Size-growth relationship among domestic and exporting firms: The role of investment and heterogeneous financial constraints

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Abstract

In this paper, I provide a framework that can help reconcile diverging results obtained in the literature on firm-level size and growth. I show that from a theoretical point of view, the relationship between firm-level initial size and investment or performance growth depends on three main determinants: the shape of the profit function with respect to size, the shape of marginal returns to investment (in terms of size) with respect to initial size and the shape of marginal cost of investment with respect to size. I then test some implications of the theoretical framework on French data. I first identify, thanks to augmented Euler equations, sectors in which financial constraints are homogeneous across firms, and sectors in which financial constraints are more intense for smaller firms. I show that profits have the same concave shape in both types of industries. As predicted by the theoretical framework, investment and sales or employment growth are, all else equal, higher for initially smaller firms in sectors where credit constraints are homogeneous; this negative relationship is however more muted, or even disappears, in sectors where credit constraints are tougher for smaller firms. I show that these results cannot be explained by heterogeneous returns to investment in terms of size across the two groups of industries identified. Two macroeconomic implications are finally drawn from this work: in sectors where small firms are disproportionately credit constrained, firm-size distribution is less dispersed but more skewed on the right, and small firms participate less to sectorial growth.

1 Introduction

The relationship between firm-level size and performance growth has been debated in the literature over the past decades, and the question still remains open. While the Gibrat law

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stipulates that firm-level growth rate should be independent of firm size, Birch (1979, 1981) shows that small firms grow faster and create a disproportionate share of US jobs. Further studies on the US, Canada or Netherlands partly corroborate these results (see, e.g. Dunne, Roberts, and Samuelson, 1989; Baldwin and Picot, 1995; Broersma and Gautier, 1997). This has fueled the policy-makers' point of view that "small is beautiful", and that SMEs are a crucial engine of growth. However, these conclusions have been challenged by several authors (in particular Davis and Haltiwanger, 1992; Davis, Haltiwanger, and Schuh, 1998), mainly from a statistical viewpoint. The controversy is still very vivid today, with conflicting recent contributions on US data by Neumark, Wall, and Zhang (2011) and Haltiwanger, Jarmin, and Miranda (2010).

This debate on the size-growth relationship percolates in different fields of economics. For example, it is now well-known that exposure to international trade induces productivity gains within industries through firm selection, market-shares reallocation and within-plant productivity gains (see, e.g., Melitz, 2003; Pavcnik, 2002; De Loecker, 2007). Regarding this latter channel, a consensus has emerged to say that entry on export markets is often associated with firm-level technology adoption or innovation. But which type of firms invest more? Initially bigger and more productive ones, or on the opposite smaller and less productive ones? Again, the very recent literature in international trade diverges on this question. Bustos (2011) shows that following the signature of MERCOSUR, Argentinian firms increased technology spendings, this increase being more spectacular for initially bigger firms. By contrast, in Canada, Lileeva and Trefler (2010) find that following the CUSFTA agreement, productivity gains and technology investments were concentrated among initially smaller and less productive new exporters.

In this paper, I provide a framework that can help understand and reconcile diverging results obtained in the literature. I assume that a firm can make a capacity or a productivity-enhancing investment in period 0 to increase its profits in period 1. I show that from a theoretical point of view, the relationship between firm-level initial size, investment, and performance growth depends on three main determinants: the shape of the profit function with respect to size, the shape of marginal returns to investment in terms of size with respect to initial size and the shape of marginal cost of investment with respect to size. If profits are concave in size (i.e. first derivative of the profit function with respect to size positive, and second derivative negative), and if marginal returns to investment do not depend on size, initially smaller firms have greater incentives to invest; they consequently grow more. The opposite is true if profits are convex in size (first and second derivatives positive). However, the relationship between initial size and performance growth determined by the shape of profits can be altered by the shape of the marginal cost of investment. In particular, if the marginal cost of investment is higher for smaller firms, due for example to tougher financial constraints on small firms, the convergence process at play when firm-level profits are concave is attenuated or reversed.

I then test the predictions of the model on French firm-level data over the period 1996-2002. I first identify, thanks to augmented Euler equations, sectors in which financial constraints are homogeneous across firms, and sectors in which financial constraints are more intense for smaller firms. I show that profits have the same concave shape in both types of industries. As predicted by the theoretical framework, investment and sales or employment growth are, all else equal, higher for initially smaller firms in sectors where credit constraints are homogeneous; this negative relationship is however more muted, or even disappears, in sectors where credit constraints are tougher for smaller firms. Results are qualitatively the same for domestic and exporting firms. However, for a given type of industry in terms of financial constraints, the convergence process is more rapid among domestic firms. This is explained by the fact that profits of exporting firms are less concave than profits of domestic ones. I show that these results cannot be explained by heterogeneous returns to investment in terms of size across the two groups of industries identified. Two macroeconomic implications are finally drawn from this work: the shape of financial constraints affect firm size distribution on the one hand, and the share of SME's in aggregate growth on the other. More specifically, in sectors where small firms are disproportionately credit constrained, firm-size distribution is less dispersed but more skewed on the right, and small firms participate less to sectorial growth.

The rest of the paper proceeds as follows. Section 2 presents a brief overview of previous research and emphasizes the contribution of the present work. I develop my theoretical framework in section 3, I present the data and analyze the shape of financial constraints and profits in section 4, and I present the results on the size-invetsment and size-growth relationship in section 5. Section 6 concludes.

2 Previous research and contribution

This paper relates to three strands of the literature: the literature on the firm size-growth relationship, the literature on firm-level investment and financial constraints, and finally the literature on firm-level size, trade and investment.

2.1 Firm-level size and growth

The law of proportional effect developed by Robert Gibrat is the first attempt to formalize the link between firm-level growth and the distribution of activities within an industry (for a detailed review on the Gibrat law, see Sutton, 1997). In this framework, firm-level growth is seen as a stochastic process where increments in terms of size between two periods are proportional to initial size of the firm. This ensures that expected firm-level growth rate and initial size are not correlated. One appealing feature of random growth processes is that they are able to generate power laws distribution for the variable which dynamics is considered (see Gabaix, 1999, in the case of cities). And power laws appear to be a good fit for firm size distribution in many countries and industries, at least above a certain threshold (Axtell, 2001; Luttmer, 2007; di Giovanni, Levchenko, and Ranciere, 2010).

However, the empirical evidence on the relationship between firm-level size and growth is rather mixed. Birch (1979, 1981) finds on US data that smaller firms grow more rapidly than bigger ones, and that they account for a disproportionate share of jobs creations. Dunne, Roberts, and Samuelson (1989) qualify this result: the net expected growth rate of a firm depends on its expected growth rate conditional on survival, and on its probability of survival. They show that conditional on survival, small and young firms grow faster than the others. However, small and young firms have also a higher probability of default. The authors find that in the end, there is still a negative relationship between initial size and net growth rate for US single-plant firms, but the result is reversed for plants belonging to multi-plant firms.

This negative relationship between firm-level initial size and net growth rate is however questioned. Davis and Haltiwanger (1992) examine detailed patterns of jobs creations and destructions in the US. They show that small firms have a higher gross creation rate, but also a higher destruction rate. They find that in terms of net employment growth rate, manufacturing firms lose jobs in all size classes, and that no significant differences emerge across size classes. On the opposite, young firms do seem to have higher net jobs creation rates. Davis, Haltiwanger, and Schuh (1998) go further and argue that previous assessments of the size-growth relationship were plagued by measurement and statistical issues. More precisely, in some datasets (in particular US data), longitudinal linkages are difficult to follow since changes in ownership are sometimes accompanied by changes in firm-level ID. This leads to spurious firm births and death. Moreover, usual measures of firm-level growth $\frac{y_t - y_{t-1}}{y_{t-1}}$ might be subject to what these authors call the "reversion to the mean" issue: if a firm experiences a negative transitory shock in one period, it will certainly experience a high growth rate the period after, coming back to its "long run" average size, and vice versa in case of positive transitory shocks. To correct for this issue, the authors propose to use $\frac{y_t + y_{t-1}}{2}$ as the reference size, instead of y_{t-1}. This strategy, as acknowledged by the authors themselves, has its own issues, since it minimizes in particular the impact of permanent shocks.

Two very recent papers show that the controversy is not over. Neumark, Wall, and Zhang (2011) carefully address the measurement and statistical issues raised by Davis, Haltiwanger, and Schuh (1996), on a new US dataset and a more recent period of time. They show that the negative relationship, even though weakened, still holds both in the manufacturing and the services sector (even though less regular for manufacturing activities). However, Haltiwanger, Jarmin, and Miranda (2010) reply that when controlling for firm age, no statistical relationship exists anymore between firm size and growth.

In this paper, my focus is slightly different. I argue that the size-growth relationship is not given but depends on the environment in which firms operate, both in terms of technology and financing capacities. This can explain differences in the nature and the intensity of this relationship across countries, sectors or periods. I moreover relate the nature of this relationship to the investment behavior of firms, which was totally absent from the picture in the papers cited above. I consequently focus on stayers, that is to say of firms that remain active on the market for a given period of time, and do not deal with entry and exit. I also introduce a distinction between domestic and exporting firms, which had not been done so far. In terms of data, I use the French annual business surveys. In France, firms obtain at their birth an ID that they conserve all their life long, even in case of mergers and acquisitions. This washes out measurement issues for the identification of stayers. Regarding the regression fallacy issue, I consider firm-level growth over a long time-span (6 years in the main regressions); I moreover rely on a regression analysis linking firm-level growth and size, and not on a comparison of average growth rates across size classes. This mitigates the noise introduced by transitory shocks in the estimation of the size-growth relationship.

2.2 Firm-level investment, financial constraints and growth

A huge literature exists on firm-level financial constraints, investment and growth.

From a macroeconomic point of view, the negative impact of credit constraints on growth has been widely emphasized. Rajan and Zingales (1998), based on a difference-in-differences approach, show that industrial sectors that are more dependent on external finance grow disproportionately faster in countries that are better financially developed. The underlying idea is that financial services, when efficient, allow to allocate capital to the highest value use. At a micro level, Demirgüç-Kunt and Maksimovic (1998) show that the proportion of firms using long-term external financing is higher in countries with better legal and financial systems. These papers however do not deal with the heterogeneous impact of financial constraints on firms that differ in size.

Beck, Demirgüç-Kunt, and Maksimovic (2005) use firm-level survey data on self-reported financing and legal obstacles experienced by firms; they show that firms declaring to face financial constraints have, all else equal, a lower growth rate. This negative impact is measured to be more important for smaller firms. Beck, Demirguc-Kunt, Laeven, and Levine (2008) adopt a strategy *à la* Rajan and Zingales (1998), and show that industries that are technologically more dependent on small firms grow more in countries that are financially better developed.[1] These two papers, taken together, tend to show that financial constraints slow down firm-level growth, and that SMEs might be disproportionately affected by these obstacles. Gorodnichenko and Schnitzer (2011) use survey data on firms in emerging countries and show that financial constraints restrain more innovation for smaller and younger firms.

Two other papers investigate directly the heterogeneity of financial constraints, by estimating the sensitivity of firm-level investment to cash flow for firms of different size. Following Modigliani and Miller (1958), the idea is that when financial markets are frictionless, invest-

[1] They calculate the share of firms below 20 employees in total sectoral employment in the US, and use the ranking of US industries as a benchmark to define the "technological dependence on small firms" of a given sector.

ment should be independent of firm-level internal financing capacity. A positive correlation between investment and cash flow is then interpreted as evidence of financial constraints, and a bigger coefficient for smaller firms would be interpreted as a sign of tougher credit constraints for smaller firms. Kadapakkam, Kumar, and Riddick (1998), and Audretsch and Elston (2002), do not find such a heterogeneity for 6 OECD countries and Germany respectively. However, for both studies, the results might be due to the small number of observations and to an over-representation of big firms.

Regarding financial constraints in France, Bach (2011) analyzes a specific targeted loans program. He exploits both an exogenous increase in available liquidities and an extension of the program to the retail sector, previously ineligible. He shows that following the positive liquidity shock, newly eligible firms increased more than the others their externally financed debt. This increase is not attributable to substitution between subsidized and non subsidized debt, and the returns on subsidized debt appear to be higher than its market cost. The program reform did not induce significant increase in the default risk of subsidized firms. These results demonstrate the existence of credit constraints for small firms in France.

I depart from these papers along two dimensions. First, they are focused on the measure of specific credit constraints for smaller firms and their impact on macroeconomic growth, while I am interested in the role of heterogeneous credit constraints on the firm-level size-growth relationship. Second, it is implicitly assumed in these papers that if small firms are disproportionately credit constrained, this should be true for all sectors. However, loaners might consider size, as a determinant for the obtention of external credits, differently across sectors depending on the competitive environment in the industry or on the maturity of the sector for example. I will thus distinguish in the analysis French industrial sectors with homogeneous credit constraints and sectors with heterogeneous credit constraints.

