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FINANCIAL CONSTRAINTS
AN APPLICATION TO PORTUGUESE FIRMS

Dissertação de Doutoramento na área científica de Economia, orientada pelo Professor Doutor Carlos Manuel Gonçalves Carreira e apresentada à Faculdade de Economia da Universidade de Coimbra.

Março de 2012

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Universidade de Coimbra

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Grupo de Estudos Monetários e Financeiros GEMF
FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA EDUCAÇÃO E CIÊNCIA
POPH PROGRAMA OPERACIONAL POTENCIAL HUMANO
QREN QUADRO DE REFERÊNCIA ESTRATÉGICO NACIONAL PORTUGAL 2007.2013
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FACULTY OF ECONOMICS

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DOUTORAMENTO EM ECONOMIA

PhD in ECONOMICS

FINANCIAL CONSTRAINTS: AN APPLICATION TO PORTUGUESE FIRMS

Filipe Manuel Fernandes Rosa Baptista e Silva

Supervisor: Professor Doutor Carlos Manuel Gonçalves Carreira

March 2012

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ABSTRACT

This thesis addresses the financing problems faced by firms. Specifically, we test for the existence of firms' financial constraints, as well as we analyse their role upon firm behaviour. We argue that: a) Portuguese firms face significant financial constraints; b) the extent to which firms are affected by constraints depends on a number of distinct characteristics, beyond financial aspects; c) financial constraints clearly influence firm behaviour, namely with regard to export and innovation activities; d) suitable policies to mitigate financial constraints should be considered, even though subsidies might not be the most effective policy instrument. To support these arguments, we conduct several tests, using a large representative sample of Portuguese firms and different approaches to measure financial constraints. Accordingly, this thesis contributes to the understanding of firms' behaviour under financial problems, while it points directions for future research. Finally, this work has serious implications upon future policy actions.

JEL Classification: D92; G32; F14; F36; L00; L2; L8; O30.

Keywords: Financial constraints; Firm-level studies; Portugal; Services; Exports; European financial integration; Innovation; R&D investment; Subsidies.

RESUMO

A presente tese analisa os problemas de financiamento enfrentados pelas empresas. Em particular, investiga a existência de restrições ao financiamento das empresas e o seu impacto no comportamento das mesmas. Nesta tese defende-se que: a) as empresas portuguesas enfrentam restrições financeiras significativas; b) a existência de restrições ao financiamento das empresas depende de um conjunto de características distintas, que vão para além de aspectos meramente financeiros; c) as restrições financeiras têm um impacto visível no comportamento das empresas, nomeadamente no que respeita às actividades de inovação e exportadoras; d) deverão ser consideradas políticas que visem o combate às restrições ao financiamento das empresas, ainda que a atribuição de subsídios possa não ser a política mais adequada. De modo a sustentar esta tese, são efectuados vários estudos, utilizando uma amostra representativa de empresas portuguesas, bem como diferentes medidas de restrições financeiras. Como tal, este trabalho não só contribui para uma melhor compreensão do comportamento das empresas afectadas por problemas financeiros, como também identifica um conjunto de linhas de investigação futura. Por fim, este estudo leva a conclusões relevantes para a condução de política.

Classificação JEL: D92; G32; F14; F36; L00; L2; L8; O30.

Palavras-chave: Restrições financeiras; Empresas; Portugal; Serviços; Exportação; Integração financeira Europeia; Inovação; Investimento em I&D; Subsídios.

PRELIMINARY NOTE

The present thesis is the outcome of an endeavour that started in 2007 with my enrolment in the PhD program at the Faculty of Economics. Although at the early start I already had intentions to work on firm behaviour, it was not until the beginning of 2008 when, in the course of my supervisor's, Carlos Carreira, lectures that I became genuinely interested on the role of financial constraints on firm behaviour. Therefore, even though I do not intend to sound selfish, I might dare to say that the recent financial crisis, in full swing since 2008, by renewing the interest in the analysis of firms' financial constraints, gave me further motivation for these writings—albeit all the suffering that the crisis has and still does provoke.

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I can not find the appropriate words to express my gratitude to my mentor Carlos Carreira. He has always had the time and the patience to guide me through the several difficulties that I encountered throughout the elaboration of this work. His expertise, vision and commitment to excellence, have undoubtedly shaped my approach towards research and definitely pushed this work a huge step forward. With him, who introduced and taught me the arts of this craft, I had the most insightful and inspiring conversations—not only with respect to the confines of research work, but also to the multiple aspects of life. Therefore, I would prefer to refer to him as a mentor, rather than a supervisor. It has been a privilege and an honour to work under his mentoring.

I would also like to acknowledge all my teachers and those that contributed to my education, who—since the early beginning at primary school and either at Coimbra or at Glasgow—guided me and contributed to the development of my critical stance, my work ability and my intellect. Special thanks to Adelaide Duarte, my undergraduate tutor, for her remarkable guidance and motivation through all these years that I have spent at the University of Coimbra and to Paulino Teixeira, the PhD Program Coordinator, for his support and excellent guidance during my years as a PhD student.

The most deep thank you to all my friends—including former colleagues, as well as those at the "Núcleo Duro", the "Abutres" and my fellow mates at the CNAc waterpolo team (even though some would argue that researching is not a proper job)—, who gave me further support to accomplish this titanic task and with whom I cleared my temper so many times. I am additionally grateful to all PhD colleagues—at Coimbra and abroad—, with whom I shared the gloom, anguish and despair inherent to being a PhD student, but who were nevertheless there to pull my confidence up allowing me to carry on with research. Special thanks to Rodrigo Martins who was always keen to share his vision and experience that greatly contributed to my motivation to teach, to research and indeed to these writings.

For all their remarkable patience, help and support given at several situations, a warm thank you to the staff of the Faculty of Economics, University of Coimbra and the staff of the Faculty bar.

Throughout the elaboration of this thesis, I have participated in several conferences, submitted papers to journals and had inspiring and insightful conversations with many colleagues and researchers that undoubtedly have contributed to the elaboration of this work.

Despite risking omitting key names unintentionally (to whom I apologise), I would like to thank Andrés Barge-Gil, Giulio Bottazzi, Jesper Christensen, Alex Coad, Dirk Czarnitzki, Alessandra Guariglia, Stuart Holland, Paul Kattuman, Óscar Lourenço, Rodrigo Martins, José Murteira, Tobias Schmidt, Armando Silva, Frederico Tamagni, Paulino Teixeira and Tania Treibich for their most helpful comments, suggestions, as well as insightful discussions. Furthermore, I am grateful to the Editor and two anonymous referees of the Journal of Economic Surveys, the Editor and an anonymous referee of Notas Económicas, the Editor and three anonymous referees of Economics of Innovation and New Technology, for their comments and suggestions. I would additionally like to thank seminar participants at: 23rd Annual Congress of ASEPELT, 2009; 13th Conference of the International J. A. Schumpeter Society, 2010; 5th International Symposium on Economic Theory, Policy and Applications, 2010; GEMF Seminars "Os artigos digerem-se bem", October 20, 2010; MICRO-DYN Summer School, 2010; DIME workshop on Financial Constraints, Firms and Aggregate Dynamics, 2010; DRUID-DIME Academy Winter Conference, 2011; EMAEE 2011 Conference; 5th Meeting of the Portuguese Economic Journal, 2011. Nevertheless, this acknowledgement does not implicate anyone but myself in all remaining errors that may exist.

I am also thankful to the INE (National Statistical Office) for providing the data necessary to the research work. Financial support from FCT (Portuguese Science Foundation) through the doctoral grant SFRH/BD/44067/2008 (POPH/FSE program), the GEMF (Grupo de Estudos Monetários e Financeiros) and the Faculty of Economics, University of Coimbra is greatly appreciated. Without it, the elaboration of this thesis would not have been possible. Nevertheless, this work represents the views of the authors, and not necessarily those of these institutions. The usual disclaimer applies.

Finally, but most importantly, I would like to note that without the extraordinary support of my girlfriend, Raquel Margarido, my sister Inês Silva and my parents Ana Rosa and José Silva, this thesis would have never seen the light of day. They were the driving force, the safe port and the key motivators that helped me to achieve this goal. They were also those who turned the hardest day into a joyful one, always giving me the strength to carry on. Special thanks to my grandparents José Nelson Rosa and Rita Angelina for their remarkable support through my life and to my uncle Nelson Rosa, who since my earliest days, triggered and encouraged my deep interest in Economics. To them and to my family, who have helped and guided me, as well as have been remarkably supportive in so many times throughout my life, especially during this endeavour, I am eternally indebted.

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LIST OF ABBREVIATIONS

ACW	Almeida, Campello and Weisbach
BdP	Banco de Portugal
CAE	Classificação de Actividade Económica (Industry Classification)
CCFS	Cash to Cash-Flow Sensitivity
CFS	Cash-Flow Sensitivity
CIS	Community Innovation Survey
ECB	European Central Bank
EUROSTAT	Statistical Office of the European Communities
EVP	D'Espallier, Vandemaele and Peeters
FHP	Fazzari, Hubbard and Petersen
FUE	Ficheiro de Unidades Estatisticas
GCFS	Growth to Cash-Flow Sensitivity
GDP	Gross domestic product
HH	Hovakimian and Hovakimian
ICFS	Investment to Cash-Flow Sensitivity
IEH	Inquérito às Empresas Harmonizado
INE	Instituto Nacional de Estatística
ISIC	International Standard Industrial Classification
KZ	Kaplan and Zingales
MM	Mondigliani and Miller
MDA	Multiple Discriminant Analysis
NUTS	Nomenclatura Comum das Unidades Territoriais Estatísticas
NW	Nelson and Winter
OECD	Organisation for Economic Co-operation and Development
R&D	Research and Development
SA	Size and Age
SMEs	Small and Medium Enterprises
WW	Whited and Wu

INTRODUCTION

> *"Co-operators who have firstly a high order of business ability and probity, and secondly the "personal capital" of a great reputation among their fellows for these qualities, will have no difficulty in getting command of enough material capital for a considerable undertaking: the real difficulty is to convince a sufficient number of those around them that they have these rare qualities. And the case is not very different when an individual endeavours to obtain from the ordinary sources the loan of the capital required to start him in business."*
>
> Marshal (1890: Book IV, Chapter XII, pp. 308)

The dissociation, in a capitalist society, of the holders of funds ("lenders") and the agents that produce the goods ("borrowers")—may them be called firms, industrial capitalists or entrepreneurs—introduces an important dimension to be taken into account in the study of the economic processes: the extent to which a "capable producer" may lack the necessary funds from the "borrower" to start, continue or increase the production of "desirable goods", just because he does not have the required *"personal capital"*—i.e. reputation in a Marshallian view.[1]

In fact, "reputation" or confidence is at the very core of the financing problems that firms may face. A "lender" (or a financial intermediary such as a bank), when deciding to allocate funds will naturally opt for lending to that who he believes will guarantee a safer or a higher return. Since the "lender" may not be able to distinguish between "cherries" (good) and "lemons" (bad) "borrowers", due to asymmetric information (Akerlof, 1970), it might be the case that the "lemons" prevail and significant "cherries" are not chosen. Implicit in this rationale is the possibility that many "borrowers" will not obtain a loan or, if they do, they will be required an additional premium (or interest). These two scenarios will ultimately lead to what we call "financial constraints".

The existence of these constraints at the firm-level has serious consequences upon economic change. In fact, borrowing from a Schumpeterian perspective, if innovation is the driver of economic evolution (a term that in the view of Schumpeter should be used in place of economic growth) and if, in a capitalist society, *"innovations are carried out by means of*

[1] We define "desirable goods" as those that are demanded by the society in the present and\or in the future (even though we do not currently know what is to be demanded in the future).

borrowed money" (Schumpeter, 1939, pp. 223), then the extent to which money is directed to innovators will shape the evolution of the economy.

The recent financial crisis and the associated shortage of liquidity have raised new interest, among both researchers and policymakers, on the financing of firms. In fact, while several researchers devote their time to the investigation of firms' financial constraints (as we will see in Chapter III), the financing problems and public financial support of firms' activity (notoriously SMEs) has been given particular attention from, at least, the Portuguese and European media.

Even though much is talked and discussed about firms' financial constraints, the very definition of what are financial constraints is still subject to debate. In effect, financial constraints is a rather abstract concept since it cannot be directly observable. Accordingly, it is quite difficult to come up with a clear-cut definition. As a starting point, in the spirit of Kaplan and Zingales (1997), we can apply a precise, but broader definition by stating that financial constraints are present whenever there is a wedge between the costs of obtaining internal and external funds. The problem with such definition is that it virtually covers every firm. As an alternative, even though quite theoretically, we prefer to define financial constraints as the inability of a firm to raise the necessary amounts (due to external finance shortage), at acceptable costs, in order to finance its investment and growth.

In this thesis, we argue that a significant number of firms face financial constraints, that the intensity of these constraints varies across firms with distinct characteristics and that financial constraints unfalteringly influence firm behaviour.

Even thought this thesis builds on separate, but related research effort (papers and articles), we articulated the pieces in order to obtain a coherent body. Consequently, the structure of this work is built in a logical sequence that takes the reader from a theoretical discussion of what are financial constraints, to a number of empirical findings regarding the determinants of constraints and their implications upon firm behaviour. In the meantime, we endow the reader with the empirical tools and frameworks used by researchers, while blending in the empirical literature of this prolific academic field. Accordingly, this work is organized as follows.

In Chapter I we deepen our definition of financial constraints and review the major theoretical contributions to the field. This theoretical anchorage is crucial for the understanding of subsequent Chapters of methodological and empirical nature.

Chapter II overviews the existing approaches and methodologies used to empirically measure firms' financial constraints. Additionally it compares the different frameworks by pinpointing the major advantages and drawbacks of each one.

Having discussed the different methodological tools, in Chapter III we summarize the empirical literature regarding financial constraints. It is organized as a series of stylized results, which mirror what is generally understood about severity of financial constraints and the effects that they have upon firms. Accordingly, this Chapter allows us to position this work within the prolific literature on such constraints. [Part of the material in this Chapter has been published as: Carreira, C., and Silva, F. (2010). "No Deep Pockets: Some stylized results on firms' financial constraints". *Journal of Economic Surveys,* 24(4):731–753.]

We support the arguments made in this thesis with data on Portuguese firms. Therefore, in Chapter IV we describe the data sources and different firm-level datasets used throughout our empirical analysis based on the Portuguese economic reality.

Accordingly, in Chapter V we depart to the empirical analysis. Specifically, we implement different approaches in order to verify if, and measure the extent to which, Portuguese firms are financially constrained. This exercise also allows us to uncover some relationships between constraints and firm characteristics, as well as to compare different methodologies. [Previous versions of this Chapter have circulated as Silva, F. and Carreira, C. (2010a). "Measuring firms' financial constraints: Evidence for Portugal through different approaches". GEMF Working Paper No. 15/2010.]

Subsequently, Chapter VI deepens the analysis of the previous Chapter by examining the extent to which there are significant differences in financial constraints between sectors of economic activity (Manufacturing and Services), as well as between firms operating in distinct industries. Additionally, we test if the commonly agreed relationships between constraints and both size and age (see Chapter III) are robust to economic sector disaggregation. [Previous versions of this Chapter have circulated as Silva, F. and Carreira, C. (2010b). "Financial constraints: Are there differences between manufacturing and services?". GEMF Working Paper No. 16/2010.]

In Chapter VII we explore the impact of the European monetary integration process upon firms' financial constraints. Additionally, we analyse the nexus between these constraints and firms' engagement in international trade, with a particular emphasis on firm exporting behaviour. [Part of the material in this Chapter is based on Silva, F. and Carreira, C. (2011). "Financial constraints and exports: An analysis of Portuguese firms during the European monetary integration" *Notas Económicas* 0(34): 35-56.]

Last, but not least, in Chapter VIII we broadly address the financing problems of the innovation process. In particular, we examine the extent to which financial constraints hinder firms' investment in R&D and innovation. In addition, we investigate the role of public financial support in alleviating such constraints. [Part of the material in this Chapter has been published as Silva, F. and Carreira, C. (2012). “Do financial constraints threat the innovation process? Evidence from Portuguese firms”. *Economics of Innovation and New Technology* (forthcoming). DOI: 10.1080/10438599.2011.639979.]

Finally, the last section of this work overviews and summarizes the major findings and implications of this thesis with respect to policymaking as well as future research.

CHAPTER I – DEFINITION AND THEORETICAL PERSPECTIVES

The term "financial constraints" became, in the past few years, extensively used in the literature. However, it is still rather difficult to come up with a clear-cut definition of "financial constraints". In fact, this is a rather abstract concept since it cannot be directly observable. Throughout this work we define "financial constraints" as the inability of a firm to raise the necessary amounts (due to external finance shortage), at acceptable costs, in order to finance its investment and growth. Such a definition still carries a great amount of abstraction. Therefore, in this Chapter we will come down to the phenomena that are at the root of the existence of such term. Accordingly, this Chapter overviews the theoretical anchorage, crucial for a clearer understanding of what are "financial constraints".

1. The Modigliani-Miller theorem: a departing point

The Modigliani-Miller theorem (1958), hereafter MM, states that, under certain conditions, firms' financial structure is irrelevant to investment decisions. This result arises because, in such scenario, external finance is a perfect substitute for internal funds. Accordingly, changes and differences in the cost of capital will be driven by investment demand. Therefore, investment decisions will be independent of a firms' financial status.

However, the theorem requires a number of assumptions to hold. We summarize these conditions as follows: a) corporate taxes are neutral; b) firms and investors borrow at the same interest rate (symmetric access to credit); c) a firm's financial policy is uninformative of its economic condition; d) perfect financial markets and perfect information—inexistence of frictions due to information asymmetries.

Even though the required assumptions are hardly met in reality, this theorem provides the departing point for, among others, the literature devoted to the study of financial market imperfections. In this Chapter, we focus our attention on the extent to which the MM theorem is not verified due to information asymmetries. These asymmetries set a wedge between the costs of internal and external finance and ultimately lead to what we define as "financial constraints". Finally, we describe a number of models that derive implications of financial constraints on firms financial and investment decisions as well as their dynamic path.

2. Information asymmetries and financial market imperfections

Financial market imperfections arise mostly due to information asymmetries. Among other types asymmetric information, adverse selection (Akerlof, 1970; Meyers and Majluf, 1984; Stiglitz and Weiss, 1981) and agency problems (Jensen and Meckling, 1976; Townsend, 1979; Bernanke et al., 1996 for an overview) are at the core of such imperfections.

Stiglitz and Weiss (1981) describe how, in the presence of imperfect information, there may exist an equilibrium in the loan market that entails "credit rationing". They argue that interest rate (and collateral) works as a screening device. Additionally, they point that, above a certain interest rate, the expected returns to a bank of a given loan portfolio is, in fact, a decreasing function of the interest rate.

To see this, suppose that firms only undertake investment projects if they can borrow the difference of the cost to their internal funds. Each project has a risk of θ and a profitability distribution of returns R given by F(R,θ). The distribution is not altered by the firm and each firm as its specific distribution. The bank (lender) only observes different mean returns but not different risks—they do not have full information on projects' payoffs. Additionally, let r^* be the interest rate that maximizes bank's expected returns. In this set up, firms borrow B at an interest rate of r and default if:

$$C + R \leq B(1+r), \tag{I. 1}$$

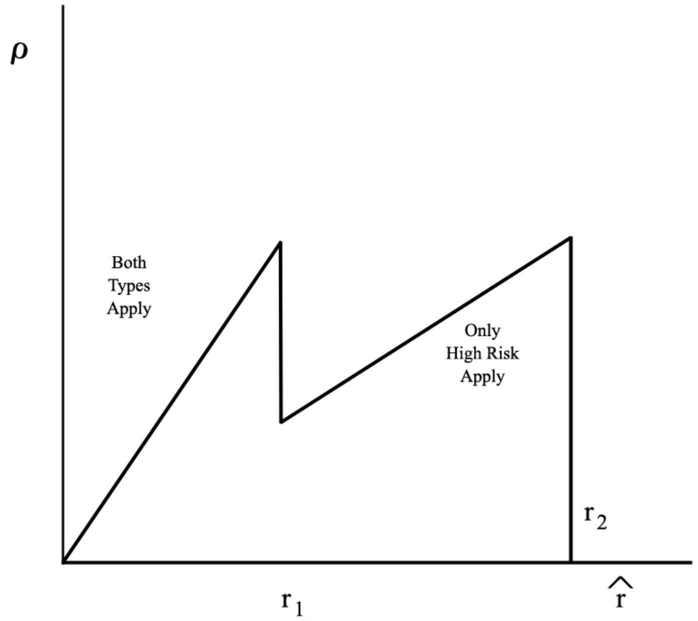
where C is collateral. The net profit of the firm is:

$$\pi(R,r) = \max(-C; B(1+r) - R), \tag{I. 2}$$

and that of banks is given by:

$$\rho(R,r) = \min(R + C; B(1+r)). \tag{I. 3}$$

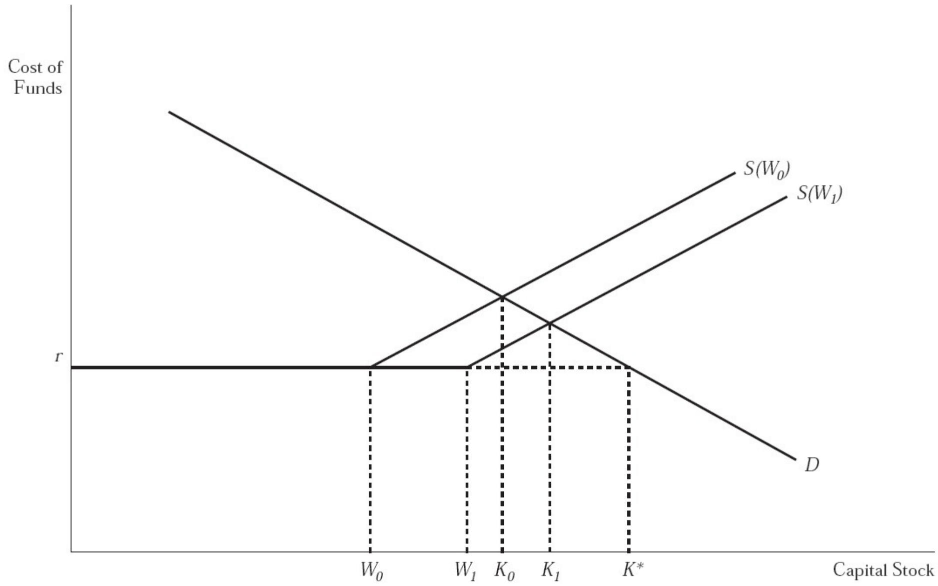
There is a critical value θ^* for which firms only borrow if $\theta > \theta^*$ because $\pi(R,r)$ is a convex function of R. Additionally, the critical value is an increasing function of interest rates, i.e. $\partial\theta^*/\partial r > 0$. With respect to banks, $\rho(R,r)$ is concave function of R. Therefore, the expected return to a bank is a decreasing function of the loan risk. The intuition follows from adverse selection. Let us introduce some heterogeneity in the projects (or firms). If there are 2 types of projects, "safe" and "risky", that borrow below r_1 and r_2 ; $r_1 < r_2$, respectively. Even though risky projects may have higher mean payoffs, above r_1 none of the safe projects will borrow (see Figure 1). Such change in the mix of applicants may reduce the mean payoff to a bank. In other words, different projects (loans) with different risks θ imply that the mean returns to the bank $\overline{\rho}(R,r)$ are a non monotonic function of r due to bankruptcy events. This implies that a bank would not increase the interest charged beyond r^* since it reduces its mean return. As a result, it is possible that r^* is under a market clearing r_m, leading to excess demand for loans and consequently credit rationing.



