A new perspective on the firm size-growth relationship: Shape of profits, investment and heterogeneous credit constraints

F. Mayneris

Discussion Paper 2011-44

Institut de Recherches Économiques et Sociales
de l'Université catholique de Louvain

IRES

UCL

A new perspective on the firm size-growth relationship: Shape of profits, investment and heterogeneous credit constraints*

Florian Mayneris[1]

November 29, 2011

Abstract

This paper shows that the diverging results obtained in the literature on the firm size-growth relationship can be reconciled in a very general theoretical framework featuring firm-level heterogeneity and investment decision. Three main elements determine the nature and the intensity of the relationship between firm-level size and investment: the shape of operating profits 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. Any difference across countries, industries or periods in one of these three dimensions can modify the sign and the intensity of the firm size-investment and the firm size-growth relationship at equilibrium. As an example, I show that in France, heterogeneous credit constraints, which affect the shape of the marginal cost of investment, can explain cross-sectoral variations in the firm size-investment and firm size-growth relationship over the 1996-2002 period. As a consequence, from a macroeconomic viewpoint, firm size distribution is, all else equal, more right-skewed in sectors where small firms are disproportionately credit constrained and small firms participate less to sectorial growth in these sectors. The analytical framework proposed in this paper is general enough to apply to the analysis of any heterogeneous response of economic agents.

Keywords: Investment, size, firm size-growth relationship, financial constraints.

JEL classification: D21, D22, L11, L25.

*I am grateful to Maria Bas, Paola Conconi, Gilles Duranton, Thibault Fally, Gabriel Felbermayr, John Haltiwanger, Jérôme Héricourt, Julien Martin, Philippe Martin, Thierry Mayer, Volker Nitsch, Mathieu Parenti, Jens Sudekum, Thierry Verdier, Maurizio Zanardi and participants at several seminars and conferences for very helpful comments on earlier versions of this work. I thank the Belgian French-speaking Community (convention ARC 09/14-019 on "Geographical Mobility of Factors") for financial support.

[1]Université catholique de Louvain, IRES, CORE. florian.mayneris@uclouvain.be

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 stipulates that firm-level growth rate should not depend on 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; Konings, 1995; 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 firm size-growth relationship percolates in different fields of economics. For example, it is 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? 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, 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. 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. Since the three determinants I highlight might vary across countries, sectors and/or time, the firm size-growth relationship might itself be heterogeneous along these three dimensions.

I then test the predictions of the theoretical framework 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, conditioning on the shape 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 then show that these cross-sectoral differences in the firm size-growth relationship cannot be explained by heterogeneous returns to investment in terms of size. From a macroeconomic point of view, I finally emphasize that the shape of financial constraints can affect both firm size distribution and the share of SME's in aggregate growth. More specifically, in sectors where small firms are disproportionately credit constrained, firm-size distribution is more right-skewed, and small firms participate less to sectorial growth.

The role of financial constraints in shaping the firm size-investment and firm-size growth relationship is one possible application of the general theoretical framework provided in this paper. This framework more generally applies to the analysis of any potentially heterogeneous response of economic agents. In this respect, this paper provides an analytical framework that could be useful for other topics in trade, urban economics, empirical IO or labour, among others.

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 across sectors 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, firms face stochastic business opportunities so that increments in terms of size they can reach is proportionate to their initial size. Expected firm-level growth rate and initial size are thus 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, for the size of cities), power laws being 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 that in the US, 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 firm 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 identification number. This leads to spurious firm births and deaths. 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; 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 covering 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 (technology, financial constraints etc.). This can explain why the nature and the intensity of this relationship varies across countries, sectors or periods. I moreover relate the nature of this relationship to the investment behavior of firms, while investment was not taken into account in the papers cited above. I consequently focus on stayers, that is to say on firms that remain active for a given period of time; I do not deal with entry and exit. I also introduce a distinction between domestic and exporting firms. 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

An extensive literature exists on firm-level financial constraints, investment and growth.

From a macroeconomic viewpoint, 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. However, these papers do not deal with the heterogeneous impact of financial constraints on firms of different sizes.

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

[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

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 sizes. Following Modigliani and Miller (1958), the underlying idea is that investment should not depend on firm-level internal financing capacity when financial markets are frictionless. 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 for Germany respectively. However, in 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 market cost of this debt. 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 on their impact on macroeconomic growth, while I am interested in the role of heterogeneous credit constraints on the firm size-growth relationship. Second, in these papers, it is implicitly assumed 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.

sector.

Costantini and Melitz (2008), Atkeson and Burstein (2010), Aw, Roberts, and Xu (2011) 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 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 the 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 Canadian 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 2002. 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 determining the relationship between firm-level size and investment, and through investment, firm-level 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 $I(\phi_0)$

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

which will increase their size in period 1 following a function Φ:

$$\phi_1 = \Phi[I(.), \phi_0] \tag{1}$$

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. 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:

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

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:

$$\frac{\delta \Pi}{\delta I(.)}(\phi_1) = \frac{\delta \Phi}{\delta I(.)}[I(.), \phi_0)] \times \frac{\delta \pi}{\delta \Phi}[\Phi(I(.), \phi_0)] - \frac{\delta C}{\delta I(.)}[I(.), \phi_0] = 0 \tag{3}$$

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:

$$\begin{aligned} \frac{\partial^2 \Pi}{\partial I(.) \partial \phi_0}(\phi_1) = & \frac{\partial \Phi}{\partial I(.)}[I(.), \phi_0] \times \frac{\partial \Phi}{\partial \phi_0}[I(.), \phi_0] \times \frac{\partial^2 \pi}{\partial^2 \Phi}[\Phi(I(.), \phi_0)] \\ & + \frac{\partial \pi}{\partial \Phi}[\Phi(I(.), \phi_0)] \times \frac{\partial^2 \Phi}{\partial I(.) \partial \phi_0}[I(.), \phi_0] - \frac{\partial^2 C}{\partial I(.) \partial \phi_0}[I(.), \phi_0] \end{aligned} \tag{4}$$

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:

- **The concavity of operating profits with respect to size**, given by $\frac{\partial^2 \pi}{\partial^2 \Phi}[\Phi(I(.), \phi_0)]$. It can be linked to *preferences* or to *technology of production*. For a given technology, if we assume that bigger firms are more productive and produce cheaper varieties, as in Hopenhayn (1992) for example, bigger (smaller) firms will tend to have greater incentives to invest if demand increases more and more (less and less) rapidly when price decreases, . 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 demand and supply conditions.
- **The shape of marginal returns to investment in terms of size**, given by $\frac{\partial^2 \Phi}{\partial I(.)\partial \phi_0}[\Phi(I(.), \phi_0)]$. This term is 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.
- **The concavity of the investment cost function**, given by $\frac{\partial^2 C}{\partial I(.)\partial \phi_0}[I(.), \phi_0]$. 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, when they bind disproportionately on small firms, also explain why the marginal cost of investment might be higher for initially smaller firms.

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: operating profits, investment technology 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 studied by Mrazova and Neary (2011). They analyze 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 the forces that determine this sub/supermodularity, focusing on the case of capacity investment. 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 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, the marginal cost of investment decreases with size when credit constraints bind disproportionately on small firms. This can be due for example to higher interest rates applied to small firms, which 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.

3.4 Theoretical framework and existing literature

It is worth noting that this simple framework is rich enough to reconcile apparently conflicting results obtained in the literature. For example, in Bustos (2011), several elements generate the positive relationship between firm-level initial size and technology adoption she obtains:

– She assumes CES preferences and fixed marginal cost of production $\frac{1}{\phi}$, so that firm-level operating profits are of the form $A\phi^{\sigma-1}$, where $A{>}0$ and $\sigma{>}1$. Firm-level profits are concave ($\frac{\partial^2\pi}{\partial^2\Phi}[\Phi(I(.),\phi_0)]{<}0$) for $\sigma{<}2$ and convex ($\frac{\partial^2\pi}{\partial^2\Phi}[\Phi(I(.),\phi_0)]{>}0$) for $\sigma{>}2$.