2.3 Firm-level size, trade and investment

The fact that exporting firms are on average bigger and more productive than domestic ones is now well documented. The literature has long tried to asses whether this export premium was a cause (selection) or a consequence (learning by exporting) of activities on foreign markets (e.g. Bernard and Jensen, 1999; Melitz, 2003; Van Biesebroeck, 2005; De Loecker, 2007). More recently, the emphasis has been put on the joint decision of firms to invest and export. Costantini and Melitz (2008), Atkeson and Burstein (2010), Aw, Roberts, and Xu (2010) show for example that the decision to enter on export markets might be correlated with the decision to make product or process innovation, since exporting firms benefit from a larger market on which to amortize their investment.

Bustos (2011) and Lileeva and Trefler (2010) investigate the heterogeneity of this joint decision along the firm-level productivity/size dimension. Bustos (2011) builds a model *à la* Melitz in which she introduces a technology choice. She finds that initially more productive and bigger firms are more likely to both invest in the "high" technology and export, and confirms empirically these results studying Argentinian firms' response to the implementation of MERCOSUR. Lileeva and Trefler (2010) assume in their theoretical framework that firms differ both in terms of initial size/productivity and, for a given size, in terms of marginal returns to investment. There are fixed export and investment costs. In presence of this two dimensional heterogeneity, they show that following a trade liberalization episode, productivity gains are concentrated among initially smaller new exporters. This helps them rationalize their empirical findings about Canadian firms : following the CUSFTA trade liberalization, initially smaller and less productive new exporters experienced higher labor productivity gains and invested more than other new exporters.

The focus of this paper is different. I use French firm-level data from 1996 to 2004. I do not address the issue of simultaneous decision of exporting and investing.[2] However, I show in a very general theoretical framework that the relationship between firm-level size and investment depends on the relative concavity of three elements with respect to size: firm-level profits, post-investment size and investment cost. I believe this framework can be useful to understand cross-country differences that appear in Bustos (2011) and Lileeva and Trefler (2010) for example. I actually show in the empirical part of the paper that the existence of heterogeneous credit constraints, which impact on the concavity of the investment cost function, allows to understand cross-sectoral differences in the relationship between firm-level size and investment/growth in France.

3 Theoretical framework

I present in this section a simple theoretical framework that emphasizes the forces which determine the relationship between firm-level size and investment, and through investment growth.

3.1 General framework

There are two periods, 0 and 1. Firms draw in period 0 their initial size ϕ_0 from a distribution $G(\phi_0)$. At that time, they can also decide to make a capacity enhancing investment $I(\phi_0)$ which will increase their size in period 1:

$$\phi_1 = \Phi[I(.), \phi_0]$$

with $\frac{\partial \Phi[I(.)]}{\partial I(.)} > 0$. In most models in industrial economics, firm-level sales, employment and profits are entirely determined by a cost or productivity parameter specific to the firm. However, since I am interested here in the size-investment and size-growth relationship issue, I prefer dealing with firm-level size (in terms of sales or employment) rather than productivity.

[2] No natural experiment of trade liberalization is exploitable in France over this period.

I focus on firms that are present in both periods, and thus do not deal with entry and exit in the industry.

Firms are assumed to be rational and to evolve in an environment with perfect information; there is no uncertainty. Optimizing firms choose their level of investment in period 0 by maximizing their total expected profit in period 1:

$$\begin{aligned}\Pi(\phi_1) &= \pi(\phi_1) - C[I(.), \phi_0] \\ &= \pi[\Phi(I(.), \phi_0)] - C[I(.), \phi_0] \end{aligned} \tag{1}$$

where $C[I(.), \phi_0]$ is the total cost of investment $I(\phi_0)$ for a firm with nitial size ϕ_0. The level of optimal investment is the solution of the following first-order condition:

$$\frac{\delta\Pi}{\delta I(.)}(\phi_1) = \frac{\delta\Phi}{\delta I(.)}[I(.), \phi_0)] \times \frac{\delta\pi}{\delta\Phi}[\Phi(I(.), \phi_0)] - \frac{\delta C}{\delta I(.)}[I(.), \phi_0] = 0 \tag{2}$$

The nature of the relationship between initial size ϕ_0 and optimal investment $I(\phi_0)$ is then given by the sign of the following expression:

$$\begin{aligned}\frac{\partial^2\Pi}{\partial I(.)\partial\phi_0}(\phi_1) &= \frac{\partial\Phi}{\partial I(.)}[I(.), \phi_0] \times \frac{\partial\Phi}{\partial\phi_0}[I(.), \phi_0] \times \frac{\partial^2\pi}{\partial^2\Phi}[\Phi(I(.), \phi_0)] \\ &+ \frac{\partial\pi}{\partial\Phi}[\Phi(I(.), \phi_0)] \times \frac{\partial^2\Phi}{\partial I(.)\partial\phi_0}[I(.), \phi_0] - \frac{\partial^2 C}{\partial I(.)\partial\phi_0}[I(.), \phi_0]\end{aligned} \tag{3}$$

In other words, if marginal returns to investment in terms of overall profit increase with firm-level initial size, i.e. $\frac{\partial^2\Pi}{\partial I(.)\partial\phi_0}(\phi_1) > 0$, initially bigger firms will invest more and grow more. On the opposite, if marginal returns to investment in terms of overall profit decrease with firm-level initial size, i.e. $\frac{\partial^2\Pi}{\partial I(.)\partial\phi_0}(\phi_1) < 0$, initially smaller firms will invest more and grow more. It is now important to identify the possible determinants of the concavity or convexity of total profits with respect to initial size.

3.2 Determinants of the relationship between firm-level initial size and investment

Three basic assumptions are made:

- $\frac{\partial\pi}{\partial\Phi}[\Phi(I(.), \phi_0)] > 0$: profits increase with firm-level size.
- $\frac{\partial\Phi}{\partial I(.)}[I(.), \phi_0] > 0$: for a given initial size, firm-level size in period 1 increases with the amount of investment made by the firm in period 0. This ensures that firms that invest more grow more.

- $\frac{\partial \Phi}{\partial \phi_0}[I(.), \phi_0] > 0$: for a given amount of investment, firm-level size in period 1 increases with firm-level initial size.

Given these assumptions, three main elements determine the shape of the relationship between firm-level initial size and investment:

- $\frac{\partial^2 \pi}{\partial^2 \Phi}[\Phi(I(.), \phi_0)]$: this term relates to the concavity of operating profits with respect to size. It can be linked to *demand conditions* or to *production technology.* For a given technology, bigger (smaller) firms will tend to have greater incentives to invest if demand increases more and more (less and less) rapidly when price decreases, bigger firms producing cheaper varieties when productivity determines entirely employment and sales, as in Hopenhayn (1992) for example. In the same vein, for a given demand function, bigger (smaller) firms will have greater incentives to invest if the marginal cost of production increases less and less (more and more) rapidly with size. The overall concavity/convexity of operating profits with respect to size depends on the interaction between these demand and supply conditions.

- $\frac{\partial^2 \Phi}{\partial I(.) \partial \phi_0}[\Phi(I(.), \phi_0)]$: this term relates to the relationship between marginal returns to investment in terms of size and initial size. It is thus linked to the *investment technology.* When this term is positive (negative), the investment technology is such that the increase in size generated by one unit of investment is higher for initially bigger (smaller) firms. In this case, initially bigger (smaller) firms will have more incentives to invest.

- $\frac{\partial^2 C}{\partial I(.) \partial \phi_0}[I(.), \phi_0]$: this term relates to the concavity of the investment cost function. If for a given amount of investment, marginal cost of investment decreases (increases) with size, initially bigger (smaller) firms will have, all else equal, greater incentives to invest. If any difference exists between small and big firms in terms of marginal cost of investment, the most plausible conjecture is that marginal cost of investment decreases with firm-level size. Bigger firms might obtain for example better prices from their technology suppliers because they represent a larger market for them. Credit constraints binding disproportionately on small firms might also explain why the marginal cost of investment can be higher for initially smaller firms.

This simple framework is rich enough to reconcile apparently conflicting results obtained in the literature. For example, the prediction obtained by Bustos (2011) that following a trade liberalization, initially bigger firms have more incentives to invest is in reality the outcome of several elements: she models a discrete technology choice (I(.) is a dummy in this case) in which marginal productivity gains from investment are bigger for initially more productive firms. In case of investment, $\Phi[I(.), \phi_0]{=}\gamma\phi_0$, $\gamma > 1$ and thus $\frac{\partial^2 \Phi}{\partial I(.) \partial \phi_0}[\Phi(I(.), \phi_0)]{=}\gamma - 1{>}0$. The cost of investment is on the opposite the same for all firms, equal to $(\eta - 1)f$, where

f is the fixed production cost and $\eta > 1$, so that $\frac{\partial^2 C}{\partial I(.)\partial \phi_0}[I(.), \phi_0]$=0. Finally, she assumes CES preferences and fixed marginal cost of production $\frac{1}{\phi}$, so that in the end firm-level operating profits are of the form $A\phi^{\sigma-1}$, where A>0 and σ>1. Firm-level profits are concave ($\frac{\partial^2 \pi}{\partial^2 \Phi}[\Phi(I(.), \phi_0)]$<0) for σ<2 and convex ($\frac{\partial^2 \pi}{\partial^2 \Phi}[\Phi(I(.), \phi_0)]$>0) for σ>2. In all cases, functional forms are such that the convexity of the relationship between initial productivity and post-investment productivity dominates the potential concavity of operating profits, so that $\frac{\partial^2 \Pi}{\partial I(.)\partial \phi_0}(\phi_1)$>0 whatever σ.

Things are slightly different for Lileeva and Trefler (2010). Here again, there is a dichotomous investment choice. But now, firms are also heterogeneous, for a given initial productivity and a given investment decision, in terms of productivity gains they obtain. There are thus two sources of heterogeneity, so that $\frac{\partial \Phi}{\partial I(.)}[I(.), \phi_0] > 0$, but $\frac{\partial \Phi}{\partial \phi_0}[I(.), \phi_0]$=0 if I(.)=1 and $\frac{\partial^2 \Phi}{\partial I(.)\partial \phi_0}[I(.), \phi_0]$=0. Marginal cost of investment is the same for all firms: $\frac{\partial^2 C}{\partial I(.)\partial \phi_0}[I(.), \phi_0]$=0. Consequently, the negative relationship they obtain for new exporters between initial productivity and productivity gains derives entirely from the selection mechanism on export market and from the second source of heterogeneity they introduce: following trade liberalization, new exporters are the firms that can pass the new (lower) export threshold. Among them, some have invested to pass this threshold, while it was not profitable before: the firms that were further from the new threshold threshold are those that experienced the higher growth.

To sum up, in a framework where initial size is the only exogenous source of heterogeneity, the relationship between firm-level initial size, investment and growth depends on three elements: investment technology that relates post-investment firm-level size to initial size, operating profits and investment cost. The shape of these three functions with respect to initial firm-level size determines the concavity/convexity of the total profit function. Depending on the sign and the magnitude of the forces at play, a positive, a negative or an absence of relationship between initial size and investment/growth is possible. This approach provides a different perspective on the issue of the submodularity or supermodularity of profits. Mrazova and Neary (2011) study the way firms choose to serve a market (FDI, R&D etc.) and show that initially more efficient firms will engage in the lower market-access cost alternative if and only if firm-level profit function is supermodular in production and market-access cost. I detail here some of the forces that determine this sub/supermodularity. Identifying the shape of these forces and their overall impact is then a matter of empirics.

3.3 Testable predictions

This is actually what I want to show in this paper, by testing the two following predictions of the theoretical framework:

– *Result 1*: when operating profits are concave with respect to size, and when marginal returns to investment (in terms of size) and marginal cost of investment are the same for all firms, initially smaller firms invest more and grow more, all else equal, than bigger ones.

– *Result 2*: this negative relationship is attenuated, or even reversed, when credit constraints bind disproportionately on small firms.

Result 1 derives directly from the previous theoretical framework. It corresponds to situations where $\frac{\delta^2\Phi}{\delta I(.)\delta\phi_0}$=0, $\frac{\delta^2 C}{\delta I(.)\delta\phi_0}[I(.),\phi_0]$=0 and $\frac{\delta^2\pi}{\delta^2\Phi}[\Phi(I(.),\phi_0)]$<0. This implies that the overall profit function is submodular, i.e. $\frac{\delta^2\Pi}{\delta I(.)\delta\phi_0}[I(.),\phi_0]$<0. On the other hand, assuming that investment is externally financed, when credit constraints bind disproportionately on small firms, the marginal cost of investment increases when size decreases, due for example to higher interest rates applied to small firms that are seen by investors as more risky than the others: $\frac{\delta^2 C}{\delta I(.)\delta\phi_0}[I(.),\phi_0]$<0, so that $\frac{\delta^2\Pi}{\delta I(.)\delta\phi_0}[I(.),\phi_0]$ increases and becomes positive for high enough degree of heterogeneity of credit constraints.