Source: Stiglitz and Weiss (1981)

Figure I.1. The mix of applicants for loans

The existence of financial constraints is particularly relevant if it leads to sub-optimal levels of investment and growth. As an example of how financial constraints may lead to underinvestment (Figure 2), suppose the following scenario of informational imperfections described by Hubbard (1998).



Source: Hubbard (1998)

Figure I.2. Informational imperfections and underinvestment

The neoclassical credit supply is given by the horizontal line at the interest rate r. Without information asymmetry problems, the chosen capital stock is K^*—the intersection between demand and supply—, where the expected marginal profitability of capital should equal the interest rate. For simplicity, ignore depreciation, taxes and adjustment costs. An entrepreneur with net worth W_0 identifies an investment opportunity *D* that requires an amount of capital stock given by *K*. In the presence of information asymmetries, he will be required to pay a premium over the amount he wants to borrow. This premium results, for example, from the fact that the entrepreneur may divert borrowed funds to personal gains, since the lenders can only partially monitor the entrepreneur's allocation of funds.[1] It is worthwhile mentioning that the problem of asymmetric information has also motivated a large body of literature devoted to the analysis of incomplete contracts (e.g. Aghion and Bolton, 1992; Hart, 1995 for an overview).[2]

As a result, the entrepreneur faces an upward sloping supply of funds for desired amounts of capital larger than its personal net worth. Consequently, the entrepreneur will end up with an amount of capital $K_0 < K^*$, leading to underinvestment. Shifts in the wealth of the

[1] As an example Townsend (1979) introduces verification (or monitoring) costs that each lender has to pay to verify the returns (i.e. state) of a firm, whereas for firms this information is costless.

[2] However, this type of analysis is beyond the scope of this work.

entrepreneur, lead to shifts in the supply curve of funds from $S(W_0)$ to $\mathrm{S(W_1)}$, but the slope of the curve remains unchanged as long as the level of informational asymmetry is the same.

In order to reduce information asymmetry problems, financial intermediaries (e.g. banks; rating agencies; funds) collect, monitor and transmit firm (borrower) information to investors (lenders). However, such financial institutions are never as informed as the borrowing firms. Therefore, the existence of these intermediaries may also lead to asymmetric information at two levels—between the lenders and the intermediaries as well as between the latter and borrowers (Diamond, 1984). We should also distinguish between "hard information" that can be easily transmittable across agents and "soft information" that can not be diffused (Berger and Udell, 2002; Stein, 2002). While the former comprises for example financial accounts and other reports, the latter includes reputation and relationships built over time. The existence of this "soft information" adds to the information asymmetry problem.

It is not possible to proceed in the clarification of the concept of financial constraints without referring to the debate over how firms chose their debt and equity. In fact, the MM theorem spawned a vast literature based on two theories. On the one hand, the "pecking order theory" (Donaldson, 1961; Myers and Majluf, 1984) builds on the asymmetric information problems. According to this view, firms always prefer internal funds to finance their investments. In the event that external finance is required, then they opt for the safest security (debt), while issuing equity is eventually the last resort. On the other hand, the "trade off theory" (e.g. Kraus and Litzenberger, 1973) argues that managers evaluate the costs and benefits of issuing debt. In other words they focus on bankruptcy costs and tax considerations—it is cheaper to finance a project with debt rather than with equity due to taxes (see Fama and French, 2002 or Frank and Goyal, 2007 for a comparison of the two approaches).

The connection between asymmetric information theories and the financing hierarchy (pecking order) view appears to be very close for small and medium sized firms (see Bernanke et al., 1996). However, with respect to traded (larger) firms the link is not trivial. The question is whether retained earnings should be treated as internal finance, since they are ultimately owned by shareholders.

Overall, assuming that information asymmetries lead to a financing hierarchy (pecking order theory holds), firms will only resort to external finance whenever their internal funds are not sufficient to cover the costs of undertaking valuable investment opportunities. If a firm faces a valuable investment opportunity, but has insufficient internal funds and can not obtain external finance (or external funds are too expensive), we define it as "financially constrained".

3. Sources of funds

Even though in this thesis we focus on the dichotomy between internal and external funds, rather than on the different types of external funding, we should briefly address the large panoply of financing sources. There are several ways through which a firm may raise the necessary amounts to finance investment and growth. In terms of internal funds, these are usually seen as cash-flows resulting from profits or entrepreneurs' wealth (in the case of start-ups).[3] With respect to external funds, these can be classified in different categories. First, those obtained from capital markets where a firm is able to issue debt or equity. However, we should note that only a minority of firms is able to resort to financial markets (namely larger and older ones). Second, bank loans are a commonly used source of external finance, particularly in economies with less developed financial markets. As an example, in Europe bank loans are the predominant source of SMEs finance (Storey, 1994). In a brief parenthesis, formal venture capital and business angels should be stressed as a crucial source of external finance to start-ups as well as to risky R&D projects (Hall and Lerner, 2010). Third, public financial support through grants, tax credits, special credit lines and other incentives, provide an additional source of external funding for certain types of firms depending on economic policy goals—e.g. innovative, exporting, start-ups (see Chapter III, *Stylized result 6*). Fourth, trade credit is probably the most common form of external credit (e.g. Yang, 2011). It is obtained from suppliers through either formal payment contracts with established maturity or through rather informal agreements with lower enforceability. Fifth, wage variations may work as a way to obtain credit from workers in periods where there is an additional need for funds (e.g. Guiso et al., 2009). Therefore, firms compensate inefficiencies in the financial markets by resorting to workers. Finally, we classify as informal finance, any sort of lending relationships established by a firm and non-typical lenders (other than banks, suppliers, public institutions) or through non-typical channels (markets, financial intermediaries).

[3] Retained earnings in stock traded (large) companies may also be seen as internal funds, even though they are the property of shareholders.

4. Models incorporating financial constraints: Different perspectives

4.1. Dynamic investment models: Q theory and Euler equation

Both Q theory and Euler equation investment models (see Chirinko, 1993 for an overview) have their roots on a dynamic investment problem with adjustment costs. In this optimization setting, were firms are assumed to be rational profit-maximizing agents, we follow Adda and Cooper (2003). The profit maximization problem is given by:

$$V(A,K,p)=\max_{K'}[\Pi(A,K,p)-C(K',A,K)-p(K'-(1-\delta)K)]+$$

$$+\beta \mathrm{E}_{A',p'|A,p}V(A',K',p')\,. \qquad \text{(I. 4)}$$

Here, the prime (') denotes the following period. The relationship $K'=K(1-\delta)+I$ governs the accumulation of capital *K*, that depends on depreciation δ and investment *I*. Other factors of the production function are represented by *A*, while *p* and *C* represent the costs acquiring new capital and the adjustment costs function, respectively. Finally, the profit function and the value of the firm are given by $\Pi(\cdot)$ and $V(\cdot)$, respectively.

4.1.1. Q-theory

Let $\Pi(\cdot)$ be proportional to *K,* $C(\cdot)$ be quadratic and *p* constant. Introducing these assumptions, consistent with the Q theory of investment, yields:

$$V(A,K)=\max_{K'} AK-\frac{\gamma}{2}\left[\frac{K'-(1-\delta)K}{K}\right]^2 K-p(K'-(1-\delta)K)]+\beta \mathrm{E}_{A'|A}V(A',K')\,. \qquad \text{(I. 5)}$$

Additionally, the investment rate is given by:

$$\frac{I}{K}=\frac{1}{\gamma}\left[\beta \mathrm{E}_{A'|A}V_K(A',K')-p\right], \qquad \text{(I. 6)}$$

where $\mathrm{E}_{A'|A}V_K(A',K')$ is the expected value of the derivative of the firm’s value with respect to capital. This term is known in the literature as “marginal *Q*” (Tobin, 1969; Hayashi, 1982). In practical terms, “Tobin's *Q*” measures the increase in the present value of a firm’s profits resulting from a unit increase in the firm’s capital stock—*Q* is the market value of an additional unit of capital. Therefore, a firm invests until the cost of acquiring capital equals the value of capital (i.e. while *Q* is greater than the unity). A high level of *Q* thus indicates the presence of an investment opportunity. However, marginal *Q* is empirically not observable. To overcome this problem one further has to assume that the value of a firm is proportional to its capital stock $V(A,K)=F(A)K$. In other words, the expected values of average *Q* (given by F(A) and denoted by $\overline{Q}$) and marginal *Q* are exactly the same. The resulting empirical equation (e.g. Gilchrist and Himmelberg, 1995) is therefore given by:

$$\left(\frac{I}{K}\right)_{it} = \alpha_{i0} + \alpha_1 \beta E\overline{Q}_{it} + \alpha_2 \left(\frac{X}{K}\right)_{it} + e_{it}, \qquad \text{(I. 7)}$$

where in *X* are included a number of other variables. The prediction of the *Q* model is that *Q* should summarize all relevant information for a firm's investment decision. Therefore, if other variables are found to be relevant, one should reject the model.

Usually, the significance of financial variables, such as cash-flow, in these regressions is attributed to financial market imperfections, that lead to a rejection of the model—see Blundell et al. (1992) for an example and Gomes (2001) for a critique on this interpretation.

4.1.2. Euler equation

Alternatively, the Euler equation approach uses the necessary condition for optimality given by:

$$\left(\frac{I}{K}\right) = \frac{1}{\gamma}\left(\beta\left\{\mathrm{E}_{A'|A}\left[\Pi_K(A',K') + p'(1-\delta) + \frac{\gamma}{2}\left(\left(I/K\right)'\right)^2 + \gamma(1-\delta)\left(I/K\right)'\right]\right\} - p\right). \qquad \text{(I. 8)}$$

The advantage is the elimination of the $\mathrm{E}_{A'|A}V_K(A',K')$ term. In other words, this approach avoids the complications with Q missmeasurements (Chirinko, 1993; Erickson and Whited, 2000; Gomes, 2001). The empirical test of financial constraints (e.g. Whited, 1992) is then a test of whether this equality holds for realized values of these variables as follows:

$$\varepsilon_{it+1} = \left(\frac{I}{K}\right)_{it} -,$$

$$-\frac{1}{\gamma}\left[\beta\left(\Pi_K(A_{it+1},K_{it+1}) + p_{t+1}(1-\delta) + \frac{\gamma}{2}\left(\left(I/K\right)_{it+1}\right)^2 + \gamma(1-\delta)\left(I/K\right)_{it+1}\right) - p_t\right], \qquad \text{(I. 9)}$$

where $\varepsilon_{it+1} = 0$ if the equality holds. A GMM estimator that uses $E_t\varepsilon_{it+1} = 0$ can then be employed.

We should note however, that the empirical work using these approaches tests the null hypothesis of "no financial constraints" against an alternative hypothesis of "financial constraints". However, these models only derive empirical implications for the scenario of the null hypothesis. Therefore, it might be daring to assume that the only discrepancy to reality of such models is the existence of financial market imperfections and financial constraints. If this is not the case, then it is possible that a test rejection of the frictionless model implies that there is something else to be rejected, rather than the absence of financial constraints.

Overall the idea is that, because investment might be financed by current profits, one can introduce financial constraints of the form $I \leq AK^{\alpha}$. This leads to a constraints function such as:

$$\Psi(A,K) = [0,(1-\delta)K + AK^{\alpha}] \qquad \text{(I. 10)}$$

Accordingly, the firm's maximization problem becomes:

$$V(A,K) = \max_{K'\in\Psi(A,K)} AK^{\alpha} - \frac{\gamma}{2}\left[\frac{K'-(1-\delta)K}{K}\right]^2 K - p[K'-(1-\delta)K)] +$$

$$+\beta \mathrm{E}_{A'|A} V(A',K') \qquad \text{(I. 11)}$$

The question now lies on the form of the function of constraints $\Psi(A,K)$. In this thesis we will shed some light on a number of factors that probably shape this function.

4.2. The liquidity management approach

In a somewhat different perspective, Almeida Campello and Weisbach (2004)—hereafter ACW—argue that the existence of financial constraints is reflected on firms' cash policy. Even though, the ACW model can be compared to the type of dynamic programming problem described above, the view is focused on liquidity management rather than on investment itself. One of the advantages of this approach is that it provides a clear null and alternative hypothesis setup for empirical investigation.

The model has 3 dates $\{0;1;2\}$ and a firm initially with a cash-flow of c_0 that faces, at date 0, a long-run investment project I_0 that pays $F(I_0)$ at date 2. The firm also faces another investment opportunity at the next period I_1 that pays $G(I_1)$ also at time 2.[4] The returns *F* and *G* of these projects are not verifiable.

At time 1, the firm's existing assets generate high c_1^H or low c_1^L cash-flows with probabilities p and $(1-p)$, respectively. For simplicity, the discount factor and the cost of investment goods are assumed to be 1 (at both time 0 and 1). The investments I_0 and I_1 are liquidated at time 2, generating payoffs in a proportion *q* of the amounts invested. Cash-flows

[4] Both functions are assumed to be increasing, concave and continuously differentiable. Additionally all agents are assumed to be risk neutral.

of $f(I_0) = F(I_0) + qI_0$ and $g(I_1) = F(I_1) + qI_1$ are therefore generated from these investments. In the event of firm liquidation, creditors capture only a fraction τ of total assets ("hard assets") given by $(1-\tau)qI$. Therefore, for high values of τ, firms may become financially constrained, passing up positive net present value (NPV) projects due to lack of external finance. Furthermore, the firm can borrow *B* and is allowed an hedging policy through payments *h*.

In this framework, the firm has to decide the amounts of cash *C* that that should be carried from period 0 to period 1. Accordingly the problem of the firm can be summarized as the maximization of expected sum of all dividends *d*, given by:

$\max\limits_{C,h,I}\left[d_0 + pd_1^H + (1-p)d_1^L + pd_2^H + (1-p)d_2^L\right]$, subject to: (I. 12)

i) The dividend payments that are given by:

$$d_0 = c_0 + B_0 - I_0 - C \geq 0 \quad \text{(I. 13)}$$

$$d_1^S = c_1^S + h^S + B_1^S - I_1^S + C \geq 0\ ; \quad \text{S=H,L} \quad \text{(I. 14)}$$

$$d_2^S = f(I_0) + g(I_1^S) - B_0 - B_1^S \quad \text{(I. 15)}$$

ii) A hedging restriction in the form

$$ph^H + (1-p)h^L = 0 \quad \text{(I. 16)}$$

iii) The borrowing constraints given by:

$$B_0 \leq (1-\tau)qI_0 \quad \text{(I. 17)}$$

$$B_1^S \leq (1-\tau)qI_1^S \quad \text{(I. 18)}$$

If a firm is financially unconstrained, it is able to take advantage of both investment opportunities at times 0 and 1, thus investing at first-best levels of I_0^* and $I_1^{*,S}$, respectively. Therefore, the financial policy of such firm, given by the vector $[B_0, B_1^S, C, h^H]$, satisfies all dividend, hedging and borrowing constraints. Such firms are those that either have sufficient internal funds *c* to finance the investment projects *I*, or can easily resort to external finance (low τ). In this situation, firms are indifferent between two alternative financial policy vectors because they can compensate increases in cash savings *C* with increases in external funds B_0 or temporal adjustments in dividend policy *d*. As long as constraints are not binding, and firms investment policy is $[I_0^*, I_1^{*,S}]$, there is no unique optimal cash policy.

We now turn to the constrained firm solution. A constrained firm investment policy is given by $[I_0^-, I_1^-] < [I_0^*, I_1^*]$.[5] Since such firm faces financial constraints—either have insufficient internal funds c to finance the investment projects I, or face borrowing constraints (high τ)—, holding cash is costly because it means passing up investment opportunities. Conversely, saving cash will allow taking advantage of future investment opportunities. Consequently, the optimal cash policy of a firm will result from the tradeoff between $f(I_0)$ and $g(I_1)$. Additionally, a constrained firm will no longer pay dividends at periods 0 and 1, as well as it will borrow to the maximum extent it cans at the period when it invests. The problem can now be written as:

$$\max_{C,h^H}\left[f\left(\frac{c_0 - C}{\lambda}\right) + pg\left(\frac{1}{\lambda}\left(c_1^H - \frac{1-p}{p}h^L + C\right)\right) + (1-p)g\left(\frac{c_1^L + h^L + C}{\lambda}\right)\right], \tag{I.19}$$

with $\lambda \equiv 1 - q + \tau q$.

Assuming that hedging is fairly priced and optimal hedging is $h^L = p(c_1^H - c_1^L)$, implying equal cash flows across states (we can write $E_0[c_1]$), the optimal cash policy C^* solves:

$$\frac{\partial}{\partial C} f\left(\frac{c_0 - C^*}{\lambda}\right) = \frac{\partial}{\partial C} g\left(\frac{E_0[c_1] + C^*}{\lambda}\right). \tag{I.20}$$

Which tells us that the opportunity cost of increasing cash holdings in the present, equals the marginal benefit that result from being able to invest in the future—constraints were relaxed due to the cash transfer across periods. As a result, ACW argue that the empirically testable implications of the model are:

i) $\dfrac{\partial C^*}{\partial c_0} > 0$ for financially constrained firms;

ii) $\dfrac{\partial C^*}{\partial c_0}$ is indeterminate for unconstrained firms.

4.3. The evolutionary perspective

Evolutionary models were built to explore the role of the Schumpeterian notion of innovation as a central piece of the workings of the economy. Firm heterogeneity persists over time as well as it is not a consequence of market imperfections but rather the result of a competitive

[5] We omit the state S because the productivity of investments $g(I_1^S)$ is assumed not to vary across states

process between firms with different capabilities, assuming away equilibrium notions (see Carreira, 2006). To illustrate this point we resort to the primordial model of Nelson and Winter (1982), chapter 12, hereafter NW, that formalizes Schumpeter's (1942) evolutionary concept.

Consider an industry with n firms i for whom each period's production Q_{it} is a function of capital K_{it} and their individual productivity A_{it} (that results from the best technology they can employ). While these technologies are characterized by constant returns to scale and fixed input coefficients, firms face downward sloping demand with unit price-elasticity. In order to increase their productivity levels, firms must invest in new technologies or in copying existing ones.[6] Therefore, firms' operational profits per unit of capital will be given by:

$$\pi_i' = P' A_i - c - rd_i^{im} - rd_i^{in}, \tag{I.21}$$

where P is the price and c, rd^{im}, and rd^{in} are respectively production, imitation and innovation costs, by unit of capital.

Each period's firm productivity is given by:

$$A_i' = \max\left[A_i, A_i^*, A_i^{in}\right], \tag{I.22}$$

where A_i^* is the industry best technology, and A_i^{in} firm's newly developed technology. The probability of imitating is directly proportional to the imitation expenses. If successful, the firm's new technology is A_i^*. Similarly, the probability of innovating is directly proportional to innovation expenses. However, only innovative firms can innovate ($rd^{in} > 0$). If successful, A_i^{in} is drawn from a distribution of a random variable X with E[X] given by the industry's lagged average productivity and a parameterized V[X].[7]

Finally, new levels of capital stock are given by the function:

$$K_i' = I\left[\frac{P' A_i}{c}, \frac{Q_i}{\sum_i Q_i}, f(\pi_i), \delta\right] K_i + (1-\delta) K_i, \tag{I.23}$$

[6] Note that NW identify 2 distinct types of R&D policies: "innovators" and "imitators"

[7] The probabilities of successfully imitating or innovating are given by: $\Pr(d^{im}=1) = a^{im} RD^{im}$ and $\Pr(d^{in}=1) = a^{in} RD^{in}$, respectively, where a are parameters of the model and represent firms' ability to imitate\innovate, while d are random binary variables.

where δ are the depreciation costs of capital. However, in investment function $I(\cdot)$, profit enters as a function of operational profits, depreciation costs and a parameter *B*, that represents external finance:

$$f(\pi)=\begin{cases}\delta+\pi & ;\pi\leq 0\\ \delta+B\pi & ;\pi>0\end{cases};\quad \text{B>1} \tag{I.24}$$

Accordingly, B is an exogenous parameter that defines the extent to which firms can borrow above their profits. Therefore, in this primordial model, NW already recognize that access to external funds is to be taken into account when analysing firm dynamics, even though the supply of credit was exogenously set.

A significant body of recent evolutionary literature has focused on the role of innovation and different technological regimes upon firm dynamics (see Carreira, 2006). However, the extent to which financial constraints might affect such dynamics within this framework still requires further exploration (Coad, 2010a). Within models of evolutionary inspiration that explicitly incorporate endogenous financial constraints we should note the recent contributions of Delli Gatti et al. (2005) and Dosi et al. (2011). These models are essentially aimed at the study of macroeconomic fluctuations, but rely heavily on microeconomic foundations. However, in clear contrast with representative agent models, the individual heterogeneity principle prevails (see Hartley, 1997; Dosi, 2007). These models can be classified in the family of Agent-based models (Dawid H, 2006; Tesfatsion L, 2006).

Delli Gatti et al. (2005) model financial market imperfections through the price of loans (interest rate) but assume that there is no "credit rationing" (as defined by Stiglitz and Weiss, 1981). Additionally, they also assume that firms can only obtain external finance through debt—a hypothesis of full equity-rationing. The interest rate on debt is then defined as the sum of an exogenous component and a risk premium:

$$r_{it}=r\left[1+\rho f\left(\bar{v}(t)\right)+(1-\rho)g\left(v_{\max}(t)-v_{it}\right)\right],\;\; 0<\rho<1 \tag{I.25}$$

The risk premium r_{it} is defined as the sum of a decreasing function of the economy's average equity to capital ratio ($\bar{v}$) and an increasing function of the slack between the maximum equity-capital ratio in the economy and that of the firm—associated with bankruptcy costs. In this way, they intend to capture the systemic risk of the economy as well the firm's idiosyncratic risk. The latter can rather be seen as an endogenous measure of financial constraints, in the sense that firms with lower relative value will be required to pay higher interest rates for the same loan. Accordingly, the existence of these constraints contributes to a concentration of growth opportunities in a few financially sound firms that have lower costs of capital.

The approach used by Dosi et al. (2011) to model financial constraints relies on rationing, rather than on interest rates charged—the latter are assumed not to contain an idiosyncratic component. Specifically, they introduce heterogeneous financial intermediaries (banks), whose supply of credit depends on their individual history and a credit multiplier parameter. Banks sort firms according to their net-worth to sales ratio and provide credit until exhaustion of their supply (if requested). Therefore, if there is an excess demand for funds, firms with lower rankings will be denied credit.

However, with respect to financial constraints, these types of models still have a long road ahead. Particularly the introduction of a number of other determinants of financial constraints (see Chapter III), rather than just firms' financial soundness, is certainly a feature that deserves being explored. Additionally, the quality of an investment project should be considered in lender's decision to supply credit—even though difficult to model without rather strong assumptions regarding agent's rationality.

Overall, while clarifying the concept of financial constraints, this Chapter summarizes the theoretical foundations (and perspectives) of the literature analysing firms' constraints. The remaining Chapters of the thesis will be devoted to the discussion of the different strategies that can be used to measure firms' financial constraints (Chapter II), as well as to the empirical analysis of such constraints for the Portuguese case (Chapters V-VIII).