– She models a discrete technology choice between a high and a low technology in which marginal productivity gains from investment in the high technology are higher for initially more productive firms. Indeed, I(.) is a dummy in this case, and when it is equal to 1, she assumes that $\Phi[I(.),\phi_0]{=}\gamma\phi_0$, with $\gamma > 1$, so that $\frac{\partial^2\Phi}{\partial I(.)\partial\phi_0}[\Phi(I(.),\phi_0)]{=}\gamma{-}1{>}0$.

– On the contrary, the cost of investment in the high technology as compared to the low technology is assumed to be the same for all firms, equal to $(\eta-1)f$, where f is the fixed production cost under the low technology and $\eta > 1$, so that $\frac{\partial^2 C}{\partial I(.)\partial\phi_0}[I(.),\phi_0]{=}0$.

Functional forms are such that in the end, the convexity of the relationship between initial and post-investment productivities dominates the potential concavity of operating profits, implying that $\frac{\partial^2\Pi}{\partial I(.)\partial\phi_0}(\phi_1){>}0$ whatever σ.

Lileeva and Trefler (2010) obtain the opposite prediction in a model featuring a dichotomous investment choice too. However, in their framework, for a given initial productivity, firms are also heterogeneous in terms of marginal returns to investment they can expect. There are thus two sources of heterogeneity: firms increase their productivity thanks to investment ($\frac{\partial\Phi}{\partial I(.)}[I(.),\phi_0] > 0$), but for a given investment decision, there is no systematic relationship between initial productivity and post-investment productivity ($\frac{\partial\Phi}{\partial\phi_0}[I(.),\phi_0]{=}0$ if I(.)=1). The link between marginal returns to investment and initial efficiency is consequently undetermined ($\frac{\partial^2\Phi}{\partial I(.)\partial\phi_0}[I(.),\phi_0]{=}0$). Finally, the marginal cost of investment is the same for all the firms: $\frac{\partial^2 C}{\partial I(.)\partial\phi_0}[I(.),\phi_0]{=}0$. The negative relationship they obtain between initial productivity and productivity gains thus 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.

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

I now turn to one possible application of the theoretical framework I propose, the explanation of cross-sectoral differences in the firm size-investment and the firm-size growth relationship by heterogeneous credit constraints. As a first step, this section presents the data I use, and then analyses the shape of credit constraints and of profits in French manufacturing industries.

4.1 The data

I use the French "Enquêtes annuelles d'entreprises" (EAE, Annual Business Surveys), provided by the French ministry of Industry. The data set covers all firms with more than 20 employees, and smaller firms with sales higher than 5 millions euros. 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 have data from 1996 to 2004.

I conserve in the sample firms from continental France[3] and from manufacturing industries, with more than 10 employees. All my results about size must thus be interpreted as valid above this threshold. Having a sample restrained to firms bigger than 10 employees implies that the analysis mainly covers firms mature enough to pass this threshold: this ensures that size does not capture effects that would be in reality related to age (see Haltiwanger, Jarmin, and Miranda, 2010).

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, I estimate production functions at the 2-digit industry level following the Levinsohn and Petrin (2003) methodology (see Appendix A).

4.2 Identification of heterogeneous credit constraints

There exists a vast literature on the identification of credit constraints. The majority of papers identify the existence of credit constraints thanks to the estimation of a Euler investment equation (see, e.g., Love, 2003; Bond, Elston, Mairesse, and Mulkay, 2003; Harrison, Love, and McMillan, 2004; Javorcik and Spatareanu, 2009; Poncet, Steingress, and Vandenbussche, 2010). This method has been questioned, as illustrated by the controversy between Kaplan and Zingales (1997) and Fazzari, Hubbard, and Petersen (2000). However, in the absence of direct measures of firm-level financial constraints, it 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 for 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; in this case, they are said to be credit-constrained.

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

I estimate an augmented Euler equation to test for the existence of heterogeneous credit constraints depending on firm size. Indeed, it might be the case that small firms are more subject to credit constraints, due to higher sensitivity to business cycles or to absence of collateral to offer to banks. 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:

$$\begin{aligned}\ln\left(\frac{\mathrm{I}}{\mathrm{K}}\right)_{it} &= \alpha\ln\left(\frac{\mathrm{I}}{\mathrm{K}}\right)_{it-1} + \beta\ln^2\left(\frac{\mathrm{I}}{\mathrm{K}}\right)_{it-1} + \delta\ln\left(\frac{\mathrm{Sales}}{\mathrm{K}}\right)_{it-1} + \gamma\ln\mathrm{L}_{it} + \\ &\quad \eta\ln\left(\frac{\mathrm{CF}}{\mathrm{K}}\right)_{it-1} + \mu\ln\mathrm{L}_{it}\times\ln\left(\frac{\mathrm{CF}}{\mathrm{K}}\right)_{it-1} + \theta_t + \epsilon_{it} \qquad (5)\end{aligned}$$

where $\frac{\mathrm{I}}{\mathrm{K}}$ is the level of investment of firm i scaled by the level of assets at time t, $\frac{\mathrm{Sales}}{\mathrm{K}}$ is the ratio of sales to assets of firm i, L is employment of firm i and $\frac{\mathrm{CF}}{\mathrm{K}}$ is the ratio of cash flow to assets of firm i. Lagged value of $\frac{\mathrm{I}}{\mathrm{K}}$ and its square account for the (potentially non linear) dynamic structure of the investment model, $\frac{\mathrm{Sales}}{\mathrm{K}}$ is a proxy for the profitability of the firm (the higher the ratio of sales to capital, the more profitable the firm) and $\frac{\mathrm{CF}}{\mathrm{K}}$ is an index of liquidities available within the firm.[4] Consequently, the parameter η will capture average credit constraints in the sample: a positive and significant correlation between firm-level investment in t and available internal liquidities 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 credit constrained they are. What is important here 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.

The Euler equation is estimated separately for each 2-digit industry, allowing the shape of credit constraints to differ across sectors. There are several reasons why the shape of credit constraints may not be the same across sectors within the same country: 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 example, 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). However, they also state that size is weighted differently in their rating grids depending on industry determinants such as the market structure or the maturity of the sector. Size might consequently not necessarily be a disadvantage[5]

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

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

I present in Appendix B more details on the estimation of this equation. The classification of industries obtained with the Euler equation is presented in Table 1. It is robust to different estimation strategies (no fixed effects, industry-year fixed effects, firm-level fixed effects, industry-year and firm-level fixed effects, GMM estimations yielding unreliable results), to alternative time-structure (including firm-level employment at time $t-1$ instead of t) and to alternative specifications (in particular the accelerator-profit model, also used in Konings, Rizov, and Vandenbussche (2003) and Harrison, Love, and McMillan (2004) for example).

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	

4.3 Shape of credit constraints and firm size distribution

No direct intuition allows to rationalize the classification of industries that emerges from the estimation of credit constraints by sector (maturity or capital-intensity of sectors, competition etc.). This is not so surprising given the multiplicity of possible determinants of the shape of credit constraints. However, the idea that this classification correctly captures cross-sectoral differences in the shape of credit constraints is supported by the analysis of firm-size distribution within sectors. Indeed, in sectors where small firms are disproportionately credit constrained, we expect firms at the bottom of the distribution to be relatively smaller with respect to the average in the industry than in sectors where credit constraints are homogeneous. On the opposite, we expect the relative size of firms at the top of the distribution to be bigger in sectors with heterogeneous credit constraints than in sectors with homogenous credit constraints.

This is exactly the pattern described in Tables 2 for firm-level employment. For each 2-digit sector and each category of firms, domestic or exporters (defined as firms declaring more than 50,000 euros of exports), firm-level relative size is calculated by computing the ratio for year 1996 of firm-level employment to firm-level average employment in the industry and firms' category. Firms are then divided into quantiles of relative size (still at the industry and firms'

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

	Homog. cred. const. ind.		Heterog. cred. const. ind.	
Percent.	Domestic	Exporters	Domestic	Exporters
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 industry-level firm average employment is equal, on average, to 44% for domestic firms in industries where credit constraints are homogenous, and to 37% for domestic firms in industries where small firms are disproportionately credit-constrained. Exporting firms are firms declaring exports bigger than 50 000 euros.

category level). The average value of different quantiles of domestic and exporting firms is calculated separately for industries with homogenous et heterogeneous credit constraints. Two important regularities appear. First, whatever the shape of credit constraints, the relative size of exporters at the bottom of the distribution 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 the results obtained by di Giovanni, Levchenko, and Ranciere (2010); they 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, implying a stronger size dispersion for exporters. 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 constraints are homogeneous. Moreover, in sectors with homogenous credit constraints, domestic firms at the 95th percentile of the distribution are 5.23 times larger than domestic firms at the 1st decile, vs 6.86 in sectors with heterogeneous credit constraints (resp. 16 and 27 for exporters). This suggests that firm-level relative size distribution is more right-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 distribution of firm-level size that is more right-skewed.