4 Shape of credit constraints, firms size distribution and shape of profits function in France

In this section, I investigate empirically how heterogeneous credit constraints might impact on the relationship between firm-level initial size, and investment and growth. To do so, I exploit differences in the shape of credit constraints across manufacturing sectors in France.

4.1 The data

I use the French Annual Business Surveys[3] data (ABS), provided by the French ministry of Industry. The data set covers all the firms with more than 20 employees, or some smaller firms with sales higher than 5 millions euros, over the period 1996-2004. It comprises all balance-sheet data (production, value added, employment, capital, exports, aggregate wages, investment etc.) and information about firm location, firm industry classification and firm structure (number of plants, etc.).

I conserve in the sample firms from continental France[4] and from manufacturing industries.

Value added and sales are deflated by a branch-specific value-added price index, inputs by a branch-specific inputs price index, and capital and investment by a gross fixed capital formation price index common to all manufacturing industries. To calculate Tfp, we estimate production functions at the 2-digit industry level following the Levinsohn and Petrin (2003) methodology (see Appendix A).

[3]Called in French "Enquêtes annuelles d'entreprises".

[4]That is to say overseas départements and Corsica excluded.

4.2 Identification of heterogeneous credit constraints

An important literature exists on the identification of credit constraints. The vast majority of the papers on this topic are based on the estimation of a Euler equation (see, e.g., Love, 2003; Bond, Elston, Mairesse, and Mulkay, 2003; Harrison, Love, and McMillan, 2004; Javorcik and Spatareanu, 2009). Even though questioned, as the controversy between Kaplan and Zingales (1997) and Fazzari, Hubbard, and Petersen (2000) shows, this methodology is still extensively used. It is based on a dynamic model of the firm value optimization and interprets the sensitivity of firm-level investment to internal level of cash-flow as a measure of credit constraints. Following Modigliani and Miller (1958), the underlying idea is that in the absence of financial constraints, firm-level investment should not depend on its internal level of cash-flow. Consequently, a positive relationship between investment and cash-flow is interpreted as difficulties for firms to find external finance: They are thus said to be credit-constrained.

I estimate in this paper an augmented version of the Euler equation to test for the existence of heterogeneous credit constraints depending on firm size. Because they are supposed to be more sensitive to business cycles or because they have less collateral to offer to banks, small firms could be more impacted by credit constraints. The existence of such heterogeneous credit constraints has been emphasized by Beck, Demirgüç-Kunt, and Maksimovic (2005) for example. I thus estimate the following equation, largely inspired by Bond, Elston, Mairesse, and Mulkay (2003):

$$\begin{aligned} \ln\left(\frac{\mathrm{I}}{\mathrm{K}}\right)_{it} &= \alpha\ln\left(\frac{\mathrm{I}}{\mathrm{K}}\right)_{it-1} + \beta\ln^2\left(\frac{\mathrm{I}}{\mathrm{K}}\right)_{it-1} + \delta\ln\left(\frac{\mathrm{Sales}}{K}\right)_{it-1} + \gamma\ln\mathrm{L}_{it} + \\ & \eta\ln\left(\frac{\mathrm{CF}}{\mathrm{K}}\right)_{it-1} + \mu\ln\mathrm{L}_{it}\times\ln\left(\frac{\mathrm{CF}}{\mathrm{K}}\right)_{it-1} + \theta_t + \epsilon_{it} \end{aligned} \quad (4)$$

where $\frac{I}{K}$ is the level of investment of firm i scaled by the level of assets, $\frac{Sales}{K}$ is the ratio of sales to assets of firm i, L is employment of firm i and $\frac{CF}{K}$ is the ratio of cash flow to assets of firm i. Lagged value of $\frac{I}{K}$ and its square account for the (potentially non linear) dynamic structure of the investment model, $\frac{Sales}{K}$ is a proxy for the profitability of the firm (the higher the ratio of sales to capital, the more profitable the firm) and $\frac{CF}{K}$ is an index of liquidities available within the firm.[5] Consequently, the parameter η will capture average credit constraints in the sample: A positive and significant coefficient between firm-level investment in t and the internal liquidities the firm had the year before will indicate difficulties for firms to access external finance. However, our parameter of interest is μ. Indeed, if μ turns out to be insignificant, it will mean that credit constraints are homogeneous across firms. On the contrary, a negative and significant μ will indicate that the bigger the firm, the less sensitive the investment to cash-flow: Credit constraints are in this case more severe

[5] Cash-flow is defined as follows: CF = Sales-Wages+Amortizement.

for small firms. What is important for our results is not that credit constraints exist or not within a sector, but that these credit constraints are the same for all firms or on the opposite that they disproportionately bind on small firms.

I present in Appendix B more details on the estimation of this equation. The classification of industries obtained with the Euler equation is robust to different estimation strategies (no fixed effects, industry-year fixed effects, firm-level fixed effects) and to alternative specifications (in particular the accelerator-profit model).

4.3 Classification of industries depending on the shape of credit constraints

The classification of industries obtained from this first-stage analysis is presented in Table 1. There are several reasons why the shape of credit constraints may not be the same across sectors within the same country. For example, in the guide presenting their rating methodology, Standard & Poor's acknowledge the fact that smaller firms are generally perceived negatively because they tend to benefit less from economies of scale and to be less diversified (and thus more risky).[6] However, they also state that industry determinants are taken into account, such as the market structure, the maturity or the cyclicality of the sector, to assess the reliability of a firm. Size might consequently not necessarily be a disadvantage, and we can conjecture that its appreciation by investors might depend on other sectoral and/or national characteristics.

Table 1: Heterogeneous credit constraints-Classification of 2-digit industries

Homogeneous credit constraints	**Heterogeneous credit constraints**
Textile	Paper
Clothing	Chemicals
Leather	Rubber
Wood	Mineral products
Printing/Publishing	Non electric machines
Metals	Electric machines
Metal products	Telecom equipment
Office machinery	Instruments
Other transports	Cars
Furniture/Miscellaneous	

No direct intuition allows to rationalize the classification of industries that emerges from the estimation of credit constraints by sector. However, the idea that this classification captures actually cross-sectors differences in the shape of credit constraints is supported by the analysis of firm-size distribution within sectors. Indeed, we expect that in sectors where small firms are more-credit constrained than big ones, a divergence process between small

[6] "Corporate Ratings Criteria", 2008, Standard & Poor's.

and big firms generates a distortion of the size distribution, so that firms at the bottom of the distribution are relatively smaller with respect to the average in these industries than in sectors where credit constraints are homogeneous.

Table 2: Firm-level relative size distribution in 1996: Employment

	Homog. cred. const. ind.		Heterog. cred. const. ind.	
Percent.	Dom.	Exp	Dom.	Exp
10	0.44	0.21	0.37	0.13
25	0.53	0.29	0.45	0.19
50	0.69	0.44	0.60	0.33
75	0.98	0.92	0.87	0.82
90	1.62	1.97	1.59	1.90
95	2.30	3.35	2.54	3.50

Note: The table reads as follows: in 1996, the 10th percentile of the ratio of firm-level employment to firm-level average employment is equal, on average, to 44% for domestic firms in industries where small firms are disproportionately credit-constrained, and to 37% for domestic firms in industries where credit constraints are homogeneous. Exporting firms are firms declaring exports bigger than 50 000 euros.

Table 3: Firm-level relative size distribution: Sales

	Homog. cred. const. ind.		Heterog. cred. const. ind.	
Percent.	Dom.	Exp	Dom.	Exp
10	0.26	0.11	0.19	0.07
25	0.35	0.17	0.27	0.11
50	0.53	0.32	0.41	0.22
75	0.85	0.70	0.73	0.57
90	1.52	1.63	1.45	1.52
95	2.25	3.03	2.31	2.86

Note: The table reads as follows: in 1996, the 10th percentile of the ratio of firm-level sales to firm-level average sales is equal to 26% for domestic firms in industries where small firms are disproportionately credit-constrained, and to 19% for domestic firms in industries where credit constraints are homogeneous.

This is exactly the pattern described in Table 2 for firm-level employment. For each 2-digit sector and each category of firms, domestic or exporters, firm-level relative size is calculated by computing the ratio of firm-level employment to firm-level average employment in the industry and firms' category for year 1996. Firms are then divided into quantiles of relative size (still at the industry and firms' category level) and the average value of different quantiles of domestic and exporting firms is calculated for industries where credit constraints are homogeneous on the one hand and industries where credit constraints are heterogeneous on the other. Two important regularities appear. First, whatever the shape of credit constraints, firm-level employment of exporters is more dispersed around its mean than firm-level employment of domestic firms: The relative size of exporters at the bottom of the distribution in their industry is smaller that the relative size of their domestic counterparts, while the opposite is true for exporters at the top of the size distribution. This finding is coherent with di Giovanni, Levchenko, and Ranciere (2010), who show, also on French data, that if we approximate firm-size distribution by a Pareto distribution, the shape parameter of the Pareto is smaller for exporting firms than for domestic ones. More importantly, statistics in Table 2 show that for both domestic and exporting firms, firms at the bottom of the distribution are relatively bigger in industries where credit constraints are homogeneous than is sectors where credit constraints affect small firms disproportionately. On the opposite, firms at the top of the distribution are relatively smaller in industries where credit are homogeneous. This suggests that the dispersion of firm-level employment is higher in industries with heterogeneous credit constraints. Moreover, the ration of size of 95th percentile to the 1st decile, equal to 5.23 for domestic firms (resp. 16 for exporters) in sectors with homogenous credit constraints and to 6.86 (resp. 27 for exporters) in sectors with heterogeneous credit constraints, shows that firm-level relative size distribution is more skewed in industries with heterogeneous credit constraints.

Altogether, these elements are coherent with the idea that industries identified as exhibiting disproportionate credit constraints for small firms are indeed industries where small firms are relatively less able to develop as compared to big firms, leading to a dispersion of firm-level size in these industries that is both more dispersed and more skewed. As shown in Appendix C, the picture is the same if we consider value added or total sales as an index of size.

4.4 Concavity of operating profits

The differences across sectors in terms of shape of financial constraints can be interpreted as differences in the shape of marginal cost of investment. I now investigate whether the shape of operating profits differs across the two groups of industries identified in subsection 4.3. To do so, I estimate the following equation:

$$\ln\pi_{ijt} = \alpha\ln\mathrm{L}_{ijt} + \beta\ln^2\mathrm{L}_{ijt} + \gamma\ln\mathrm{K}_{ijt} + \eta\ln\mathrm{Tfp}_{ijt} + d_{jt} + \epsilon_{ijt} \tag{5}$$

where π_{it} is profits of firm i from industry j at time t, defined as the fraction of value added that does not accrue to workers (Value added-Wages). Profits are supposed to depend on the quantity of labour L and capital K used by the firm, and on firm-level Tfp. The impact of firm-level employment is allowed to be non-linear thanks to the inclusion of a quadratic term in L. The regression includes 3-digit industry-year fixed effects, so that the impact of each variable is estimated through repeated cross-sections, by comparing firms within the same industry for a given year.

Table 4: Concavity of firm-level profits

	Dependent Variable: ln Y-Wages			
	Domestic firms		Exporting firms	
	Homog. cred. const.	Heterog. cred. const.	Homog. cred. const.	Heterog. cred. const.
ln L	0.842^{a}	0.812^{a}	0.564^{a}	0.665^{a}
	(0.049)	(0.033)	(0.026)	(0.016)
$\ln^2$ L	-0.038^{a}	-0.035^{a}	-0.005^{c}	-0.016^{a}
	(0.005)	(0.004)	(0.003)	(0.001)
ln K	0.264^{a}	0.259^{a}	0.262^{a}	0.231^{a}
	(0.012)	(0.007)	(0.008)	(0.005)
ln Tfp	1.739^{a}	1.664^{a}	1.742^{a}	1.717^{a}
	(0.018)	(0.016)	(0.014)	(0.014)
N	39448	20508	51927	49168
R^2	0.781	0.865	0.892	0.925

Note: Industry 3-digit-Year fixed effects are included in all the regressions. Standard errors in parentheses ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels. Robust standard errors.

The regression is run separately for domestic firms and exporters (defined as firms declaring more than 50,000 euros of exports). Results presented in Table 4 show that for all types of firms and all types of industries, firm-level profits are concave in firm-level employment: the coefficient on the square of labour is always negative and significant. Moreover, Tfp and firm-level capital stock both have a positive impact, and their estimated coefficients are very close across sectors and types of firms. These results suggest that whatever the industry and the export status of the firms, as far as profits are concerned, smaller firms have higher incentives to invest than small ones, which should translate into higher growth rates for initially smaller firms over a given period.