CHAPTER II – HOW TO MEASURE FINANCIAL CONSTRAINTS

1. Introduction

The recent years have been prolific in terms of development of new measures of financial constraints. In this Chapter, we summarize the existing approaches and methodologies to measure financial constraints. It is organised in a way that facilitates the comparison of the different methodologies, taking into account the advantages and disadvantages of each approach. This allows us to adequate the most appropriate technique for a research purpose and available data.

Financial constraints are empirically not observable. In fact, there is no item on the balance sheet that tells us if, and the extent to which, a firm is financially constrained. As a result, researchers have strived to develop methodologies that consistently allow identifying and measuring such constraints.

There are, however, a number of specificities associated with financial constraints that one should expect to be reflected in a good measure of financial constraints. Firstly, financial constraints are firm-specific. Even though interest lies in making inferences regarding a certain firm characteristic (e.g. firm size or age) or firm behaviour (e.g. innovation activity), one should expect highly heterogeneous levels of access to external finance. Additionally, constraints are time-varying, since a firm may move from constrained to unconstrained states (or across different degrees of constraint) as, for example, it establishes stronger investor-lender relationships and gains better visibility. The reverse may also be true if, for example, a firm's previously sound economic and financial conditions start to deteriorate (eventually defaulting on previous loans), investment opportunities change or idiosyncratic shocks occur. In this case, it might happen that this previously unconstrained firm will now find it difficult to obtain external finance. Therefore, one might expect different states of constraints along the timeline (e.g. Hubbard, 1998; Cleary, 1999). Finally, financial constraints is not a clear-cut phenomena where a firm is either financially constrained or not, but there are different degrees of constraint (Musso and Schiavo, 2008). As a result, each firm, for a given period of time, may move along a spectrum of constraints.

These characteristics signify that, beyond eventual theoretical issues, finding an appropriate measure of financial constraints may prove to be a rather difficult task. Optimally, the perfect measure of financial constraints should be objective, firm-specific, continuous and, time varying. Unfortunately, to our knowledge, there is no such measure. Nevertheless, we will present and discuss the main advantages and disadvantages of existing approaches to measure constraints.

2. Indirect measures

2.1. Prologue: Primordial tests and the Q-theory of investment

Within the traditional Q model for investment (presented in Chapter I), one should expect that Tobin's Q summarizes all future information that is relevant for a firm when deciding to invest.[1] Consequently, marginal Q should be the only predictor for investment (Chirinko, 1993). Therefore, we should not expect that additional variables (particularly financial ones) have a significant explanatory power in Q investment regressions. However, while financial variables such as cash-flow, have been shown to be relevant in firms' investment decisions, the contribution of Q was found to be disappointingly low (e.g. Blundell et al., 1992). This type of result has driven researchers to argue that (after controlling for Q) investment may not be independent from financial decisions due to the presence of financial markets imperfections. Specifically, the extent to which financial constraints increase the bias of average Q with respect to marginal Q has been given particular attention (see Hayashi, 1982; Gomes, 2001). If this is the case, then one should expect that financial variables, and specifically those that relate to firms' ability to generate funds, will turn out to be significant in an investment regression—see Chapter I for further discussion on Q-based models.

2.2. Cash-Flow Sensitivities

2.2.1. Investment

Theoretically, financial constraints have been incorporated in several models in the past (see Chapter I). However, the empirical assessment of financial constraints can essentially be traced back to the seminal work of Fazzari Hubbard and Petersen (1988)—hereafter FHP—that introduced investment to cash-flow sensitivity as a measure of constraints (ICFS).

[1] The theory was introduced by Brainard and Tobin (1968) and Tobin (1969).

The argument is the following. Financially constrained firms can not obtain external finance—at least the full required amounts, or they do obtain them at significantly high costs. Therefore, these firms must rely on their internally generated funds once an investment opportunity arises. Meanwhile, financially unconstrained firms can easily resort to external funds to finance their investments. Accordingly, while constrained firms will exhibit a positive propensity to use cash-flows to finance investment (positive and significant ICFS), no systematic relationship should be found for unconstrained ones.

The approach used consisted in classifying firms *a priori* as constrained and unconstrained, based on their dividend policy. By assuming that constrained firms, in order to finance their investment, *"retain all of the low-cost internal funds they can generate"* and so pay lower dividends, FHP proceed to the estimation of ICFS for each class of firms. They regress investment on cash-flow, estimated Q (investment opportunities) and year and firm dummies, upon a sample consisting of 422 USA firms (1970-84).[2] Their findings, that low-dividend firms (constrained) exhibit higher ICFS than high-dividend ones (unconstrained), provided evidence that ICFS could be a useful measure of financial constraints.

Since the influential work of FHP, numerous studies focused on the use of ICFS to identify and measure firms' financial constraints—the contributions of Hadlock (1998) for the US, Chapman et al. (1996) for Australia; Guariglia (2008) for the UK; Audretsch, and Elston (2002) for Germany; Kadapakkam et al. (1998) and Bond et al. (2003a) for different countries are just examples. Even though this approach is, by far, the most commonly used methodology to assess financial constraints (see Chapter III for an overview), it received severe criticism both at the theoretical and empirical levels. We summarize them into three main critiques that follow.

The first study that definitely challenged FHP's approach was Kaplan and Zingales (1997)—hereafter KZ. They pointed out that, not only certain assumptions made on the curvature of the cost function of external finance may not be verified (e.g. positive third derivatives), but also that the classification scheme used by FHP was flawed. In particular, due to precautionary savings and potentially risky adverse management, the dividend policy is an inaccurate sorting variable.

[2] As an alternative to the typical Q theory investment regression augmented with cash flow, some researchers also use an accelerator and\or error-correction specifications (e.g. Scellato, 2007; Guariglia, 2008).

The second main critique, concerns problems associated with controlling for investment opportunities (FHP use Q). First, it is impossible to measure marginal Q and thus the empirical approximation, average Q (Hayashi, 1982), entails potential missmeasurements due to the violation of certain assumptions, such as imperfect competition and the relationship between firms' investment and financial decisions in these particular types of models (see Chirinko, 1993, and Hubbard, 1998, for a discussion). Second, Cash-Flow might itself contain information about investment opportunities, particularly for firms that face high uncertainty about their investment projects (usually young and growth firms). In this case, cash flow might indicate the direction to go, by revealing additional information on the projects' quality. As a result, one should expect that part of the ICFS is due to investment opportunities that were not captured by Q. In fact, Alti (2003), in a financially frictionless model, shows that even after Q correction firms still present significant ICFS. (In Chapter III we briefly overview empirical findings corroborating this point.)

Finally, several authors such as Povel and Raith (2002), Cleary et al. (2007) or Lyandres (2007) found the ICFS relationship to be non-monotonic. They argue that ICFS are U-shaped with respect to constraints due to the risk associated with firm default and the efforts of investors in trying to avoid corresponding liquidation losses—by providing larger amounts to mitigate the risk of default—, for sufficiently low levels of internal funds. In this case, a decrease in internal funds below a certain threshold would imply an increase in investment (see Chapter III for further detail).

Overall, these critiques cast serious doubts on the robustness of ICFS as a measure of financial constraints.

2.2.2. Growth

The approach described in the preceding section, has been extended to firm growth. As a result, a number of researchers have studied financial constraints by estimating the sensitivity of firm growth to cash flow (GCFS). We group these studies into 3 major categories, depending on the variable used to measure firm growth. Namely, we distinguish between employment growth (e.g. Oliveira and Fortunato, 2006), growth of total assets (e.g. Carpenter and Petersen, 2002) and sales growth (e.g. Fagiolo and Luzzi, 2006).

In this line of thought, we should note that some of these authors conclude that financial constraints (proxied by cash-flow) have a negative impact upon firm growth (e.g. Fagiolo and Luzzi, 2006; Oliveira and Fortunado, 2006). This type of conclusion may, however, be too impetuous. Cash-flow *per se* is just a proxy (a better or worst one) for financial constraints (see Section 5.3). Therefore a positive and significant coefficient for cash-flow only tells us that firm growth responds positively to increases in cash-flow. Accordingly, unless we use a real measure of financial constraints as explanatory variable, or observe different sensitivities for different groups of firms (distinguishing their growth levels), there is not much we can say about the impact of constraints on firm growth. On the other hand, several papers (e.g. Serrasqueiro et al., 2010, Sarno, 2008) fail to control for investment opportunities. In this case, interpreting positive and significant sensitivities for a group of firms as evidence of financial constraints is flawed, due to investment opportunities hidden in cash-flows (see Alti, 2003).

2.2.3. Cash

Recently, in a different perspective of demand for liquidity, ACW (Almeida et al., 2004) suggest that financially constrained firms may alternatively be identified by looking at their cash policy (see Chapter I). If a firm is constrained, it has to pass-up present investment opportunities and hoard cash, in order to be able to take advantage of profitable future investment opportunities and hedge against future shocks. The same is not true when it comes to unconstrained firms, since they are able to resort to external finance whenever investment opportunities arise (by definition of financial constraints). Therefore, one should expect a positive and significant association between cash stocks and cash-flow for constrained firms, while no such relationship should be found for unconstrained ones. Finally, the degree to which a certain group of firms is financially constrained should be reflected on the cash to cash-flow sensitivity estimate (CCFS), as in ICFS—the higher the CCFS, the more constrained is such group of firms. ACW test if financially constrained firms exhibit high cash-flow sensitivities, while unconstrained firms do not. Results for four out of five classification schemes for constrained\unconstrained firms confirm their hypothesis. Only for the classification based on Kaplan and Zingales (1997), do the results differ.[3] Examples of this approach can also be found in Han and Qiu (2007) or Baum et al. (2011).

The financial nature of the cash stock variable is a shield against miss-measurements in Q and investment opportunities hidden in cash-flow. The reason being that it is not expected that firms will increase their cash stocks if cash-flow signals a new\better investment opportunity, unless they are financially constrained. However, constrained firms may use cash to reduce debt if hedging needs are low (Acharya et al, 2007). Accordingly, one

[3] The classification schemes are based on: payout ratio, asset size, bond rating, commercial paper rating, and KZ index.

should nevertheless control for debt issuances and investment opportunities. Additionally, as pointed by Almeida et al. (2011) in a subsequent paper, investment in relatively liquid assets, other than cash, may be used to transfer resources across time.[4] Therefore, any liquid types of investment should also be taken into consideration.

Finally, a few papers have empirically questioned the validity of this measure. They find that all firms, regardless of the *a-priori* classification as (un)constrained, exhibit positive and significant CCFS (e.g. Pal and Ferrando, 2009). Nevertheless, the sensitivity is found to be higher for firms that are expected to be constrained (Lin, 2007).

2.2.4. Common pitfalls

The above mentioned approaches share a number of drawbacks, mostly associated with the *ex ante* classification of firms, that are worthwhile mentioning. Sample partition into different groups of firms according to a certain segmenting variable that, *ex-ante*, is expected to provide information on the degree to which firms are financially constrained is, in fact, quite problematic.

First, it is questionable that the segmenting variable correctly distinguishes between constrained and unconstrained firms, since a superior proxy is yet to be found (Musso and Schiavo, 2008). Accordingly, some classification schemes may be flawed. The leading example is provided by Kaplan and Zingales's (2000) critique of FHP's use of dividend policy as a segmenting variable. They find that according to FHP (1988; 2000) Microsoft would be classified as financially constrained, even if it *"had net income of $3.5 billion, capital expenditures of $0.5 billion, no investment in inventories, no dividends, and no debt, yet held almost $9 billion of cash—or eighteen times capital expenditures"*.[5]

Second, it is also unclear that this proxy for constraints is not itself affected by financial constraints. In this situation, one will end up with an *a-priori* classification scheme based on an endogenous variable with respect to constraints—see for example Bond et al. (2003a) for ICFS endogeneity problems and estimation biases.

[4] In the original model they assumed that firms transfer resources only through cash.

[5] Firms in FHP (1988) and FHP (2000) were *a-priori* classified as financially constrained if they did not pay dividends and had high cash balances, respectively.

Third, to categorize firms into different groups using continuous segmenting variables, one has to define cut-off points that are not arbitrary. The reason is that the relationship between the segmenting variable and financial constraints may be non-monotonic. As an example, even if it is generally agreed that larger and older firms are not as financially constrained as smaller and younger ones, some studies have shown that this relationship may in fact be U-shaped (e.g. Hadlock and Pierce, 2010).

Fourth, a firm may move across different states of the segmenting variable. Consequently, it might happen that a firm is also moving across different groups. As an example, if one uses firm size as proxy, it might happen that a small, but fast growing firm, classified as constrained in the present, will be classified as unconstrained in the future just because it grew. This entails significant problems in the assignment of firms into such classes within a dynamic perspective.

Nevertheless, within cash-flow sensitivities (CFS), an alternative to perform a sample partition with respect to a given variable, is to test interaction terms of that variable with cash-flow. These interaction terms will then provide the sign (but not the magnitude) of the relationship between the variable and financial constraints. This slightly different approach also allows to test for non-monotonic relationships by introducing interactions of cash-flow with power values (e.g. square) of the variable in matter. Additionally, it also permits the treatment of such variable as endogenous in the regression. However, one still has to assume that CFS correctly identifies and measures financial constraints.

2.3. Euler Equation test

Based on Q-Theory and within the models for investment with adjustment costs, a strand of literature as attempted to identify financially constrained firms by estimating a reduced form Euler equation (see Whited, 1992).

The underlying Euler equation model (see Chapter I) describes an optimal path for investment given certain parametric adjustment costs. Accordingly, the marginal costs of investment in the present are set equal to the future's marginal costs of foregone investment. This approach prescribes that under perfect capital markets—i.e. under Modigliani-Miller theorem—a number of parameter restrictions must be verified (see Table A1, Appendix). Failure to verify such restrictions is interpreted as evidence of financial constraints. Note that these parameters are themselves functions of the model's structural parameters.

This test is then applied to a given subsample of firms. As with cash-flow sensitivity (CFS), researchers classify firms *ex-ante* as financially constrained based on a given variable (proxy) that is believed to clearly distinguish financially constrained from unconstrained firms. Accordingly, after deriving an empirical estimating equation from the underlying Euler equation model, one should be able to reject the parameter restrictions for groups of firms that are financially constrained. Conversely, for groups unconstrained firms, the parameter constraints should be met.[6] Applications of this methodology can be found, inter alia, in Bond and Meghir (1994) or Love (2003).

The main advantage of this approach over the traditional ICFS is that it avoids measuring Q, that may prove to be substantially difficult and confines the analysis to quoted firms. Additionally, the type of data required to the empirical test can be found in many datasets, as it is mostly based on information available in firms' balance sheets. However, the test is derived upon a large number of assumptions and on highly parametric models (see Coad, 2010a for a critique). Furthermore, the framework is based on parameter tests and does not directly produce a variable that can be used in subsequent estimations (see Section 3.2 for an index based on this approach). Finally, as in CFS approaches, *a-priory* classification schemes may be flawed due to non-monotonic relationships, endogeneity and aggregation issues regarding the proxy used.

2.4. Evolutionary test of selection forces

Recent trends, within Evolutionary theory, question the extent to which GCFS are indicative of the presence of financial constraints, rather than just a reflection of the selection process mechanism. They challenge the core assumptions of rational optimization and optimal size, present in models of Neoclassical inspiration—such as Q theory and Euler equation approaches. The rationale is that a firm's growth will depend positively on its "fitness", or in other terms, on their financial performance relative to others—which explains the positive GCFS found in the literature (see Chapter III). Therefore, it is natural to expect that the "fittest" firms will grow faster (see Coad, 2007).

[6] Within these parameters there is usually at least one that relates to the shadow cost of external finance (see Whited, 1992).

Firms have "bounded rationality" (e.g. Simon, 1991), in the sense that they make decisions based on the information they presently have, rather than based on future states. Within this perspective, only highly productive firms are able to identify highly profitable investment opportunities due to an higher knowledge stock, better routines and a set of capabilities (Coad, 2010a), that lead to a persistence of profit levels (e.g. Geroski and Jacquemin, 1988; Dosi , 2007). As a result, it is reasonable to expect a high correlation between profitability and investment opportunities—this rationale is in line with the argument that cash-flows contain information on investment opportunities (Alti, 2003).

Another implication of bounded rationality is that it no longer makes sense thinking in terms of "optimal size" or "optimal path of growth". In fact, firms always want to grow. Coad (2010a) notes that *"evolutionary firms are thus eternally financially constrained, irrespective of information asymmetries, simply because they would always prefer to be a little bit bigger than they currently are"*. Accordingly, the extent to which one finds a positive impact of a profitability measure (e.g. operating margin) on firm growth (e.g. sales), is only indicative of the workings of the selection mechanism. In other words, there is a correct reallocation of market share to the most productive firms.[7] If on the contrary, growth does not strongly respond to profitability (operating margin), then the selection mechanism is not selecting "the fitter" firms (e.g. Coad, 2007; Bottazzi et al., 2008).

However, we should note that the major force behind evolutionary dynamics is firms' ability to innovate (Schumpeter, 1939; Nelson and Winter, 1982; Nelson, 1995), of which one should stress radical innovation—where financial constraints are shown to be particularly severe (Czarnitzki and Hottenrott, 2011b). In this perspective, selection forces "unfit" firms to exit, therefore having a "cleansing effect". As a result, if there are external factors that inhibit firms innovation capacity (financial constraints), the selection process may drive out of the market firms that, even though having the right capabilities, did not have sufficient funds to overtake promising innovation projects. The extent to which financial constraints to innovation ultimately lead to the survival of inert big and established firms in detriment of vibrant new and small innovative firms, therefore distorting the selection process, is certainly a question that deserves our attention in the future.[8]

[7] Usually sales growth is preferred with respect to investment because it captures firms' intangible capital, knowledge and processes.

[8] Note that several empirical studies find a negative impact of financial constraints on firm survival as well as on innovation (see Chapter III).

2.5. Considerations on the data required

The type of data required to apply the methodologies described in this section is, essentially, information from firms' balance sheets. Despite the pitfalls of these approaches, it is certainly valuable that most National Statistical Offices are able to provide such information for very large (and representative) samples of firms operating in a certain region or country.[9]

However, for some of these approaches, one might also need information from financial markets (e.g. to compute average Q). In the event that such information is strictly necessary, the corresponding sample will only contain publicly traded firms. This has serious implications on the measurement of financial constraints. In fact, these firms are expected to be less financially constrained than untraded ones (see Chapter III, *Stylized result 9*). First, traded firms can easily issue equity and debt. Second they have more visibility and are eventually more credible at the eyes of other types of investors\lenders. Third, information on these firms is widely available and circulates in a more efficient way (Fama, 1970). This reduces information asymmetries, therefore having a crucial impact upon firms' ability to obtain external funding. This distinction between traded and non-traded firms is particularly relevant for countries with less developed capital markets such as Portugal.

Overall, we should reinforce that indirect measures have two main problems. The first results from the fact that these measures rely on (sometimes strong) theoretical assumptions needed to construct the underlying models for empirical equations. The second is a practical problem associated with the type of measure that is obtained from the estimations. In fact, none of the measures produces a variable that is firm-specific and time-varying. Conversely they only provide a test, based on regression coefficients (or parameters), for the presence of financial constraints within a group\subsample of firms.

3. Direct measures

As an alternative to measuring financial constraints in an indirect way, when available, a direct measure of financial constraints can prove to be a useful tool that avoids the theoretical and measurement issues described in the preceding section. However, there are specificities associated with this type of measures that one must bear in mind. In this section we refer to two possible ways of directly measuring financial constraints and discuss the implications of using them.

[9] Even for cross-country comparisons, it is possible, although not easy, to obtain such data from supra-national bodies (e.g. OECD or The World Bank), or to buy this information from specialized data collecting companies.

3.1. Company reports

Major firms usually provide a report along with their end-of year financial statement—at least those firms that are traded in stock markets are obliged to do so in most countries. These reports contain rich qualitative information regarding firm's financial position and need for external finance. This information allows researchers to assign each firm a level of financial constraints (e.g. Kaplan and Zingales, 1997; Hadlock and Pierce, 2010).

Here follows an example given by Kaplan and Zingales (1997) of a report of a firm classified as "not financially constrained": *"We ended the year in an exceptionally strong financial condition for a company of our size. During the year we paid off all long-term debt, and our cash and cash-equivalent assets have throughout the year exceeded all current liabilities."*

In practice, researchers gather a sample of firms with available company reports. The first step is to search these statements for keywords and expressions that are symptomatic of the presence of financial constraints (see Table A1, Appendix). Secondly, each firm is assigned a level of financial constraints according to the information reported. Finally, if possible, this qualitative information should be complemented with quantitative information (e.g. financial variables) in order to build a final score of financial constraints—in line with Kaplan and Zingales (1997).

While the major advantage of using this type of approach is the richness of information available for the researcher to sort firms according to their levels of constraints, the major drawback is related to the sample size and representativeness of corresponding samples. If on the one hand company reports provide rich and relatively accurate information, on the other hand it is difficult to obtain such information for a large number of firms. Reports are only made available by a small number of firms. Therefore, inferences to the population regarding financial constraints can not be made due to representativeness problems. Among other reasons, these particular firms are usually publicly traded. Accordingly, such firms will, in principle, not be as financially constrained as the untraded ones (see Chapter III, *Stylized result 9*).

Additionally, analysing company reports entails a significant amount of time and effort. In fact, even if reports were available for the whole population of firms, it would be extremely difficult (or virtually impossible) for the researcher to examine all of them with the necessary level of detail.

Finally, problems associated with managers misreporting may also be relevant in countries where managers may not be held liable for disclosure of false information, or whenever it is not possible to match the information from reports with quantitative data.

3.2. Self-evaluation: Survey data

The recent advances in data collection and availability have spawned a new wave of empirical literature that relies on business surveys to identify and measure firms' financial constraints—e.g. Savignac (2008); Beck et al. (2008).

The alternative to using firm reports as direct information on firms' ability to obtain external funds, is simply to ask firms whether or not they are financially constrained. This can be done either by a single question, directly asking firms about financial constraints (or access to external finance), or through a combination of a number of different questions. Such questions should regard, among others, the cost of external funds (excessive interest rates), credit denials and the availability of external financing sources. The latter approach requires the construction of a score based on the variables obtained from the different questions, following a given criteria.[10]

The main advantage of using this type of data is the fact that firms are the best informed agents with respect to the quality of their investment projects. Therefore one should expect that investment opportunities are already taken into account in firms' responses.[11] In addition to directly knowing firms' perception of constraints, unlike reports, one can measure constraints for small and young firms, provided that they are included in the survey's target population.

However, the subjective nature of the self-assessed variables means that potential biases, resulting from individuals' perception, may exist. As an example, we might have respondents that feel that their firm is highly financially constrained, when it actually is much less constrained than another firm reporting a low level of constraints.[12]

Furthermore, it is worthwhile noticing that, due to the non-linear nature of the resulting financial constraints variable, this measure can only be used as a dependent variable, with the appropriate non-linear regression technique. Nevertheless, the non-linear

[10] As a mere example, if we have 3 different questions, each one with 3 distinct degrees of response (3 different ordinal variables with 3 levels), a plausible criteria is to build a score of constraints with 3 levels. Firms that answered the maximum (minimum) degrees in all questions are assigned the level 3 (1). The remaining firms, that have mixed responses, are assigned the level 2.

[11] Note that deliberate missreporting should not be an issue since these types of surveys are usually anonymous.