The picture is the same if we consider sales (see Table 3) or value added (see Appendix C) as a proxy for size.

Table 3: Firm-level relative size distribution: Sales

	Homog. cred. const. ind.		Heterog. cred. const. ind.	
Percent.	Domestic	Exporters	Domestic	Exporters
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 industry-level firm average sales is equal, on average, to 26% for domestic firms in industries where credit constraints are homogenous, and to 19% for domestic firms in industries where small firms are disproportionately credit-constrained. Exporting firms are firms declaring exports bigger than 50 000 euros.

4.4 Concavity of operating profits

Differences in the shape of financial constraints across sectors can be interpreted as differences in the shape of marginal cost of investment. However, I have shown in Section 3 that size-investment and size-growth relationships are also determined by the shape of profits with respect to size. I thus 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 flexible profit equation:

$$\begin{aligned} \ln\pi_{ijt} &= \alpha\ln\left(\frac{\mathrm{K}}{\mathrm{L}}\right)_{ijt} + \beta\ln^2\left(\frac{\mathrm{K}}{\mathrm{L}}\right)_{ijt} + \gamma\ln\mathrm{K}_{ijt} + \delta\ln^2\mathrm{K}_{ijt} + \eta\ln\mathrm{Tfp}_{ijt} + \kappa\ln^2\mathrm{Tfp}_{ijt} + \\ & \phi\ln\left(\frac{\mathrm{K}}{\mathrm{L}}\right)_{ijt} \times \ln\mathrm{K}_{ijt} + \nu\ln\left(\frac{\mathrm{K}}{\mathrm{L}}\right)_{ijt} \times \ln\mathrm{Tfp}_{ijt} + \xi\ln\mathrm{K}_{ijt} \times \ln\mathrm{Tfp}_{ijt} + d_{jt} + \epsilon_{ijt} \end{aligned} \quad (6)$$

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). For a given capital to labor ratio $\left(\frac{\mathrm{K}}{\mathrm{L}}\right)_{ijt}$, profits are supposed to depend on the quantity of capital K used by the firm and on firm-level Tfp. Investments made by the firm might be either capacity-enhancing, increasing the capital stock, or productivity-enhancing, increasing the level of Tfp. I thus investigate non-linearities in the effect of capital stock and Tfp on firm-level profits by including quadratic terms of control variables. Bilateral interactions of capital to labor ratio, capital stock and Tfp are also included to keep the estimated profit function flexible. This amounts to estimate a Taylor approximation of the profits function. The regression includes 3-digit industry-year fixed effects, so that the impact of each variable is estimated by comparing, for a given year, firms within the same industry.

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.
$\ln \frac{K}{L}$	-0.172	-0.542^a	-0.049	-0.297^a
	(0.125)	(0.083)	(0.065)	(0.046)
$\ln^2 \frac{K}{L}$	-0.094^a	-0.012	-0.026^a	0.004
	(0.012)	(0.007)	(0.007)	(0.005)
ln K	1.001^a	0.952^a	0.745^a	0.741^a
	(0.055)	(0.056)	(0.036)	(0.026)
$\ln^2$ K	-0.039^a	-0.032^a	-0.003	-0.012^a
	(0.005)	(0.005)	(0.004)	(0.002)
ln Tfp	3.526^a	3.145^a	3.465^a	3.485^a
	(0.134)	(0.154)	(0.082)	(0.089)
$\ln^2$ Tfp	-0.187^a	-0.194^a	-0.193^a	-0.229^a
	(0.016)	(0.021)	(0.014)	(0.012)
ln K × ln Tfp	0.011	0.035^b	0.014	0.048^a
	(0.012)	(0.017)	(0.015)	(0.008)
$\ln \frac{K}{L}$ × ln Tfp	-0.144^a	-0.074^a	-0.096^a	-0.068^a
	(0.028)	(0.023)	(0.020)	(0.011)
ln K × $\ln \frac{K}{L}$	0.103^a	0.051^a	0.007	0.002
	(0.013)	(0.011)	(0.009)	(0.005)
N	39448	20508	51927	49168
R^2	0.791	0.869	0.897	0.929
hline N	39448	20508	51927	49168
R^2	0.791	0.869	0.897	0.929

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

The regression is run separately for domestic firms and exporters. Again, exporters are defined as firms exporting more than 50,000 euros in a given year. We use a definition based on the amount of exports, and not on the share of exports in total sales. Indeed, the idea is that exporters might differ from domestic firms due to the presence of fixed export costs or due to bigger sales on which to amortize investments.[6] It is thus the value of exports that matters and not their relative size as compared to domestic sales.

Results are presented in Table 4 and in Figures 1 to 4. For domestic firms, profits are concave in capital and Tfp: the coefficient on the square of capital and Tfp is always negative and significant. Moreover, the coefficients obtained on the quadratic terms are not significantly different across both types of industries. These results suggest that whatever the shape of credit constraints in the industry, profits have the same concavity, providing the same incentives to invest for firms. *As far as profits are concerned, smaller domestic firms have higher incentives to invest than big ones, which should translate into higher growth rates for initially smaller domestic firms over a given period.* Assessing whether the concavity of

[6]Exports coming in addition to domestic sales, as in most models of international trade.

profits is due to technology or preferences, as emphasized in Section 3, is beyond the scope of this paper.

Profits of exporters are much less concave in capital than profits of domestic firms: conditioning on the shape of credit constraints, the coefficient obtained on the square of capital stock, even though negative, is much smaller, in absolute value, for exporters than for domestic firms. This is coherent with the fact that exports 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 (Melitz, 2003); bigger exporters will better amortize the fixed exports costs and will hence be more profitable. Some scope economies across destinations and/or products might also boost the profitability of big exporters. These scale economies might attenuate the concavity of profits. *As a consequence, the negative relationship between firm-level size and investment/growth should be less intense for exporters than for domestic firms.*

Moreover, profits of exporters are more concave in sectors with heterogeneous credit constraints, the coefficient on the square of capital stock being not significant for exporters belonging to industries with homogenous credit constraints. Consequently, for exporters, the shape of profits and the shape of marginal cost of investment play in opposite directions: *we can thus expect differences in the size-investment and size-growth relationship to be less important across sectors for exporters than for domestic firms.*

5 Size-investment and size-growth relationship

I now turn to the analysis of the size-investment and size-growth relationship for domestic and exporting firms in the both types of industries identified in Section 4.

5.1 Empirical strategy

I analyze, for a given firm, the determinants of average investment and performance growth between 1996 and 2002. I consequently focus on firms that remain active over this relatively long period of time (7 years). I restrict the analysis to the period 1996-2002 to conserve more firms in the sample. However, all results are qualitatively the same if I consider firms remaining active from 1996 to 2004.[7] My approach is different from Neumark, Wall, and Zhang (2011) and Haltiwanger, Jarmin, and Miranda (2010): they analyze yearly variations of employment within cells of firms of different sizes, and they thus take into account both employment variations of stayers and employment losses due to firms' deaths. Here, I am interested in the behavior of stayers only, as in Lileeva and Trefler (2010) and Bustos (2011).

A two-step empirical strategy is adopted. An investment function over the period 1996-2002 is first estimated. In the theoretical framework, firms take into account expected profits in period 1 to choose their optimal investment in period 0, expected sales being determined by

[7]Results available upon request.

