma}\left(\frac{1+i_{t-1}}{1+\pi_t^{CPI}}\right)\right\} \quad (3.40)$$

$$m_t^H = \beta(1-\delta)E_t\left[\frac{C_{H,t}}{C_{H,t-1}}\right]^{-\sigma} \quad (3.41)$$

- Final good producers

$$\frac{y_t}{Y_t} = \widetilde{N}_t^{\frac{\varepsilon}{\varepsilon-1}} \tag{3.42}$$

$$\frac{p_t}{P_t} = \widetilde{N}_t^{\frac{1}{\varepsilon-1}} \tag{3.43}$$

- Investors

$$C_{I,t} + (N_{t-1} + N_t^E) q_t s_t \leq N_{t-1} s_{t-1} (q_t + d_t) \tag{3.44}$$

$$\beta_I (1-\delta) E_t \left[\frac{q_{t+1} + d_{t+1}}{q_t} \left(\frac{C_{I,t+1}}{C_{I,t}} \right)^{-\rho_I} \right] = 1 \tag{3.45}$$

$$m_t^f = \beta_I (1-\delta) \left(\frac{C_{I,t}}{C_{I,t-1}} \right)^{-\rho_I} \tag{3.46}$$

- Incumbents

$$V_t(j) = d_t(j) + E_t \left[m_{t+1} V_{t+1}(j) \right] \tag{3.47}$$

$$V_t^a(j) = \frac{b_t(j)}{1+r_t} + E_t \left[m_{t+1} V_{t+1}(j) \right] \tag{3.48}$$

$$y_t(j) = A_t l_t(j) \tag{3.49}$$

$$d_t(j) = (1-\tau_t^f) \frac{p_t(j)}{P_t} y_t(j) - w_t l_t(j) - \left[b_{t-1}(j) - \frac{b_t(j)}{1+r_t} \right] \tag{3.50}$$

$$\pi_t(j) = \frac{p_t(j)}{P_t} y_t(j) - w_t l_t(j) \tag{3.51}$$

- Collateral constraints, optimal pricing and bond policies

$$w_t l_t(j) \leq \xi_t E_t \left[m_{t+1} V_{t+1}(j) \right] \tag{3.52}$$

$$\frac{p_t(j)}{P_t} = \lambda_t(j)(1+\mu_t)\frac{w_t}{A_t} \tag{3.53}$$

$$\mu_t = \frac{1/(1+r_t) - E_t m_{t+1}}{\xi_t E_t m_{t+1}} \tag{3.54}$$

$$\lambda_t(j) = \frac{\varepsilon}{(\varepsilon-1)\left[(1-\tau_t^f) - \frac{\kappa}{2}\left(\pi_t^{PPI}\right)^2\right] + \kappa\left\{\left(1+\pi_t^{PPI}\right)\pi_t^{PPI} - E_t\left[m_{t+1}\frac{Y_{t+1}}{Y_t}\frac{N_t}{N_{t+1}}(1+\pi_{t+1}^{PPI})\pi_{t+1}^{PPI}\right]\right\}} \tag{3.55}$$

- Entrants

$$V_t^n(j) = (1-\tau_t^f)\frac{p_t(j)}{P_t}y_t(j) - w_t l_t(j) + \frac{b_t(j)}{1+r_t} + E_t\left[m_{t+1}V_{t+1}^n(j)\right] \tag{3.56}$$

$$V_t^n(j) = K_t^E \tag{3.57}$$

$$N_t = (1-\delta)\left(N_{t-1} + N_t^E\right) \tag{3.58}$$

- Labor Market

$$L_t = \left(N_{t-1} + N_t^E\right) l_t(j) \tag{3.59}$$

$$K_t^E = K_{SS}^E \left(\frac{N_t^E}{N_{t-1}^E}\right)^\tau \tag{3.60}$$

- Economy

$$C_t = C_{H,t} + C_{I,t} \tag{3.61}$$

$$Y_t = \frac{C_t + G_t + N_t^E K_t^E}{\left(1 - \frac{\kappa}{2}\left[\pi_t^{PPI}\right]^2\right)} \tag{3.62}$$

- Government

$$\frac{D_t}{1 + r_t} - D_{t-1} + \tau_t^L w_t L_t + \tau_t^f Y_t = G_t \tag{3.63}$$

- Shocks

$$\ln a_t = (1 - \rho_a) \ln a_{ss} + \rho_a \ln a_{t-1} + \varepsilon_t^a \tag{3.64}$$

$$\ln \xi_t = (1 - \rho_\xi) \ln \xi_{ss} + \rho_\xi \ln \xi_{t-1} + \varepsilon_t^\xi \tag{3.65}$$

$$\ln g_t = (1 - \rho_g) \ln g_{SS} + \rho_g \ln g_{t-1} - \gamma_{gd} \left[\ln \left(\frac{D}{Y}\right)_{t-1} - \ln \left(\frac{D}{Y}\right)_{SS}\right] - \gamma_{gy} \left[\ln Y_t - \ln Y_{SS}\right] + \varepsilon_t^g \tag{3.66}$$

$$\ln \tau_t^f = (1 - \rho_f) \ln \tau_{SS}^f + \rho_f \ln \tau_{t-1}^f + \gamma_{fd} \left[\ln \left(\frac{D}{Y}\right)_{t-1} - \ln \left(\frac{D}{Y}\right)_{SS}\right] + \gamma_{fy} \left[\ln Y_t - \ln Y_{SS}\right] + \varepsilon_t^f \tag{3.67}$$

$$\ln \tau_t^L = (1 - \rho_l) \ln \tau_{SS}^L + \rho_l \ln \tau_{t-1}^L + \gamma_{ld} \left[\ln \left(\frac{D}{Y}\right)_{t-1} - \ln \left(\frac{D}{Y}\right)_{SS}\right] + \gamma_{ly} \left[\ln Y_t - \ln Y_{SS}\right] + \varepsilon_t^L \tag{3.68}$$

$$\ln i_t = (1-\rho_i)\ln i_{ss} + \rho_i \ln i_{t-1} + \phi_\pi(\pi_t - \pi^*) + \phi_y(\ln Y_t - \ln Y_{SS}) + \varepsilon_t^i \quad (3.69)$$

3.4 Quantitative Analysis

To examine the dynamic properties of the model in response to financial and fiscal shocks, we log-linearize the 38 equilibrium conditions around the unique steady state, we calibrate the parameters of the model, and finally, we numerically solve the log-linearised model using the method of generalized Schur decomposition.

3.4.1 Calibration

All parameter values are calibrated from the literature and they are compatible with US data. In our baseline calibration, periods are interpreted as quarters.