[12] Some studies overcome this problem by using data on the credit requested and effectively granted (e.g. Russo and Rossi, 2001; Angelini and Generale, 2005).

nature of an independent variable can be partially overcome if one previously estimates the corresponding non-linear regression and obtains fitted values of the underlying latent variable—provided that suitable instruments are available and the regression has a good fit. However, in this case we would be working with an index (Section 3.1).

With respect to data availability, although in the past this type of information was rather scarce and with an insufficient level of detail (Claessens and Tzioumis, 2006), we should note that the recent financial crisis has encouraged surveys directly aimed at firms' financial constraints. Examples for the European case are the EUROSTAT's "*Access to Finance*" and the ECB's "*Survey on the access to finance of SMEs in the euro area*". We therefore expect availability of this type of data to be more frequent and detailed in the near future.

A somewhat different approach (when analysing the bank lending channel) is to ask financial institutions (notoriously banks), rather than firms, the extent to which firm credit was denied and for which reasons—see for example Del Giovane et al., 2010. In this approach, one has the advantage of knowing the reasons for credit denial (controls for lenders perception of risk and project quality). However, there are a number of reasons for which this measure is seldom used. First, it is rather difficult to obtain such data from banks or even specialized institutions (a rare example is the ECB's *"Bank Lending Survey For The Euro Area"*).[13] Second, if one wants to analyse the relationship of financial constraints with other aspects of firm behaviour, one has to match bank with firm level information. This is virtually impossible due to anonymity legal motives (data disclosure policies). Third, but related to the previous points, even if it possible to obtain bank-firm level data, the extent to which the sample will be representative of the population is rather questionable.[14]

These direct measures of constraints all share the advantage of being firm-specific and eventually time-varying—if the reports\surveys are collected periodically. Additionally, in contrast with indirect approaches, it is possible to use this type of measure either as a dependent or explanatory variable. However, the subjective and qualitative nature of these measures often calls for the use of quantitative information. As a result, it is advisable to combine these direct measures with firms' financial data. The resulting measures are often referred to as indexes.

[13] Note that this is a bank level survey, that does not contain firm-specific information. Therefore, one can only observe the evolution of the credit policies, demand and supply of funds within banks' perspective.
[14] As an example, for this to occur, cooperation with the vast majority of banks with desired levels of regional and industry representativeness (branch representativeness) would be necessary.

4. Indexes

In order to avoid some of the disadvantages of direct and indirect measures of financial constraints, the combination of different types of information and different variables into indexes provides a useful tool in the analysis of firms' constraints. The main motivations for the use of indexes is that they allow a firm-specific treatment of financial constraints, as well as they can be used either as dependent or explanatory variables, due to their continuous nature.[15]

4.1. With a qualitative dependent variable

The use of indexes of financial constraints is rather recent. This approach was, to our knowledge, first implemented by Lamont et al. (2001). They build on KZ's identification of constrained firms and scores of constraints (using company reports, see Section 3.1). Using KZ's ordered logit regression of financial constraints scores on relevant financial variables, they construct a firm-specific and time-varying index of constraints (known in the literature as the KZ index).[16]

The idea is that, given a qualitative variable of financial constraints, one can estimate the impact of a number of different determinants of constraints. These determinants are usually proxies that are expected to influence firms ability to obtain external finance (see Chapter III). Using the appropriate non-linear regression technique, one can estimate coefficients for each of the determinants of financial constraints.[17] Having these coefficients, it is then possible to construct an index that results from a linear combination of the determinants, weighted by the estimated coefficients (see Table A1, Appendix).

Even though the outcome is a continuous, firm-specific and time-varying measure of constraints, there are a number of problems associated with this approach. First, it relies on the availability of a qualitative dependent variable. Therefore, it also carries along all the sampling and subjectivity issues raised in Section 3

[15] Note that the Class Ranking Index (Section 4.2.3) is an exception.

[16] The index is given by $KZ_{it} = -1.002 * CF_{it} + 3.139 * B_{it} - 39.368 * D_{it} - 1.315 * C_{it} + 0.283 * Q_{it}$,where CF is cash-flow over total assets, B is long-term debt over total assets, D is total dividends over total assets, C is liquid assets over total assets and Q is Tobin's q.

[17] The estimation of the coefficient is based on a latent variable specification (since the dependent variable is binary\ordinal). See for example Greene and Hensher (2010) for details.

Second, the index is constructed using a specific sample of firms. Accordingly, it is not reasonable to expect that the index coefficients will remain unchanged if one intends to apply it to a different sample—see Chapter V for a discussion of the SA index (Hadlock and Pierce, 2010). Consequently, the index can not be universally used as a measure of constraints.

Third, unless the non-linear regression has a very good fit, the corresponding index will only provide a noisy signal of financial constraints. This bias will be particularly severe if there are a number of unobservable and\or omitted variables in the regression, that strongly determine financial constraints.

4.2. Without a qualitative dependent variable

In order to avoid the problems associated with the availability of qualitative data and sample specificity, a number of researchers have devoted their time to construct indexes of constraints that do not rely on this type of data. We summarize these indexes into the three following categories.

4.2.1. Euler equation index

Building on the Euler equation approach (Section 2.2), Whited and Wu (2006) construct an index of constraints that does not require qualitative information. Instead, they use a structural parameter of Whited's (1992) model—the shadow cost of equity finance—that is set to be a function of observable firm characteristics.

In practice, the strategy comes down to estimate the Euler equation model's resulting empirical equation. In this framework, the shadow cost of finance is set, outside of the model, to be a function of observable "financial health" variables. As a result, they obtain a vector of coefficients, that is then used to build the index (known in the literature as the WW index).[18]

[18] The index is given by: $\mathrm{WW}_{\mathrm{it}} = -0.091 * CF_{it} + 0.021 * B_{it} - 0.062 * \mathrm{D}_{it} - 0.044 * A_{it} - 0.035 * Y_{it} + 0.102 * IY_{it}$, where CF is cash-flow over total assets, B is long-term debt over total assets, D is an indicator of whether or not a firm pays cash dividends, A is the logarithm of total assets, Y is sales growth and IY is 3-digit industry sales growth.

Although the data requirements for the construction of this index are not particularly difficult to meet—essentially balance sheet data and financial markets information—,the major concern when using this approach is the fact that the index results from a highly parameterized structural model (as in Section 2.2). Additionally, due to the number of parameters involved in the underlying model, this approach is of far more complex implementation than any other measure discussed here. Finally, as in the preceding Section, we should note that the estimated coefficients (therefore the index) are sample-specific, thus they should not be applied to other economic realities.

4.2.2. MDA index

An alternative strategy that neither requires a qualitative dependent variable, nor a structural underlying model was implemented by Cleary (1999). Using multiple discriminant analysis (MDA), one can examine which variables are likely to influence the characterization of a firm as either financially constrained or not—in line with Altman, 1968 for the case of bankruptcy.

The procedure takes two steps. First, one should use a segmenting variable that enables the distinction of firms into two (or more) mutually exclusive groups. Second, use MDA to assess the ability of each independent variable (determinants of financial constraints) to distinguish a firm between groups. As a result, one can build the index using the coefficients estimated through MDA. Within the same rationale, one can use the segmenting variable to distinguish two (or more) groups of firms (e.g. financially constrained and non-financially constrained) and then estimate a probit\logit on the determinants of financial constraints. The resulting coefficients will then be used to build the index.[19]

The major drawback of this approach is the need to have a superior segmenting variable that correctly discriminate between financially constrained and unconstrained firms. Cleary (1999) assumes that dividend policy serves as such variable because firms reducing dividends are likely to be constrained, whereas a firm will only increase dividends if it knows it can maintain them (financially unconstrained).[20] However, if the segmenting variable does not consistently discriminate between constrained and unconstrained firms, the resulting index will biased. This problem is similar to the choice of a variable for an a-priory firm classification (Section 2).

[19] Note that multiple discriminant analysis is the predecessor of non-linear approaches such as the probit and logit. One can see the Z score as a latent variable of financial constraints, as in Section 4.1.

[20] Using this type of segmenting variable usually further requires information from financial markets, which may result in sample biases.

4.2.3. Class Ranking Index

An alternative to the traditional indexes of constraints, first introduced by Musso and Schiavo (2008), is to rank firms in a certain class (e.g. region or industry) that is believed to be reasonably homogeneous. These rankings are computed upon on a number of variables that are found to have a given relationship to financial constraints (proxies).[21] Therefore, one can build a score of constraints based on the relative rankings of a given number of variables for a certain firm, within a certain class. The motivation to disaggregate firms into homogeneous classes is to account for specificities that may affect the relationship of the proxies and the genuine level of constraints.

The procedure takes two steps. First, identify a number of variables that can serve as proxies of financial constraints—see Section 5.3. For each of these variables, compute the relative position of each firm to the corresponding class mean. Second, collapse the rankings from all the proxies into a single score of financial constraints. As an example, if a firm is very old and large, has a higher dividend payout ratio, it is considered not to be constrained. If the reverse it's true, then such firm is assigned as constrained. Intermediate levels may also be built based on the ranking—quantiles of these variables. Examples of this approach can also be found in Bellone et al. (2010) and Silva (2011b).

The first problem arises if we wish to use the score of constraints as a continuous variable. In fact, the score variable is of an ordinal nature. Nothing guarantees that the difference between a firm scoring 1 and 2 is the same as the difference between the levels 2 and 3. As a result, the score of constraints must be analysed as an ordinal variable, which has significant implications in the choice of the estimation procedure.

Secondly, if there are non-linearities in the relationship between the proxy and the effective level of constraints, the final score will misrepresent the level of constraints. As an example, while it is generally agreed that financial constraints are lower for larger and older firms, we point that such relationship might rather be non-monotonic (U-shaped). If this is the case, then we will have firms assigned the maximum score, while in fact they face a lower level of constraints.

[21] Musso and Schiavo (2008) construct their index based on the following variables: size (total assets), profitability, liquidity (current asset over current liabilities), cash flow generating ability (the maximum amount of resources that a firm can devote to self-financing), solvency (own funds over total liabilities), trade credit over total assets, repaying ability (financial debt over cash flow).

Finally, we should point that the disaggregation in relatively homogeneous classes of firms might entail considerable difficulties when comparing firms across classes. As an example, if the index is built on relative rankings for each industry, and if the less constrained firms in industry A is more constrained than the most constrained firm in industry B, one can not compare the scores of firms in industries A and B because of different benchmarks.[22]

5. Other approaches

5.1. Firm level cash-flow sensitivities

A recent strand of literature, based on the CFS rationale, tries to overcome the problems associated with aggregation, as well as *a priori* classification schemes that CFS approaches usually face. This approach consists in introducing firm-level heterogeneity in the measure of financial constraints, without the necessity to use qualitative data or heavily parameterized underlying models. Within this framework, two different methodologies should be mentioned. On the one hand Hovakimien and Hovakimien (2009), hereafter HH, suggested based on time averages weighted by cash-flow. On the other D'Espallier, Vandemaele and Peeters (2008), hereafter EVP, recommend the estimation of heterogeneous cash-flow slopes of a CFS regression.

The measure introduced by HH compares the time average of investment weighted by cash-flow, against the simple average investment. Accordingly, investment in years when cash-flow is higher receives a higher weight, which means that if a firm invests more (less) in years with higher cash flow, the HH index will turn our positive (negative). The reverse is also true. As a result, this measure is expected to capture the sensitivity of investment with respect to variations of cash-flow. The approach can also be extended to other types of CFS (Section 2.1).

However simple, this methodology fails to control for investment opportunities and other variables affecting investment. As an example, the ICFS test relies on the on the assumption that, holding investment opportunities constant, investment responds positively to cash-flow if a firms is financially constrained (no sensitivity should be found for unconstrained firms). Additionally this measure does not explore marginal effects (see D'Espallier et al., 2009 for a critique).

[22] Note that firms operating in some industries are, on average, more constrained than firms in other industries (Chapter VI).

A different perspective, introduced by EVP, is to estimate heterogeneous cash-flow slopes of a CFS regression. Using the same rationale of a CFS regression, one obtains a coefficient vector instead of a scalar. As result, we will have a cash-flow sensitivity for each firm. Accordingly, in contrast with the HH index, this methodology allows to control for a number of other relevant variables affecting the dependent variable (e.g. investment opportunities). However, the estimation of firm-level slopes requires refined estimation techniques that may introduce some complexity in the implementation.[23]

Nevertheless, both these methodologies share a couple of shortcomings. Even though they are firm-specific, the extent to which firms move from financially unconstrained to constrained states and *vice-versa* is not captured by these time averages. Additionally, they require that the underlying CFS methodology consistently identifies and measures constraints.

5.2. Credit ratings

Credit ratings are the evaluation given by certain agencies to firms. These ratings are the basis for establishing the cost of external funding of a given credit rated firm—either by private investors in capital markets or by financial institutions.

The main benefits from using credit ratings relate to the fact that they summarize a vast set of firms' characteristics, are firm-specific and vary over time, as well as they represent the opinion of the markets (e.g Bottazzi et al., 2008 for an application). Even though using this measure partially picks the credibility of a given firm in the market for funds, it has three major pitfalls.

First, it relies on the quality of the assessment of credit rating agencies. In other words, one must believe that these agencies correctly screen credible companies.[24] Second, these ratings are based on the credibility of a given firm at a certain time (mostly relying on past economic and financial information, as well as default events), therefore they may fail to capture the true quality of investment projects to be overtaken in the near future. Third, there are sample representativeness problems. Normally, firms that ask to be rated are usually large, mature and traded—we would expect them to be unconstrained, or at least, less constrained than other firms (see Chapter III). This problem can be partially addressed if, in the analysis of a larger sample that covers non-rated firms, we classify firms as constrained or

[23] EVP use a Generalized Maximum Entropy estimator after Golam et al. (2006), while D'Espallier and Guariglia (2009) use Bayesian econometrics (Lancaster, 2004, Koop, 2003 and Hansen et al., 2004).

[24] Note that the rating itself results from a multivariate score summarizing firms' characteristics.

not, depending on being rated or not, rather than on the rating itself. Once again, we might incur in significant biases if there exist unconstrained firms that avoid being rated simply because they do not want to depend on such ratings for obtaining external finance.

5.3. Proxies

The use of proxies is the simplest and most practical way to measure constraints. By definition, if a given variable is highly correlated with financial constraints, it may prove to be a good proxy. If a superior proxy is available, then it can easily be used as either a dependent or explanatory variable that is firm-specific and time-varying.

The large majority (if not all) of the empirical literature on financial constraints relies on a different variety of proxies either as explanatory or segmenting variables. Examples of commonly used proxies are the following: Cash-flow, Cash stocks, Size, Age, Export, R&D intensity, Leverage, Dividend payout ratio, Group membership and Ownership. (For a survey of the empirical findings regarding the relationship of financial constraints with other variables, please see Chapter III.)

Even though there exist different variables that correlate with financial constraints, a good proxy for financial constraints is rather hard to find (Cleary et al., 2007). Additionally, the use of proxies relies on previously devised relationships between financial constraints and the respective variable. Finally, if these relationships are non-monotonic, then the corresponding variable will only work as a good proxy for a subset of its space (see Section 2.2.4).

6. Conclusion

This Chapter overviews the existing methodologies used to identify and measure financial constraints. It is clear that the researcher has a wide range of different measures, with perhaps complementary advantages and disadvantages. Therefore it is hard to clearly point a superior approach. In fact, we would risk saying that there is no perfect measure of financial constraints. This scenario has serious implications on economic research and certainly on policymaking. First, while future research should definitely make an effort to develop better methodologies to assess firms' financial constraints, empirical work on this field should be cautious when providing conclusions and suggesting policy actions. Second, policymakers should not to take single studies as the sole basis for policy actions—such as subsidies, special lines of credit and credit guarantee schemes. Particularly, if such policies require redirecting public funds from other public goals and may even lead to market distortions in the event that funds are not allocated correctly to constrained firms.

Finally, this Chapter bridges the theoretical anchorage provided in Chapter I with the recent empirical findings described in Chapter III and our contributions to the literature, as detailed in Chapters V-VIII. We make use of different measures to identify and assess the level of financial constraints faced by Portuguese firms. Specifically, while in Chapter V we explore the ICFS and CCFS approaches, as well as the SA index, in Chapter VI we also resort to the HH index. Furthermore, while in Chapter VII we make use of CCFS, in Chapter VIII, using a specific survey, we are able to analyse financial constraints using both CCFS and a direct self-assessed measure of such constraints.

Appendix

Table II.A1. Methodologies used to assess financial constraints

Measures	Data	Strategy	Typical regression\question used	Advantages	Disadvantages	Example
Indirect						
ICFS (Coefficient)	BS, preferably matched with FM.	Split-sample or interact CF with variable of interest. ICFS provide the magnitude of constraints.	$\left(\frac{I}{K}\right)_{it} = \alpha Q_{it} + \beta \left(\frac{CF}{K}\right)_{it} + \varepsilon_{it}$ Alternative specifications, even though following the same ICFS principle, are also used. Examples are the accelerator and error correction models.	Easy to compute\estimate; Availability of data.	Consistency of theory behind empirical test; Is an average over time and firms (endogeneity and aggregation biases); Cannot use as dependent or explanatory variable; Not firm-specific; Not time-varying; Use of segmenting variable and endogeneity of *a priori* classification scheme.	FHP (1988) Scellato (2007) Guariglia (2008)
GCFS: Employment Sales Assets (Coefficient)	BS, preferably matched with FM.	Split-sample or interact CF with variable of interest. GCFS provide the magnitude of constraints.	$\left(\frac{\Delta G}{G}\right)_{it} = \alpha Q_{it} + \beta \left(\frac{CF}{G}\right)_{it} + \varepsilon_{it}$ Where G is the variable whose growth is analysed (e.g. total assets). Some authors drop Q (investment opportunities) and use CF as a proxy for financial constraints. Any sensitivity to CF is then interpreted as evidence of financial constraints. These are often referred to as reduced-form models.	Easy to compute\estimate; Availability of data.	Consistency of theory behind empirical test; Is an average over time and firms (endogeneity and aggregation biases); Cannot use as dependent or explanatory variable; Not firm-specific; Not time-varying; Use of segmenting variable and endogeneity of *a priori* classification scheme.	Carpenter and Petersen (2002) Oliveira and Fortunato (2006) Fagiolo and Luzzi (2006)
CCFS (Coefficient)	BS, preferably matched with FM.	Split-sample or interact CF with variable of interest. CCFS provide the magnitude of constraints.	$\left(\frac{\Delta CS}{A}\right)_{i,t} = \beta_1 \left(\frac{CF}{A}\right)_{i,t} + \beta_2 Q_{i,t} + \beta_3 \left(\frac{X}{A}\right)_{i,t} + \varepsilon_{i,t}$ Where X contains controls for firm's size as well as sources, demands and substitutes of cash.	Easy to compute\estimate; Availability of data.	Consistency of theory behind empirical test; Is an average over time and firms (endogeneity and aggregation biases); Cannot use as dependent or explanatory variable; Not firm-specific; Use of segmenting variable and endogeneity of *a priori* classification scheme.	ACW (2004)

(Continued)

Measures	Data	Strategy	Typical regression\question used	Advantages	Disadvantages	Example
Euler equation test (Parameters)	BS, preferably matched with FM.	Using an Euler equation model: For a given sample\ sub-sample check if parameter restrictions hold.	$\left(\frac{I}{K}\right)_{i,t+1} = \beta_1 \left(\frac{I}{K}\right)_{it} + \beta_2 \left(\frac{I}{K}\right)_{it}^2 +$ $\beta_3 \left(\frac{C}{K}\right)_{it} + \beta_4 \left(\frac{Y}{K}\right)_{it} + \beta_5 \left(\frac{B}{K}\right)_{it}^2 + \varepsilon_{it}$ Under the null hypothesis of absence of financial constraints, the following parameter restrictions should be met: β_1>1; β_2<-1; β_3<0; β_4=0 under perfect competition; >0 otherwise; β_5=0 under Mondigliani-Miller; <0 otherwise; These parameters are functions of the underlying model's structural parameters. We should note that the specification and corresponding parameter decision depend on the derivation of the specific Euler equation.	Availability of data; Avoids the necessity to estimate Q.	Consistency of theory behind empirical test; Cannot use as dependent or explanatory variable; Complexity; Not firm-specific; Not time-varying; Use of segmenting variable and endogeneity of *a priori* classification scheme.	Bond and Meghir (1994)
Evolutionary test of selection (Coefficient)	BS	If selection is present, growth should be associated with profitability ("growth of the fitter"). If not, the economy may not be reallocating market shares to the most productive firms.	$\left(\frac{\Delta Y}{Y}\right)_{it} = \beta \left(\frac{OM}{Y}\right)_{i,t-1} + \varepsilon_{it}$	Availability of data.	Does not test financial constraints but rather the selection mechanism; Cannot be used as dependent or explanatory variable; Not firm-specific; Not time-varying;	Coad (2007)

(Continued)

Measures	Data	Strategy	Typical regression\question used	Advantages	Disadvantages	Example
Direct						
Company reports (Ordinal)	Reports	Build a score based on information from qualitative financial reports. Qualitative may be complemented with quantitative information as in KZ (1997).	Search reports for keywords such as: *"financing, finance, investing, invest, capital, liquid, liquidity, note, covenant, amend, waive, violate, and credit"* (Hadlock and Pierce, 2010) Assign firms a classification of constraints according to reports.	Richness of information; Can be used as dependent variable; Firm-specific, and time-varying;	Requires exhaustive analysis of reports; Small and biased samples; Managers may misreport; Qualitative nature of data.	KZ (1997)
Self-evaluation (Ordinal)	Survey	Directly use the variable from the survey question or build a score from different survey questions regarding financial constraints.	Survey questions such as: *Classify the degree to which the lack of external finance hampered your projects.* *Classify the degree to which high interest rates on external finance hampered your projects.* *At the current interest rate do you want additional credit?* *Are you willing to obtain additional credit at higher interest rates?* *Have you seen credit requests being denied?*	Can be used as dependent variable; Firm-specific, and time-varying.	Subjective; Qualitative nature of data; Availability data.	Guiso (1998)
Indexes						
Qualitative index (Continuous)	BS matched with qualitative data (Reports or Survey)	Use qualitative information as dependent variable; Estimate parameters of the index using a non-linear regression of the qualitative variable on FC determinants.	Use a qualitative variable of financial constraints (normally a score\ordinal) and estimate a logit\probit. The underlying latent variable of financial constraints is given by: $FC_{it}^{*} = \beta_1 L_{it} + \beta_2 M_{it} + \varepsilon_{i,t}$ Therefore, financial constraints will depend on the variables L and M. The coefficients are then used to build the index of the form: $Index_{it} = \beta_1 L_{it} + \beta_2 M_{it}$	Can be used as dependent or explanatory variable; Firm-specific, and time-varying.	Availability data; Sample-specific; Non-linear regression must have a good fit.	Lamont et al. (2001)
Euler equation index (Continuous)	BS	Using an Euler equation approach: estimate the impact of observable financial variables on the model parameter of the unobserved shadow cost of finance (λ_{it}).	The unobserved shadow cost of finance (λ_{it}) of the Euler equation model is set to be a function of observable firm characteristics (used as instruments) such that: $\lambda_{it} = \beta_1 L_{it} + \beta_2 M_{it}$ Therefore, financial constraints will depend on the variables L and M. The index is built with the coefficients: $Index_{it} = \beta_1 L_{it} + \beta_2 M_{it}$	Can be used as dependent or explanatory variable; Firm-specific, and time-varying.	Sample-specific; Consistency of underlying structural model; Complexity.	Whited and Wu (2006)