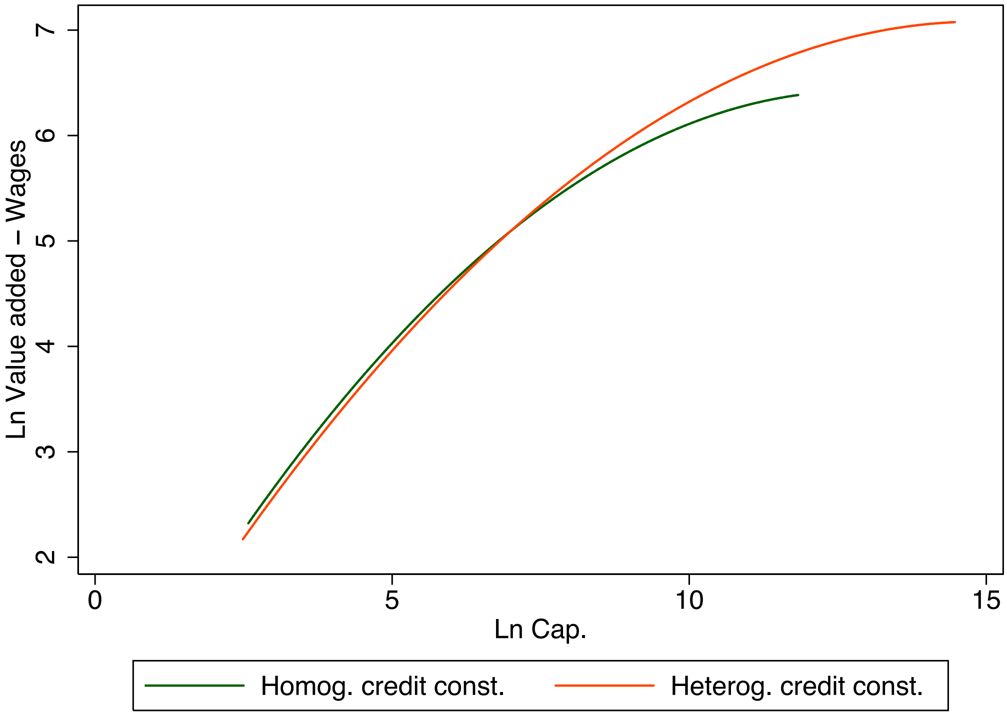

Figure 1: Domestic firms - Concavity in Capital

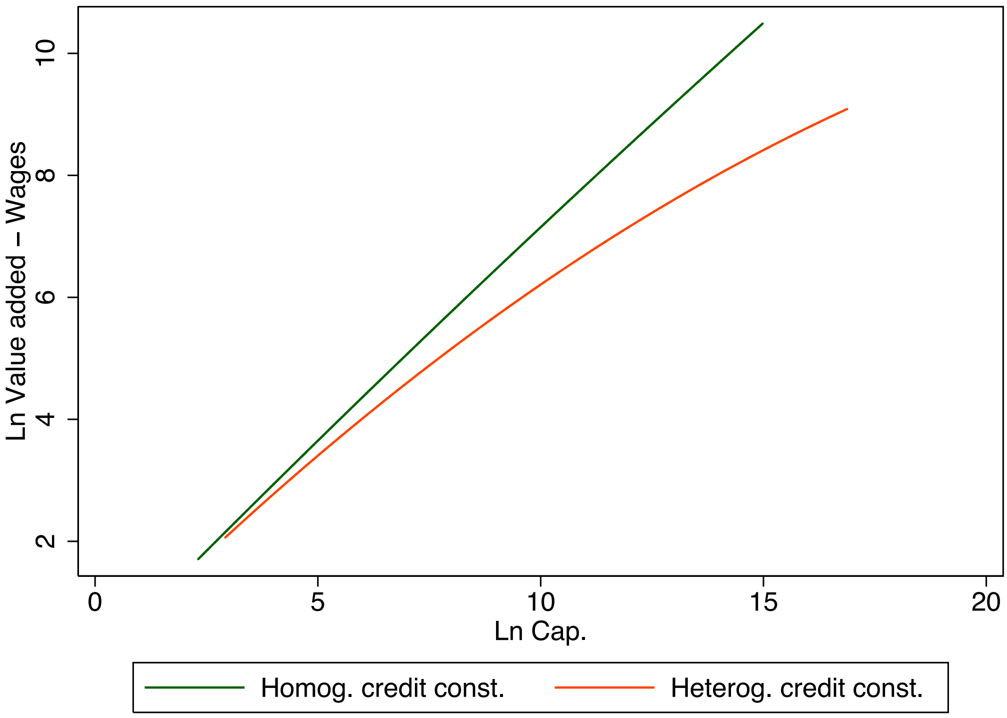

Figure 2: Exporting firms - Concavity in Capital

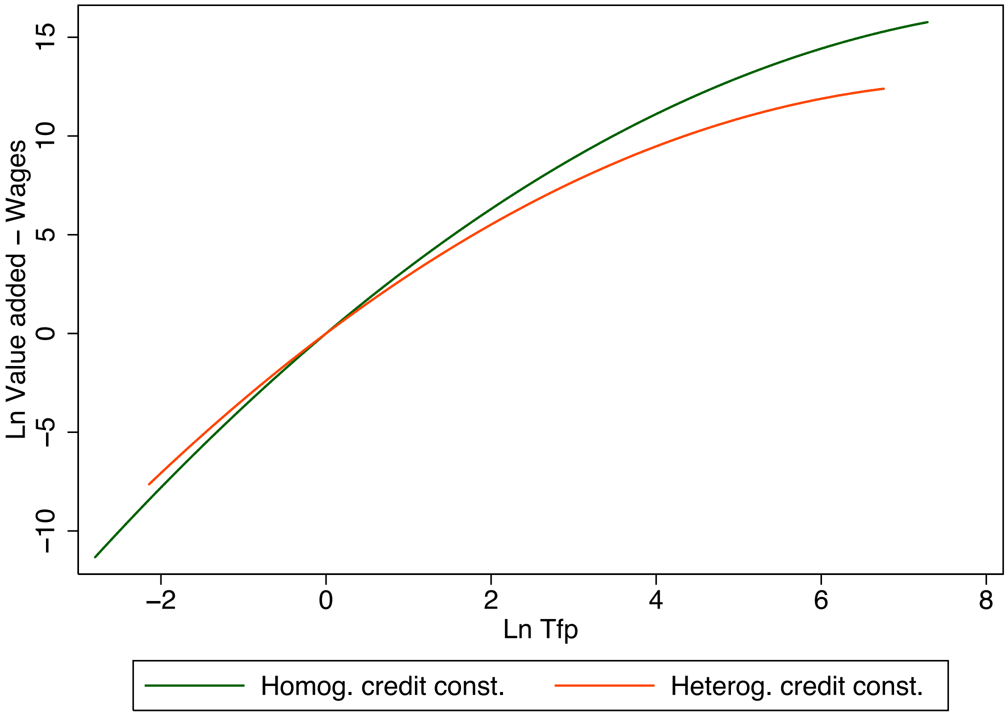

Figure 3: Domestic firms - Concavity in Tfp

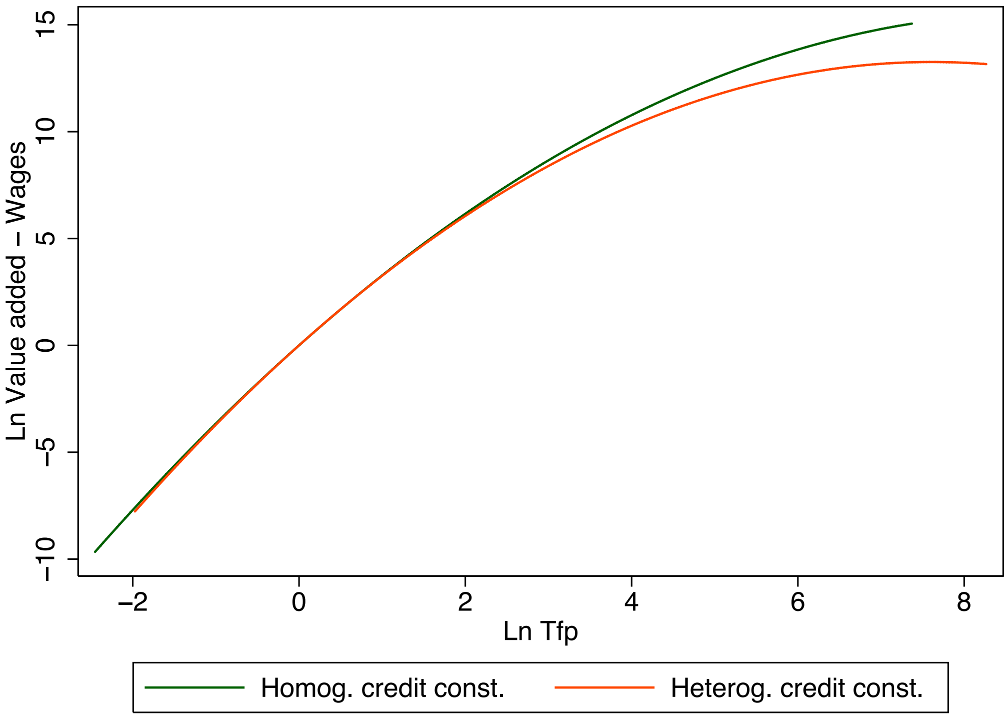

Figure 4: Exporting firms - Concavity in Tfp

their initial size draw and their level of investment. Combining these insights with methods developed in the literature on firm-level determinants of investment, I estimate the following baseline equation:

$$\begin{aligned}\ln\left(\frac{\mathrm{I}}{\mathrm{K}}\right)_{ij1997-2002} &= \alpha\ln\left(\frac{\mathrm{I}}{\mathrm{K}}\right)_{ij1996}+\beta\ln\left(\frac{\mathrm{Sales}}{\mathrm{K}}\right)_{ij1996} \\ &\quad +\gamma\ln\left(\frac{\mathrm{CF}}{\mathrm{K}}\right)_{ij1996}+\theta\ln\mathrm{L}_{ij1996}+\mathrm{d}_j+\epsilon_i \qquad (7)\end{aligned}$$

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.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 Section 5.2 below). Hence, there is in the sample one observation per firm. A literature exists on the nature of investment adjustment costs at the plant-level (convex, non-convex, irreversible) and their implications on aggregate investment (see, e.g., Caballero, 1999; Cooper and Haltiwanger, 2006). However, in contrast with these works, I am not interested here in the characterization of the dynamics of investment (spikes, bursts, sensitivity to shocks). I am rather focusing on how the average annual quantity of investment over a given period of time is related to initial firm-level characteristics, independently of firm-level investment path.

Average annual investment of firm i over the period 1997-2002 is thus 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 and exporting firms, and for each category of firms, separately for industries in which 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. 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:

$$\Delta \text{lny}_{ij1996-2004} = \alpha \text{lny}_{i1996} + \theta \text{lnL}_{i1996} + \text{d}_j + \epsilon_i \tag{8}$$

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 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 average skills of employees.

5.2 Construction of the sample and descriptive statistics

Given the empirical methodology I adopt, the sample used for the regressions is a specific subsample of the initial French Annual Business Surveys.

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 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 for which we have less than 5 observations over the 7-year period under study. In the end, the sample is composed of 12,703 firms.

Table 5 compares the sample of firms used for the estimations to the firms that disappear before 2002 and which are dropped from the sample. 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, firms in the final sample represent 60% to 66% of firms active in 1996, and 66% to 70% of total employment and value added.

5.3 Definition of export status

The definition of firm-level export status over the period is not trivial, due to multiple entries and exits on export markets for the same given firm. I hence 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 flows are not taken into account to define the export status of the firm.[8] Note however that all the results are robust if I consider that firms

[8] Note that firm-level intra-EU exports must be bigger than 100,000 euros in total to be recorded in Customs data. The threshold I apply on the Annual Business surveys is thus not much conservative. 50,000 euros is equal to the 13th centile of the distribution of exports in the sample used for regressions.

Table 5: Descriptive statistics - Year 1996

	Homogenous credit constraints	
	Firms active until 2002	Firms disappearing before 2002
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	
	Firms active until 2002	Firms disappearing before 2002
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.

are exporting in a given year 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 exporting firms".

5.4 Firm-level investment and initial size

I first analyze the relationship between initial size and firm-level average annual investment.

For initially domestic firms, results presented in Table 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 positively related to average annual investment the years after. 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 correlated in industries where credit constraints are homogeneous. In these industries, a 10% increase in firm-level employment decreases, all else equal, average annual investment by around 1%. In column 2, firm-level

[9] Results available upon request.

Tfp and average wage in 1996 are included, as well as a dummy identifying continuing domestic firms that exported at least once over the period (i.e. in 1998, 1999 or 2000, to control for potential surplus of investment by occasional exporters).[10] The intensity and the significancy of the negative relationship between firm-level employment and investment is roughly unaffected. On the opposite, the last two columns of Table 6 show that there is no statistically significant relationship between firm-level initial size and investment. Consequently, for initially domestic firms, the prediction of the 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 insignificant.