We set the time preference parameters for households and investors at $\beta = 0.995$ and $\beta_I = 0.985$, respectively (Iacoviello, 2005; 2015). The risk aversion parameters are set respectively at $\rho = 2$ (Arellano et al., 2012) and $\rho_I = 1$ (Iacoviello, 2005) indicating that workers have higher risk aversion than investors. Labor disutility is set at $\chi = 1$ without affecting the quantitative results. Fritch elasticity of labor supply is set at $1/\lambda = 1.9$ (Hall, 2009). The exogenous exit shock probability is set at $\delta = 0.015$ (Bergin et al., 2018). The elasticity of substitution across varieties is set at $\sigma = 6$ to match the 20% markup of price over marginal cost documented in Rotemberg and Woodford (1992). Following Bergin and Corsetti (2008) and Bilbiie et al. (2007), the love of variety parameter is set at $\gamma = \sigma/(\sigma - 1)$. The initial steady-state entry cost K^E_{SS} does not affect any impulse response; we, therefore, set $K^E_{SS} = 1$ without loss of generality. We set the price stickiness parameter at $\kappa = 77$, following Bilbiie et al. (2007b). We use the value of entry adjustment cost parameter τ from Bergin et al. (2018) and set at $\tau = 2.42$, which was calibrated to fit U.S. macro data.

We receive the parameter values of financial and productivity shocks from Jermann and Quadrini (2012): the persistence and standard deviation of financial shocks are set at $\rho_\xi = 0.97$ and $\sigma_\xi = 0.0098$, whilst the same parameters for productivity are set at $\rho_A = 0.95$ and $\sigma_A = 0.0045$. The steady-state values are set at $A_{SS} = 1$ and $\xi_{SS} = 1$.

The parameters for the Taylor-type interest rate rule received from Galí (2008) and are set at $\rho_i = 0.90$, $\sigma_i = 0.0098$, $\phi_\pi = 1.25$, and $\phi_y = 0.125$. These values are chosen so that the Taylor principle is satisfied and the gross nominal interest rate does not violate the zero lower bound (ZLB)[9].

The choice of the parameter values of fiscal shocks is more complex. Although feedback policy coefficients do not play any role in steady state solutions, they are crucial to determinacy together with the monetary reaction to inflation (Leith and Wren-Lewis, 2008). Therefore, we appropriately adjust the feedback policy coefficients on public debt and output in the fiscal policy rules, together with the parameters of persistence, in order to ensure both the local determinacy and the dynamic stability of our model[10]. More specifically, these parameters are set at $\rho_g = 0.5$, $\gamma_{gd} = 0.001$

[9]The magnitude of the inflation coefficient in the Taylor rule and of the feedback coefficients in the fiscal rules are crucial to determinacy (Leith and Wren-Lewis, 2008). Moreover, recent work has found that fiscal dynamics can change substantially when monetary policy is passive, failing to satisfy the Taylor principle, or when the monetary authorities' interest rate instrument is at or near the zero lower bound (see for instance, Christiano et al., 2011).

[10]Due to the importance of feedback policy coefficients, it would be more appropriate to determine them optimally either by computing their welfare-maximizing values (this is what Schmitt-Grohé and Uribe (2005; 2007) call optimized policy rules) or by estimating them (as Leeper et al. (2010) did, using

and $\gamma_{gy} = 0.0025$ for government spending, at $\rho_f = 0.90$, $\gamma_{fd} = 0.0015$ and $\gamma_{fy} = 0.0005$ for the tax on firm revenues and at $\rho_l = 0.75$, $\gamma_{ld} = 0.004$ and $\gamma_{ly} = 0.0035$ for the tax on labor income[11]. Finally, the steady state tax rates are set to their average values in the data for the USA over the period 1993–2019.

3.4.2 Impulse Responses

In this section, we analyze the dynamic properties of our benchmark model by means of numerical examples. We compute impulse responses to financial and fiscal policy shocks. To disentangle the linkage between firm entry and financial shocks, and the role of fiscal policy in this interlinkage we analyze two alternative versions of the model: (i) the "baseline model" in which both firm entry and financial constraints are incorporated, and (ii) a version of the model without endogenous entry.

3.4.2.1 Financial Shock

Figure 3.3 illustrates the responses to a negative financial shock. The adverse financial shock translates into a tightening of the collateral constraint for borrowing working capital that firms face, which reduces the scale of both firm labor and firm production. A firm can mitigate credit tightness, and thus to smooth its real production, by reducing its debt. By reducing its debt issuance, a firm, on the one hand, decreases the current period dividend payments but on the other hand, attains a higher end-of-period equity value and thus an eased credit constraint, insomuch as equity is used

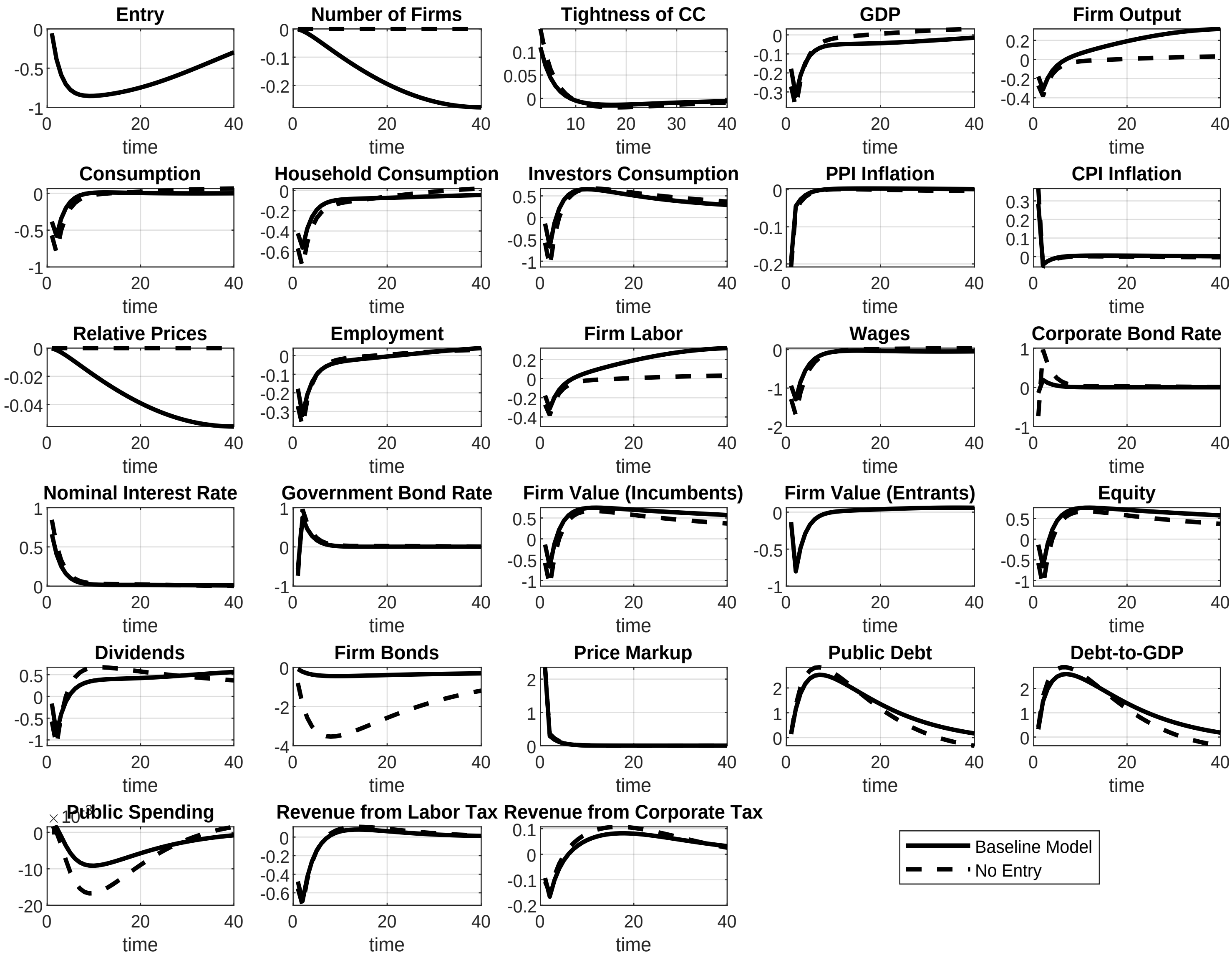
Bayesian techniques). However, due to its complexity we leave this task for the future.