However, regarding the intensity of this negative relationship between initial size and investment/growth, two important conclusions can be drawn from Figures 1 and 2. First, whatever the type of industries, profits of domestic firms are more concave than profits of exporting firms. This is coherent with the fact that the estimated coefficient on the square of employment is smaller, in absolute value, for exporting firms than for domestic ones. Several explanations can account for this result: export activities are associated with fixed costs linked to the search of trading partners or with the adaptation of products to the tastes of foreign consumers etc. (Melitz, 2003), so that bigger exporters will be more profitable since they better amortize the fixed exports costs. Some scope economies across destinations

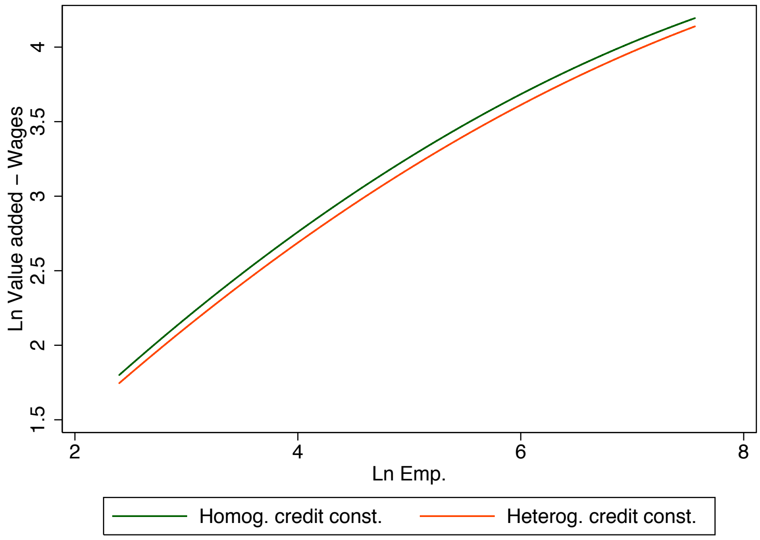

Figure 1: Domestic firms

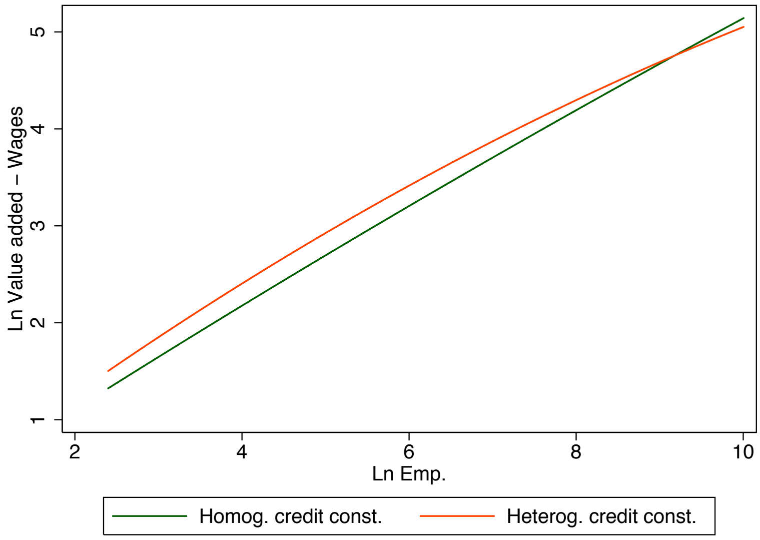

Figure 2: Exporting firms

and/or products might also be at play, making bigger exporters more profitable. These mechanisms might attenuate the concavity of the profit function with respect to size. This first stylized fact suggests that the intensity of the negative relationship between firm-level size and growth should be lower for exporting than for domestic firms. Second, for a given type of firms, the slope of the profits function is very similar in industries with homogeneous credit constraints and in industries where small firms are more credit constrained. If anything, for exporters, profits are slightly more concave in sectors with heterogeneous credit constraints. Consequently, any relaxation of the negative relationship between size and investment/growth in industries where small firms are disproportionately credit constrained cannot be attributed to the shape of the profit function with respect to size; in the case of exporters, this force even goes in the opposite direction.

Assessing whether the concavity of profits function is due to technology or preferences is beyond the scope of this paper. Moreover, note that results are qualitatively the same if we add a cubic term for employment in equation 5 or if we consider non-linearities of profits with respect to Tfp instead of employment (see Appendix D).

In light of our theoretical framework, and assuming for the moment that marginal returns to investment in terms of ex-post size/productivity do not vary with firm-level size ($\frac{\delta^2\Phi}{\delta I(.)\delta\phi_0}[\Phi(I(.),\phi_0)]$=0), two empirical conjectures can be made at this stage:

- In industries where credit constraints are measured to be homogeneous, smaller firms should, all else equal, invest more and grow more than the others.
- This negative relationship between firm-level initial size and investment/growth should be attenuated or even reversed in industries where credit constraints are measured to be disproportionately binding on small firms.

5 Size-investment and size-growth relationship

In this section, I test the empirical conjectures derived from the previous analysis.

5.1 Empirical strategy

I analyze, for a given firm, the determinants of its average investment and its performance growth between 1996 and 2002. I consequently focus on firms that remain active over this relatively long period of time (7 years). This is different from Neumark, Wall, and Zhang (2011) and Haltiwanger, Jarmin, and Miranda (2010) who analyze yearly variations of employment within cells of firms of different sizes, and who thus take into account both employment variations of stayers and employment losses due to firms' deaths. Here, I am interested in the behavious of stayers only, in the same vein as Lileeva and Trefler (2010) and Bustos (2011) who

A two-step empirical strategy is adopted. An investment function over the period 1996-2002 is first estimated. In the model, firms take into account expected profits in period 1 to choose their optimal investment in period 0, expected sales being determined by their initial size draw and their level of investment. Combining insights from the model and methods developed in the literature on firm-level determinants of investment, I estimate the following baseline equation:

$$\begin{aligned}\ln\left(\frac{\mathrm{I}}{\mathrm{K}}\right)_{ij1997-2002} &= \alpha\ln\left(\frac{\mathrm{I}}{\mathrm{K}}\right)_{ij1996} + \beta\ln\left(\frac{\mathrm{Sales}}{\mathrm{K}}\right)_{ij1996} \\ &\quad +\gamma\ln\left(\frac{\mathrm{CF}}{\mathrm{K}}\right)_{ij1996} + \theta\ln\mathrm{L}_{ij1996} + \mathrm{d}_j + \epsilon_i \end{aligned} \tag{6}$$

where $\ln\left(\frac{I}{K}\right)_{i1997-2002}$ is the log of the average annual investment of firm i, from sector j, over the period 1997-2002.[7] Average investment over the period is equal to the total amount of investment made by a firm between 1997 and 2002 divided by the number of observations for this firm over the same period (see below).

Investment of firm i over the period 1997-2002 is explained by firm-level characteristics in 1996. As in the Euler equation, investment in 1996 is included to take into account persistency in investment behavior. Sales and cash flow to capital ratios control for firm-level profitability and availability of internal funds. Firm-level investment might also depend on the size of the market and on competitive pressure in the industry, which are controlled for by sectoral fixed effects d_j, defined at the 3-digit industry level. The impact of these determinants are thus estimated thanks to cross-sectional variations within a given industry.

θ is the coefficient of interest; it measures the correlation between firm-level size, measured by employment, and investment, having controlled for firm-level investment persistency, profitability and cash-flow, and for sectoral determinants of investment over the period. This equation is estimated separately for domestic an exporting firms, and within each category of firms, separately for industries where credit constraints are homogeneous and for industries in which small firms are disproportionately credit constrained.

I then analyze how firm-level performance growth varies with initial size and export status. Again, the regression is run separately for domestic and exporting firms and for industries with different shapes of credit constraints.

For a performance index y, the baseline regression brought to data is the following:

$$\Delta\ln\mathrm{y}_{ij1996-2004} = \alpha\ln\mathrm{y}_{i1996} + \theta\ln\mathrm{L}_{i1996} + \mathrm{d}_j + \epsilon_i \tag{7}$$

Some other characteristics, correlated with firm-level employment, could impact on firm-level investment and performance growth, and bias the estimation of θ. I thus also control

[7]The measure of investment I use is intended as net of firms' contribution.

for firm-level initial TFP (empirically positively correlated, but not collinear, with size) and firm-level average wage in 1996, used as a proxy for the level of qualifications of employees.

5.2 Construction of the sample and descriptive statistics

The sample used for the regressions is thus a specific subsample of the initial French Annual Business Surveys I use.

More precisely, after basic checks (exclusion of observations with missing or negative employment, capital, value added and investment) and having removed firms that change industry (at the 2-digit level) or which have less than 10 employees on average over the period, there are 20,198 observations in 1996 corresponding to firms operating in manufacturing industries and located in continental France (vs 21,743 firms in the raw data). I then conserve in the sample those firms for which there are observations in 1996, 1997, 2001 and 2002. This ensures that only the firms that stay on the market over the period remain in the sample. These four years will be moreover necessary to identify domestic and exporting firms (see below). After this step, 12,720 firms are present in the sample. Then, in order to be sure that average firm-level investment is calculated on a sufficient number of observations, I drop the firms that we observe less than 5 times during the 7-year period under study. In the end, the sample is composed of 12,703 firms.

Table 5 displays some descriptive statistics for year 1996 that allow to compare the sample of firms used for our estimations to the sample of firms active in 1996, but which then disappear. We distinguish industries with homogeneous credit constraints from industries where small firms are more credit constrained. Not surprisingly, firms in our final sample are bigger in terms of employment, sales, exports and value added than manufacturing firms which disappear before 2002. Their labour productivity is also higher. This is true whatever the shape of financial constraints. In the end, even though firms in the final sample represent 60 to 66% of firms active in 1996, they account for a higher share of total activity.

5.3 Definition of export status

Another issue is related to the definition of firm-level export status over the period. I will indeed analyze separately domestic and exporting firms, but due to multiple entries and exits on export markets for the same given firm, the classification of firms is not trivial. I adopt the following conventions:

- a firm is said to export in a given year if it declares exports bigger than 50,000 euros. This ensures that negligible export activities are not taken into account to define the export status of the firm.[8] Note however that all our results are robust if we consider

[8] This threshold corresponds to the 13th centile in terms of exports. Note that in customs data, firm-level intra-EU exports must be bigger to 100,000 euros in total to be recorded. our definition is thus not too much conservative.

Table 5: Descriptive statistics - Year 1996

	Firms active until 2002	Firms disappearing before 2002
	Homogenous credit constraints	
Employment	104.34	82.25
Sales	12755.41	10775.13
Exports	3756.04	3541.42
Value added	4203.38	3138.86
Labour productivity	36.55	34.63
Share in total employment	66.14	33.86
Share in total sales	64.57	35.43
Share in total exports	62.02	37.98
Share in total value added	67.34	32.66
Number of firms	7157	4648
Share in total number of firms	60.63	39.37
	Heterogeneous credit constraints	
Employment	195.75	168.70
Sales	32788.63	32142.95
Exports	12869.59	12446.67
Value added	9481.90	8203.84
Labour productivity	43.20	39.15
Share in total employment	69.33	30.67
Share in total sales	66.52	33.48
Share in total exports	66.82	33.18
Share in total value added	69.24	30.76
Number of firms	5546	2854
Share in total number of firms	66.08	33.92

Note: Monetary values are in thousands euros.

firms as exporters as soon as they declare positive exports.[9]

- a firm is said to be domestic at the beginning of the period is it does not export neither in 1996 nor in 1997. It is said to be domestic at the end of the period if it does not export neither in 2001 nor in 2002.

- the symmetric is true to define exporters at the beginning and at the end of the period.

Based on these definitions, four mutually exclusive categories of firms can be identified: *continuing domestic firms* which do not export neither at the beginning nor at the end of the period (2,683 firms), *switching firms* which are domestic at the beginning and exporters at the end of the period (640 firms), *continuing exporters* which export both at the beginning, and at the end of the period (6,642 fims) and *ceasing exporters* which export at the beginning of the period but are domestic at the end of the period (385 firms). A fifth category, *alternate exporters* are firms which export status sequences at the beginning and at the end of the period does not allow to classify them in one of the four preceding categories (2,353 firms).

Continuing domestic firms, switching exporters and alternate exporters are pooled together in the category of "initially domestic firms", while continuing exporters and ceasing exporters form the group of "initially domestic firms".

5.4 Firm-level investment and initial size

I first analyze the relationship between initial size and firm-level average annual investment. To do so, I compare average annual investment between 1997 and 2002 of firms within a given 3-digit industry.

If we focus on initially domestic firms, results presented in Tables 6 show that whatever the shape of credit constraints, firm-level profitability (measured by the sales to capital ratio) and firm-level internal liquidities (measured by the cash flow to capital ratio) have, as expected, a positive and significant coefficient. Firm-level investment also exhibits persistency since the initial investment to capital ratio is also positively related to average annual investment the following years. Moreover, all else equal, switching exporters invest much more than continuing domestic firms (from 25% to 37.5% more depending on the type of industry and the specification). This is consistent with papers by Lileeva and Trefler (2010) and Bustos (2011) showing that entry on export markets is associated with firm-level investment. Alternate exporters are also shown, but to a lesser extent, to invest more than domestic firms.