(Continued)

Measures	Data	Strategy	Typical regression\question used	Advantages	Disadvantages	Example
MDA index (Continuous)	BS	Use a segmenting variable to perform MDA and assign firms into mutually exclusive groups; Estimate parameters of the index through the impact of variables that influence the assignment of firms into the different groups.	Determinants of financial constraints affect the score Z, that is used to discriminate groups: $Z_{it} = \beta_1 L_{it} + \beta_2 M_{it} + \varepsilon_{i,t}$ The variables L and M discriminate firms between mutually exclusive groups; The coefficients are used to build the index of the form: $Index_{it} = \beta_1 L_{it} + \beta_2 M_{it}$	Can be used as dependent or explanatory variable; Firm-specific, and time-varying.	Availability data; Use of segmenting variable.	Cleary (1999)
Class Ranking index (Ordinal)	BS	Build a score of a number of proxies, based on the relative position of a firm within a class (e.g. industry).	For each proxy L and M, the relative values to the class k average is L_{itk}/L_{tk} ; M_{itk}/M_{tk} The quantiles of order p of the resulting distributions are respectively $\xi_{F_L;p}$; $\xi_{G_M;p}$ Build scores $S_{i;L}$ and $S_{i;M}$ with 1/p classes for each proxy and each firm. Combine the proxy scores to obtain a final score of financial constraints (different types combinations are possible). The simplest is just the sum of scores: $S_i = S_{i;L} + S_{i;M}$	Availability of data; Can be used as dependent or explanatory variable; Firm-specific, and time-varying.	Comparability across classes; Non-monotonic relationships between proxies and financial constraints.	Musso and Schiavo (2008) Silva (2011b)

(Continued)

Measures	Data	Strategy	Typical regression\question used	Advantages	Disadvantages	Example
Other						
Firm CFS (Continuous)	BS	Mimic CFS types of measures through: i) time averages weighted by CF; ii) estimating firm-specific slopes of a typical CFS regression.	$HH_i = \sum_{t=1}^{n}\left(\frac{\left(\frac{CF}{K}\right)_{i,t}}{\sum_{t=1}^{n}\left(\frac{CF}{K}\right)_{i,t}} * \left(\frac{I}{K}\right)_{i,t}\right) - \frac{1}{n}\sum_{t=1}^{n}\left(\frac{I}{K}\right)_{i,t}$ OR $\left(\frac{I}{K}\right)_{it} = \alpha_i Q_{it} + EVP_i\left(\frac{CF}{K}\right)_{it} + \varepsilon_{it}$ Where β_i is the firm-specific index of financial constraints.	Easy to compute (HH); Availability of data; Can be used as dependent or explanatory variable; Firm-specific.	Not time-varying; Assumes CFS effectively measures constraints; Fails to control for investment opportunities and other relevant variables (HH); Requires different estimation techniques (EVP).	HH (2009) EVP (2008)
Credit Ratings (Ordinal)	Ratings	Match firm information with rating.	Use the credit rating available for each firm The rating represents the markets' perception of a firm's risk. Lower ratings signal higher financial constraints.	Availability data; Represents the market's perception; Can easily be used as dependent or explanatory variable; Firm-specific, and time-varying.	Relies on credit agencies; Small and biased samples (only few firms are rated).	Bottazzi et al. (2008)
Proxies (Continuous)	BS	Use one of established proxies in the estimation.	Common proxies: CF; Cash stocks; Size; Age; Export; R&D intensity; Leverage; Dividend policy; Group membership, Ownership, among others (Chapter III).	Simplicity; Availability of data; Can easily be used as dependent or explanatory variable; Firm-specific and time-varying.	Weak correlation; Relies on previously devised relationships; Non-monotonic relationships between the proxy and financial constraints;	

Notes: BS stands for firms' balance sheet information, FM for financial markets information, MDA for multiple discriminant analysis and CFS for cash-flow sensitivity. CF is cash-flow, K is capital, I is investment, Q is Tobin's Q or an appropriate proxy (such as average Q), C is real cash-flow, B is debt, A is total assets, Y is sales, OM is operating margin, i and t under scripts stand for individual (firm) and time, ε is an error term

CHAPTER III – WHAT DO WE KNOW ABOUT FINANCIAL CONSTRAINTS?

1. Introduction

What do we know about financial constraints? As shown in Chapter I, theory on the impact of financial constraints upon investment is old, but only recently it did experience a widespread of empirical applications. Moreover, with respect to the impact of financial constraints on firm performance, theoretical models incorporating such constraints—some incorporate financial market frictions, although financial constraints are a result of these frictions—are rather scarce. This may be due to the difficulties in objectifying the term "financial constraints" (see Chapter I).

Although the existing theoretical literature on the effects of financial constraints is extensive, in particular with respect to the investment literature, there is a large body of recent empirical literature that deserves our attention. This new wave of empirical studies has been mainly the result of increasing micro data available (in particular panel data) along with developments in the field of (micro)econometrics—not to mention the obvious renewed interest on the topic brought by the recent financial crisis. Additionally, one of the particular features of literature on financial constraints is the contribution from diverse fields of economics. Examples can be found in areas such as finance, business, economic growth or industrial dynamics.

The aim of this Chapter is to review the increasing empirical contributions on financial constraints, focusing on recent contributions that are expected to foster the formulation of theory on the field. Despite not being the ultimate goal of the Chapter to focus on theoretical contributions, we will provide theoretical explanations, whenever needed to understand a particular stylized result.

The framework chosen to tackle this task has been to pinpoint and discuss stylized results that have gathered consensus among empirical researchers. The Chapter will be organized as follows. Section 2 will prepare the ground for empirical evidence by providing a discussion over investment-cash flow sensitivities and other measures of financial constraints. Section 3 presents fourteen stylized results, while Section 4 raises some practical concerns that researchers in the field might find. Section 5 will pull the pieces together and concludes.

2. Investment-Cash Flow Sensitivity as a measure of financial constraints: An ongoing debate

The first issue raised when analysing financial constraints is the definition and measurement. While it is difficult to clearly define what is understood by financial constraints (see Chapter I), the rather abstract nature of the concept has challenged researchers to find consistent measures of the degree of financial constraints (see Chapter II).

Is Investment-Cash Flow Sensitivity (ICFS) higher for financial constrained or unconstrained firms? This is the same as asking whether or not is high ICFS a good measure of the presence of firm's financing constraints. The large body of empirical literature on firms' financial constraints, essentially came after the influential paper by FHP (Fazzari et al., 1988), who investigate the impact of cash-flow sensitivities on investment by classifying firms according to their dividend policy.[1] The reason for this classification lies on the argument that *"firms might pay low dividends [because] they require investment finance that exceeds their internal cash flow and retain all of the low-cost internal funds they can generate"*—see Chapter II. Using a pooled regression of investment/capital stock on the cash-flow/capital stock ratio, estimated Q—controls for investment opportunities (see Chapter I)—and dummies for each firm and year, upon a sample consisting of 422 USA firms (1970-1984), they found that the coefficient of cash-flow for the low-dividend group is higher and statistically different than the coefficient for the high-dividend group. This suggests that low-dividend firms invest more of their extra cash-flow than high-dividend firms. Building on this study, a large body of literature investigates the presence and the impact of financing constraints through ICFS. Carpenter et al. (1998), who compare three measures of financial constraints (cash-flow sensitivity, cash stocks and coverage ratio), find evidence confirming cash-flow as the preferred variable to test for the presence of financing constraints. Chapman et al. (1996) also find, for Australian firms, that investment is less sensitive to cash-flow when firms are financially unconstrained, while Bo et al. (2003), for a sample of Dutch listed firms, find that riskier firms face more severe financial constraints and argue that ICFS is a good proxy for financial constraints if "firms are classified by the degree of uncertainty they face and if the uncertainty originates from cost uncertainty".[2]

[1] Firms that pay low dividends are classified as financially constrained, while high-dividend firms are classified as unconstrained.

[2] Chapman et al. (1996) classify firms as financially unconstrained when a firm's net acquisition of financial assets exceeds its net incurrence of equity and debt liabilities.

On the other hand, KZ (Kaplan and Zingales, 1997) argue that cash-flow is not a good measure of the existence of financing constraints (see Chapter II). As an alternative, they classify firms according to information obtained from company annual reports and find evidence that constrained firms are the less sensitive to cash-flow.[3] This argument is also supported by Kadapakkam et al. (1998) and Cleary (1999). Almeida and Campello (2001) draw similar conclusions. Recently, Dasgupta and Sengupta (2007), for Japan, find that the response of investment to cash-flow shocks is non-monotonic, supporting Kaplan and Zingales (1997) and Cleary (1999). However, Allayannis and Mozumdar (2004) present an explanation for Cleary (1999) and Kaplan and Zingales (1997) argument that investment is more sensitive to cash-flow for less constrained firms—influential observations for Kaplan and Zingales and negative cash-flow observations for Cleary.

As pointed in Chapter II, recent literature has found the Investment-Cash Flow relationship to be U-shaped, further adding to the controversy about the interpretation of cash flow sensitivities. The rationale is that below a certain level of internal funds the risk of the firm defaulting is present and, as long as the revenues of the investment are large enough to allow the lender to be willing to provide larger amounts in order to mitigate the risk of the firm defaulting, a decrease in internal funds will lead to an increase in investment. Meanwhile, at higher levels of internal funds it is straightforward that such a decrease in internal funds will lead to a decrease of investment in order to avoid the costs of resorting to larger amounts external finance due to higher expected liquidation losses. Examples of these findings are Povel and Raith (2002), Cleary et al. (2007), Lyandres (2007), within a dynamic framework, and Guariglia (2008) for the UK (1993-2003 period, with 99% firms not traded) finds this relationship to hold for a wide range of industrial sectors.[4]

Finally, as noted in Chapter II, another group of literature points that cash-flows might contain information about firm's investment opportunities, meaning that Q should be corrected—e.g., Chirinko, 1997; Erickson and Whited, 2000; Gomes, 2001; Alti, 2003; Cummings et al., 2006; and Abel and Eberly, 2004.[5] This group of authors argues that firms have a high level of uncertainty about their investment projects quality and so cash-flow realizations reduce the level of uncertainty by providing new information and revealing the quality of such projects. Specifically, if this relation holds for certain groups of firms (which

[3] Kaplan and Zingales (1997) re-examine the low-dividend Fazzari et al. (1988) firms and categorize the firms as unconstrained, possibly constrained and constrained.
[4] Agriculture, forestry and mining, manufacturing, construction, retail and wholesale, hotels and restaurants and business and other services; excludes regulated and financial sectors.
[5] In particular for small firms, cash-flows reveal them the direction to go in presence of growth prospects uncertainty. Bond and van Reenen (1999) point that ICFS might also indicate other sources of misspecification.

appears to be the case for young and growth firms), then it is natural to expect high sensitivities of investment to cash-flow even if firms are not financially constrained. In particular, Alti (2003), in a model where financial frictions are absent, shows that, even after Q correction, firms present sensitivity to cash-flow. In addition, Bhagat et al. (2005) find evidence that financially distressed firms exhibit positive investment-cash flow sensitivities if they operate at a profit, low sensitivity if operate at a loss and invest less than in the previous year and strong negative sensitivity if operate at a loss and invest more than in the previous year, while Chang et al. (2007) find supportive evidence for the case of Australia.

Overall, since Fazzari et al. (1988) and Kaplan and Zingales (1997) the debate over the consistency of ICFS in measuring the degree of financial constraints has been intense and is still open for discussion (see Chapter II for recent approaches to measure constraints). Not only it led to a debate between the original authors (see Fazzari et al., 2000, and Kaplan and Zingales, 2000), but it also raised a number of both theoretical and empirical issues related to the topic—see for example the recent work of Hadlock and Pierce, 2010.

On the whole, the results and conclusions that several empirical studies have reached are always questionable on the very nature of the proxies and measures of financial constraints—see Chapter II for an overview of existing methodologies. Surprisingly, despite its limitations, ICFS still is the most commonly used measure. Accordingly, in the next section, when no reference is made to a different measure, the mentioned empirical contributions will be assumed to be using such measure. Keeping these caveats in mind, we were able to pinpoint 14 main results that reflect the topics that suffered major contribution during recent years.

3. Stylized results

Stylized result 1. Financial constraints are more severe for younger and smaller firms.

The problems with asymmetric information in capital markets are more severe for small and young firms. This will happen either because there is still not much information on these firms available to most potential lenders, or because of "weight" and visibility of such firms. Potential lenders are not able to observe the "quality" of the risk or do not have control over the firm's investment. Under these conditions, smaller and younger firms are expected to be more credit rationed, according to the models of Jaffe and Russell (1976) and Petersen and Rajan (1995), for example.

In fact, Hyytinen and Vaananen (2006), using firm self perception, find evidence that Finnish SMEs face severe adverse selection and moral hazard problems and that the former is empirically more prevalent than the latter. These problems, particularly the former, are found to restrict firms' ability to raise external funds needed to take advantage of investment opportunities. Although Kadapakkam et al. (1998), anchoring their results in investment-cash flow and investment-cash stock sensitivities, and Clearly (1999), for developed countries, find the opposite relationship (i.e. cash flow-investment sensitivity is highest in the large firm size group and smallest in the small firm size group), this result can possibly arise because "larger firms have greater flexibility in timing their investments and have more managerial agency problems" (Kadapakkam et al., 1998). Pratap (2003), resorting to dividend payout ratio, advances the hypothesis that adjustment costs explain possible insensitivity of small firms' investment-cash flow, as firms do not take major investments before they attain a threshold level of liquidity.

Egeln et al. (1997), classifying firms into financially constrained and unconstrained along with firm self evaluation and credit ratings, find evidence for Germany (1989-1994) supporting greater constraints for smaller and younger firms.[6] In addition, using a panel of small USA firms for the period 1980-1992, Carpenter and Petersen (2002) find that the typical firm retains all of its income and raises relatively little external finance and that, for firms that rely mostly on internal finance (90% of their sample), the impact of cash-flow on growth is greater than the unity, meaning that the growth of most small firms is constrained by internal finance. Even if for constrained firms cash-flow is independent of size, then growth will be independent of size, but the variance of growth rates will decline with size as larger firms appear to be less constrained to internal finance. Further supporting evidence is found in Oliveira and Fortunato (2006) who, using an unbalanced panel of Portuguese manufacturing firms (1990-2001), also find that smaller firms' growth is more sensitive to cash-flow implying the existence of financing constraints for such firms. Additionally, this finding also applies for younger firms. As to the overall sample, this sensitivity continues to be significant but lower.[7]

[6] Two classification schemes are used by the authors: self-evaluation and CREDITREFORM (largest credit agency by the time)

[7] Small firms are defined as those with less than 50 employees and young firms defined as with less than 10 years.

Although Audretsch and Elston (2002), for the German case from 1970 to 1986, find that the firms which report higher ICFS are medium sized, they argue that SMEs in Germany appear to benefit from a bank-oriented financial system and an institutional set that prevents smaller firms to face greater liquidity constraints.[8] Their study also confirms that very large firms do not appear to be liquidity constrained. In the case of Italian manufacturing firms (1989-1997), Becchetti and Trovato (2002), using a mix of proxies to measure financial constraints (namely leverage, subsidised investment, self evaluation, and credit rationing), find that while for small firms (<50 employees) the access to external finance is a key limiting determinant of growth, for larger firms (>100 employees) the financial factor appears to be neutral. Bhaduri (2008), resorting to ICFS and long term debt, also reaches the same conclusions for the Indian manufacturing case. Finally, Budina et al. (2000) find evidence suggesting that firms in Bulgaria (over the period 1993-1995) are financially constrained and in particular for smaller firms the constraints are more severe, while Honjo and Harada (2006), using cash-flow, leverage and the approval in a public incentives program to identify constraints, for a sample of Japanese manufacturing firms during the period 1995-1999, find higher growth-cash flow sensitivity for younger SMEs, confirming Ogawa et al. (1996) earlier findings.

As we will see in Chapter VII, we show that the relationships of size and age to financial constraints might in fact be non-monotonic (U-shaped) and not robust to economic sector disaggregation.

Stylized Result 2. Size distribution of firms is skewed due to financial constraints.

A set of studies concerning the evolution of firm size distribution focus on the idea that, contrary to the theorized by Gibrat's Law, growth rates and growth volatility are negatively associated with firm size (and age). One of the explanations lies on the financial constraints argument—one should expect that the presence of financing constraints leads to a skewed distribution of firm size. Cooley and Quadrini (2001) develop a model of financial market frictions in line with the models of optimal lending contracts (see Albuquerque and Hopenhayn, 2004) and find that smaller firms face higher probability of default, take on more

[8] Note that the authors divide firms into 4 classes according to their size (<500 employees; 500-1300 employees; 1300-5500 employees; >5500 employees) and thus the first class might be seen as small and medium enterprises (SMEs). Higher and most significant sensitivities are found for classes 2 and 3.

debt, issue more shares and pay fewer dividends, and have higher growth rates and volatility. So, they argue, imperfect markets will lead to a skewed size distribution of firms.

Using another framework, Cabral and Mata (2003) develop a model of heterogeneous constraints at the entrepreneur level and analyse the evolution of the distribution of firm size.[9] Their findings suggest that age has a significant influence upon the size distribution and, in particular, the younger firms/entrepreneurs are, the greater is the skewness of the distribution explained by the financial constraints.[10] Faggiolo and Luzzi (2006) reach the same conclusions using a sample of Italian manufacturing firms during the period 1995-2000, while Desai et al. (2003), following the rationale of Cabral and Mata (2003), for European economies in 1998 also support these results.

Stylized Result 3. Start-ups/new entrepreneurs appear to be financially constrained.

The founders of new firms, as being unable to raise the desired capital through their own wealth, have to apply for external finance. In order to finance such projects, banks, due to information asymmetry problems, require collateral as well as minimum equity-debt ratio levels that in their turn are difficult to be achieved by founders. This credit rationing eventually hinders the creation of such firms, possibly firms whose expected returns on investment are higher than interest rates charged on remaining capital required. For example, Heino (2006) finds that, in the Mexican case, there is evidence that start-ups are financially constrained, as there is a strong positive relationship between probability of entering the market and entrepreneurs using their own personal savings to finance the initial investment. Meanwhile, Blumberg and Letterie (2008), through an entrepreneur perspective in an application to the Dutch reality, find that there are a set of characteristics that banks take into account when providing credit to start-ups. In particular, personal wealth, home ownership, use of own capital in the initial investment and earning capacity, all reduce the probability of a bank credit being denied. They also point out that banks tend to prefer commitments and signals when deciding to lend and that decisions to apply, even with potentially very profitable projects, might not occur due to the fact that entrepreneurs might know in advance that their project will be denied, according to the characteristics that banks value most (financial aspects). In another perspective, Bohacek (2006) finds that business families have

[9] Note that they only allow for 2 periods and use entrepreneur's age as proxy for financial capacity. They argue that younger firms/entrepreneurs have higher probability of being financially constrained
[10] Their empirical results are obtained using a sample of Portuguese manufacturing firms in 1984 and 1991

high levels of savings that are explained by the incentive to overcome the financing constraint that prevents them from operating their firms at the optimal size. In recent papers, Magri (2009) and Nykvist (2008) find a positive relationship between personal wealth and entrepreneurship, respectively, in Italy and Sweden.

There is a body of empirical literature that points in the opposite direction. However, such conclusions might be flawed due to correlations between personal wealth and human capital. If human capital is shown to be highly correlated with personal wealth, then including both variables in the model might lead to the loss of explanatory power of one of them. This is what happened, for example, with Cressy (1996) and Kim et al. (2006), respectively for the UK and the USA cases. Grilo and Irigoyen (2006) also find that the perception of the lack of financial support has no power to explain latent entrepreneurship. Van Gelderen et al. (2006) find that one of the factors that affect negatively start-up success in Netherlands (1998-2001) is intended start-up capital. The interpretation in this case flows from the fact that is easier to raise smaller amounts to start a business, whilst potential successful entrants who require larger amounts of initial capital and have to resort to external financing, end up compromising their success.

Finally, van Auken, (1999) and Aghion et al. (2007) find financing constraints to work as a barrier to entry, even after controlling for other entry barriers. The reasoning is that capital requirements deter entry of new firms that have limited access to funds, in particular small firms.

Stylized Result 4. Financial constraints are determinant for firm survival.

The financial constraints faced by firms can obviously have important effects on the firm's ability to stay in the market. For example, Musso and Schiavo (2008), introducing a new index to measure financial constraints, find that, for French manufacturing firms over the period 1996-2004, the greater the financial constraints firms face, the higher the probability that they do not survive and then exit the market. With respect to the probability of default, using a sample of Italian firms during 1996-2003, Bottazzi et al. (2011), find that the lower it is the credit rating of a firm, the higher is the likelihood of defaulting. Additionaly, Cowling and Mitchell (2003), for the UK (1984-1998), find that failure is related to the cost of capital, with higher severity for smaller firms.

It is also widely accepted that the survival rate of entrants is low, which can be at least partially caused by financial constraints. Fotopoulos and Louri (2000) find evidence for Greek manufacturing firms established in 1982-1984 that initial financial capital and the ratio of fixed to total assets significantly lowers the probability of a firm dying, while leverage increases the probability of death. For the Portuguese case (in the period 1985-1998), in turn, Farinha (2005) finds that the probability of survival is lower for new firms that face financial constraints, have smaller initial capital, are more leveraged and have a higher number of credit relationships (as opposite to a stable relationship). She also points that the effects of financing constraints appear to be persistent in time. Petrunia (2007) draw similar conclusions for the Canadian case (firms birth between 1985 and 1995).

Pfaffermayr (2007) uses a sample selection model (generalized Heckman) to analyze σ-convergence in firm size. If no sample selection is taken into account there will exist a selection bias towards the surviving firms, so the growth rates of young and small firms would be overestimated. Controlling for this bias, he finds that σ-convergence only occurs for younger firms, survival is positively related to initial size, though the impact is small and not significant, and that "financial constraints and revealed underperformance reduce the probability of survival, as expected".

Finally, it might be reasonable to argue that financial constraints also have a (negative) indirect impact on firm survival. In fact, start-up size is generally accepted to have a positive impact on survival (smaller entrants face higher probabilities of failure; see for example Audretsch and Mahmood, 1995, for the USA, and Mata and Portugal, 1994, for Portugal) and one of the main determinants of start-up size is external financing (see Colombo and Grilli, 2005, for the Italian case and Eisfeldt and Rampini, 2007, for the USA case). However, further research considering this hypothesis is warranted.

Stylized Result 5. R&D investment appears to be more financially constrained.

The existence of financial constraints appears to be particularly severe for firms that decide to invest in R&D because of the high risks associated with the investment (typically longer term projects with uncertain outcomes). As argued before, credit markets will no longer be efficient, generating a wedge between internal and external financing faced by firms as well as a financing hierarchy. This problem is usually associated with Akerlof's (1970) adverse selection in the "market for lemons" (see also Leland and Pyle, 1977, and Myers and Majluf, 1984, for information asymmetries in R&D financing). The informational problems in this type of investment are further amplified because firms are reluctant to provide information about their projects, as it might entail a loss of a potential comparative advantage to their competitors. Moreover, the intangible assets generated by R&D investment are difficult to be used as collateral. In particular, Almeida and Campello (2004), argue that firm's investment will usually increase their borrowing capacity, which is higher for firms who create assets with higher tangibility. As a result, investment in intangible assets, which is the case of R&D, will not entail a multiplier effect, as do investments in more tangible assets—see Chapter VIII for a more detailed discussion.