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 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,

[10]These are different from *alternate exporters*, which are firms which cannot be classified as exporting or domestic firms at the beginning and at the end of the period.

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 as compared to other 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 of firm-level profits with respect to employment measured 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, profits are more concave with respect to size in industries with heterogeneous credit constraints (see Figure 2), this is not enough to completely counterbalance the impact of heterogeneous credit constraints on the size-investment relationship.

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 displayed in Appendix D.

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 faster 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%.

For initially exporting firms, we also observe in Table 9 a negative relationship between

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.

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.

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 is explained by the fact that profits are less concave with respect to size for exporting firms than for domestic ones (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 across industries is not significant. This is surely explained by the greater concavity of exporters' profits in industries where credit constraints are heterogeneous (cf Figure 2 above), which compensates the distorsion in the size-growth relationship generated by the shape of marginal investment cost.

The analysis is very similar if we consider sales growth instead of employment growth. In this case, size is proxied by initial sales and not by employment, both variables being correlated at almost 90%. For domestic firms, the elasticity of firm sales growth to initial sales is equal to -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, for which the speed of convergence is also lower in industries with heterogeneous credit constraints.

Results on Tfp and value added growth are presented in Appendix D and are qualitatively

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.

similar. Note also that the difference across sectors in the coefficient on the size variable is always significant at at least 10 %, except for investment of domestic firms (due to imprecision of the estimate for sectors with heterogeneous credit constraints) and for employment-growth of exporters (probably due to the shape of profits, as explained above).

To have some sense of the magnitude of the effects measured so far, let's compare the growth rate of two firms, identical in all their characteristics except size: one has employment and sales equal to the first decile of the distribution while the other one is at the 9th decile. If those two firms are domestic, based on the regressions results presented above, the growth rate of employment and sales is respectively 26.45% and 27.39% higher for the smaller than for the bigger one in sectors with homogenous credit constraints. These figures are equal to 18.25% and 17.36% only in sectors with heterogeneous credit constraints. For exporters, as suggested by the results, the growth differential between big and small firms does not vary across sectors for employment, but it does by 10 percentage points for sales (16.07% in sectors with homogenous credit constraints vs 6.21% in sectors with heterogeneous credit constraints).

5.6 The role of investment

In the theoretical framework, 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 this mechanism, I must verify that once firm-level investment

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.

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

	Dependent Variable: Δ Ln sales_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.

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 positively and significantly impacts on 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 both domestic and exporting firms. Regarding sales growth, for a given type of firms in terms of export status, the cross-sectoral difference in the intensity of the size-growth relationship is also sharply reduced as compared to regressions where investment was not controlled for (cf Tables 10 and 11). Note that for a given type of firms, the magnitude of the correlation between firm-level growth and average annual investment is also very comparable across sectors. Thus, the differences across sectors observed so far cannot be explained by differences in terms of marginal returns to investment controlling for size or *vice versa*, i.e. by differences in the absolute value of the first derivatives $\frac{\partial \Phi}{\partial I(.)}[I(.), \phi_0]$ and $\frac{\partial \Phi}{\partial \phi_0}[I(.), \phi_0]$ (which also intervene in the determination of the firm size-investment relationship, see equation 4).