[11] These values are not unique. We determined particular intervals for values of these coefficients that lead to determinacy. Further details regarding these ranges of feedback policy coefficients guaranteeing local determinacy are available upon request.

as collateral. In other words, excess tightness creates an incentive for firms to finance their operations through equity and not through bond issuance. Firms can redistribute their financing from bond issuance to equity issues by deferring current dividends and using the proceeds to repay the debt. The fall in current dividends, which are income for investors, reduces the current consumption of investors, makes them less willing to save, and as a result their stochastic discount factor decreases. Figure 3 shows clearly these negative responses of dividends, debt (bonds) and investors' consumption. Since equity price equals the discounted sum of future dividend payments, the fall in dividends together with the fall in firm discount factor leads to a fall in equity price.

Figure 3.3 shows that equity price initially decreases but then recovers and after some periods increases. This improvement is due to the decline in firm entry. New firms respond to the negative financial shock as incumbents do, that is, they reduce their debt to achieve a higher end-of-period equity value and therefore to ease the collateral constraint they face. Our assumption that investors are less patient than households makes this shift toward equity to give a rise in the entry cost and therefore discourage potential entrants. Figure 3.3 illustrates this phenomenon: the adverse financial shock leads to a negative hump-shaped response of firm entry, a finding that lies in accordance with our empirical findings in section 3.2. The drop in firm entry translates into a gradual but persistent decline in the total mass of firms in the economy. Moreover, Figure 3.3 shows that the firm value for incumbents ($V_t(j)$) and new entrants ($V_t^n(j)$) follow a similar pattern to equity price, initially falling but then gradually rising over time (although the magnitude of the response in $V_t^n(j)$ is more dampened).

The tightening of the collateral constraint increases the effective cost of



Notes: This figure presents the simulated impulse responses to an one standard deviation decrease in financial shock ε_t^{ξ}. The solid lines correspond to the baseline model; the dashed lines corresponds to a version of the model without firm entry. The x-axis measures years.

Figure 3.3: Simulated Impulses Responses to a Negative Financial Shock

labor and thus it reduces the scale of both firm labor and firm output. As a result, aggregate output and employment fall. The drop in output and employment is augmented by the decline in the firm entry. Moreover, wages and consumption (both for households and investors) decrease, following similar patterns to output and employment. As the negative financial shock prevents firms from financing their labor costs through intra-temporal loans, it directly reduces the income of the households. The income of investors also declines because of the reductions in dividends caused by the capital restructuring response to the shock.

The fall in firm numbers mitigates the variety effect and together with the aggravation of the tightness of the collateral constant (i.e the rise in μ_t) lead to an increase in price markups (λ_t) and to a drop in relative prices (p_t). Hence, both production- and consumption-based inflation rates decline. The persistence of the nominal interest rate in the Taylor-type feedback rule (3.31) together with the additional degree of endogenous persistence that CPI-inflation displays lead to a temporary increase of the CPI-inflation in the first two periods and to a slight increase of the nominal interest rate[12]. Finally, the fall in households' discount factor triggers an increase in real interest rates (of both corporate and government bonds).

The fall in output leads to a significant decrease in government's revenues from the tax on firm revenue, whilst the fall in wages and employment reduces the revenues from the tax on labor income. The fall in tax revenues associated with the increase in the rate of government bonds leads to a significant expansion of public debt which in turn reduces government expenditures (from fiscal rule (3.28)). Therefore, the adverse financial shock

[12] Bilbiie et al. (2007b) provide a meticulous analysis for the role that the form of the monetary policy rule plays in a New Keynesian model with endogenous firm entry.

increases public debt, even though it reduces government expenditures, a finding that lies in accordance with our empirical findings in section 3.2.

The above results indicate that the firm's endogenous decision on the means of financing between equity and debt allows a negative financial shock to affect not only the real production and profits but the firm entry as well. The decline in the total mass of firms mitigates the impact of the negative financial shock at firm production and profits of incumbents. This stems from a fundamental implication of the free entry condition (3.15), that the effect of an adverse financial shock is split between a decline in firm value (and thus in firm equity price) and a drop of firm numbers. To the extent that a negative financial shock reduces the total mass of existing firms, each active firm gains a larger share of aggregate profits, moderating the drop in its equity price. This means that the collateral constraint becomes less tighten for incumbent firms and thus the repercussions of the financial shocks are significantly alleviated for them. Figure 3.3 illustrates clearly this result. In the version of the model without firm entry (dashed lines), the non-adjustment in firm numbers prevents real production and labor demand of incumbents for recovering and increasing after the adverse financial shock.

However, the most interesting finding is that the drop in firm numbers leads to the significantly slower recovery of the aggregate output as it is clearly illustrated in Figure 3.3. The U.S. Great Recession was associated with a dramatic and persistent decline (27%) in firm entry. Our model suggests that there is a direct linkage between these two phenomena, in the sense that an adverse financial shock drives to a significant decline in firm numbers, and that this persistent decline is responsible for the slower recovery of the aggregate economy.

There is important literature suggesting that the large and persistent decline in firm entry that occurred during the 2007-2009 financial crisis accounted for a large part of the slow recovery of the U.S. economy due to the significant adverse repercussions that had on the aggregate employment given that startups are vital for job creation (Clementi and Palazzo, 2013; Sedlacek, 2019). Our finding provides a new theoretical standpoint to this argument, connecting the drop in firm entry directly with the slow recovery of aggregate output and not through employment. Our findings also are suggestive of policies aimed at alleviating the impact of recessions on aggregate output that work by mitigating the failure of incumbent firms and stimulating the creation of new firms.