More importantly, the first column of Table 6 shows that all else equal, firm-level annual investment and initial size are significantly negatively related in industries where credit constraints are homogeneous. In these industries, a 10% increase in firm-level employment

[9] Results available upon request.

decreases average annual investment by around 0.15%. In column 2, firm-level Tfp and average wage in 1996 are added, as well as a dummy identifying continuing domestic firms that exported at least once over the period (i.e. in 1998, 1999 or 2000). The intensity and the significancy of the negative relationship between firm-level employment and investment is roughly unaffected. On the opposite, the two last columns of Table 6, there is no statistically significant relationship between fir-level initial size and investment. Consequently, for initially domestic firms, the prediction of our theoretical framework is verified: small firms invest more, all else equal, than bigger ones, in sectors where credit constraints are homogenous only. When small firms are disproportionately credit constrained, this negative relationship is attenuated and becomes in the present case non significant.

Table 6: Firm-level average annual investment from 1997 to 2002 - Initially domestic firms

	Dependent Variable: Ln $\frac{\text{Avg annual inv.}}{\text{K}}$			
	Homogenous credit constraints		Heterogeneous credit constraints	
Ln $\frac{\text{I}}{\text{K}}_{i1996}$	0.209^a	0.208^a	0.214^a	0.207^a
	(0.024)	(0.025)	(0.038)	(0.037)
Ln $\frac{\text{Sales}}{\text{K}}_{i1996}$	0.306^a	0.276^a	0.342^a	0.331^a
	(0.027)	(0.036)	(0.070)	(0.073)
Ln $\frac{\text{CF}}{\text{K}}_{i1996}$	0.394^a	0.453^a	0.298^a	0.328^a
	(0.070)	(0.094)	(0.056)	(0.092)
Switching exporters	0.249^a	0.284^a	0.375^a	0.358^a
	(0.063)	(0.064)	(0.057)	(0.055)
Alternate exporters	0.054	0.098^c	0.165^a	0.160^a
	(0.051)	(0.050)	(0.044)	(0.046)
Ln L_{i1996}	-0.105^a	-0.094^a	-0.035	-0.026
	(0.023)	(0.021)	(0.039)	(0.052)
Ln LP Tfp_{i1996}		-0.167^c		-0.033
		(0.097)		(0.205)
Ln Avg Wage_{i1996}		-0.229^c		-0.484^b
		(0.131)		(0.194)
Occasional exporters		0.127^a		-0.165^c
		(0.045)		(0.092)
Observations	3644	3644	1985	1985
R^2	0.474	0.480	0.437	0.448

Note: Industry 3-digit fixed effects are included in all the regressions. Standard errors in parentheses ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels. Robust standard errors.

The picture is a little bit different for initially exporting firms. As shown in Table 7, initial investment, profitability and internal cash flow have all the positive and significant positive coefficient we expect. Ceasing exporters are shown to invest significantly less, all else equal, than continuing exporters. This does not come as a surprise since those firms that exit from export markets probably experience bad shocks that negatively affect their investment path.

This result is to a certain extent symmetric to the investment premium observed for switching exporters among initially domestic firms. Regarding the size-investment relationship, in industries where credit constraints are homogenous, no statistically significant relationship is detected. This remains true when Tfp, average wage and a dummy identifying continuing exporters which exit export markets at least once over the period are controlled for. On the opposite, when these three variables are included, a positive and significant relationship between firm-level employment and investment is measured for exporters operating in industries where small firms are more credit constrained. Again, these results are in line with the theoretical framework provided in section 3. In sectors where credit constraints are homogenous, due to the very weak concavity between firm-level profit and employment for exporters (cf figure 2 above), no correlation exists between firm-level employment and investment in this sample. On the opposite, as predicted by the theoretical framework, the relationship tends to become positive in sectors where small firms face tougher financial constraints than bigger ones (even though for exporters, as shown in figure 2, profits are more concave with respect to size in these industries).

Table 7: Firm-level average annual investment from 1997 to 2002 - Initially exporting firms

	Dependent Variable: Ln $\frac{\text{Avg annual inv.}}{\text{K}}$			
	Homogenous credit constraints		Heterogeneous credit constraints	
Ln $\frac{\text{I}}{\text{K}}_{i1996}$	0.231^a	0.230^a	0.254^a	0.247^a
	(0.023)	(0.022)	(0.032)	(0.030)
Ln $\frac{\text{Sales}}{\text{K}}_{i1996}$	0.294^a	0.268^a	0.209^a	0.115^b
	(0.057)	(0.062)	(0.047)	(0.052)
Ln $\frac{\text{CF}}{\text{K}}_{i1996}$	0.294^a	0.369^a	0.399^a	0.580^a
	(0.057)	(0.059)	(0.042)	(0.082)
Ceasing exporters	-0.245^a	-0.272^a	-0.178^a	-0.222^a
	(0.076)	(0.071)	(0.061)	(0.056)
Ln L_{i1996}	-0.005	0.020	0.003	0.083^a
	(0.018)	(0.023)	(0.018)	(0.031)
Ln LP Tfp_{i1996}		-0.199		-0.401^a
		(0.124)		(0.114)
Ln Avg Wage_{i1996}		0.014		-0.137
		(0.121)		(0.133)
Occasional domestic firms		-0.053		-0.102^c
		(0.057)		(0.053)
Observations	3449	3449	3519	3519
R^2	0.423	0.426	0.454	0.469

Note: Industry 3-digit fixed effects are included in all the regressions. Standard errors in parentheses ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels. Robust standard errors.

5.5 Firm-level growth and initial size

I now turn to the analysis of the relationship between firm-level performance growth and initial size. I present results on employment and sales growth, while results on Tfp are presented in Appendix E.

Among initially domestic firms, employment growth of switching exporters is higher, all else equal, than employment growth of continuing domestic firms, whatever the shape of credit constraints within the industry. This is intuitive and coherent with the results obtained about investment. The result of interest is the coefficient on initial size in terms of employment. In all cases, there is a negative and significant relationship between initial size and employment growth: smaller firms grow more in terms of employment than bigger ones. However, in line with the predictions of the theoretical framework, this convergence process is more rapid in industries where credit constraints are homogenous than in industries where small firms are more credit constrained. A 10% increase in firm-level initial employment is associated with a 1.5 to 1.7% decrease in firm-level employment growth in industries with homogeneous credit constraints (depending on the on the controls included in the regression). In industries where small firms are disproportionately credit constrained, the elasticity of employment growth to initial size is lower in absolute value, comprised between 0.8 and 1.2%.

Table 8: Firm-level employment growth- Domestic firms

	Dependent Variable: Δ Ln Employment$_i$			
	Homogenous credit constraints		Heterogeneous credit constraints	
Ln L_{i1996}	-0.154^a	-0.168^a	-0.079^a	-0.120^a
	(0.015)	(0.015)	(0.016)	(0.015)
Switching exporters	0.135^a	0.134^a	0.134^a	0.124^a
	(0.017)	(0.017)	(0.034)	(0.036)
Alternate exporters	0.016	0.016	0.023	0.012
	(0.012)	(0.013)	(0.020)	(0.018)
Ln LP Tfp$_{i1996}$		0.149^a		0.306^a
		(0.035)		(0.051)
Ln Avg Wage$_{i1996}$		-0.060		-0.237^a
		(0.048)		(0.065)
Occasional exporters		0.020		-0.086^a
		(0.020)		(0.025)
Observations	3678	3678	1998	1998
R^2	0.075	0.088	0.029	0.076

Note: Industry 3-digit fixed effects are included in all the regressions. Standard errors in parentheses ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels. Robust standard errors.

For initially exporting firms, we also observe in Table 9 a negative relationship between initial size and employment growth, whatever the shape of credit constraints and the specification. For a given group of industries, the speed of convergence I measure among initially exporting firms is lower than the speed of convergence measured among initially domestic firms. This can be explained by the fact that profits are less concave with respect to size for exporting than for domestic firms (cf figures 1 and 2 above). On the other hand, comparisons across groups of industries go in the same direction as for domestic firms: the speed of convergence tends to be, all else equal, lower in industries where credit constraints are heterogeneous. However, now, the difference of coefficients across industries is not significant. This is surely due to the fact that in industries where small firms are more credit constrained, profits of exporting firms are more concave than in industries where credit constraints are homogenous (cf figure 2 above): differences across industries in terms of concavity of the profit function play in the opposite direction as compared to differences in terms of shape of credit constraints.

Table 9: Firm-level employment growth- Initially exporting firms

	Dependent Variable: Δ Ln Employment$_i$			
	Homogenous credit constraints		Heterogeneous credit constraints	
Ln L_{i1996}	-0.069^a	-0.079^a	-0.054^a	-0.077^a
	(0.014)	(0.010)	(0.005)	(0.008)
Ceasing exporters	-0.145^a	-0.121^a	-0.120^b	-0.119^b
	(0.028)	(0.026)	(0.047)	(0.046)
Ln LP Tfp_{i1996}		0.123^b		0.182^a
		(0.052)		(0.034)
Ln Avg $Wage_{i1996}$		0.088		-0.209^a
		(0.090)		(0.053)
Occasional domestic firms		-0.018		-0.046
		(0.030)		(0.031)
Observations	3479	3479	3548	3548
R^2	0.033	0.059	0.024	0.048

Note: Industry 3-digit fixed effects are included in all the regressions. Standard errors in parentheses ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels. Robust standard errors.

The analysis is very similar if we consider sales growth and not employment growth. In this case, size is proxied by initial sales and not by employment, which are correlated at almost 90%. Among domestic firms, the elasticity of firm sales growth to initial sales is equal to roughly -0.12 in industries where credit constraints are homogenous, whether firm-level Tfp, average wages and occasional presence on export markets are controlled for or not. It is equal to -0.08 only in industries where small firms face tougher credit constraints than the others. Results go in the same direction when we focus on exporters and now, when firm-level Tfp, average wages and occasion exit from export markets are controlled for, the speed of convergence is significantly lower in industries with heterogeneous credit constraints.

Results on Tfp growth presented in Appendix E are qualitatively similar.

Table 10: Firm-level sales growth- Initially domestic firms

	Dependent Variable: Δ Ln Sales_i			
	Homogenous credit constraints		Heterogeneous credit constraints	
Ln Sales_{i1996}	-0.118^a	-0.121^a	-0.077^a	-0.080^a
	(0.014)	(0.014)	(0.015)	(0.018)
Switching exporters	0.202^a	0.206^a	0.187^a	0.177^a
	(0.034)	(0.035)	(0.046)	(0.049)
Alternate exporters	0.068^a	0.073^a	0.006	-0.000
	(0.023)	(0.024)	(0.028)	(0.028)
Ln LP Tfp_{i1996}		0.045		0.115
		(0.038)		(0.078)
Ln Avg Wage_{i1996}		-0.074		-0.279^b
		(0.071)		(0.110)
Occasional exporters		0.017		-0.080^c
		(0.024)		(0.045)
Observations	3678	3678	1998	1998
R^2	0.050	0.051	0.035	0.049

Note: Industry 3-digit fixed effects are included in all the regressions. Standard errors in parentheses ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels. Robust standard errors.

5.6 The role of investment

In this paper, cross-sectoral variations in firm-level size-growth relationship are explained by the investment behavior of firms, which is itself affected by the shape of financial constraints. To corroborate the mechanism I propose, I must verify that once firm-level investment has been accounted for, the heterogeneity across sectors in terms of size-growth relationship vanishes, or is at least reduced. Results presented in Tables 12 and 13 actually validate the investment channel. Indeed, they show that firm-level investment is positively and significantly related to firm-level employment and sales growth. Moreover, after having controlled for firm-level average annual investment over the period 1997-2002, the elasticity of firm-level employment growth to initial size is the same whatever the shape of financial constraints among domestic firms on the one hand and among exporters on the other. Regarding sales growth, for a given type of firms in terms of export status, the difference across sectors is relatively smaller as compared to regressions where investment is not controlled for.