However, one last check must be made to be sure that heterogeneous credit constraints mainly explain the cross-sectoral variations observed in France. In the theoretical framework, the size-investment and the size-growth relationships have been shown to depend on three main elements: 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. I investigate this issue in Tables 14 and 15, where I introduce both investment and the interaction between investment and initial size in the growth analysis, in order 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 I measure would be actually more intense in these latter industries if marginal returns to investment were homogeneous across firms. This would reinforce the cross-sectoral differences in the intensity of the size-investment and the size-growth relationships I 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 constraints 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: Δ 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 $\text{inv.}_{i1997-2002}$	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)
$Investment_{i1996}$	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)
Investment$_{i1996}$	0.140^a	0.063^a	0.150^a	0.125^a
	(0.011)	(0.018)	(0.012)	(0.015)
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)
Investment$_{i1996}$	0.186^a	0.107^a	0.179^a	0.139^a
	(0.013)	(0.019)	(0.018)	(0.026)
Investment$_{i1996}$ $\times$ 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

So far, the analysis so 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. Again, I focus on firms remaining active over the period, and I do not consider employment and sales variations linked to firms' entry and exit. Results in Table 16 show that employment in continuously active firms 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 into quartiles of initial size. In sectors where credit constraints are homogeneous, domestic firms whose employment in 1996 is below the median (in their industry) account for almost 60% of total employment growth of domestic firms. In sectors where small firms are disproportionately credit constrained, firms whose size is below the median 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 other manufacturing sectors, while no such significant difference is detected for exporting firms.

On the whole sample of firms, firms whose initial employment is below the median account for almost 45% of employment growth in sectors with homogenous credit constraints, vs 33% in sectors where small firms face tougher financial constraints than big firms.

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

6 Concluding remarks

This paper shows that the diverging results obtained in the literature on the firm size-growth relationship can be reconciled in a very general theoretical framework featuring firm-level heterogeneity and investment decision. Three main elements determine the nature and the intensity of the relationship between firm-level size and investment: the shape of operating profits 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. Any

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

difference across countries, industries or periods in one of these three dimensions can modify the sign and the intensity of the firm size-investment and the firm size-growth relationship at equilibrium. As an example, I show that in France, heterogeneous credit constraints, which affect the shape of the marginal cost of investment, can explain cross-sectoral variations in the firm size-investment and firm size-growth relationship over the 1996-2002 period. A more structural approach could then be useful to get insights on the quantitative aspects of the mechanisms I highlight, to estimate for example how much heterogeneous credit constraints should be to induce a reversal in the size-growth relationship. Such an approach could for example help determine whether and to which extent conflicting results obtained by Lileeva and Trefler (2010) and Bustos (2011) are explained by the shape of profit, the shape of credit constraints or the technology of investment.

From a macroeconomic perspective, the framework I propose is useful to understand the distribution of activities and of opportunities across firms. It is then crucial to assess whether there exists an unexploited growth potential among SME's, and to design adequate policies aiming at reducing potential barriers to the development of small firms. Indeed, even though small firms are disproportionately credit constrained, it will not be necessarily efficiency-improving to facilitate their access to credit if potential growth of smaller firms is lower than growth of big firms.

This paper also relates to recent analysis on the role of "granularity" in explaining macroeconomic fluctuations. Gabaix (2011) shows that when the size distribution of firms is fat-tailed, the law of large number breaks down so that the idiosyncratic shocks affecting big firms might explain a large share of output variations. I propose here a potential determinant of the granularity of economic activities, so that my results suggest that heterogeneous credit constraints might impact on aggregate output volatility through the granularity channel.

Finally, beyond the example of the firm size-growth relationship, the theoretical and empirical framework I develop in this paper can be applied in many fields to understand heterogeneous responses of economic agents: firm-level outsourcing or location decisions in international trade and urban economics, participation to various programs in labour and development economics are a few examples of possible applications.

References

Atkeson, A., and A. T. Burstein (2010): "Innovation, Firm Dynamics, and International Trade," *Journal of Political Economy*, 118(3), 433–484.

Audretsch, D. B., and J. A. Elston (2002): "Does firm size matter? Evidence on the impact of liquidity constraints on firm investment behavior in Germany," *International Journal of Industrial Organization*, 20(1), 1–17.

Aw, B. Y., M. J. Roberts, and D. Y. Xu (2011): "R&D Investment, Exporting, and Productivity Dynamics," *American Economic Review*, 101(4), 1312–44.

Axtell, R. L. (2001): "Zipf Distribution of US Firm Sizes," *Science*, 293, 1818–1820.

Bach, L. (2011): "Are Small Businesses Worthy of Financial Aid? Evidence From a French Targeted Credit Program," Discussion paper.

Baldwin, J., and G. Picot (1995): "Employment Generation by Small Producers in the Canadian Manufacturing Sector," *Small Business Economics*, 7(4), 317–31.

Beck, T., A. Demirguc-Kunt, L. Laeven, and R. Levine (2008): "Finance, Firm Size, and Growth," *Journal of Money, Credit and Banking*, 40(7), 1379–1405.

Beck, T., A. Demirgüç-Kunt, and V. Maksimovic (2005): "Financial and Legal Constraints to Growth: Does Firm Size Matter?," *Journal of Finance*, 60(1), 137–177.

Bernard, A. B., and B. J. Jensen (1999): "Exceptional exporter performance: cause, effect, or both?," *Journal of International Economics*, 47(1), 1–25.

Birch, D. (1979): "The Job Generation Process," unpublished report for the U.S. Department of Commerce.

——— (1981): "Who Creates Jobs?," *The Public Interest*, 65, 3–15.

Bond, S., J. A. Elston, J. Mairesse, and B. Mulkay (2003): "Financial Factors and Investment in Belgium, France, Germany, and the United Kingdom: A Comparison Using Company Panel Data," *The Review of Economics and Statistics*, 85(1), 153–165.

Broersma, L., and P. Gautier (1997): "Job Creation and Job Destruction by Small Firms: An Empirical Investigation for the Dutch Manufacturing Sector," *Small Business Economics*, 9(3), 211–24.

Bustos, P. (2011): "Trade Liberalization, Exports, and Technology Upgrading: Evidence on the Impact of MERCOSUR on Argentinian Firms," *American Economic Review*, 101(1), 304–40.

Caballero, R. J. (1999): "Aggregate investment," in *Handbook of Macroeconomics*, ed. by J. B. Taylor, and M. Woodford, vol. 1 of *Handbook of Macroeconomics*, chap. 12, pp. 813–862. Elsevier.

Cooper, R. W., and J. C. Haltiwanger (2006): "On the Nature of Capital Adjustment Costs," *Review of Economic Studies*, 73(3), 611–633.

Costantini, J., and M. Melitz (2008): “The Dynamics of Firm-Level Adjustment to Trade Liberalization,” in *The organization of firms in a global Economy*, ed. by D. M. E. Helpman, and T. Verdier. Harvard University Press.

Davis, S. J., J. Haltiwanger, and S. Schuh (1996): “Small Business and Job Creation: Dissecting the Myth and Reassessing the Facts,” *Small Business Economics*, 8(4), 297–315.

Davis, S. J., and J. C. Haltiwanger (1992): “Gross Job Creation, Gross Job Destruction, and Employment Reallocation,” *The Quarterly Journal of Economics*, 107(3), 819–63.

Davis, S. J., J. C. Haltiwanger, and S. Schuh (1998): *Job Creation and Destruction*, vol. 1 of *MIT Press Books*. The MIT Press.

De Loecker, J. (2007): “Do exports generate higher productivity? Evidence from Slovenia,” *Journal of International Economics*, 73(1), 69–98.

Demirgüç-Kunt, A., and V. Maksimovic (1998): “Law, Finance, and Firm Growth,” *Journal of Finance*, 53(6), 2107–2137.

di Giovanni, J., A. A. Levchenko, and R. Ranciere (2010): “Power Laws in Firm Size and Openness to Trade: Measurement and Implications,” forthcoming *Journal of International Economics*.

Dunne, T., M. J. Roberts, and L. Samuelson (1989): “The Growth and Failure of U.S. Manufacturing Plants,” *The Quarterly Journal of Economics*, 104(4), 671–98.