3.4.2.2 Fiscal Shocks

Figures 3.4-3.6 plot the impulse responses following a temporary one standard deviation exogenous increase in each fiscal instrument.

Figure 3.4 illustrates the dynamic effects of an expansionary government spending shock. The shock raises aggregate demand, thus aggregate output rises and puts pressure in the general price level. Thus, inflation rises initially and as a result, monetary authorities raise the basic nominal interest rate. Private consumption falls whilst aggregate employment rises due to the negative wealth effect, a standard counterfactual prediction in New Keynesian DSGE models due to Ricardian behavior of households[13]. Also, and as we expected, the shock in public spending raises public debt but the increased tax revenues alleviate this increase.

Initially and before the number of firms starts to adjust, the rise in ag-

[13] As standard solution for this counterfactual prediction in the literature is the incorporation of a set of non-Ricardian consumers in the model (see e.g. Gali et al., 2007). In our setting, the effect of a public spending shock on private consumption becomes positive if the proportion of non-Ricardian agents in the economy is greater than 80%. However, this analysis is beyond the scope of this study.

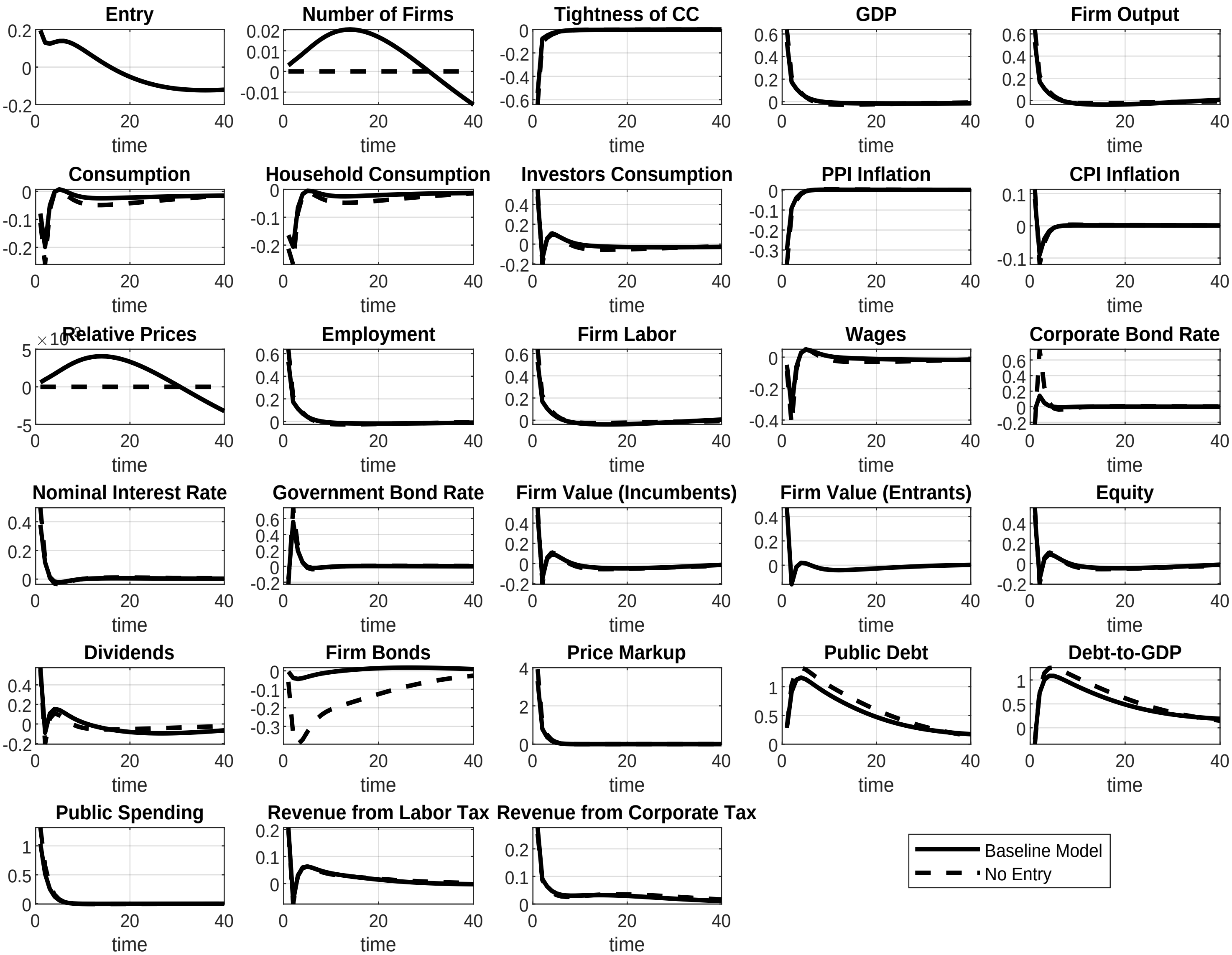
gregate demand pushes up firm output, firm labor and profits/dividends. The rise in current dividends, which are income for investors, temporarily increases the current consumption of investors, makes them more willing to save, and as a result their stochastic discount factor increases. Since equity price equals the discounted sum of future dividend payments, the rise in dividends and in the firm discount factor leads to a significant increase in equity prices. This increase leads to an eased collateral constraint. These results make the business environment temporarily more attractive, drawing a higher number of entrants which translates into a gradual increase in the number of firms. This gradual adjustment in firm numbers smooth general prices and thus real economy. This finding lies in accordance with both previous literature (Chugh and Ghironi, 2011) and the empirical evidence, presented in section 3.2. It is notable that the increase in public consumption leads to a quite short-lived stimulation of firm entry (it lasts only 4 years)[14].

Figures 3.5 and 3.6 illustrate the dynamic effects of positive shocks in tax rates on labor income and firm revenue, respectively. Naturally, both taxes lead to a contraction of the aggregate economy reducing the scale of output, employment, and consumption. Initially and before the number of firms adjusts, the decline in aggregate demand pushes down firm output, firm labor, profits/dividends, and prices. The drop in current dividends, which are income for investors, reduces the current consumption of investors, makes them less willing to save, and as a result their stochastic discount factor falls. Since equity price equals the discounted sum of future dividend

[14] This effect depends to a large extent on the persistence of government shock spending, as has already been pointed out in the literature (Lewis, 2009). We find that for moderate (lower than 0.70) and very large (larger than 0.99) values of ρ_g, an expansionary government spending shock stimulates firm creation. To the contrary, if $\rho_g \in [0.75, 0.99]$, an increase in government spending can crowd out investments in firm entry.