However, if the investment channel clearly explains the heterogeneity across sectors in terms of size-growth relationship, one last check must be made to be sure that heterogeneous credit constraints mainly explain in France these cross-sectoral variations. In the theoretical framework, I have identified three main determinants of the size-investment or size-growth

Table 11: Firm-level sales growth- Initially exporting firms

	Dependent Variable: Δ Ln Salest$_i$			
	Homogenous credit constraints		Heterogeneous credit constraints	
Ln Sales$_{i1996}$	-0.041^a	-0.047^a	-0.032^a	-0.019^c
	(0.010)	(0.011)	(0.007)	(0.010)
Ceasing exporters	-0.200^a	-0.203^a	-0.200^a	-0.205^a
	(0.037)	(0.034)	(0.055)	(0.053)
Ln LP Tfp$_{i1996}$		0.033		-0.010
		(0.040)		(0.037)
Ln Avg Wage$_{i1996}$		-0.015		-0.176^a
		(0.068)		(0.060)
Occasional domestic firms		-0.040		-0.016
		(0.035)		(0.049)
Observations	3479	3479	3548	3548
R^2	0.020	0.021	0.014	0.022

Note: Industry 3-digit fixed effects are included in all the regressions. Standard errors in parentheses ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels. Robust standard errors.

relationship: the concavity of profits with respect to size, the relationship between marginal returns to investment in terms of size and initial size and the relationship between marginal cost of investment and initial size. If sectors where credit constraints are heterogeneous are also sectors in which the marginal returns to investment in terms of size increase with initial size, it might be the case that the heterogeneity across sectors in terms of size-investment and size-growth relationship is due to the shape of marginal returns to investment and not to the shape of marginal cost of investment. In investigate this issue in Tables 14 and 15, where I introduce in the employment and sales growth analysis both investment and the investment between investment and initial size, to measure potential differences across sectors in the shape of marginal returns to investment in terms of size. If anything, what I find is that marginal returns to investment in terms of size are slightly higher for initially bigger firms in industries where credit constraints are homogeneous only (interaction term between investment and size positive and significant). This result means that the negative relationship between firm-level size and investment or growth we measure would be actually lower if marginal returns to investment were homogeneous across firms in these industries. This would reinforce the differences in the intensity between firm-level size and investment or growth we already measure. I can thus safely claim that the fact that the negative relationship between size and investment/growth is more intense in sectors with homogeneous credit constraints than in sector with heterogeneous credit is actually due to differences in the shape of marginal costs of investment across both types of industries.

Table 12: Firm-level employment growth and investment

	Dependent Variable: Ln $Employment_i$			
	Domestic firms		Exporting firms	
	Homog. cred. const.	Heterog. cred. const.	Homog. cred. const.	Heterog. cred. const.
Ln L_{i1996}	-0.264^a	-0.266^a	-0.252^a	-0.244^a
	(0.015)	(0.021)	(0.013)	(0.018)
Ln LP Tfp_{i1996}	0.102^a	0.249^a	0.046	0.115^a
	(0.024)	(0.037)	(0.040)	(0.033)
Ln Avg $Wage_{i1996}$	-0.088^c	-0.238^a	-0.003	-0.220^a
	(0.046)	(0.057)	(0.075)	(0.048)
Avg annual $inv._{i1997-2002}$	0.112^a	0.139^a	0.173^a	0.158^a
	(0.017)	(0.019)	(0.011)	(0.016)
Switching exporters	0.082^a	0.051		
	(0.015)	(0.036)		
Alternate exporters	-0.012	-0.029		
	(0.011)	(0.020)		
Occasional exporters	0.006	-0.062^b		
	(0.021)	(0.027)		
Ceasing exporters			-0.051^b	-0.074
			(0.019)	(0.044)
Occasional domestic firms			-0.001	-0.012
			(0.026)	(0.029)
Observations	3678	1998	3479	3548
R^2	0.195	0.207	0.241	0.198

Note: Industry 3-digit fixed effects are included in all the regressions. Standard errors in parentheses ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels. Robust standard errors.

Table 13: Firm-level sales growth and investment

	Dependent Variable: Δ Ln Sales_i			
	Domestic firms		Exporting firms	
	Homog. cred. const.	Heterog. cred. const.	Homog. cred. const.	Heterog. cred. const.
Ln Sales_{i1996}	-0.279[a]	-0.251[a]	-0.246[a]	-0.210[a]
	(0.022)	(0.033)	(0.015)	(0.023)
Ln LP Tfp_{i1996}	0.062[c]	0.123[c]	0.061[c]	0.015
	(0.031)	(0.072)	(0.032)	(0.035)
Ln Avg Wage_{i1996}	-0.028	-0.181	0.023	-0.074
	(0.054)	(0.110)	(0.060)	(0.064)
$\text{Investment}_{i1996}$	0.169[a]	0.171[a]	0.198[a]	0.179[a]
	(0.017)	(0.028)	(0.014)	(0.020)
Switching exporters	0.155[a]	0.095[c]		
	(0.032)	(0.050)		
Alternate exporters	0.055[b]	-0.035		
	(0.021)	(0.033)		
Occasional exporters	0.008	-0.046		
	(0.024)	(0.051)		
Ceasing exporters			-0.152[a]	-0.160[a]
			(0.030)	(0.051)
Occasional domestic firms			-0.022	0.016
			(0.030)	(0.046)
Observations	3678	1998	3479	3548
R^2	0.187	0.171	0.199	0.166

Note: Industry 3-digit fixed effects are included in all the regressions. Standard errors in parentheses [a], [b] and [c] respectively denoting significance at the 1%, 5% and 10% levels. Robust standard errors.

Table 14: Heterogeneous impact of investment on employment growth

	Dependent Variable: Δ Ln Employment_i			
	Homogenous credit constraints		Heterogeneous credit constraints	
Ln L_{i1996}	-0.239[a]	-0.494[a]	-0.248[a]	-0.333[a]
	(0.009)	(0.048)	(0.015)	(0.051)
Ln LP Tfp_{i1996}	0.070[b]	0.070[c]	0.153[a]	0.152[a]
	(0.034)	(0.035)	(0.027)	(0.027)
Ln Avg Wage_i1996	-0.046	-0.059	-0.221[a]	-0.226[a]
	(0.060)	(0.061)	(0.040)	(0.039)
$\text{Investment}_{i1996}$	0.140[a]	0.063[a]	0.150[a]	0.125[a]
	(0.011)	(0.018)	(0.012)	(0.015)
$\text{Investment}_{i1996} \times L_{i1996}$		0.019[a]		0.006[c]
		(0.004)		(0.003)
Observations	7157	7157	5546	5546
R^2	0.203	0.210	0.195	0.196

Note: Industry 3-digit fixed effects are included in all the regressions. Standard errors in parentheses [a], [b] and [c] respectively denoting significance at the 1%, 5% and 10% levels. Robust standard errors.

Table 15: Heterogeneous impact of investment on sales growth

	Dependent Variable: Δ Ln Sales_i			
	Homogenous credit constraints		Heterogeneous credit constraints	
Ln Sales_{i1996}	-0.238[a]	-0.364[a]	-0.220[a]	-0.282[a]
	(0.012)	(0.037)	(0.023)	(0.048)
LnLP Tfp_{i1996}	0.066[b]	0.068[b]	0.047	0.047
	(0.026)	(0.026)	(0.030)	(0.030)
LnAvg Wage_i1996	0.018	0.031	-0.109[c]	-0.108[c]
	(0.059)	(0.064)	(0.057)	(0.057)
$\text{Investment}_{i1996}$	0.186[a]	0.107[a]	0.179[a]	0.139[a]
	(0.013)	(0.019)	(0.018)	(0.026)
$\text{Investment}_{i1996} \times \text{Ln Sales}_{i1996}$		0.009[a]		0.004
		(0.002)		(0.003)
Observations	7157	7157	5546	5546
R^2	0.174	0.176	0.160	0.161

Note: Industry 3-digit fixed effects are included in all the regressions. Standard errors in parentheses [a], [b] and [c] respectively denoting significance at the 1%, 5% and 10% levels. Robust standard errors.

5.7 Shape of credit constraints and small firms' contribution to growth

The analysis so far has been conducted at a micro level. It has however implications at the macro level. In particular, a natural conclusion we can draw from the analysis is that the shape of credit constraints will determine the share of SME's in aggregate growth: all else equal, in sectors where credit constraints are homogenous, small and medium sized firms should play a more important role in aggregate growth than in sectors where credit constraints are heterogeneous. This is actually what I find. I focus the analysis on employment and sales growth of firms in our final sample, i.e. firms remaining active over the period. Results in Table 16 show that employment has grown by 7.78% in industries where credit constraints are homogenous. On these 7.78%, 4.86 percentage point accrue to exporters and 2.92 percentage point to domestic firms. For industries where credit constraints are heterogeneous, these figures are equal, respectively, to 7.43%, 4.83 pp and 2.60 pp.

Within each 3-digit industries, firms are then classified in quartiles of size, based on their size in 1996. Domestic firms whose employment in 1996 is below the median in their industry account for almost 60% of total employment growth in domestic firms in sectors where credit constraints are homogeneous. In sectors where small firms are disproportionately credit constrained, firms whose size is below the median in their industry account for a little bit more than 30% of domestic firms' employment growth only. No such difference appears for exporting firms. This is consistent with our result that convergence in terms of employment among domestic firms is more rapid in sectors where credit constraints are homogenous than in the other industrial sectors, while no such significant difference is detected for exporting firms.

On the whole sample of firms, the share of firms with employment below the median in total employment growth is equal to almost 45% in sectors with homogenous credit constraints, vs 33% in sectors where small firms face tougher financial constraints than the bigger firms.

Results are very similar when we consider sales growth. In industries where credit constraints are homogenous, firms with sales below the median in their sector in 1996 account for 12.5% of sales growth between 1996 to 2002. In industries where small firms are more credit constrained than the others, the first half of firms in terms of sales account for 7% of sales growth over the period.

6 Conclusion

In this paper, I provide a framework that can help reconcile diverging results obtained in the literature on firm-level size and growth. I show that from a theoretical point of view, the relationship between firm-level initial size and investment or performance growth depends on three main determinants: the shape of the profit function with respect to size, the shape of marginal returns to investment (in terms of size) with respect to initial size and the shape of

Table 16: Credit constraints and industry-level employment growth 1996-2002

	Homog. cred. const. ind.		Heterog. cred. const. ind.	
Quartile	In pp of init. ind. level	Share in firm-type growth	In pp of init. ind. level	Share in firm-type growth
	Domestic firms			
1	1.01	34.59	0.47	18.08
2	0.73	25.00	0.34	13.08
3	0.69	23.63	0.45	17.31
4	0.49	16.78	1.34	51.54
Total	2.92	100	2.60	100
	Exporting firms			
1	0.75	15.43	0.89	18.43
2	1.04	21.40	1.04	21.53
3	1.51	31.07	2.25	46.58
4	1.56	32.10	0.65	13.46
Total	4.86	100	4.83	100
	All firms			
1	1.78	22.88	1.27	17.09
2	1.69	21.72	1.18	15.88
3	1.81	23.26	2.66	36.80
4	2.51	32.26	2.32	31.22
Total	7.78	100	7.43	100

Table 17: Credit constraints and industry-level sales growth 1996-2002

	Homog. cred. const. ind.		Heterog. cred. const. ind.	
Quartile	In pp of init. ind. level	Share in firm-type growth	In pp of init. ind. level	Share in firm-type growth
	Domestic firms			
1	0.96	11.91	0.35	7.99
2	1.18	14.64	0.48	10.96
3	1.98	24.57	0.85	19.41
4	3.93	48.76	2.71	61.87
Total	8.06	100	4.38	100
	Exporting firms			
1	1.21	3.92	1.15	2.58
2	2.36	7.64	1.79	4.02
3	4.62	14.96	4.82	10.82
4	22.69	73.88	36.77	82.57
Total	30.88	100	44.53	100
	All firms			
1	1.86	4.78	1.31	2.68
2	3.03	7.78	2.24	4.58
3	5.82	14.95	4.80	9.81
4	28.23	72.50	40.57	82.95
Total	38.94	100	48.91	100

marginal cost of investment with respect to size. I then test some implications of the theoretical framework on French data. I first identify, thanks to augmented Euler equations, sectors in which financial constraints are homogeneous across firms, and sectors in which financial constraints are more intense for smaller firms. I show that profits have the same concave shape in both types of industries. As predicted by the theoretical framework, investment and sales or employment growth are, all else equal, higher for initially smaller firms in sectors where credit constraints are homogeneous; this negative relationship is however more muted, or even disappears, in sectors where credit constraints are tougher for smaller firms. I show that these results cannot be explained by heterogeneous returns to investment in terms of size across the two groups of industries identified. Two macroeconomic implications are finally drawn from this work: in sectors where small firms are disproportionately credit constrained, firm-size distribution is less dispersed but more skewed on the right, and small firms participate less to sectorial growth.

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A Production functions

Table 18: Production functions

	Dependent Variable: ln Value added$_t$									
	Textile	Cloth.	Leather	Wood	Paper	Print./Publish.	Chem.	Rubber	Min. prod.	Metals
ln L_t	0.692^{a}	0.570^{a}	0.669^{a}	0.655^{a}	0.632^{a}	0.854^{a}	0.683^{a}	0.655^{a}	0.617^{a}	0.701^{a}
	(0.0186)	(0.0189)	(0.0326)	(0.0298)	(0.0265)	(0.0243)	(0.0264)	(0.0155)	(0.0209)	(0.0237)
ln K_t	0.162^{a}	0.269^{a}	0.235^{a}	0.144^{a}	0.197^{a}	0.0452^{b}	0.141^{a}	0.145^{a}	0.227^{a}	0.138^{b}
	(0.0315)	(0.0351)	(0.0492)	(0.0442)	(0.0409)	(0.0189)	(0.0353)	(0.0214)	(0.0362)	(0.0662)
N	10,042	8,747	2,816	5,298	4,879	14,119	8,898	12,116	7,307	3,657

Note: Year fixed effects are included in all the regressions. Standard errors in parentheses ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels. Standard errors are corrected to take into account correlation at the firm level.