Fazzari, S. M., R. G. Hubbard, and B. C. Petersen (2000): “Investment-Cash Flow Sensitivities Are Useful: A Comment On Kaplan And Zingales,” *The Quarterly Journal of Economics*, 115(2), 695–705.

Gabaix, X. (1999): “Zipf’S Law For Cities: An Explanation,” *The Quarterly Journal of Economics*, 114(3), 739–767.

——— (2011): “The Granular Origins of Aggregate Fluctuations,” *Econometrica*, 79(3), 733–772.

Gorodnichenko, Y., and M. Schnitzer (2011): “Financial constraints and innovation: Why poor countries don’t catch up,” Discussion paper, forthcoming *Journal of the European Economic Association*.

Hall, B. H., J. Mairesse, and B. Mulkay (1999): “Firm-Level Investment in France and the United States: An Exploration of What We Have Learned in Twenty Years,” *Annales d’Economie et de Statistique*, (55-56), 03.

Haltiwanger, J. C., R. S. Jarmin, and J. Miranda (2010): "Who Creates Jobs? Small vs. Large vs. Young," NBER Working Papers 16300, National Bureau of Economic Research, Inc.

Harrison, A. E., I. Love, and M. S. McMillan (2004): "Global capital flows and financing constraints," *Journal of Development Economics*, 75(1), 269–301.

Hopenhayn, H. A. (1992): "Entry, Exit, and Firm Dynamics in Long Run Equilibrium," *Econometrica*, 60(5), 1127–50.

Javorcik, B. S., and M. Spatareanu (2009): "Liquidity Constraints and Firms' Linkages with Multinationals," *World Bank Economic Review*, 23(2), 323–346.

Kadapakkam, P.-R., P. C. Kumar, and L. A. Riddick (1998): "The impact of cash flows and firm size on investment: The international evidence," *Journal of Banking & Finance*, 22(3), 293–320.

Kaplan, S. N., and L. Zingales (1997): "Do Investment-Cash Flow Sensitivities Provide Useful Measures of Financing Constraints," *The Quarterly Journal of Economics*, 112(1), 169–215.

Konings, J. (1995): "Gross Job Flows and the Evolution of Establishment Size in the U.K.," *Small Business Economics*, 7(3), 213–220.

Konings, J., M. Rizov, and H. Vandenbussche (2003): "Investment and financial constraints in transition economies: micro evidence from Poland, the Czech Republic, Bulgaria and Romania," *Economics Letters*, 78(2), 253–258.

Levinsohn, J., and A. Petrin (2003): "Estimating Production Functions Using Inputs to Control for Unobservables," *Review of Economic Studies*, 70(2), 317–342.

Lileeva, A., and D. Trefler (2010): "Improved Access to Foreign Markets Raises Plant-Level Productivity... for Some Plants," *The Quarterly Journal of Economics*, 125(3), 1051–1099.

Love, I. (2003): "Financial Development and Financing Constraints: International Evidence from the Structural Investment Model," *Review of Financial Studies*, 16(3), 765–791.

Luttmer, E. G. J. (2007): "Selection, Growth, and the Size Distribution of Firms," *The Quarterly Journal of Economics*, 122(3), 1103–1144.

Melitz, M. J. (2003): "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity," *Econometrica*, 71(6), 1695–1725.

Modigliani, F., and M. Miller (1958): "The Cost of Capital, Corporation Finance and the Theory of Investment," *American Economic Review*, 48(3), 261–297.

MRAZOVA, M., AND P. NEARY (2011): "Selection effects with heterogeneous firms," Discussion paper.

NEUMARK, D., B. WALL, AND J. ZHANG (2011): "Do Small Businesses Create More Jobs? New Evidence for the United States from the National Establishment Time Series," *The Review of Economics and Statistics*, 93(1), 16–29.

PAVCNIK, N. (2002): "Trade Liberalization, Exit, and Productivity Improvement: Evidence from Chilean Plants," *Review of Economic Studies*, 69(1), 245–76.

PONCET, S., W. STEINGRESS, AND H. VANDENBUSSCHE (2010): "Financial constraints in China: Firm-level evidence," *China Economic Review*, 21(3), 411–422.

RAJAN, R. G., AND L. ZINGALES (1998): "Financial Dependence and Growth," *American Economic Review*, 88(3), 559–86.

SUTTON, J. (1997): "Gibrat's legacy," *Journal of Economic Literature*, 35(1), 40–59.

VAN BIESEBROECK, J. (2005): "Exporting raises productivity in sub-Saharan African manufacturing firms," *Journal of International Economics*, 67(2), 373–391.

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
	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 Euler investment equation I estimate is the following:

$$\begin{aligned}\ln\left(\frac{\mathrm{I}}{\mathrm{K}}\right)_{it} &= \alpha\ln\left(\frac{\mathrm{I}}{\mathrm{K}}\right)_{it-1}+\beta\ln^2\left(\frac{\mathrm{I}}{\mathrm{K}}\right)_{it-1}+\delta\ln\left(\frac{\mathrm{Sales}}{\mathrm{K}}\right)_{it-1}+\eta\ln\left(\frac{\mathrm{CF}}{\mathrm{K}}\right)_{it-1}+\\ &\quad \gamma\ln\mathrm{L}_{it}+\mu\ln\mathrm{L}_{it}\times\ln\left(\frac{\mathrm{CF}}{\mathrm{K}}\right)_{it-1}+\theta_t+\epsilon_{it} \qquad (9)\end{aligned}$$

where $\left(\frac{\mathrm{I}}{\mathrm{K}}\right)_{it}$ is the investment to capital stock ratio of firm i at time t, $\left(\frac{\mathrm{Sales}}{\mathrm{K}}\right)$ is the sales to capital ratio, proxying for firm-level profitability, $\left(\frac{\mathrm{CF}}{\mathrm{K}}\right)$ is the cash-flow to capital ratio, controlling for internal liquidities of the firm and L stands for firm-level employment. 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 four specifications: without fixed effects, with industry-year fixed effects, with firm-level fixed effects and with both industry-year and firm fixed effects. 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 19. They show that my classification of industries is robust to the estimation strategy: in the first sample of industries, the coefficient μ is never significant and close to 0. On the contrary, the coefficient μ is always negative and significant for the pooled sample of firms belonging to industries that had been identified as industries with heterogeneous credit constraints in the first step. Results are the same for the modified Euler model and for the accelerator model (see Tables 20 and 21). Note that results are qualitatively the same with a different time-structure, including firm-level employment at time $t-1$ instead of t.[11]

[11] Results available upon request.