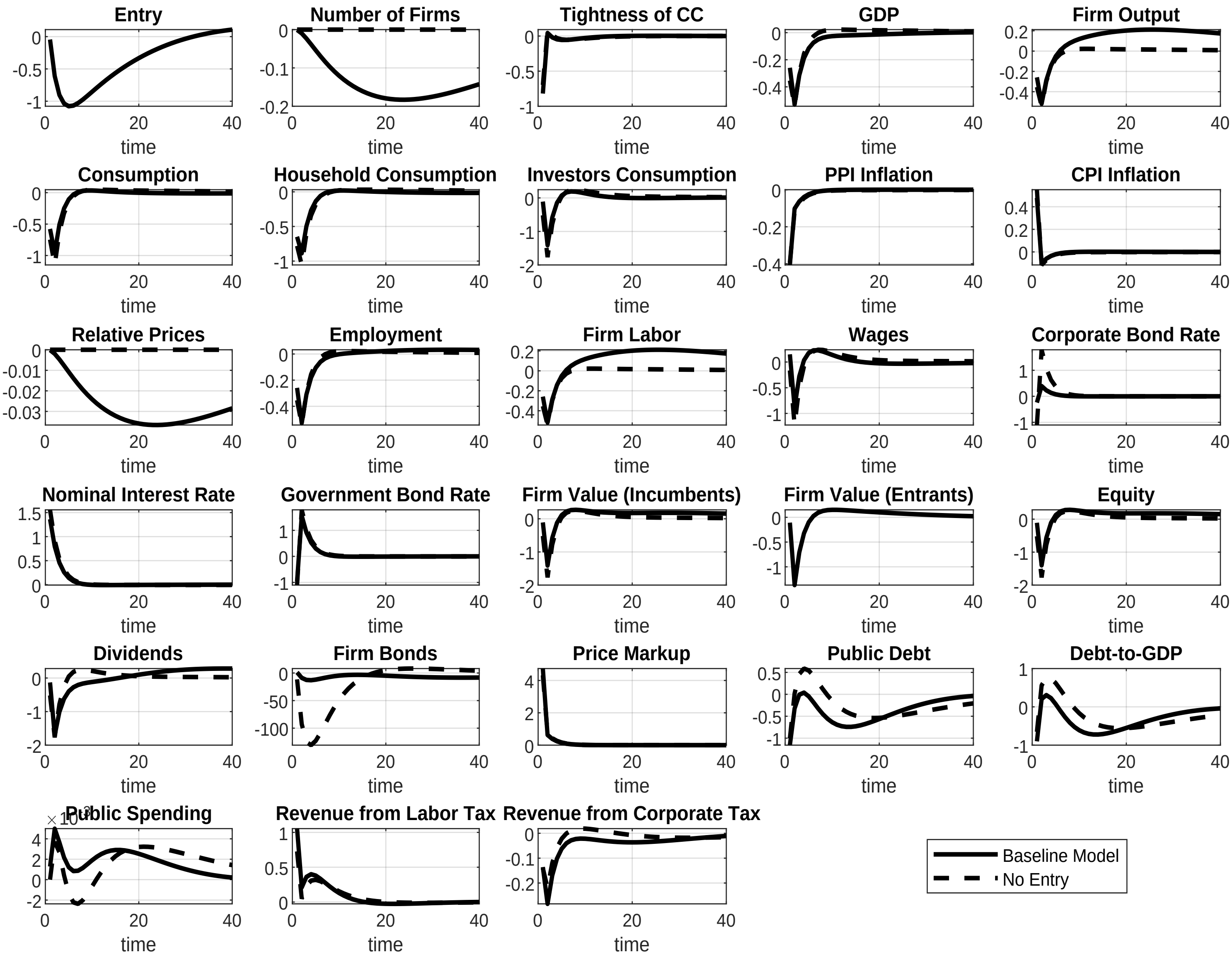
payments, the drop in both dividends and the firm discount factor leads to a significant drop in equity prices deterring potential entrants from entering. As a result, firm entry starts to fall leading to a gradual and persistent decline in the total mass of firms. This gradual adjustment in firm numbers smooths the contraction of the real economy and thus firm production of incumbents starts to recover. Figures 3.5 and 3.6 show clearly that the adjustment in firm numbers leads to a much slower recovery of the aggregate economy from the adverse effects of increased taxation, especially in the case of the tax on firms. Finally, the rich specifications of fiscal rules we use, lead to interesting real debt dynamics: increased taxes (and thus higher tax revenues) reduce public debt and allow higher levels of government spending.

The above results suggest that firm entry dynamics is a crucial dimension for fiscal policy analysis since they affect substantially both the size and the persistence of the impact of fiscal shocks on aggregate economy.



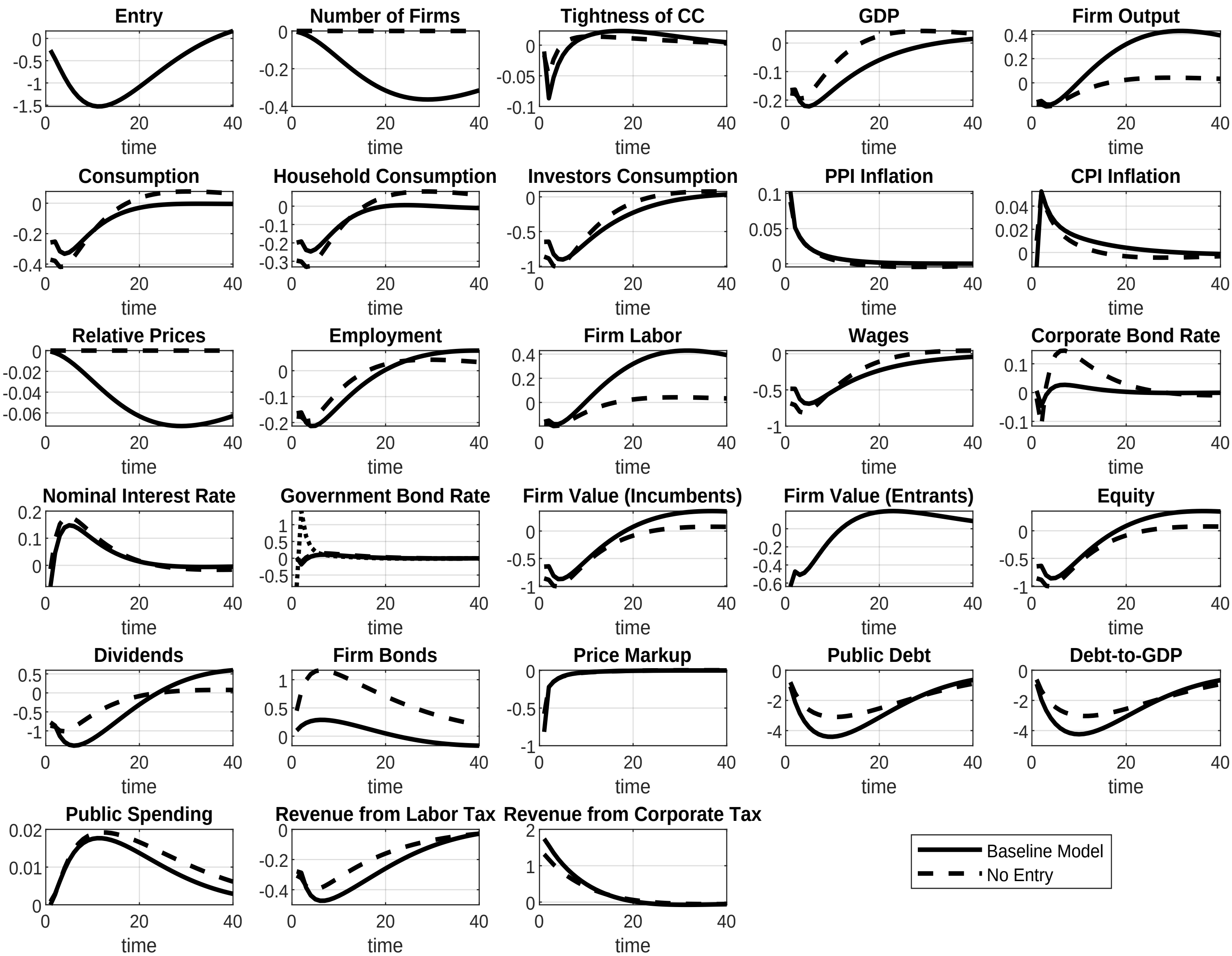
Notes: This figure presents the simulated impulse responses to a one standard deviation increase in government spending shock ε_t^g. The solid lines correspond to the baseline model; the dashed lines correspond to a version of the model without firm entry.