Table 19: Production functions bis

	Dependent Variable: ln Value added$_t$								
	Met. Prod.	Non elec. mach.	Off. mach.	Elec. mach.	Telecom. equip.	Instr.	Cars	Other transp.	Misc.
ln L_t	0.708^{a}	0.799^{a}	0.753^{a}	0.717^{a}	0.747^{a}	0.724^{a}	0.639^{a}	0.807^{a}	0.664^{a}
	(0.00760)	(0.0133)	(0.0857)	(0.0259)	(0.0337)	(0.0281)	(0.0404)	(0.0354)	(0.0230
ln K_t	0.152^{a}	0.0877^{a}	0.284^{c}	0.123^{b}	0.134^{b}	0.182^{a}	0.171^{a}	0.123^{b}	0.162^{a}
	(0.0113)	(0.0292)	(0.161)	(0.0572)	(0.0583)	(0.0386)	(0.0551)	(0.0534)	(0.0255
N	37,641	18,067	490	5,499	3,974	6,689	4,322	2,291	8,796

Note: Year fixed effects are included in all the regressions. Standard errors in parentheses ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels. Standard errors are corrected to take into account correlation at the firm level.

B Identification of heterogeneous credit constraints

The baseline equation is:

$$\ln\left(\frac{\mathrm{I}}{\mathrm{K}}\right)_{it} = \alpha\ln\left(\frac{\mathrm{I}}{\mathrm{K}}\right)_{it-1} + \beta\ln^2\left(\frac{\mathrm{I}}{\mathrm{K}}\right)_{it-1} + \delta\ln\left(\frac{\mathrm{Sales}}{\mathrm{K}}\right)_{it-1} + \gamma\ln\mathrm{L}_{it} + \eta\ln\left(\frac{\mathrm{CF}}{\mathrm{K}}\right)_{it-1} + \mu\ln\mathrm{L}_{it}\times\ln\left(\frac{\mathrm{CF}}{\mathrm{K}}\right)_{it-1} + \theta_t + \epsilon_{it} \quad (8)$$

The estimation of this equation is subject to several drawbacks. First, firm-level unobserved characteristics, invariant across time, might impact on both investment behaviour and explanatory variables (risk-aversion of the entrepreneur, network of the entrepreneurs in terms of potential investors etc.). These determinants can be taken into account by first differencing the variables or by including firm-level fixed effects. However, some industry-level and/or firm-level shocks might also bias the results, while the dynamic nature of the model makes the firms fixed effects and first-differenced estimations potentially spurious. This is why GMM estimations are sometimes adopted. However, as emphasized by Hall, Mairesse, and Mulkay (1999), GMM often behave poorly due to relatively weak instruments.

I actually propose three specifcations: without fixed effects, with industry-year fixed effects and with firm-level fixed effects. None of these specifications is entirely satisfying. However, if results on the coefficient of interest μ all go in the same direction, this will be an index of the reliability of my findings. I tried to implement GMM estimations but instruments perform very poorly.

I also estimate two other models: a slightly modified Euler equation sometimes used in the literature (based on different assumptions on the adjustment cost function, see Love, 2003; Harrison, Love, and McMillan, 2004) and an accelerator specification (Hall, Mairesse, and Mulkay, 1999; Javorcik and Spatareanu, 2009).

I first estimate the equation separately for each 2-digit manufacturing industries (results available upon request). Several reasons can explain why in a given country like France, the shape of credit constraints differ across industries: the asymmetries in terms of information about the financial health of firms may not be the same across sectors, the degree of competition within the industry might impact on the access of small firms to external finance, sectors might be heterogeneous in terms of collateralizable assets etc. For a given industry, I consider that credit constraints are tougher for smaller firms if μ is negative and significant in the firm-fixed effect specification for at least two of the three estimated models.

I then pool together the observations of each type of industries and run the estimations on these pooled observations. Results are presented in Table 20. They show that my classification of industries is robust to the estimation strategy: In the first sample of industries, the coefficient μ is always negative and significant. On the contrary, the coefficient μ is never significant for the pooled sample of firms belonging to industries that had been identified as industries with homogeneous credit constraints in the first step. Results are the same for the modified Euler model and the accelerator model (see Tables 21 and 22).

Table 20: Heterogeneous credit constraints according to firm size-Euler equation

	Dependent Variable: $\ln_t \frac{I}{K}$					
	Homogenous credit constraints			Heterogeneous credit constraints		
$\ln_{t-1} \frac{I}{K}$	0.558^a	0.517^a	0.0436^b	0.595^a	0.595^a	0.0878^a
	(0.0183)	(0.0181)	(0.0186)	(0.0232)	(0.0230)	(0.0249)
$\text{Log}^2_{t-1} \frac{I}{K}$	-0.0315^a	-0.0300^a	-0.0132^a	-0.0309^a	-0.0322^a	-0.0155^a
	(0.00206)	(0.00204)	(0.00226)	(0.00240)	(0.00238)	(0.00306)
$\ln_{t-1} \frac{\text{Sales}}{K}$	-0.0412^a	0.0358^a	0.320^a	-0.00480	0.00768	0.317^a
	(0.0114)	(0.0119)	(0.0336)	(0.0126)	(0.0139)	(0.0473)
$\ln_t$ Emp	0.103^c	0.176^a	0.670^a	0.410^a	0.461^a	1.256^a
	(0.0551)	(0.0574)	(0.113)	(0.0650)	(0.0676)	(0.191)
$\ln_{t-1} \frac{CF}{K}$	0.297^a	0.305^a	0.192^a	0.446^a	0.484^a	0.594^a
	(0.0376)	(0.0386)	(0.0731)	(0.0463)	(0.0479)	(0.128)
$\ln_t$ Emp $\times \ln_{t-1} \frac{CF}{K}$	0.00306	-0.00618	-0.000741	-0.0519^a	-0.0590^a	-0.102^a
	(0.00866)	(0.00899)	(0.0166)	(0.0102)	(0.0106)	(0.0277)
N	76,330	76,330	76,330	59,411	59,411	59,411
R^2	0.175	0.157	0.078	0.196	0.180	0.085
Industry-Year fixed effects	no	yes	no	no	yes	no
Firm fixed effects	no	no	yes	no	no	yes

Note: Year fixed effects are included in all the regressions. Standard errors in parentheses ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels. Standard errors are corrected to take into account correlation at the firm level.

Table 21: Heterogeneous credit constraints according to firm size-Euler equation bis

	Dependent Variable: $\ln_t \frac{I}{K}$					
	Homogenous credit constraints			Heterogeneous credit constraints		
$\ln_{t+1} \frac{I}{K}$	0.251^a	0.233^a	-0.0453^a	0.273^a	0.268^a	-0.0189^a
	(0.00469)	(0.00484)	(0.00606)	(0.00548)	(0.00560)	(0.00716)
$\text{Log}_{t-1} \frac{I}{K}$	0.255^a	0.240^a	-0.0878^a	0.272^a	0.266^a	-0.0654^a
	(0.00537)	(0.00561)	(0.00726)	(0.00665)	(0.00695)	(0.00938)
$\ln_{t-1} \frac{\text{Sales}}{K}$	-0.0331^a	0.0118	0.303^a	-0.0196^c	-0.0137	0.290^a
	(0.0103)	(0.0109)	(0.0360)	(0.0107)	(0.0118)	(0.0460)
$\ln_t$ Emp	0.120^b	0.171^a	0.650^a	0.351^a	0.387^a	1.269^a
	(0.0530)	(0.0557)	(0.133)	(0.0533)	(0.0551)	(0.192)
$\ln_{t-1} \frac{CF}{K}$	0.240^a	0.255^a	0.183^b	0.363^a	0.391^a	0.625^a
	(0.0369)	(0.0383)	(0.0859)	(0.0390)	(0.0402)	(0.130)
$\ln_t \text{Emp} \times \ln_{t-1} \frac{CF}{K}$	-0.00414	-0.0102	-0.00234	-0.0449^a	-0.0500^a	-0.106^a
	(0.00828)	(0.00867)	(0.0192)	(0.00838)	(0.00866)	(0.0277)
N	61,955	61,955	61,955	48,477	48,477	48,477
R^2	0.230	0.209	0.067	0.260	0.244	0.075
Industry-Year fixed effects	no	yes	no	no	yes	no
Firm fixed effects	no	no	yes	no	no	yes

Note: Year fixed effects are included in all the regressions. Standard errors in parentheses ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels. Standard errors are corrected to take into account correlation at the firm level.

Table 22: Heterogeneous credit constraints according to firm size-Accelerator model

	Dependent Variable: $\ln_t \frac{I}{K}$					
	Homogenous credit constraints			Heterogeneous credit constraints		
$\ln_{t-1} \frac{I}{K}$	0.529^a	0.480^a	0.0230	0.593^a	0.603^a	0.0637^b
	(0.0233)	(0.0231)	(0.0223)	(0.0327)	(0.0327)	(0.0299)
$\ln^2_{t-1} \frac{I}{K}$	-0.0269^a	-0.0250^a	-0.0165^a	-0.0293^a	-0.0322^a	-0.0170^a
	(0.00272)	(0.00269)	(0.00269)	(0.00356)	(0.00352)	(0.00353)
$\Delta \ln_t$Sales	0.101^a	0.132^a	0.509^a	0.132^a	0.157^a	0.453^a
	(0.0143)	(0.0143)	(0.0235)	(0.0144)	(0.0149)	(0.0332)
$\Delta \ln_{t-1}$Sales	-0.0943^a	-0.0673^a	0.217^a	-0.0310^b	-0.0177	0.168^a
	(0.0141)	(0.0138)	(0.0198)	(0.0140)	(0.0140)	(0.0240)
$\ln_t$ Emp	0.0881	0.262^a	0.928^a	0.508^a	0.617^a	1.547^a
	(0.0607)	(0.0639)	(0.154)	(0.0781)	(0.0830)	(0.313)
$\ln_{t-1} \frac{CF}{K}$	0.265^a	0.333^a	0.394^a	0.352^a	0.398^a	0.787^a
	(0.0393)	(0.0411)	(0.101)	(0.0534)	(0.0568)	(0.191)
$\ln_t$ Emp $\times \ln_{t-1} \frac{CF}{K}$	0.00901	-0.00634	-0.0205	-0.0484^a	-0.0585^a	-0.123^a
	(0.00944)	(0.00996)	(0.0229)	(0.0124)	(0.0133)	(0.0466)
N	60,933	60,933	60,933	47,904	47,904	47,904
R^2	0.187	0.169	0.111	0.208	0.192	0.116
Industry-Year fixed effects	no	yes	no	no	yes	no
Firm fixed effects	no	no	yes	no	no	yes

Note: Year fixed effects are included in all the regressions. Standard errors in parentheses ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels. Standard errors are corrected to take into account correlation at the firm level.

C Shape of credit constraints and firm-level relative size distribution

Table 23: Firm-level relative size distribution: Value added

	Homog. cred. const. ind.		Heterog. cred. const. ind.	
Percent.	Dom.	Exp	Dom.	Exp
10	0.34	0.15	0.25	0.09
25	0.43	0.22	0.33	0.13
50	0.59	0.37	0.47	0.25
75	0.91	0.74	0.74	0.63
90	1.46	1.67	1.46	1.65
95	2.08	3.01	2.49	3.20

Note: The table reads as follows: in 1996, the 10th percentile of the ratio of firm-level value added to firm-level average value added is equal, on average, to 34% for domestic firms in industries where small firms are disproportionately credit-constrained, and to 25% for domestic firms in industries where credit constraints are homogeneous.

D Shape of credit constraints and firm-level relative size distribution

Note that the slight convexity observed for exporters when a cubic term in firm-level employment is introduced is in reality estimated on the 99th percentile of firms in terms of employment for each type of industries (respectively equal to 7.16 and 7.85 in logarithm for industries with homogeneous and heterogeneous credit constraints). It thus concerns a small minority of exporters. Also, contrary to non-linearities of profits with respect to employment, the slope of the profit function does not vary much between domestic firms and exporters when non-linearities in terms of Tfp are considered.

Table 24: Concavity of firm-level profits

	Dependent Variable: ln Y-Wages			
	Domestic firms		Exporting firms	
	Homog. cred. const.	Heterog. cred. const.	Homog. cred. const.	Heterog. cred. const.
ln L	1.236^a	1.290^a	1.030^a	0.993^a
	(0.188)	(0.122)	(0.079)	(0.047)
$\ln^2$ L	-0.129^a	-0.139^a	-0.098^a	-0.078^a
	(0.041)	(0.026)	(0.015)	(0.009)
$\ln^3$	0.007^b	0.007^a	0.006^a	0.004^a
	(0.003)	(0.002)	(0.001)	(0.001)
ln K	0.264^a	0.259^a	0.262^a	0.232^a
	(0.012)	(0.007)	(0.008)	(0.005)
ln Tfp	1.740^a	1.666^a	1.745^a	1.720^a
	(0.018)	(0.016)	(0.014)	(0.014)
N	39448	20508	51927	49168
R^2	0.781	0.865	0.892	0.925

Note: Industry 3-digit-Year fixed effects are included in all the regressions. Standard errors in parentheses ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels. Robust standard errors.