Empirical contributions comprise Hall (1992), Hao and Jaffe (1993) and Himmelberg and Petersen (1994) that for the USA firms, find support for the hypothesis that R&D investment is financially constrained in particular for small firms. Hall et al. (1999) in a comparative study of French, Japanese and the USA firms also sustain these findings, while Kukuk and Stadler (2001), analysing the lack of equity funds, find that financial constraints adversely affect the timing of innovations for German services firms. Czarnitzki (2006), despite being a cross-sectional study and resorting to measures such as price-cost margin (a proxy for cash-flow), credit ratings and public funding, also finds that, in the West Germany case, SMEs' R&D investment is financially constrained. Mohnen et al. (2008) for Dutch firms in the period 2000-2002 and Savignac (2009) for French firms in the period 1997-1999, both using firm self assessment of financial constraints, find that such constraints significantly reduce the likelihood of firms having innovative activities. In the Italian case, both Scellato (2007) and Colombo and Grilli (2007) find that most new technology-based firms finance their initial activities through founder's wealth.

When compared with physical capital, R&D appears to be more financially constrained. As pointed by Hall (1992), due to the risky nature of R&D, firms prefer to finance their projects with internally generated funds. Using the same unbalanced panel of the USA firms (1959-1991), Chiao (2002) tests this hypothesis dividing firms into two classes: science based and non-science based. He finds that, in fact, while there is a positive relationship of current debt and current physical capital investment, the relationship between current debt and current R&D depends on the type of industry where the firm is operating. In particular, for science based industries, current R&D has a negative relationship with debt. Bougheas et al. (2003), analysing net profits and long-term debt, also find evidence of financing constraints in R&D investment in Ireland, while they do not find evidence of constraints for investment in physical capital.

Stylized Result 6. Government policy to alleviate financial constraints seems to work.

Despite the inefficiencies that public intervention might cause, subsidies through tax credits or grants and credit guarantees appear to reduce the severity of financial constraints faced by firms.[11] Becchetti and Trovato (2002), for Italian SMEs, for example, suggest a positive impact of subsidies on alleviating firms' financial constraints, while Li (2002) reaches the same conclusions analysing the USA Government credit subsidies to poor and capable entrepreneurs. Honjo and Harada (2006), for Japanese manufacturing firms during the period 1995-1999, also observe that public programs to foster SMEs have a high and positive impact in their growth. Following Hall's (2002) suggestion that public incentives to R&D might have an alleviating effect on constraints, Czarnitzki (2006) investigates SMEs in Germany (1994, 1995 and 1998) and finds that, while in West Germany SMEs' R&D investment is financially constrained, in East Germany where public subsidies seems to be the driving force behind R&D investment, firms appear not to suffer from external finance constraints. In the case of the USA and Canadian firms, Klassen et al. (2004) observe that tax incentives to foster R&D have a positive impact in the R&D spending. With respect to R&D and innovation subsidies, in Chapter VIII we provide a more detailed overview of the literature.

With respect to credit guarantees, Cowling and Mitchell (2003), analysing the impact of backed debt contracts on default probabilities for the UK firms, find that the policy undertaken by the Government was successful in alleviating a very real capital constraint for the majority of small business, while Kang and Heshmati (2008) observe that a Korean public policy providing credit guarantee to SMEs had significant impact on survival of the latter. Guaranteed firms had clear higher survival rates and better performance. Zecchini and Ventura (2009) also find that Italy's credit guarantees on credit to SMEs has reached to reduce their borrowing cost and easing their financing constraints.

[11] Public financial support can be regarded as an additional source of external funding—see Chapter I.

However, the major pitfall in the majority of these studies (noticeably those regarding innovation), results from the fact that the impact of subsidies (and other forms of public financial support) on financial constraints is not directly measured—perhaps due to difficulties in measuring constraints (Chapter II). Instead, the conclusion that subsidies mitigate financial constraints is drawn from the observation of the positive impact of subsidies on other variables such as firm growth (e.g. Becchetti and Trovato, 2002), survival (e.g. Kang and Heshmati, 2008), or R&D investment (e.g. Klassen et al. 2004). As we will see in Chapter VIII, our results cast some doubts on the validity of this *Stylized Result*, when it comes to innovation subsidies

Stylized Result 7. Financially constrained firms hold more cash.

Almeida et al. (2004) suggested that financially constrained firms save cash for precautionary motives and to be able to take advantage of future investment opportunities (see Chapter I). Additionally, in the presence of financial constraints, cash should not be a perfect substitute of debt due to a premium in the costs of the latter—that results from information asymmetries. As Acharya et al. (2007) point, cash can only be seen as negative debt in the absence of financial market frictions.

Because holding cash entails an opportunity cost associated with foregone investment opportunities, firms should undertake financial policies consisting of low cash holdings (DeAngelo and DeAngelo, 2006). Conversely, there is substantial evidence from the literature that analyses the determinants of cash holdings (e.g. Opler et al., 1999), that firms holding more cash are financially constrained. Examples can be found in Faulkender and Wang (2006) and Denis and Sibilkov (2010) for U.S. public firms, Bigelli and Sánchez-Vidal (2012) for Italian private firms, Arslan et al (2006) for publicly traded Turkish firms, as well as Ferreira and Vilela (2004) for firms in European Monetary Union countries.

Furthermore, evidence that firms hold more cash for precautionary motives can be found, for example in Han and Qiu (2007) or McLean (2011), while Hahn (2010) supports that holding liquid assets may work as a good hedging policy for firms, when there are imperfections in financial markets. Finally, Kusnadi and Wei (2011), find that in countries with strong legal protection of investors (that reduce financial constraints) firms hoard less cash than in countries with weaker legal protection.

Stylized Result 8. Close bank relationships alleviate financial constraints.

Close bank relationships facilitate the contact between firms and banks, reducing the information asymmetries, which means lower financing constraints for firms with close but few relationships (in particular if such relationships are stable). As Diamond (1991) argues, the risk associated with any particular loan is not neutral with respect to the duration of the relationship. Additionally, Petersen and Rajan (1994) argue that close ties with an institutional creditor increases the availability of financing and find that multiple bank relationships significantly increase the interest rate charged on loans. This evidence is corroborated, for example, by Farinha (2005). Further adding to the argument, banks play a central role in the management of some firms by being shareholders, especially for the case of larger firms.

In another perspective, because of the role that close bank relationships play in alleviating financial constraints, one can expect differences in constraints between market-oriented economies (such as the USA and the UK) and bank-oriented ones (Germany for example). In fact, Fohlin (1998), in an historic perspective (1903-1911), finds that Germany's close bank relationships had a significant impact in reducing financing constraints. Bond et al. (2003a) analyse ICFS of firms in Belgium, France, Germany and the UK and they find that, while for Belgian firms there is no evidence of firms facing financial constraints, there is strong evidence suggesting that firms in the UK face severe financial constraints.[12] For the French and German case, there still exist significant financial constraints but to a lesser extent than the UK case. This finding adds to the hypothesis that a bank-oriented financial system (continental case) lightens constrains on (usually small) firms, when compared to a market-oriented system. The same rationale is used by Audretsch and Elston (2002), who find that the firms that report higher ICFS are medium sized.[13] They argue that this results from the fact that SMEs in Germany appear to benefit from a financial system that is bank-oriented and an institutional set that prevents smaller firms to face greater liquidity constraints. Recently, in a study comparing 11 OECD Countries covering the years 1993 to 2000, Semenov (2006) also gives supportive evidence of the presence of greater financial constraints in market-oriented economies.

[12] Have high significant cash-flow sensitivities and strongly rejects the Euler's equation null hypothesis of no financial constraints.
[13] Note that the authors divide firms into 4 classes according to their size (<500 employees; 500-1300 employees; 1300-5500 employees; >5500 employees) and thus the first class might be seen as small and medium enterprises (SMEs). Higher and most significant sensitivities are found for classes 2 and 3.

Stylized Result 9. Publicly traded companies face lower financial constraints than non-traded ones

Even though this result is highly related to financial development (*stylized result 10*), we highlight it because of its important practical implications. The reasons underlying lower financial constraints for traded firms are quite straightforward. First, traded firms can easily issue equity and debt. Second they have more visibility and credibility to investors (lenders). Third, information on these firms is widely available and circulates in a more efficient way (Fama, 1970). This reduces information asymmetries and information costs, therefore having a crucial impact upon firms' ability to obtain external funding.

In fact, Pagano et al. (1995), for Italian firms, analyse the impact of the decision to go public and find that borrowing costs decline after firms go public. Examples of corroborating evidence can also be found in Gilchrist and Himmelberg (1995) and Schenone (2010) for the U.S., Kim (1999) for small Korean manufacturing firms, Zia (2008) for Pakistanis exporting firms, or Saunders and Steffen (2011) for U.K. firms. The latter also argue that the result drives from higher costs in information production for private firms. This result is particularly relevant because it tell us that whenever using solely traded firms—which is quite common in this field—one should not make inferences with respect to the population of firms due to selection bias.

Stylized Result 10. Firms are less financially constrained in economies with more developed financial markets

It has been argued that financial constraints arise with imperfect financial markets owing to asymmetric information between firms and finance suppliers, leading to adverse selection and moral hazard problems and thus to a wedge between the costs associated with internal funds and those associated with external finance. As a result, one can expect that firms operating in countries with less developed financial markets will be more exposed to the constraints as there will be a greater amount of frictions in the market.

Before we continue with the analysis we must firstly clarify what is meant by the development of financial markets. Assuming Mondigliani-Miller's perfect capital markets as a benchmark, financial market development would comprise every efforts made in order to achieve it. As examples we have financial innovation (new instruments and new mechanisms within the financial sector), development of financial institutions or increasing market efficiency (the speed at which the market reacts to new information). It is also important to distinguish financial market development from financial liberalization. Despite being two related processes, financial liberalization is usually associated with the governance of the country in analysis (Auerbach and Siddiki, 2004) and the existence of different degrees of development is distinct from a policy of liberalization. The effects of the latter are quite controversial and thus interesting per se, so they will be discussed separately in *stylized result 11*.

With respect to financial market development, Oliveira and Fortunato (2006) point out that one of the reasons why Portuguese manufacturing firms are financially constrained, particularly small and young ones, might be due to a relative underdevelopment of capital markets in Portugal when compared to the USA or the UK (firms in Portugal rely mostly on banks for external finance). In the same line, Hutchinson and Xavier (2006) compare the role of internal finance in Slovenia (a leading transition country with still less developed financial markets) with the mature market economy of Belgium. They find that Slovenian firms' growth is more sensitive to cash-flow than Belgian, with the sensitivity being greater for the case of small firms in either country. Also for Eastern European countries, Budina et al. (2000) for Bulgaria and Konings et al. (2003) for Poland, Czech Republic, Bulgaria and Romania, identify high ICFS, possibly indicating the presence of relevant financial constraints.[14] Desai et al. (2003), comparing the skewness of distributions between Western, Central and Eastern Europe, as well as particularising for the UK case, also support these results. Hartarska and Vega (2006) and Hartarska and Nadolnyak (2008), respectively, for Russia and Bosnia-Herzegovina, find higher ICFS for firms that had no access to microfinance, vital in less financially developed economies.

In addition, for a sample of harmonized firm-level data for 16 industrialized and emerging countries, Aghion et al. (2007) also reinforce the importance of the development of financial markets in allowing the access to external finance for small firms. [15] They also stress the impact that financial constraints do have for entry of small firms, working as an entry barrier. Meanwhile, Islam and Mozumdar (2007), for a sample of 31 countries covering the period 1987-1997, provide evidence consistence across different measures of financial development and different measures of financial constraints and cash-flow that confirms that

[14] Konings et al. (2003) also find that firms in Poland and Czech Republic experience higher ICFS than in Bulgaria and Romania (explained by soft-budget constraints).

[15] Specifically Argentina, Denmark, Chile, Colombia, Finland, France, Germany, Hungary, Italy, Mexico, the Netherlands, Portugal, Romania, Slovenia, the UK and the USA.

investment is more sensitive to cash-flow for firms in economies with less developed financial markets.[16] Love (2003) also supports this evidence for a sample of 40 countries.

On another perspective, Haas and Peeters (2006) show that, for ten transition economies,[17] firms increased their leverage during the transition period in order to reach their optimum target leverage level, despite many firms still prefer internal funding due to information asymmetries in the market for cash. These results imply that, before transition, firms were operating below optimal leverage levels and thus suffered from external finance constraints.

With respect to regional financial development, in a comparison between southern and northern regions of Italy, Sarno (2005) finds that SMEs in the less financially developed southern Italian regions are more severely affected by credit constraints. Guiso et al. (2004) also for the Italian case, analysing the impact of local financial development, confirm that the development of local financial markets has a major impact in relieving financial constraints in particular for smaller firms that have no access to broader capital markets.

Stylized Result 11. Financial liberalization seems to alleviate financing constraints of firms, especially for smaller ones.

In the economies where financial markets are overregulated, several inefficiencies arise due to information hampering along with heavy bureaucratic procedures. Usually, financial liberalization facilitates the access of firms to credit, especially small ones, by reducing the institutional barriers and transaction costs in the market for credit. However, one must also take into consideration that financial liberalization might allow the lender to “hide” the real risk of the assets, allowing them to accept projects with higher risk.

On one hand, Gelos and Werner (2002), analysing the Mexican manufacturing sector for the period 1984-1994, find that investment was generally financially constrained and that liberalization eased the access of small firms to external funds (note that large firms previously had a preferential treatment). Bhaduri (2005) and Ghosh (2006), both using cash-flow and leverage measures, also show that financial liberalization in India during the 1990s alleviated financial constraints faced by manufacturing firms, in particular for small ones.

[16] Islam and Mozumdar (2007) use three different measures of financial development: the first is based on the stock market capitalization to GDP held by minorities (not owned by the top 3 shareholders), the second is based on the aggregate size of equity and credit markets to GDP and the last makes use of accounting standards.

[17] Namely Estonia, Slovenia, Latvia, Lithuania, Slovak Republic, Bulgaria, Hungary, Czech Republic, Romania and Poland.

Several other studies, that resort to different measures of financial constraints, all report that financial reform caused a reduction in financial constraints, for instance: Harris et al. (1994) for Indonesia, Guncavdi et al. (1998) for Turkey, Laeven (2002) and Koo and Maeng (2005) for Korea and Wang (2003) for Taiwan. In an opposing direction of liberalization, Forbes (2007), recently showed that Chilean capital controls increased financial constraints for small firms.

There is, however, some mixed empirical evidence on the effect of financial liberalization on firms' investment. Laeven (2003), for a large sample of firms in 13 developing countries, finds that financial liberalization affects firms differently: while it relaxes financial constraints faced by small firms, it results on the opposite for larger ones.

Finally, with respect to securities regulation, MacIntoch (1994) identified legal and institutional barriers to financing innovative companies in the USA and Canada. Chiu (2003) for Canada and Europe and Cohn (1999) for the USA also find supporting evidence of the negative effects of regulation in aggravating firms' financial constraints.

Stylized Result 12. Recessions and financial crisis increase financial constraints, and disproportionally affect constrained firms

The recent financial crisis has brought a wave of new empirical evidence on the effects of financial constraints on firm behaviour. Recessions, associated with a lack of liquidity, disproportionally affect financially constrained firms. As leading example, Campello et al. (2010), using survey data on chief financial officers in the U.S., Europe and Asia, find that constrained firms significantly cut more dividends and reduce their cash savings in order to face the tightening financial conditions. Additionally, they find evidence that these firms' investment, innovation and employment policies were severely affected, when compared to unconstrained firms. As another example, Ang and Smedema (2011) use an U.S. sample to investigate firms' financial flexibility during recessions and find that cash poor and financially constrained firms are unable to prepare for recessions, in contrast with unconstrained firms. This finding is complemented by evidence that industries more dependent on external finance grow at a slower pace than firms in other industries (Kannan, 2011).

Within the lender perspective, Chava and Purnanandam (2011) for the U.S. and Minamihashi (2011) for Japan, stress the role of bank failures in potentiating the effects of financial crisis. On the other hand, Santos (2011) points that, after the recent crises, banks disproportionally increased their interest rates on bank-dependent borrowers—when compared to other firms.

Stylized Result 13. Firms that belong to a business group have lower financial constraints

While on the one hand, conglomerates allow their affiliates to have higher visibility in the credit market (e.g. Dewenter et al., 2001), they also form an internal capital market (e.g. Stein, 1997; Khanna and Palepu, 2000). This internal market for funds within the group, even though not totally efficient (Shin and Stulz, 1998), allows to shift funds to wherever investment opportunities arise, or to overcome negative shocks in an easier manner (Hovakimien, 2011). Gorodnichenko et al. (2009) finds that business groups in Germany reduce financial constraints especially for small firms. Lensink et al. (2003) find the same results for Indian firms, while Manos et al (2012) analyzing Indian firms' and business groups' dividend policy find that business groups reduce financial constraints, even though not completely. This recent evidence complements previous findings such as those of Lamont (1997) for US oil companies, Shin and Park (1999) for Korea or Hoshi et al. (1991) for Japan.

Stylized Result 14. Foreign-owned firms are less financially constrained than domestic ones.

Firms that have access to foreign capital markets are expected to be less financially constrained than those that have to resort solely to national capital markets, thus facing information asymmetries and severe financial constraints. Ownership (national versus foreign) is believed to create a wedge between firms that have access to outside markets (foreign-owned) and those that do not. Resorting to leverage, Blalock et al. (2008), for example, find evidence for Indonesia (following the 1997 East Asian financial crisis) suggesting that firm ownership is an important determinant of investment as foreign ownership is associated with firms not being financially constrained. Colombo and Stanca (2006) also observe this wedge in budget constraints for firms in Hungary over the period 1989-1999. The introduction of financial reforms in the country leads domestic firms to face stronger constraints with respect to foreign-owned firms. Public firms (particularly small ones), however, were unaffected and remained under soft budget constraints. Hutchinson and Xavier (2006) show that foreign owned firms in Slovenia are less constrained and Ruiz-Vargas (2000) corroborate these results for the case of Puerto Rico.

In another perspective, Desai et al. (2007), compare multinational affiliates and local firms in the U.S. during currency depreciations (over the period 1991-1999) and find that multinational affiliates are better off than local firms by being able to exploit investment opportunities raised by currency depreciations as they are not limited to the internal market for funds. In some cases, the parent multinational may even provide equity to its affiliates. Finally, Beck et al. (2006), using a firm-level survey conducted in 1999 and 2000 over 80 countries, find that domestic firms report higher financing obstacles.

4. Measure problems and conceptual issues

We shall briefly address some empirical problems and conceptual issues, mostly related to data and sampling that are often raised when analysing financial constraints faced by firms. Firstly, when analysing small firms or SMEs, because of diverse definitions, it is important to precise what does "small" mean. Just to illustrate, a small firm might mean a firm with less than 5, 20 or 50 employees and a "small firm" in the USA is different from a "small firm" in Europe.

Secondly, one must be aware of the data source and the dismal sample. Most studies focus solely on firms in the manufacturing sector or firms that are publicly traded (both are the easiest samples to obtain). This reduced samples, might generate biases if one expects to draw conclusions for the whole economy. As an example, if one investigates if financial constraints are more severe for smaller firms using traded firms it is reasonable to expect that the observed firms will not be as constrained as if the sample included non-traded firms.

Thirdly, when analysing start-ups, it is difficult to identify potential entrants and obtaining their financial status information. One only observes firms that indeed overcome entry barriers (stressing the financial barrier). As a result, firms that did not overcome the entry barriers are not taken into account.

Fourthly, several problems emerge in survival analysis: (a) length biased sampling – if using stock sampling, one may not observe firm dynamics in between sample periods, thus survival rates tend to be larger; (b) repeated entry – one must consider *de novo entry* as not independent of previous failures (usually this is not taken into account); (c) death definition – firms may exit the sample even if they have not died (using two missing observations in a row to define death, as it is usually done, probably will not expurgate all other exits).[18]

[18] For more on exit definition see Carreira and Teixeira (2011).

Fifthly, significant problems arise when we use ICFS to test the presence of financial constraints faced by firms. In particular, we must reinforce that using Q theory derived models might entail significant mismeasurement errors due to the estimation of Q—see Poterba, 1988, Erickson and Whited, 2000, and Alti, 2003, for a discussion.

Finally, consistent financial constraints classification is a major issue of investigation. Financial constraints are an abstraction, so researchers use proxies and indexes that allow them to identify and measure the degree of constraints. Most of this measures result from previous empirical findings suggesting a strong association between variables. Additionally, research in the field has continuously been casting serious doubts on the validity of previous measures. As a striking example we have the newish Hadlock and Pierce (2010) paper that tests the KZ and WW indexes, ICFS and ACW measures by developing an appellative new index that focus on firm size and age—that are usually correlated with financial constraints and, as they argue, are "more exogenous" than other components considered—and compare it with previous indexes. They find that that the correlation between their SA index and the KZ index is almost nil, while the correlation between the SA index and the WW index is mainly due to the inclusion of size in the former index. With respect to the ACW measure, they corroborate the consistency of such measure. Accordingly, the diversity of measures that one can find in the literature, as it was discussed in Section 2, is perhaps a signal of the difficulties that researchers face to find consistent measures of constraints. Therefore, the field is still open to discussion.

5. Concluding remarks

Financial constraints are a widespread key concern for firms, hindering their ability to carry out their investment and growth. In particular, the difficulties in obtaining external funds seem to be highly dependent upon firm's ownership (national versus foreign), age and size, as well as in a set of institutional characteristics such as the structure and development of the financial system. Nevertheless, the recent financial crisis has provided evidence that financially constrained firms are particularly affected by downturns. In addition, financial constraints appear to have a determinant impact upon firm dynamics of entry (through start-ups/entrepreneurial activity) and exit (through firm survival), as well as on R&D investment. In order to alleviate these constraints, public policy, either by subsidies and credit guarantees or by improving financial market efficiency seems to be effective. Furthermore, financially constrained firms usually hold more cash, while belonging to business groups and becoming publicly traded may reduce such constraints.

Nevertheless, financial constraint analysis is still subject to much debate as most empirical studies of these effects not only deal with a set of measurement and conceptual issues, but also rely upon a fragile relationship built to identify the presence and severity of financial constraints (see Chapter II).

Overall, given the theoretical (Chapter I) and methodological (Chapter II) discussions, this Chapter overviews the state of the art developments in financial constraints literature. Therefore it is crucial for the understanding of Chapters V-VIII. These Chapters will depart from existing literature and contribute with new empirical evidence on the relationship between financial constraints and firms' characteristics, as well as on the impact of constraints on firm behaviour.