Figure 3.4: Simulated Impulses Responses to a Positive Government Speding Shock



Notes: This figure presents the simulated impulse responses to a one standard deviation increase in labor tax shock ε_t^g. The solid lines correspond to the baseline model; the dashed lines correspond to a version of the model without firm entry.

Figure 3.5: Simulated Impulses Responses to a Positive Labor Tax Shock



Notes: This figure presents the simulated impulse responses to a one standard deviation increase in firm revenue tax shock ε_t^g. The solid lines corresond to the baseline model; the dashed lines corresponds to a version of the model without firm entry.

Figure 3.6: Simulated Impulses Responses to a Positive Firm Revenue Tax Shock

3.4.3 Present Value Multipliers

The dynamic effects of fiscal shocks can be quantified by fiscal multipliers. In this section, we calculate present-value fiscal multipliers for output from changes in government spending, labor tax rates, and firm revenue tax rates. Present value multipliers are preferred over the relevant impact fiscal multipliers since they capture both short-run and long-run dynamics of fiscal shocks and they properly discount macroeconomic effects in the future.

To calculate the present value multiplier of a fiscal instrument for output we use the following formula (Moutford and Uhlig, 2009):

$$Present - Value - Multiplier(T) = \frac{E_t \sum_{j=0}^{T} \beta^j \Delta Y_{t+j}}{E_t \sum_{j=0}^{T} \beta^j \Delta F_{t+j}} \tag{3.70}$$

where ΔY_{t+j} is the response of GDP at period j, ΔF_{t+j} is the response of the fiscal variable at period j, and β is the discount factor. This multiplier measures the present value of additional output over a T-period horizon that is generated by a change in the present value of a fiscal instrument (Leeper et al., 2010). Note that for T = 0, (3.70) gives the standard impact multiplier.

Figure 3.7 illustrates the evolution of present-value multipliers for output from changes in government spending, labor tax rates, and firm revenue tax rates. We set the forecast horizon to 30 years (120 quarters) to explore the differences between short-to-medium-run multipliers and long-run multipliers. To disentangle the role of firm entry in the dynamic quantitative effects of fiscal policy in the presence of financial frictions, we repeat the same counterfactual exercise we did in the previous section. To be more precise, we calculate the present value multipliers for two alternative versions of our model: (i) the “baseline model” in which both firm entry and financial constraints are incorporated, and (ii) a version of the model without endogenous firm entry.

Figure 3.7 shows that present-value multipliers change substantially when firm entry dynamics are taken into consideration. Adjustments in firm numbers lead to higher government spending multipliers at shorter horizons but at the cost of smaller multipliers over longer horizons. Higher government expenditures stimulate intensively output in the short run, but as time passes taxes rise, output declines and the impact of present-value multiplier fades[15].

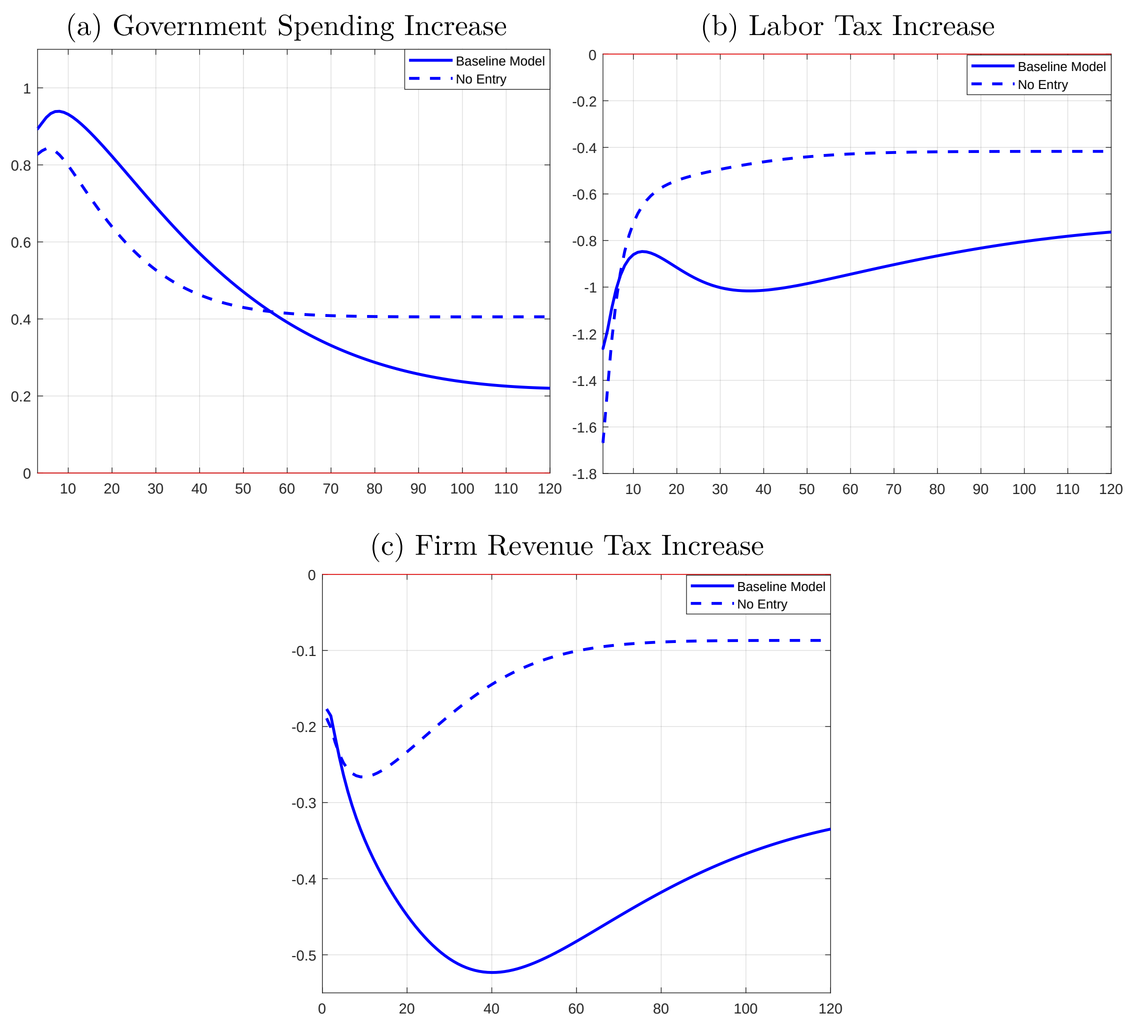
Moreover, firm entry dynamics lead to persistently higher multipliers for both labor and firm revenue tax rates in the medium and long runs. These results should not be surprising, given that in the previous section we found that in the baseline model positive shocks in taxes lead to a larger and more persistent fall in output, due to a persistent decline in firm numbers.