Table 25: Concavity of firm-level profits

	Dependent Variable: ln Y-Wages			
	Domestic firms		Exporting firms	
	Homog. cred. const.	Heterog. cred. const.	Homog. cred. const.	Heterog. cred. const.
ln L	0.521^a	0.516^a	0.510^a	0.507^a
	(0.018)	(0.013)	(0.011)	(0.008)
ln K	0.268^a	0.256^a	0.266^a	0.230^a
	(0.013)	(0.007)	(0.008)	(0.005)
ln Tfp	3.068^a	2.986^a	3.210^a	3.453^a
	(0.127)	(0.133)	(0.124)	(0.079)
$\ln^2$ Tfp	-0.176^a	-0.172^a	-0.187^a	-0.209^a
	(0.017)	(0.016)	(0.016)	(0.009)
N	39448	20508	51927	49168
R^2	0.784	0.867	0.896	0.928

Note: Industry 3-digit-Year fixed effects are included in all the regressions. Standard errors in parentheses ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels. Robust standard errors.

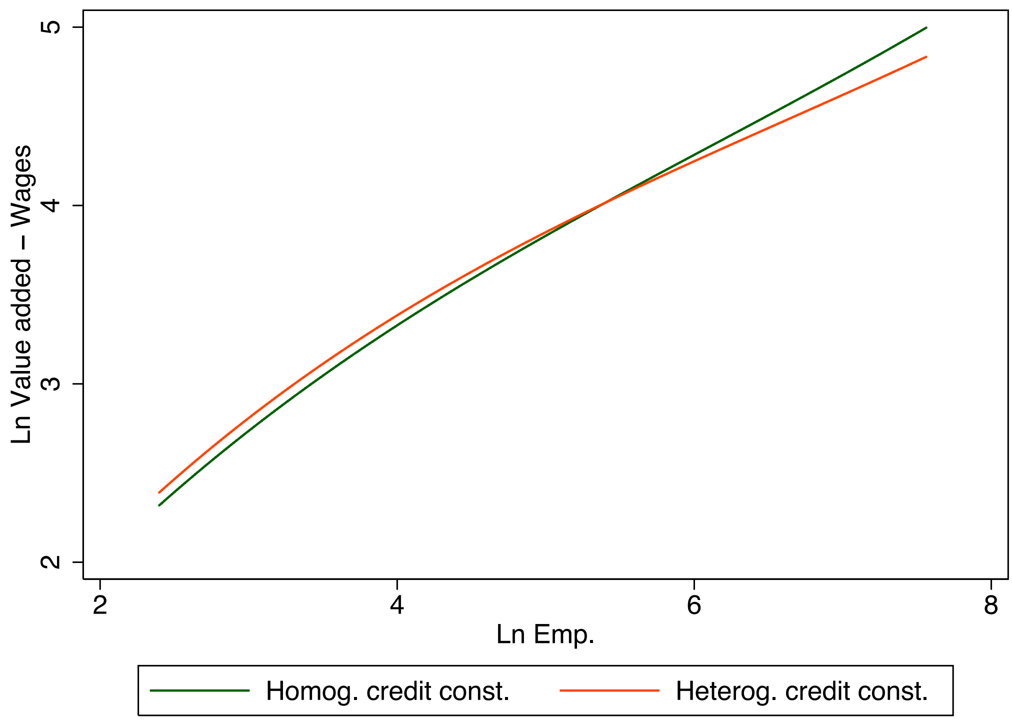

Figure 3: Domestic firms - Cubic term in emp.

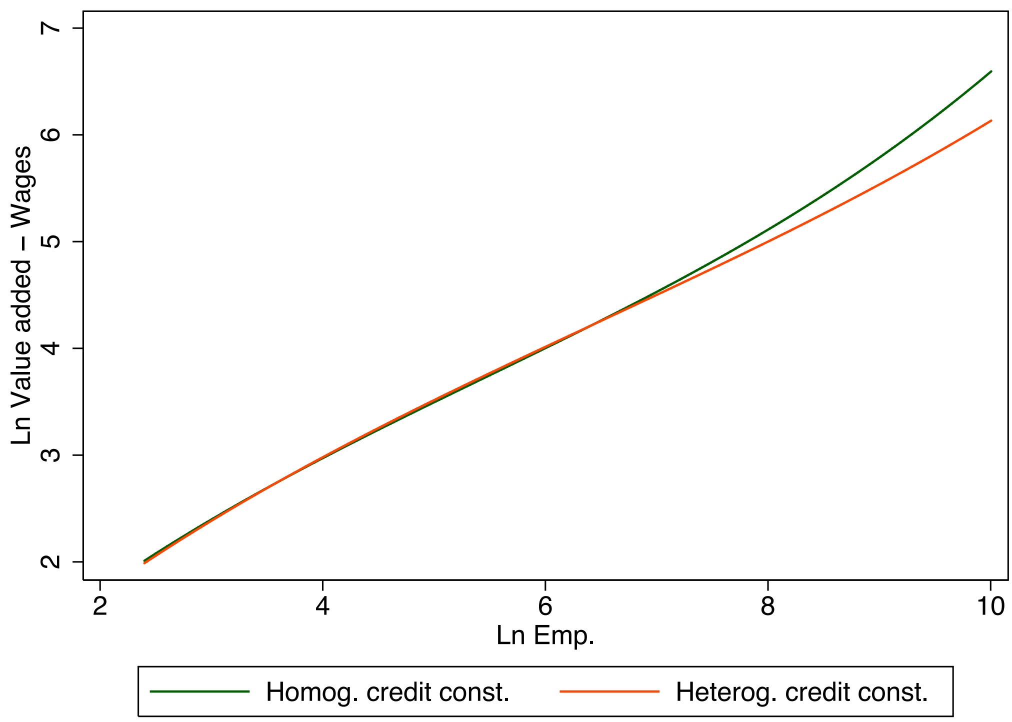

Figure 4: Exporting firms - Cubic term in emp.

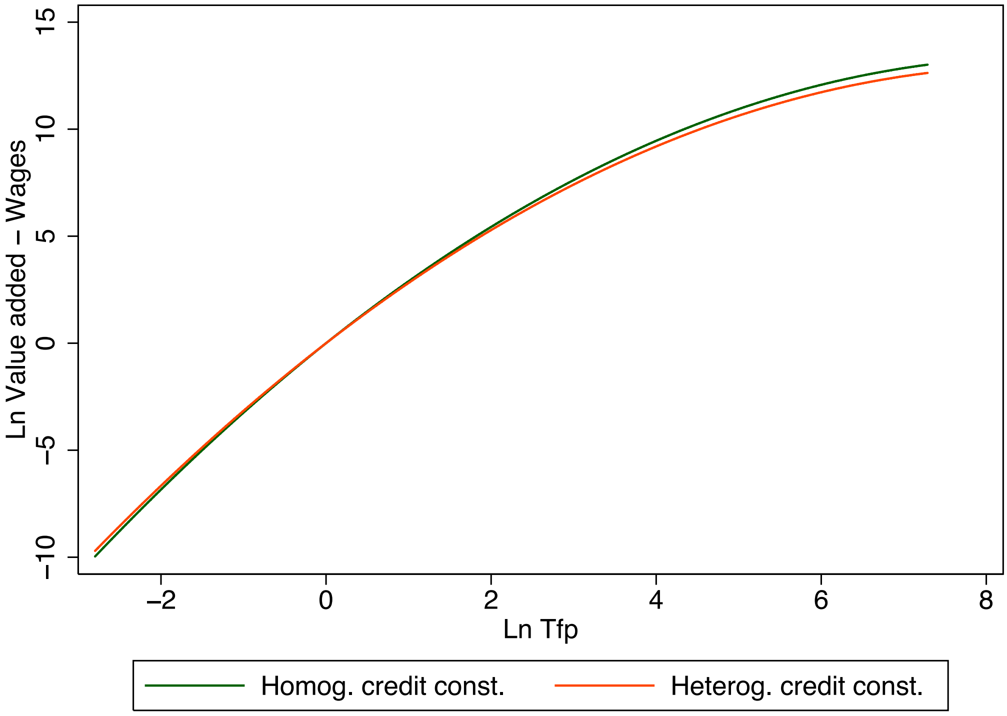

Figure 5: Domestic firms - Concavity in Tfp

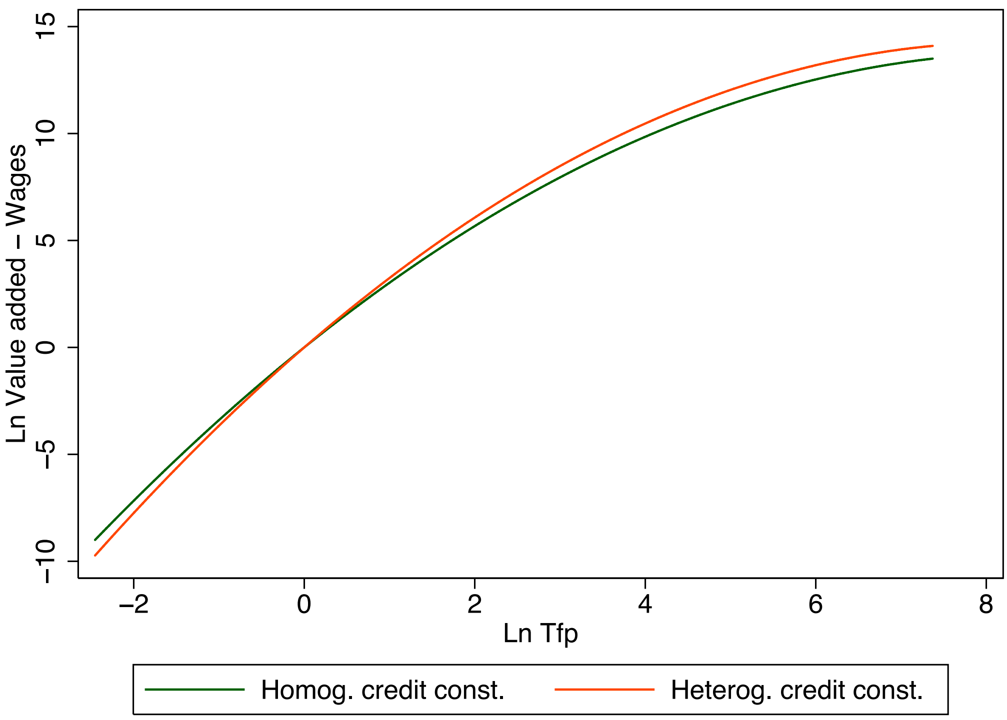

Figure 6: Exporting firms - Concavity in Tfp

E Firm-level Tfp growth and investment

Table 26: Firm-level Tfp growth - Initially domestic firms

	Dependent Variable: Δ Ln LP Tfp_i			
	Homogenous credit constraints		Heterogeneous credit constraints	
Ln LP Tfp_{i1996}	-0.404^a	-0.509^a	- 0.392^a	-0.506^a
	(0.044)	(0.059)	(0.043)	(0.058)
Switching exporters	0.041^c	0.036^c	0.021	0.011
	(0.020)	(0.020)	(0.025)	(0.026)
Alternate exporters	0.040^b	0.030^b	-0.013	-0.026
	(0.015)	(0.014)	(0.021)	(0.023)
Ln L_{i1996}	0.001	0.017	0.046^b	0.060^a
	(0.019)	(0.017)	(0.018)	(0.018)
Ln Avg Wage_{i1996}		0.237^a		0.266^a
		(0.058)		(0.093)
Occasional exporters		-0.009		-0.038
		(0.024)		(0.026)
Observations	3678	3678	1998	1998
R^2	0.145	0.160	0.136	0.154

Note: Industry 3-digit fixed effects are included in all the regressions. Standard errors in parentheses ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels. Robust standard errors.

Table 27: Firm-level Tfp growth - Initially exporting firms

	Dependent Variable: Δ Ln LP Tfp_i			
	Homogenous credit constraints		Heterogeneous credit constraints	
Ln LP Tfp_{i1996}	-0.330^a	-0.401^a	-0.391^a	-0.453^a
	(0.031)	(0.046)	(0.036)	(0.041)
Ceasing exporters	-0.090^b	-0.088^b	-0.056^b	-0.052^b
	(0.037)	(0.034)	(0.025)	(0.026)
Ln L_{i1996}	-0.010	-0.002	0.05 6^a	0.058^a
	(0.015)	(0.014)	(0.011)	(0.011)
Ln Avg Wage_{i1996}		0.198^b		0.201^a
		(0.084)		(0.060)
Occasional domestic firms		-0.040^c		-0.022
		(0.022)		(0.035)
Observations	3479	3479	3548	3548
R^2	0.097	0.107	0.120	0.128

Note: Industry 3-digit fixed effects are included in all the regressions. Standard errors in parentheses ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels. Robust standard errors.