CHAPTER IV – DATA

1. Data sources

The data used in this thesis was drawn from different data sources made available by the Portuguese National Statistical Office (INE), to whom we are very grateful. Specifically, we make use of the following three main sources:

i) *Ficheiro de Unidades Estatísticas* (FUE) is a database that registers information on all firms operating in Portugal. It is updated annually and provides specific information to characterize firms—e.g. year of constitution, location, industry classification, status of activity. Since this database covers the universe of Portuguese firms on an annually basis, and comprises a coded number (provided by INE) that uniquely identifies firms, it allows us to track firms through time. Therefore, this source not only provides crucial information on firms' generic characteristics, but, most importantly, allows us to match the different annual surveys as well as information from different sources.

ii) *Inquérito às Empresas Harmonizado* (IEH) is a business survey (since 1991) to active Portuguese firms conducted annually by INE. This survey is of compulsory response to all enquired firms. It contains information for all firms with more than 99 employees, and a random sample of firms with less than 100 employees. Sample stratification is based on location (at the NUTS II level), industry (CAE rev. 2.1 at the 4-digit level) and size (employment).[1] This source provides financial information from firms' balance sheets that is crucial to the identification of financial constraints. We should note that at the beginning of this study only data until 2004 was available. Additionally, the survey suffered major methodological changes made by INE in 1996 and 2004. Therefore we restrict our sample to this period. We intend to extend our analysis, once information on recent years is made available.[2]

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[1] For the representativeness of firms by industry to be assured, in some cases stratification is done at a higher level (e.g. 3-digit), due to a reduced number of firms in such industries. Additionally, for firms with less than 100 employees, the sample is further stratified into two classes of [0;20[and [20;100[.

[2] Currently we only have access to data until 2007, which does not provide a desirable length for estimation techniques.

iii) *Community Innovation Survey (CIS)* is a European-wide harmonized survey on firms' innovation activity. Even though we only have access to the Portuguese surveys, the questionnaire is relatively homogeneous across countries—results are comparable. The survey is conducted on a wave basis and, in Portugal, is of the responsibility of *Gabinete de Planeamento, Estratégia, Avaliação e Relações Internacionais*, even though data is made available through the INE office. For the Portuguese case, we have access to 3 waves: 1995-1997 (CIS2), 1998-2000 (CIS3) and 2002-2004 (CIS4). The sampling scheme is stratified for firms with less than 250 employees, while it covers all firms with more than 249 employees. Sample stratification is based on location (at the NUTS II level), industry (CAE rev. 2.1 at the 2-digit level) and size (employment).[3] This source provides useful information on firms' innovation activity, such has R&D investment, cooperation, subsidies and obstacles to innovate—among which financial constraints.

Finally, we should note that neither survey covers "extra-territorial organizations and bodies" and, in the CIS, "agriculture, hunting and forestry" and "fishing" are disregarded.[4]

[3] For the representativeness of firms by industry to be assured, in some cases stratification is done at a lower level (e.g. 3-digit), due to a reduced number categories at the 2-digit level. Additionally, for firms with less than 250 employees, the sample is further stratified into two classes of [0;50[and [50;250[.

[4] The legal industrial classification suffered a revision in 2003 (CAE Rev. 2.1) and in 2007 (CAE Rev. 3). For the purpose of this study we use the revised version of 2003 (CAE Rev. 2.1) and make the corresponding changes from the previous classification (CAE Rev. 2). Finally, the classification is adapted to the system provided by the United Nations Statistics Division (ISIC Rev.3). Please see Section 4 for the industry codes.

Table IV.1. Data sources

Source	**Unit**	**Periodicity**	**Time span**	**Target population**	**Sampling scheme**	**Information**
FUE	Firm	Annually	1996-2004	Portuguese firms	Population	Firm characteristics
IEH	Firm	Annually	1996-2004	Portuguese firms	<100 employees: Stratified by location (NUTS II), industry (CAE rev 2.1) and firm size (employment). >99 employees: Population	Balance sheets
CIS	Firm	Waves: 1997 (II) 2000 (III) 2004 (IV)	Wave span: 1996-1997 1998-2000 2002-2004	Portuguese firms	<250 employees: Stratified by location (NUTS II), industry (CAE rev 2.1) and firm size (employment). >249 employees: Population	Innovation activity

Notes: The data is representative at the regional, sectoral and industrial levels, of the Portuguese economy.

2. Merging the data sources

Using the FUE, we are able to match information from the different data sources. The data sources were matched using a code number, also provided by INE, that uniquely identifies each firm for the different surveys along the successive years. In what follows, we distinguish two datasets: Dataset A formed by the combination of FUE and IEH; Dataset B obtained from the combination of all the available information—FUE, IEH and CIS. The reason for this distinction results from the fact that there are a significant number firms not covered by the CIS survey, while the reverse is also true—7.079 in the CIS against 22.651 in the IEH. This results from the fact that in both survey, firms with less than 100 employees are drawn randomly. Additionally, while we have annual data for IEH and FUE, the CIS survey is carried out in waves (CIS2, 3 and 4), which brings additional complications.

2.1. Dataset A

For the purpose of this work the following cleaning procedures were necessary. First, we eliminated firms with less than 20 employees due to the lack of quality of information reported by such firms. Second, we focus only on manufacturing and most of the services sector, thus eliminating the agricultural (also includes husbandry, forestry, fishing, *inter alia*) and financial sectors—inclusion of this sector would naturally bias the estimation favouring unconstrained firms. Observations that were reported either missing or with unreasonable values were dropped. In some specific circumstances, unreasonable values suffered a treatment in order to achieve coherent values—observations whose correct values were possible to obtain from other accounting variables or resulting from changes in signal mistyping errors. As a result we have a large unbalanced panel of 22.651 firms for the period 1996-2002 resulting in 86.455 observations. Please see the Section 3 for a detailed description of the variables used.

With respect to the analysis in Chapter VI, specifically aimed at comparing manufacturing and services firms, we also exclude construction, public administration and private households with employed persons. Additionally, due to a reduced number of observations, we were forced to exclude the manufacture of coke, refined petroleum products and nuclear fuel industry (DF) as well as extraction of fossil fuels, uranium and thorium (CA), electricity, gas and water supply (E)—please see the Section 4 for the industry codes. As a result we end up with an unbalanced panel of 19.874 firms for the period 1996-2004 resulting in 77.291 observations.

The advantage of using this dataset is that it comprises detailed financial information from firm's balance sheets thus providing some insights on their status regarding financial constraints. In particular, it allows us to develop classification schemes that group firms into different levels of financial constraints. Additionally, resorting to FUE allows us to construct an unique and comprehensive dataset covering the universe of firms operating in Portugal with more than 100 employees and a large representative sample of Portuguese firms with more than 20 employees. Furthermore, the dataset comprises the broad range of economic activity sectors, including both manufacturing and services at desirable levels of disaggregation. Moreover, we have a representative sample of Portuguese services that is large enough (38.751 firm-year observations) to allow inferences to be made and to apply the proposed methodologies—this is particularly relevant for the analysis in Chapter VI. Finally, the large sample period (1996-2002) is adequate to take into account macroeconomic cyclical variations, as well as it covers the monetary integration process—this is particularly relevant for the analysis in Chapter VII. Inferences using this sample, representative of Portuguese firms, may be made with respect to, at least, the EU economy (cf. Cabral, 2007).

However, a major pitfall of this dataset is the inexistence of market information about firms. Since we only have access to a code number of each firm, we are not able to match the dataset with information from, for example, stock markets. Still, only a few firms in Portugal are publicly traded and so the benefits of such extension of the dataset would be negligible. Additionally, information on firms is limited to a relatively low level of disaggregation of balance sheets. Finally, by dropping from the database all firms with less than 20 employees, we are cutting off a significant number of observations. In addition, smaller firms would, *a priori,* be more financially constrained (e.g. Cabral and Mata, 2003 or Oliveira and Fortunado, 2006, both for the Portuguese case), thus our results might be slightly downward biased when it comes to the level of firms' financial distress. Nevertheless, information on these firms lacks in quality and further increases the unbalancedness of the panel.

Table IV.2. Structure of Dataset A

FUE and IEH		
Pattern	Frequency	Percent
111111111	2399	10.59
000000001	1178	5.20
100000000	1140	5.03
000001000	681	3.01
010000000	639	2.82
001000000	585	2.58
000000010	560	2.47
110000000	552	2.44
000000011	550	2.43
Other	14367	63.43
Total	22651	100

2.2. Dataset B

Building on the information from Dataset A, we construct an unique dataset from the combination of the three different data sources—FUE, IEH and CIS. As a result, we are able to construct a panel comprising variables on firms' financial status (IEH) and generic characteristics (FUE), further enriching the information on CISs surveyed firms. Accordingly, our final dataset is composed by 8,132 CIS observations (CIS 2, 3 and 4) appended by an unbalanced panel (Dataset A) of the respective 7.079 firms for the period 1996-2004, corresponding to 30,177 observations. This sample also covers the period 1996-2004 and is representative of the Portuguese economic sector disaggregation. The use of CIS is crucial to the analysis of firms' innovation activity (Chapter VIII) because it contains, among others, valuable information on R&D expenses, product and process innovation, cooperation, innovation subsidies and, remarkably, a direct measure of financial constraints to innovate—see Section 3 for a detailed description of the variables used. However, the use of CIS entails a number of problems that the reader should be aware of.

The main caveat of this dataset is the great loss of observations when we try to make use of both the panel structure and the CIS waves simultaneously (we use 1997, 2000 and 2004 as reference years), since not all firms in the CIS data are present in the panel data and *vice versa*—note that the panel, for firms with less than 100 employees, is composed by a random sample. Moreover, the 3 different CISs surveys are not exactly identical, so we had to abandon some variables in order to homogenise the CISs information (e.g. the use of information technologies).

Additionally, the waves of CIS refer to a certain time span (1995-97, 1998-2000 and 2002-04) meaning that, only for the case of CCFS estimation (see Chapter VIII), we must either assign a reference year for each wave, or assume that the reported information represents the average during the time span. Initially we opted for the former, however, the greatly reduced number of observations forced us to implement the later, so to have consistent estimates and to be able to use more appropriate estimation techniques.[5] Still, we expect that access to the corresponding datasets for 2004 onwards, once available, will allow us to improve these results.

Furthermore, the subjective nature of the self-assessed variables, means that there exist potential biases resulting from individuals perception. As an extreme example, while for some changing the colour of a product might be a significant improvement of the product (accounted for product innovation), for others it is not the case. This will also apply to variables such as reported financial constraints, where we might have respondents that feel that their firm is highly financially constrained, when it actually is much less constrained than another firm reporting low constraints. Please see Chapter II for a discussion of this type of measures of financial constraints.

Finally, the inclusion of the partially qualitative, subjective and censored CIS databases, in our panel of balance sheets and firms' characteristics, raises an additional number of methodological issues that must be carefully dealt with (see Mairesse and Mohnen, 2010). Examples can be found in the binary variables that identify if a firm has introduced innovations, in the ordinal categorical and subjective nature of the variable that identifies the availability of external finance as a factor hampering innovation or in the censored variable of R&D expenses (only reported for those firms that decide to invest). For detailed description of the variables used and their construction, please see Section 3.

[5] The assumption on average values during the corresponding wave period is fairly strong, however, it is a necessary evil in order to achieve consistent estimation when we split the sample to estimate CCFS in a GMM style. For robustness checks we also calculate the wave period averages of the variables in IEH and FUE, when applicable, and construct a panel of the 3 corresponding waves.

Table IV.3. Structure of Dataset B

FUE and IEH			CIS waves		
Pattern	Frequency	Percent	Pattern	Frequency	Percent
000000001	731	10.33	001	3986	56.31
101101111	726	10.26	100	1102	15.57
101111110	225	3.18	010	1080	15.26
000000011	205	2.90	011	358	5.06
000001111	192	2.71	101	219	3.09
111101110	185	2.61	110	192	2.71
000010000	174	2.46	111	142	2.01
001101111	169	2.39			
101111111	157	2.22			
Other	4315	60.95			
Total	7079	100	Total	7079	100

3. Construction of variables

From the data at our disposal we were able to create the following variables:

3.1. Generic information (FUE)

Age (AGE)	Computed as the difference between the current year and the year of establishment of the firm plus one, in logs;
Industry (CAE)	Portuguese industrial classification—using CAE rev 2.1 as reference. Different industry codes are converted into dummy indicators;
Location (NUT)	European regional classification. Different region codes are converted into dummy indicators;
Status (STA)	Variable that identifies if a firm is active, new, ceased activity, was merged or acquired. Different status codes are converted into dummy indicators;
Legal form (LF)	Variable that identifies the legal format of firms. Different legal form codes are converted into dummy indicators;

Public capital (PUB_K)	Percentage of capital owned by the public sector;
Foreign capital (FOR_K)	Percentage of capital owned by non-nationals;

3.2. Balance sheets variables (IEH)

Size (SIZE)	Measured as log of the number of employees;
Size (S)	Computed as log of inflation-adjusted assets;
Investment (I)	Measured as additions to plant, property and equipment- gross investment, scaled by total assets;
Output (Y)	Measured as total sales and services, scaled by total assets. We use the sum of both sales and services as total output and distinguish firms only by their sector of activity legal classification. If distinction was to be made on an output basis, it would be impossible to discern most firms between manufacturing and services. As an example, some manufacturing firms also provide post-sales services;
Cash- flow (CF)	Computed as net income before taxes plus depreciation, scaled by total assets;
Cash stock (CS)	Measured as total cash holdings, scaled by total assets;
Investment Opportunities (ΔY)	In most empirical studies, investment opportunities are measured using average Tobin's Q (the ratio between the total market value and asset value of a firm). However, we refrain from using this measure for two different reasons. The first is due to the fact that we are not able to calculate it since we do not have information on financial markets. Even if it was possible, we would obtain a biased sample with respect to financial constraints, not only because it is generally agreed that smaller and younger firms face severer constraints—only a few are publicly traded—, but also due to the fact that information

	on quoted firms is legally required and so, information asymmetry problems are diluted for such firms, potentially reducing financing problems. The second reason is more of a theoretical one. Firstly, marginal Q is unobservable, so researchers use average Q as a proxy—see Hayashi, 1982, for the derivation of average Q. Secondly, the introduction of cash-flow in the estimation of investment models for the purpose of analysing financial constraints may cause the sensitivities to cash-flows to be overestimated, as they might contain information about investment opportunities that were not captured by Q—Alti, 2003, in a model where financial frictions are absent, shows that, even after Q correction, firms exhibit ICFS. Sales growth is often used in empirical work on countries with less developed financial markets where information on firm's market value is scarcer (e.g. Budina et al., 2000 or Konings et al., 2003). In some cases lagged sales may even outperform Q (see FHP, 1988: p.173-74).
Debt and equity issuances (ISS)	Sum of debt and equity issuances, scaled by total assets. For the year 2001 equity issuances are reported as missing. The reason lies in legal changes that took place with the introduction of Euro (most firms adjusted their equity, not necessarily meaning issuing equity);
Non-cash net working capital (NWK)	Difference between non-cash current assets and current liabilities, scaled by total assets;
Interest payments (INT)	Interest payments of a firm, scaled by total assets. It can be argued to proxy for the credit rating of the firms;
Leverage (LEV)	Measured as the ration of liabilities to the total value of a firm;
Financial investments (FinI)	Financial investments of firms, scaled by assets. It can be seen as relatively liquid assets that allow firms to transfer resources across time;
Returns on financial investments (R_FinI)	Returns on financial investments of firms, scaled by assets;

Intangible assets (INTANG)	Computed as intangible assets, scaled by total assets. In the absence of a better alternative, this variable is intended to proxy the knowledge stock, through R&D stock and the patent stock of firms (we do not have detailed information neither on patents, nor on highly disaggregated firm accounts);
Labour productivity (LPROD)	We compute a standard ratio of value-add to number of employees;
Exports (EXP)	Firm exports, scaled by assets;
Market share (MKTS)	This variable is constructed as a firm's sales over total sales of the corresponding firm's industry—at maximum level of industrial classification disaggregation (5-digit).
Dividend Payment (DIV)	Computed as an indicator due to the lack of quality in the original survey variable "reserves". The variable will take value 0 if the firm does not pay dividends and the value 1 if a firm pays dividends.
Degree of openness to foreign markets (OPEN)	Score that captures the degree of openness of firms to foreign markets, that in its turn is obtained by the sum of export and import intensity (normalized by sales) divided by 2. A firm scores 1 (no) if it is closed and 4 (yes) if open. Scores 2 (low) and 3 (high) are obtained by dividing open firms (score 4) at the mean degree of openness. Initially we divided firms into terciles by their degree of openness, however the use of terciles implies that a significant number of non exporting\importing firms are included in the second tercile (about 40% of firms rely solely on the domestic market).
Export intensity (EXP)	Total exports to the EU divided by total sales. Export intensity scores are obtained in the same manner as openness scores (described above).
Import intensity (IMP):	Total imports from the EU divided by total sales. Import intensity scores are obtained in the same manner as openness scores (described above).

3.3. Innovation variables (CIS)

Decision to invest in R&D (RD)	Binary variable for firms that engaged in innovation activities and those that did not;
R&D investment (I_RD)	Total expenditure in R&D activities in logs. The logarithm is computed as (1+investment) because of zero expenditures;
R&D investment (RD_I)	Volume of expenditure in R&D activities in logs;
Innovation (INNOV)	Binary variable that indicates if a firm has innovated or not. It is measured in the broad sense and encompasses both product and process innovation;
Public Finance (SUB)	Binary variable for firms that received public funding and those that did not. For the sake of this paper and simplicity we will refer it as "subsidies";
Share of subsidized firms-Industry (SUB%I)	Computed as the ratio of number of subsidized firms in each industry (2-digit, CAE rev 2.1) to the total number of subsidized firms;
Share of subsidized firms-Region (SUB%R)	Computed as *SUB%I* but for each region (NUT2). Both of these variables serve as instruments for subsidies. The rationale is that, in the absence of information on public policy budgets, the share of subsidies by industry and region will reflect policy targets that favour certain industries or regions (see Schneider and Veugelers, 2010);
Cooperation (COOP)	Binary variable that indicates if a firms cooperated with other firms or institutions for the purpose of innovation activities;
Innovation opportunities (Y_IN)	Percentage of innovated products in total sales (Y);
Patent (PATENT)	Binary indicator of whether a firm registered any patent during the wave period.
R&D workers (RD_WORK)	Percentage of employers in the firm that work on R&D;

Financial constraints (FC)	Ordinal variable that measures the degree to which firms reported that the lack of external finance hampered innovation activity (self-evaluation). We do not include in this variable the "perception of excessive economic risks" and "high costs of innovation" information reported in CIS. The former can not objectively be seen as financial constraints, while the latter might carry a significant size effect ("high costs" should be normalized by a firm's assets but this is not possible since this the variable of interest is ordinal);
Financial constraints (FC^c)	FC is collapsed into a binary variable of whether or not firms report financial constraints;
Other barriers to innovate, namely:	
Employee qualification (B_TRAB)	Binary variable that indicates lack of qualified personnel as a barrier to innovate;
Technology information (B_TECH)	Binary variable that indicates lack of technological information as a barrier to innovate;
Market information (B_MARK)	Binary variable that indicates lack of market information or other market-related barriers as a barrier to innovate;
Potential innovators (POT_INNOV)	We identify potential innovators, in order to distinguish firms that do not innovate (even though they are willing to so) from firms that have no intentions to innovate. *Potential innovators* are those firms that innovated (*INNOV=1*), or attempted to innovate (either with an abandoned or ongoing project), or reported some kind of obstacle to innovate (either *FC* or other barriers). Conversely, firms that did not innovate and did not attempt to do so and reported no obstacles to innovation are classified as *firms unwilling to innovate*. Finally, of the non-innovating firms (*INNOV=0*), potential innovators are classified as *hampered firms*.

3.4. Other variables

Real GDP growth rate (GDP)	Obtained from the EUROSTAT.
Unemployment rate (U)	Obtained from the EUROSTAT.
Benchmark interest rate (R)	Annualised *Euribor* and *Lisbor* at 3 months with adjusted *Lisbor* by the mean difference in common years. We needed to compute our own series by joining two series made available by the BdP (*Euribor* for the period after the introduction of the Euro and *Lisbor* for the period before). The same change in monetary policy decision making, that accompanied the introduction of the Euro led to significant difficulties in finding comparable benchmark interest rates for the periods before and after 2000. Accordingly we focus on the interbank interest rate. Additionally we focus on the 3 months rate in order to avoid capturing the expectations incorporated in longer period rates. such as 1 year.

All continuous variables of interest were winsorized at 1% level in order to avoid problems with outliers in the estimation procedures. Deflators used include the Industrial Production Price Index and Labour Cost Index, both drawn from INE, and the GDP deflator, drawn from the Portuguese Central Bank (BdP). Nevertheless, no deflators were used when a variable was constructed as a ratio of two nominal values (normalized). In such cases we assume that the price growth rates are homogeneous.

4. Key for sector and industry disaggregation

This Section provides the key for the sector and industry disaggregation codes. The classification results from the adaptation of the Portuguese classification system appropriate for the time span of analysis (CAE- Rev. 2.1) to the international classification system provided by the United Nations Statistics Division. We excluded agriculture, hunting and forestry, fishing and financial intermediation on purpose. The disaggregation level also takes into account the number of available observations, since in some cases further disaggregation would cause serious estimation problems.

C - Mining and quarrying	
CA	
	10 - Mining of coal and lignite; extraction of peat
	11 - Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction excluding surveying
	12 - Mining of uranium and thorium ores
CB	
	13 - Mining of metal ores
	14 - Other mining and quarrying
D - Manufacturing	
DA	
	15 - Manufacture of food products and beverages
	16 - Manufacture of tobacco products
DB	
	17 - Manufacture of textiles
	18 - Manufacture of wearing apparel; dressing and dyeing of fur
DC	
	19 - Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
DD	
	20 - Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
DE	
	21 - Manufacture of paper and paper products
	22 - Publishing, printing and reproduction of recorded media
DF	
	23 - Manufacture of coke, refined petroleum products and nuclear fuel
DG	
	24 - Manufacture of chemicals and chemical products
DH	
	25 - Manufacture of rubber and plastics products

DI	26 - Manufacture of other non-metallic mineral products
DJ	27 - Manufacture of basic metals 28 - Manufacture of fabricated metal products, except machinery and equipment
DK	29 - Manufacture of machinery and equipment n.e.c.
DL	30 - Manufacture of office, accounting and computing machinery 31 - Manufacture of electrical machinery and apparatus n.e.c. 32 - Manufacture of radio, television and communication equipment and apparatus 33 - Manufacture of medical, precision and optical instruments, watches and clocks
DM	34 - Manufacture of motor vehicles, trailers and semi-trailers 35 - Manufacture of other transport equipment
DN	36 - Manufacture of furniture; manufacturing n.e.c. 37 - Recycling
E - Electricity, gas and water supply	40 - Electricity, gas, steam and hot water supply 41 - Collection, purification and distribution of water
F - Construction	45 - Construction
Services **G - Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods**	50 - Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel 51 - Wholesale trade and commission trade, except of motor vehicles and motorcycles 52 - Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods
H - Hotels and restaurants	55 - Hotels and restaurants

I - Transport, storage and communications	
	60 - Land transport; transport via pipelines 61 - Water transport 62 - Air transport 63 - Supporting and auxiliary transport activities; activities of travel agencies 64 - Post and telecommunications
K - Real estate, renting and business activities	
	70 - Real estate activities 71 - Renting of machinery and equipment without operator and of personal and household goods 72 - Computer and related activities 73 - Research and development 74 - Other business activities
M - Education	
	80 - Education
N - Health and social work	
	85 - Health and social work
O - Other community, social and personal service activities	
	90 - Sewage and refuse disposal, sanitation and similar activities 91 - Activities of membership organizations n.e.c. 92 - Recreational, cultural and sporting activities 93 - Other service activities

CHAPTER V – MEASURING FIRMS' FINANCIAL CONSTRAINTS THROUGH DIFFERENT PERSPECTIVES

1. Introduction

The recent financial crisis, the severest since 1920's Great Depression, has showed that the study of the impact of financial constraints upon firm dynamics needs further attention of researchers. In fact, despite economic theory provides some insights on the causes and effects of financial constraints, empirical literature has struggled to find consistent measures of these constraints (c.f. Chapters I and II). Firms have both internal and external forms of financing their operational and investment activities. Even if we abstain from thinking in terms of opportunity costs, obtaining funds externally requires a premium to be paid, which is associated with the risk that external investors have to bear when they decide to lend. Thus, the existence of information asymmetries (Stiglitz and Weiss, 1981; Myers and Majluf, 1984) sets a wedge between the costs of internal and external sources of finance, creating a financial hierarchy and aggravating the constraints faced by firms (Chapter I).