In particular, higher labor taxes have a quite large negative impact on output in the short run (the impact multiplier is approximately -1.25 for the baseline model). Although, this impact becomes more modest in the medium and long runs, it remains strong if we allow firm numbers to adjust.

Firm entry seems to play no role in the short-run multipliers of firm revenue taxes. However, as time passes, the multipliers become substantially larger if we allow firm numbers to adjust (approximately 5 times larger in the medium run and 3.5 times in the long run).

Our findings suggest that firm entry dynamics can be a critical determinant of fiscal policy. They affect substantially the persistence of the impact

[15] The size of the present-value multipliers depends highly on the specification of fiscal rules. We choose these particular specifications, described in section 3.3.5, since they have been found to fit well the U.S. data (Leeper et al., 2010).



Notes: This Figure presents the Present-value fiscal multipliers for output. The solid lines corresond to the baseline model; the dashed lines corresponds to a version of the model without firm entry; the dotted lines correspond to a version of the model without financial frictions.

Figure 3.7: Present-value fiscal multipliers for output

of fiscal shocks on aggregate economy and they play a crucial role in the size of fiscal multipliers, especially in the long run.

3.5 Concluding Remarks

The 2007-09 financial crisis was associated with a dramatic and persistent decline (27%) in firm entry in the U.S. economy. This study examines whether and to what extent fiscal policy can deal with these two phenomena. First, using a VAR model, covering the period 1993Q3-2019Q4, we document empirically that expansionary fiscal policy can stimulate both the credit supply and the new business formation. Second, by building a New Keynesian DSGE model combining endogenous firm entry and firm-level financial constraints, we provide a theoretical framework to explain this finding. Our model implies that fiscal stimulus can relax credit constraints faced by firms, leading to a gradual and persistent rise in firm numbers.

This study also highlights the role of firm entry in fiscal dynamics in the presence of financial frictions. We find that firm entry is a crucial dimension for fiscal policy analysis since it substantially affects both the persistence of the impact of fiscal shocks on the aggregate economy and the size of fiscal multipliers, especially in the long run. We find that expansionary fiscal policy can lead to a long-lasting expansion of aggregate output through the gradual and persistent stimulation of firm creation.

Bibliography

[1] Arellano, C., Y. Bai, and P. Kehoe, 2012, “Financial frictions and fluctuations in volatility”, Staff Report 466, Federal Reserve Bank of Minneapolis.

[2] Auerbach, A., Y. Gorodnichenko and Daniel Murphy, 2020, “Effects of fiscal policy on credit markets”, NBER Working Papers, No. 26655, National Bureau of Economic Research.

[3] Auray, S., A. Eyquem, and J.C. Poutineau, 2012, “The effect of a common currency on the volatility of the extensive margin of trade”, Journal of International Money and Finance, Vol. 31, No. 5, pp. 1156–1179.

[4] Bergin, P.R. and G. Corsetti, 2008, “The extensive margin and monetary policy”, Journal of Monetary Economics, Vol. 55, No. 7, pp. 1222–1237.

[5] Bergin, P.R., L. Feng and C.Y. Lin, 2018, “Firm entry and financial shocks”, The Economic Journal, Vol. 128, , No. 609, pp. 510-540.

[6] Bernanke, B., and M. Gertler, 1995, “Inside the black box: The credit channel of monetary policy transmission”, Journal of Economic Perspectives, Vol. 9, pp. 27-48.

[7] Bernanke, B.S. and I. Mihov, 1998, “Measuring monetary policy”, Quarterly Journal of Economics, Vol. 113, No. 3, pp. 869–902.

[8] Bilbiie, F., F. Ghironi, and M. Melitz, 2007, “Endogenous entry, product variety and business cycles”, NBER Working Paper, No. 13646, National Bureau of Economic Research.

[9] Bilbiie, F., F. Ghironi, M. Mélitz, 2007, “Monetary policy and business cycles with endogenous entry and product variety”, in: Acemoglu, D., Rogoff, K., Woodford, M. (Eds.), NBER Macroeconomic Annual 2007, 22,University of Chicago Press, Chicago (IL), pp. 299–353.

[10] Bilbiie, F., F. Ghironi, M.Mélitz, 2012, “Endogenous entry, product variety and business cycles”, Journal of Political Economy, Vol. 120, No. 2, pp. 304–345.

[11] Calvo, G.A., 1983, “Staggered prices in a utility-maximizing framework”, Journal of Monetary Economics, Vol. 12, pp. 383–398.

[12] Cantore, C. , P. Levine, G. Melina, G., and J. Pearlman, 2017, “Optimal fiscal and monetary policy, debt crisis and management”, University of Surrey, School of Economics Discussion paper, No. 0217.

[13] Cavallari, L., 2013a, “A note on firm entry, markups and the business cycle”, Economic Modelling, Vol. 35, pp. 528-535.