Table 19: Heterogeneous credit constraints-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	0.0435^b	0.595^a	0.595^a	0.0878^a	0.0891^a
	(0.0183)	(0.0181)	(0.0186)	(0.0185)	(0.0232)	(0.0230)	(0.0249)	(0.0250)
$\text{Log}^2_{t-1} \frac{I}{K}$	-0.0315^a	-0.0300^a	-0.0132^a	-0.0130^a	-0.0309^a	-0.0322^a	-0.0155^a	-0.0149^a
	(0.00206)	(0.00204)	(0.00226)	(0.00226)	(0.00240)	(0.00238)	(0.00306)	(0.00312)
$\ln_{t-1} \frac{\text{Sales}}{K}$	-0.0412^a	0.0358^a	0.320^a	0.329^a	-0.00480	0.00768	0.317^a	0.321^a
	(0.0114)	(0.0119)	(0.0336)	(0.0335)	(0.0126)	(0.0139)	(0.0473)	(0.0490)
$\ln_t$ Emp	0.103^c	0.176^a	0.670^a	0.551^a	0.410^a	0.461^a	1.256^a	0.969^a
	(0.0551)	(0.0574)	(0.113)	(0.106)	(0.0650)	(0.0676)	(0.191)	(0.176)
$\ln_{t-1} \frac{CF}{K}$	0.297^a	0.305^a	0.192^a	0.184^a	0.446^a	0.484^a	0.594^a	0.493^a
	(0.0376)	(0.0386)	(0.0731)	(0.0686)	(0.0463)	(0.0479)	(0.128)	(0.119)
$\ln_t$ Emp $\times \ln_{t-1} \frac{CF}{K}$	0.00306	-0.00618	-0.000741	0.00572	-0.0519^a	-0.0590^a	-0.102^a	-0.0768^a
	(0.00866)	(0.00899)	(0.0166)	(0.0155)	(0.0102)	(0.0106)	(0.0277)	(0.0259)
N	76,330	76,330	76,330	76,330	59,411	59,411	59,411	59,411
R^2	0.175	0.157	0.078	0.038	0.196	0.180	0.085	0.040
Industry-Year fixed effects	no	yes	no	yes	no	yes	no	yes
Firm fixed effects	no	no	yes	yes	no	no	yes	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 20: Heterogeneous credit constraints-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	-0.0422^a	0.273^a	0.268^a	-0.0189^a	-0.0163^b
	(0.00469)	(0.00484)	(0.00606)	(0.00607)	(0.00548)	(0.00560)	(0.00716)	(0.00725)
$\text{Log}_{t-1} \frac{I}{K}$	0.255^a	0.240^a	-0.0878^a	-0.0863^a	0.272^a	0.266^a	-0.0654^a	-0.0583^a
	(0.00537)	(0.00561)	(0.00726)	(0.00724)	(0.00665)	(0.00695)	(0.00938)	(0.00948)
$\ln_{t-1} \frac{Sales}{K}$	-0.0331^a	0.0118	0.303^a	0.316^a	-0.0196^c	-0.0137	0.290^a	0.293^a
	(0.0103)	(0.0109)	(0.0360)	(0.0360)	(0.0107)	(0.0118)	(0.0460)	(0.0472)
$\ln_t$ Emp	0.120^b	0.171^a	0.650^a	0.501^a	0.351^a	0.387^a	1.269^a	0.948^a
	(0.0530)	(0.0557)	(0.133)	(0.123)	(0.0533)	(0.0551)	(0.192)	(0.172)
$\ln_{t-1} \frac{CF}{K}$	0.240^a	0.255^a	0.183^b	0.162^b	0.363^a	0.391^a	0.625^a	0.503^a
	(0.0369)	(0.0383)	(0.0859)	(0.0799)	(0.0390)	(0.0402)	(0.130)	(0.118)
$\ln_t$ Emp $\times \ln_{t-1} \frac{CF}{K}$	-0.00414	-0.0102	-0.00234	0.00513	-0.0449^a	-0.0500^a	-0.106^a	-0.0775^a
	(0.00828)	(0.00867)	(0.0192)	(0.0178)	(0.00838)	(0.00866)	(0.0277)	(0.0250)
N	61,955	61,955	61,955	61,955	48,477	48,477	48,477	48,477
R^2	0.230	0.209	0.067	0.034	0.260	0.244	0.075	0.037
Industry-Year fixed effects	no	yes	no	yes	no	yes	no	yes
Firm fixed effects	no	no	yes	yes	no	no	yes	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-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	0.0281	0.593^{a}	0.603^{a}	0.0637^{b}	0.0676^{b}
	(0.0233)	(0.0231)	(0.0223)	(0.0221)	(0.0327)	(0.0327)	(0.0299)	(0.0297)
$\ln^2_{t-1} \frac{I}{K}$	-0.0269^{a}	-0.0250^{a}	-0.0165^{a}	-0.0168^{a}	-0.0293^{a}	-0.0322^{a}	-0.0170^{a}	-0.0170^{a}
	(0.00272)	(0.00269)	(0.00269)	(0.00266)	(0.00356)	(0.00352)	(0.00353)	(0.00350)
$\Delta \ln_t$Sales	0.101^{a}	0.132^{a}	0.509^{a}	0.499^{a}	0.132^{a}	0.157^{a}	0.453^{a}	0.463^{a}
	(0.0143)	(0.0143)	(0.0235)	(0.0224)	(0.0144)	(0.0149)	(0.0332)	(0.0303)
$\Delta \ln_{t-1}$Sales	-0.0943^{a}	-0.0673^{a}	0.217^{a}	0.206^{a}	-0.0310^{b}	-0.0177	0.168^{a}	0.168^{a}
	(0.0141)	(0.0138)	(0.0198)	(0.0186)	(0.0140)	(0.0140)	(0.0240)	(0.0231)
$\ln_t$ Emp	0.0881	0.262^{a}	0.928^{a}	0.870^{a}	0.508^{a}	0.617^{a}	1.547^{a}	1.279^{a}
	(0.0607)	(0.0639)	(0.154)	(0.137)	(0.0781)	(0.0830)	(0.313)	(0.259)
$\ln_{t-1} \frac{CF}{K}$	0.265^{a}	0.333^{a}	0.394^{a}	0.367^{a}	0.352^{a}	0.398^{a}	0.787^{a}	0.611^{a}
	(0.0393)	(0.0411)	(0.101)	(0.0899)	(0.0534)	(0.0568)	(0.191)	(0.158)
$\ln_t$ Emp $\times \ln_{t-1} \frac{CF}{K}$	0.00901	-0.00634	-0.0205	-0.0130	-0.0484^{a}	-0.0585^{a}	-0.123^{a}	-0.0884^{b}
	(0.00944)	(0.00996)	(0.0229)	(0.0203)	(0.0124)	(0.0133)	(0.0466)	(0.0398)
N	60,933	60,933	60,933	60,933	47,904	47,904	47,904	47,904
R^2	0.187	0.169	0.111	0.069	0.208	0.192	0.116	0.070
Industry-Year fixed effects	no	yes	no	yes	no	yes	no	yes
Firm fixed effects	no	no	yes	yes	no	no	yes	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 22: Firm-level relative size distribution: Value added

	Homog. cred. const. ind.		Heterog. cred. const. ind.	
Percent.	Domestic	Exporters	Domestic	Exporters
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 industry-level firm average value added is equal, on average, to 34% for domestic firms in industries where credit constraints are homogenous, and to 25% for domestic firms in industries where small firms are disproportionately credit-constrained. Exporting firms are firms declaring exports bigger than 50 000 euros.

D Firm-level Tfp and Value added growth

Table 23: 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 24: 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	0.056^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.

Table 25: Firm-level Value added growth - Initially domestic firms

	Dependent Variable: Δ Ln Value $added_i$			
	Homogenous credit constraints		Heterogeneous credit constraints	
Ln Value $added_{i1996}$	-0.184^a	-0.159^a	-0.104^a	-0.082^b
	(0.022)	(0.025)	(0.022)	(0.031)
Switching exporters	0.156^a	0.157^a	0.145^a	0.125^a
	(0.027)	(0.028)	(0.037)	(0.040)
Alternate exporters	0.052^a	0.051^b	0.000	-0.018
	(0.019)	(0.021)	(0.027)	(0.029)
Ln LP Tfp_{i1996}		-0.106		-0.053
		(0.069)		(0.113)
Ln Avg $Wage_{i1996}$		0.054		-0.071
		(0.060)		(0.140)
Exported once		0.006		-0.114^a
		(0.034)		(0.034)
Observations	3678	3678	1998	1998
R^2	0.076	0.078	0.036	0.042

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 26: Firm-level Value added growth - Initially exporting firms

	Dependent Variable: Δ Ln Value added$_i$			
	Homogenous credit constraints		Heterogeneous credit constraints	
Ln Value added$_{i1996}$	-0.102^a	-0.086^a	-0.071^a	-0.024^c
	(0.016)	(0.021)	(0.007)	(0.013)
Ceasing exporters	-0.196^a	-0.201^a	-0.159^a	-0.166^a
	(0.043)	(0.038)	(0.044)	(0.042)
Ln LP Tfp$_{i1996}$		-0.122		-0.181^a
		(0.074)		(0.058)
Ln Avg Wage$_{i1996}$		0.167^c		-0.088
		(0.098)		(0.064)
Occasional domestic firms		-0.060^c		-0.075^c
		(0.031)		(0.039)
Observations	3479	3479	3548	3548
R^2	0.040	0.046	0.027	0.043

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.

Institut de Recherches Économiques et Sociales
Université catholique de Louvain

Place Montesquieu, 3
1348 Louvain-la-Neuve, Belgique

IRES

ISSN 1379-244X D/2011/3082/044