[14] Cavallari, L., 2013b, “Firms’ entry, monetary policy and the international business cycle”, Journal of International Economics, Vol. 91, No. 2, pp. 263-274.

[15] Chor, D. and K. Manova, 2012, "Off the cliff and back? Credit conditions and international trade during the global financial crisis", Journal of International Economics, Vol. 87, No. 1, pp. 117–33.

[16] Christiano, L.J., M. Eichenbaum, S. Rebelo, 2011, "When is the government spending multiplier large?", Journal of Political Economy Vol. 119, No. 1, pp. 78-121.

[17] Chugh, S., and F. Ghironi, 2011, "Optimal fiscal policy with endogenous product variety", NBER Working Paper, No. 17319, National Bureau of Economic Research.

[18] Clementi, G.L., and B. Palazzo, 2016, "Entry, exit, firm dynamics, and aggregate fluctuations", American Economic Journal: Macroeconomics, Vol. 8, No. 3, pp. 1-41.

[19] Coenen, G., M. Mohr, and R. Straub, 2008, "Fiscal consolidation in the euro area: long-run benefits and short-run costs", Economic Modelling, Vol. 25, pp. 912–932.

[20] Cook, D., and T. Damjanovic, 2020, "Optimal fiscal policy in a model of firm entry and financial frictions", Review of Economic Dynamics", Vol. 35, pp. 74-96.

[21] Eichenbaum, M. and C.L. Evan, 1995, "Some empirical evidence on the effects of shocks to monetary policy on exchange rates", Quarterly Journal of Economics, Vol. 110, No. 4, pp. 975–1009.

[22] Forni, L., L. Monteforte and L. Sessa, 2009, "The general equilibrium effects of fiscal policy: Estimates for the Euro Area", Journal of Public Economics, Vol. 93, No. 3, pp. 559–585.

[23] Gali, J., 2015, “Monetary policy, inflation, and the business cycle: an introduction to the new Keynesian framework and its applications”, Princeton University Press, Princeton.

[24] Galí, J., J. López-Salido and J. Vallés, 2007, “Understanding the effects of government spending on consumption”, Journal of the European Economic Association, Vol. 5, No. 1, pp. 227-270.

[25] Ghironi, F., and M. Melitz, 2005, “International trade and macroeconomic dynamics with heterogeneous firms”, Quarterly Journal of Economics, Vol. 20, No. 3, pp. 865–915.

[26] Hall, R., 2009, “By how much does GDP rise if the government buys more output”, Brookings Papers on Economic Activity, Vol. 40, No. 2, pp. 183–231.

[27] Iacoviello, M., 2005, “House prices, borrowing constraints, and monetary policy in the business cycle”, American Economic Review, Vol. 95, No. 3, pp. 739–64.

[28] Iacoviello, M., 2015, “Financial business cycles”, Review of Economic Dynamics, Vol. 18, No. 1, pp. 140–63.

[29] Jermann, U. and V. Quadrini, 2012, “Macroeconomic effects of financial shocks”, American Economic Review, Vol. 102, No. 1, pp. 238–71.

[30] Kiyotaki, N. and J. Moore, 1997, “Credit cycles”, Journal of Political Economy, Vol. 105, No. 2, pp. 211–48.

[31] Leeper, E.M., M.Plante and N. Trauma, 2010, “Dynamics of fiscal financing in the United States”, Journal of Econometrics, Vol. 156, pp. 304-321.

[32] Leith, C. and S. Wren-Lewis, 2008, "Interactions between monetary and fiscal policy under flexible exchange rates", Journal of Economic Dynamics and ControlVol. 32, No. 9, pp. 2854–2882.

[33] Lewis, V., 2009, "Business cycle evidence on firm entry", Macroeconomic Dynamics, Vol. 13, pp. 605-624.

[34] Lewis, V., and C. Poilly, 2012, "Firm entry, markups and the monetary transmission mechanism", Journal of Monetary Economics, Vol. 59, No. 7, pp. 670-685.

[35] Melitz, M.J., 2003, "The impact of trade on intra-industry reallocations and aggregate industry productivity", Econometrica, Vol. 71, No. 6, pp. 1695–725.

[36] Miranda-Pinto, J., D. Murphy, K. Walsh, and E. Young, 2019, "Saving constraints, debt, and the credit market response to fiscal stimulus", Mimeo.

[37] Mountford, A. and H. Uhlig, 2009, "What are the effects of fiscal policy shocks?", Journal of Applied Econometrics, Vol. 24, No. 6, pp. 960-992.

[38] Murphy, D. and K. Walsh, 2018, "Government spending and interest rates", Mimeo.

[39] Orlowski, L.T., 2015, "Monetary expansion and bank credit: A lack of spark", Journal of Policy Modelling, Vol. 37, No. 3, pp. 510-520.

[40] Perri, F., and V. Quadrini, 2011, "International recessions", NBER Working Paper, No. 17201, National Bureau of Economic Research.

[41] Pugsley, B., and A. Sahin, 2019, "Grown-up business cycles", The Review of Financial Studies, Vol. 32, No. 3, pp. 1102–1147.

[42] Rossi, L., 2019, "The overshooting of firms' destruction, banks and productivity shocks", European Economic Review, Vol. 113, pp. 36–155

[43] Rotemberg, J. and M. Woodford, 1992, "Oligopolistic pricing and the effects of aggregate demand on economic activity", Journal of Political Economy, Vol. 100, No. 6, pp. 1153–207.

[44] Rotemberg, J., M. Woodford, 1999a, "Interest-rate rules in an estimated sticky-price model", in: Taylor, J.B. (Ed.), Monetary Policy Rules. University of Chicago Press, Chicago (IL).

[45] Rotemberg, J., M. Woodford, 1999b, "The cyclical behaviour of prices and costs", in: Taylor, J.B., Woodford, M. (Eds.), The Handbook of Macroeconomics, Vol. 1B, North-Holland, Amsterdam, pp. 1051–1135.

[46] Sedlacek, P., 2019, "Lost generations of firms and aggregate labor market dynamics", Journal of Monetary Economics, forthcoming.

[47] Schmitt-Grohé, S. and M. Uribe, 2005, "Optimal fiscal and monetary policy in a medium-scale macroeconomic model", In: Gertler, M., Rogoff, K. (Eds.), NBER Macroeconomics Annual, MIT Press, Cambridge MA, pp. 385–425.

[48] Schmitt-Grohé, S. and M. Uribe, 2007, "Optimal simple and implementable monetary and fiscal rules", Journal of Monetary Economics, Vol. 54, pp. 1702–1725.

[49] Taylor, J.B., 1993, “Discretion versus policy rules in practice”, Carnegie-Rochester Conference Series on Public Policy, Vol. 39, pp. 195–214.

[50] Uusküla, L., 2016, “Monetary transmission mechanism with firm turnover”, Journal of Macroeconomics, Vo. 50, pp. 1-18.