The purpose of this Chapter is threefold: (i) identify and measure the level of financial distress faced by firms; (ii) identify the group(s) of firms that suffer the most with financial constraints by distinguishing them according to their characteristics; (iii) compare and evaluate the results obtained using two distinct frameworks to analyse financial constraints. To accomplish this task, and in line with the methodologies described in Chapter II, we proceed in two steps. First we perform an *a priori* classification of firms into financially constrained and unconstrained based on their characteristics and financial information available from our dataset. Second, we estimate two empirical models from different approaches, in order evaluate the level of such constraints across groups of firms. The use of different approaches will also allow us to draw conclusions on the consistency, advantages and disadvantages of some of the methodologies described in Chapter II. To conduct our empirical test we use an unbalanced panel of Portuguese firms covering the period 1996-2004 (see Chapter V for details).

Making use of investment literature, we will resort to an investment accelerator model, within Bond et al. (2003a) framework, in order to estimate the sensitivity of investment to cash-flow (ICFS), the traditional measure of financial constraints. Meanwhile, we borrow some insights from recent literature on liquidity demand to estimate the sensitivity of cash stocks to cash-flow (hereafter CCFS), a relatively new approach to measure financial constraints proposed by ACW (Almeida et al., 2004). Additionally, we also evaluate the interesting Size and Age index (hereafter SA index) of financial constraints suggested by Hadlock and Pierce (2010). Our results, while supporting previous literature on the inverse relationship between size, dividend policy and financial constraints, they cast some doubts on previously devised relationships between age and the level of constraints. Finally, we question the direct use of the SA index to sort firms according to their constraints.

This Chapter is rather original in the sense that: (i) it explores a recent methodology to measure financial constraints (CCFS) that, although appearing useful and consistent, to our knowledge has barely been used yet; (ii) it tests a new way of classifying firms by their level of financial distress (SA index), that, as far as we know, has not yet tested; (iii) it is the first to explore this dataset to analyse financial constraints for the Portuguese economy—only a few works have investigated financial constraints in Portugal, but with different datasets and methodologies (Cabral and Mata, 2003; Oliveira and Fortunato, 2006; Silva, 2011b).

The Chapter is organized as follows. Section 2 will summarize the existent literature on financial constraints. In Section 4 we describe the empirical methodology followed, while Section 5 presents the main results. Finally, Section 6 pulls the pieces together and concludes.

2. Measuring financial constraints

As mentioned in Chapter I, financial constraints is a rather abstract concept since it cannot be directly observable. In fact, it is quite difficult to come up with a clear-cut definition. Perhaps due to this abstract nature of the concept, there is no clear methodology to determine financial constraints. Many researchers still devote their time in trying to find a method to identify and quantify this directly unobservable relationship (see Chapter II for an overview). However, such measures are usually built on fragile relationships and proxies for financial constraints (see Chapter III).

Considerable debate surrounds the best measure to use in the analysis of financial constraints. Since the seminal work of FHP (Fazzari et al., 1988), that introduced Investment-Cash Flow Sensitivities (ICFS) as way to measure such constraints, several researchers have tried to develop consistent measures of financial constraints (Chapter II). Some derive a reduced form Euler equation from a structural model and check if parameter restrictions are met. If not, then for a certain sample, there is evidence for the presence of constraints (e.g. Whited, 1992, Harhoff, 1998). However, this methodology does not allow to measure the degree to which firms are financially constrained, therefore we will abstain from using it. Within the Schumpeterian perspective, tests on the existence of financial constraints—do not dissociate current financial performance from current investment opportunities since they might be highly correlated—are rather scarce (Coad, 2010a) and rely mostly on associations between growth and a profitability measure (e.g. Bottazzi et al., 2008). Nevertheless, their interpretation is made with respect to selection forces and based on the principle of "growth of the fitter"—see Chapter II.

Recently, analyzing firm's demand for cash, ACW advance that the level of financial constraints can be measured by the sensitivity of cash stock to cash flow. As we have seen from the overview of their model in Chapter I and the discussion of the methodology in Chapter III, they argue that only constrained firms will manage liquidity to maximize their value. The rationale behind is that while constrained firms need to save cash out of cash flows in order to take advantage of future investment opportunities, unconstrained firms do not, as they are able to resort to external finance. Meanwhile, firms that hold cash incur in opportunity costs associated with present investment opportunities. As a result, only constrained firms will need to optimize their cash stocks over time, in order to maximize their profits and hedge against future shocks. Therefore, one can expect that estimates on the sensitivity of cash stocks to cash-flow would be positive and significant for constrained firms, while no such relation should be expected for unconstrained ones.

To our knowledge, only a few works have used this approach so far. Specifically, Han and Qiu (2007) for US publicly traded companies from 1997 to 2002, corroborate this finding. However other recent works do not support this view. Pál and Ferrando (2010) found that, for Euro-area firms between 1994 and 2003, all firms presented positive and significant CCFS. Meanwhile, Lin (2007), for publicly traded Taiwanese firms between 1990 and 2004, also finds that, contrary to ACW, both constrained and unconstrained firms present significant CCFS but, as expected, such sensitivity is higher for constrained firms. Finally, while some authors find that financial development alleviates financial constraints (see Chapter III, *stylized result 10*), Khurana et al. (2005), analyzing firm-level data for 35 countries between 1994-2002, find that there is a negative association between financial development and CCFS providing further evidence that this methodology is a useful measure of firm's financial constraints.

With respect to classification schemes (see Chapter III), several authors point out different variables that can be used to sort and distinguish firms according to their level of constraints. Examples of these are (i) dividend payout ratio; (i) firm self evaluation; (iii) cash stocks; (iv) degree of leverage; (v) age; (vi) size; (vii) institutional affiliation; (viii) credit ratings.

Also building on previous relations found in empirical literature, indexes of financial constraints have been advanced. Examples can be found in the KZ index of Lamont et al. (2001), the WW index of Whited and Wu (2006) and the index proposed by Musso and Schiavo (2008). In particular, the SA (Size and Age) index proposed by Hadlock and Pierce (2010) seems to be appealing since it draws on two variables that are "more exogenous" than the ones typically used. Additionally, not only it allows for a quadratic (thus non-monotonic) relationship to constraints, but it is also of simple implementation.

In this Chapter we will use different measures proposed by previous literature in an attempt to consistently distinguish financially constrained and unconstrained firms while assessing the severity of such constraints. It is clear that no consistent measure of financial constraints has yet been developed and the difficulty associated with the abstract concept of financial makes it harder to find such a perfect measure. Keeping this caveat in mind, we attempt to clarify the financing problems of Portuguese firms and compare different approaches to measure constraints. Inferences using this sample, representative of Portuguese firms, may be made with respect to, at least, the EU economy (cf. Cabral, 2007). However, some specific characteristics of the Portuguese economy must be taken into account. In particular, if indeed firms in economies with less developed financial markets suffer from more severe financial constraints, then, with respect to, for example the UK economy, firms in Portugal are expected to present high levels of financial constraints.

3. Methodology

In order to investigate the financial constraints faced by Portuguese firms we borrow insights from two different approaches: (i) investment demand based on an investment accelerator model; (ii) liquidity demand, modelling cash holdings as a function of the sources and uses of funds (see Chapter II for more details).

3.1. Model 1—Investment-Cash Flow Sensitivity

Since the primordial FHP's regression of investment on cash-flow, controlling for investment opportunities, researchers have used derivate specifications to estimate ICFS (see Chapter II). In particular, Harhoff (1998) following Bond and Meghir (1994) derives an empirical equation for the estimation of ICFS based on an accelerator specification:

$$\frac{I_{i,t}}{K_{i,t-1}} = \rho \frac{I_{i,t-1}}{K_{i,t-2}} + \beta_1 \Delta y_{i,t} + \beta_2 \Delta y_{i,t-1} + \beta_3 \frac{CF_{i,t}}{K_{i,t-1}} + \beta_4 \frac{CF_{i,t-1}}{K_{i,t-2}} + d_t + \alpha_i + \varepsilon_{i,t} \qquad \text{(V. 1)}$$

where $I_{i,t}$ is investment for firm i in period t, $K_{i,t-1}$ beginning of period t total assets, $\Delta y_{i,t}$ is output growth (measured as sales growth), $CF_{i,t}$ is cash-flow, d_t are time dummies, α_i controls for unobserved firm heterogeneity and $\varepsilon_{i,t}$ is the error term.

This particular accelerator specification has the advantageous feature of not requiring the computation of Tobin's Q (see Chapter IV, Section 3 for a justification of the use of sales growth instead of Q).

For the estimation of this model we resort to the Arellano-Bond first differences estimator that allows us to eliminate firm specific effects, takes into account heteroskedasticity and autocorrelation, while allowing for the presence of endogenous variables.[1] As a result, suitable instruments have to be devised. We use the twice and further lagged values of the right handside variables in the equation (until a maximum of 4 lags), two-digit industry indicators (CAE.Rev 2.1), variation of interest paid, age, size, a dummy for firms that invest in R&D, exports and imports—see Arellano and Bond (1991) for a detailed discussion of the estimator and Roodman (2009) for STATA implementation.[2]

3.2. Model 2—Cash-Cash Flow Sensitivity

Almeida et al. (2004) construct an alternative model of liquidity demand and derive an empirical equation to estimate the sensitivity of cash to cash-flows. In a few words, the model is based on constrained versus unconstrained firms' cash management. If a firm is constrained—its internal funds are insufficient to finance all positive net present value projects—it has to pass up some investments in the current period in order to be able to finance potentially better projects in the future. By being forced to manage liquidity, constrained firms will save cash out of cash-flows, while no systematic relationship should be found for unconstrained firms (see Chapter I for further detail). The financial nature of the cash stock variable is a shield against missmeasurements in Q (sales growth in our case) and investment opportunities hidden in cash-flow because it is not expected that firms will increase their cash stocks if cash-flow signals a new/better investment opportunity, unless they are financially constrained. As a result, we have the following empirical specification:

$$\Delta CS_{i,t} = \beta_0 + \beta_1 CF_{i,t} + \beta_2 \Delta y_{i,t} + \beta_3 S_{i,t} + \beta_4 I_{i,t} + \beta_5 \Delta NWC_{i,t} + \\ + \beta_6 \Delta STDEBT_{i,t} + d_t + \varepsilon_{i,t} \qquad \text{(V. 2)}$$

[1] We also use Windmeijer's (2005) finite-sample correction for the two-step covariance matrix
[2] Some instruments may vary or be dropped, depending on the classification scheme used.

where $\Delta CS_{i,t}$ is the variation in cash stocks, $S_{i,t}$ is a control for firm size (log of total assets), $\Delta NWC_{i,t}$ is the variation of noncash net working capital, $\Delta STDEBT_{i,t}$ is the variation of short term-debt and $\varepsilon_{i,t}$ the error term. For the very same reasons stated above, we shall use sales growth ($\Delta y_{i,t}$) instead of Q as a proxy for investment opportunities.

However, we will implement a slight modification to the model. In the spirit of Lin (2007), we substitute the variation of short term-debt by the sum of net debt and equity issuances ($ISS_{i,t}$) and interest rate variation ($\Delta INT_{i,t}$). The former modification is due to the fact that debt and equity issuances, while being a signal of easier access to external funds, might have a significant impact upon cash stocks (by accounting procedures), so we control for such effect. Additionally, debt issuances might work as a substitute for cash holdings for hedging purposes, even though this relation may well depend on the expected intensity of cash-flows in the future (Acharya et al., 2007). With respect to the latter, firms may decide to reduce their borrowings or pay back debt according to expected interest expenses. However, instead of benchmark interest rates variations, we use variations of interest paid, which allows for firm variation and thus can also be seen as a form of credit rating. In both specifications, all variables are scaled by total assets. Finally, since holding cash may not the only form of inter-temporal allocation of capital due to relatively liquid investments (Almeida et al., 2011) we also introduce financial investment ($Fin_{i,t}$). The augmented empirical equation is as follows:

$$\Delta CS_{i,t} = \beta_0 + \beta_1 CF_{i,t} + \beta_2 \Delta y_{i,t} + \beta_3 S_{i,t} + \beta_4 I_{i,t} + \beta_5 \Delta NWC_{i,t} + \beta_6 ISS_{i,t} + \beta_7 \Delta INT_{i,t} + Fin_{i,t} + d_t + \varepsilon_{i,t_{it}}. \quad \text{(V. 3)}$$

The financial and investment covariates are endogenous, so there is a need to estimate the model using instrumental variables (GMM) along with fixed effects to take account of unobserved firm-level heterogeneity and panel-robust standard errors. The set of instruments includes twice lagged cash flow, twice lagged sales growth, lagged investment, lagged variation of noncash net working capital, two-digit industry indicators (for overall samples), size (measured as number of employees), lagged bond issuance and lagged variation in interest payments.[3]

[3] Some instruments may vary or be dropped, depending on the classification scheme used.

3.3. Classification Schemes

For the purpose of comparing both ICFS and CCFS across different groups of firms, we perform an *a priori* classification of firms by their “degree" of financial distress. For this purpose we create subsamples by the following firm characteristics that are either generally agreed or believed to proxy for financial constraints: size, age (and both, SA index) and dividend payment (see Chapter III). However, we refrain from using financial variables to sort firms and focus on relatively exogenous variables in order not to incur in regression problems resulting from the simultaneous presence of a variable in the estimated equation and classification scheme. Still, for the case of CCFS estimation, this simultaneity might be present due to the high correlation between S and SIZE, though we take the appropriate precautions in order to provide robust results. Finally, the reason to include dividend policy as a sorting variable draws from the fact that it is, by large, the most common classification scheme used since the seminal work of FHP.

3.3.1. Firm Size

It is reasonable to expect that smaller firms face more severe financial constraints since such firms do not have the reach or visibility that larger firms have, so investors have difficulties in screening the quality of projects. As a result, smaller firms tend to be more credit rationed (e.g. Petersen and Rajan, 1995). As an example, if a firm is large enough to be quoted, information with respect to this firm will be widely available. We measure firm size as number of employees instead of either sales or assets, since it is expected to be less correlated with short-term firm performance, due to the stickiness of the labour force. Accordingly, we create an indicator variable *DIM* that takes values between 1 and 4. The partitions were set at 50, 100 and 250 employees. These thresholds result from an adjustment of the European Commission firm size classification to the specificity of our dataset.[4] First, since the information reported by firms with less than 20 employees is not reliable, we consider that, for the purpose of this Chapter, small firms have between 20-49 employees. Second, the threshold 100 employees (in line with OECD standards) allows to distinguish, within the 50-250 heterogeneous class, medium-small from medium-large firms. Additionally, it deals with possible representativeness problems associated with the fact that, in our dataset, firms with less than 100 employees are drawn randomly, while for firms with more than 100 employees the universe is represented. Finally, we have considered setting the last threshold at 500

[4] European Commission sets upper thresholds at 10, 50 and 250 employees for micro, small and medium enterprises, respectively.

employees (OECD benchmark), but this would be of no interest since there are only a few firms that would enter this upper category in Portugal. Finally, note that this sample partition is quite problematic as it is done directly using the variable SIZE (employees) which is highly correlated with the covariate S (total assets) in the CCFS regression.

3.3.2. Firm Age

If a firm has just been created, not much information is available to potential investors. Over time, firms tend to build relationships with creditors, banks and investors in general, allowing them to obtain external funds in an easier manner as lenders gain some insight in both firms' characteristics and quality. As a result, one should expect that younger firms face more severe financial constraints. Accordingly we create an indicator variable *AGEq* that takes the values 1, 2, and 3 if a firm is under 10, 10-40, and over 40 years old, respectively. The first threshold allows to accommodate the dynamics of entry and exit observed at early years (see for e.g. Bellone et al., 2008 for the intensity of the selection process, or Coad, 2010b for departures from an exponential distribution of age), thus distinguishing young from mature firms. However, a possible relative inertia of older firms (Hannan, 2005) or even a change in firm objectives, led us to define an upper class of old firms.[5] Still, different specifications were tested in order to provide robust results.

3.3.3. The SA index

The previous two variables (size and age) seem particularly appealing since they are somewhat "more exogenous" than other variables. In fact, in a recent work, Hadlock and Pierce (2010) develop an index of constraints based on these two proxies. The index is constructed as follows:

$$\text{SA} = -0.737 * \text{Size} + 0.043 * \text{Size}^2 - 0.040 * \text{Age} \qquad \text{(V. 4)}$$

where, *Size* is firm's size measured as log of inflation-adjusted assets and *Age* is the number of years with stock price listed on their Compustat database. However, we will measure *Age* by the number of years in activity in order to avoid sample selection bias—firms that are publicly traded face lower constraints. Hadlock and Pierce (2010) report a flattening of the relation above the 95th percentile and cap those observations. We opt to winsorize them at the top 5% in order to get an approximation to their measure while not losing too much

[5] Coad (2010b) argues that old firms are older than expected by the exponential benchmark possibly due to a shift from a profit-maximization behaviour to a risk-averse policy of long lasting survival.

information.[6] Note that they use quoted firms which are usually larger/older. Finally we split the sample according to terciles, as suggested, classifying the top (bottom) firms as financially constrained (unconstrained). However, one must bear in mind that this index is constructed upon a variable S that is a covariate in the CCFS regression.[7]

3.3.4. Dividend policy

We will also resort to the primordial classification scheme in FHP based on dividend payment since, despite arguable, firms that pay dividends are expected not to be constrained. Thus, we compute dummies that equal 1 if a firm has pays dividends and 0 otherwise.

4. Empirical Results

4.1. Summary statistics

Table 1 provides a brief summary of the selected variables, used in the estimation of Model (1), for the global sample and by classification scheme subsamples. Both means and standard deviations are reported. An interesting pattern that can be observed is that mean investment decreases with firm age. In other words, older firms tend to invest less than younger firms. A symptom of financial constraints might emerge from the comparison of firm's dividend policy, since firms that pay dividends have, on average, lower cash-flows than firms that do not pay dividends and so, the former are possibly retaining less funds than the latter. Furthermore, smaller firms exhibit lower output growth while younger firms' output growth is larger than older firms'. Table 2 reports the same statistics for the estimation of Model (2). In addition to the patterns previously discerned, younger firms, on average, have larger cash-flows, while both smaller and younger firms have lower financial investments, as expected.

[6] We tested the construction of the index with capped variables above the 95th centile but results do not differ significantly.

[7] Note that since size and age are usually highly correlated, size might capture part of the relation between age and constraints and *vice versa.* The inclusion of both (which is the case of Hadlock and Pierce's, 2010 index) might result in one of the variables "killing" the explanatory power of the other. The Spearman rank correlation coefficient between the two is 0.1629, significant at 1%.

Table V.1. Summary statistics of Model (1) variables

Variables	Total	Size classes				Age classes			SA index			Dividend payment	
		[20;50[	[50;100[	[100;250[	[250;+∞[	[0;10[	[10;40[	[40;+∞[	1st tercile	2nd terciles	3rd tercile	No	Yes
$I_{i,t}/K_{i,t-1}$	0.0750	0.0731	0.0743	0.0740	0.0726	0.0940	0.0735	0.0705	0.0721	0.0730	0.0722	0.0810	0.0732
	(0.108)	(0.114)	(0.107)	(0.100)	(0.095)	(0.136)	(0.104)	(0.107)	(0.111)	(0.098)	(0.101)	(0.106)	(0.118)
$I_{i,t-1}/K_{i,t-2}$	0.0867	0.0826	0.0865	0.0877	0.0900	0.1052	0.0858	0.0797	0.0798	0.0851	0.0894	0.0985	0.0817
	(0.119)	(0.124)	(0.118)	(0.111)	(0.112)	(0.141)	(0.115)	(0.115)	(0.117)	(0.113)	(0.120)	(0.121)	(0.124)
$\Delta y_{i,t}$	0.0410	0.0237	0.0355	0.0372	0.0775	0.0864	0.0357	0.0283	0.0134	0.0368	0.0601	0.0512	0.0409
	(0.280)	(0.297)	(0.260)	(0.258)	(0.259)	(0.374)	(0.274)	(0.231)	(0.284)	(0.282)	(0.255)	(0.258)	(0.309)
$\Delta y_{i,t-1}$	0.0627	0.0436	0.0616	0.0621	0.1081	0.1269	0.0581	0.0439	0.0282	0.0593	0.0839	0.0983	0.0527
	(0.285)	(0.302)	(0.275)	(0.262)	(0.279)	(0.367)	(0.280)	(0.234)	(0.295)	(0.291)	(0.263)	(0.249)	(0.321)
$CF_{i,t}/K_{i,t-1}$	0.0947	0.0914	0.0952	0.0945	0.1015	0.1088	0.0948	0.0835	0.0835	0.0969	0.0985	0.1085	0.0719
	(0.094)	(0.096)	(0.089)	(0.090)	(0.095)	(0.116)	(0.089)	(0.093)	(0.103)	(0.086)	(0.090)	(0.078)	(0.122)
$CF_{i,t-1}/K_{i,t-2}$	0.1020	0.0995	0.1026	0.1029	0.1078	0.1140	0.1031	0.0897	0.0912	0.1055	0.1049	0.1211	0.0715
	(0.093)	(0.094)	(0.089)	(0.090)	(0.097)	(0.112)	(0.090)	(0.091)	(0.100)	(0.087)	(0.091)	(0.076)	(0.121)
Observations	18,359	5,206	4,382	4,831	2,402	1,611	12,830	3,212	4,434	5,088	7,278	7,483	4,562
Number of firms	6,242	2,308	1,726	1,597	751	854	4,481	1,158	1,709	2,056	2,443	3,423	2,399

Notes: Both total sample and subsamples' mean values of the main variables used to estimate equation (1) are reported. Standard deviations are given in parenthesis.

Table V.2. Summary statistics of Model (2) variables

Variables	Total	Size classes				Age classes			SA index			Dividend payment	
		[20;50[	[50;100[	[100;250[	[250;+∞[	[0;10[	[10;40[	[40;+∞[	1st tercile	2nd terciles	3rd tercile	No	Yes
$\Delta CS_{i,t}$	0.0025	0.0029	0.0019	0.0018	0.0042	0.0053	0.0017	0.0032	0.0007	0.0017	0.0038	0.0023	0.0027
	(0.062)	(0.068)	(0.059)	(0.057)	(0.062)	(0.074)	(0.061)	(0.056)	(0.070)	(0.061)	(0.056)	(0.062)	(0.062)
$CF_{i,t}$	0.0850	0.0840	0.0861	0.0840	0.0876	0.0939	0.0851	0.0773	0.0733	0.0883	0.0888	0.0975	0.0703
	(0.089)	(0.089)	(0.088)	(0.088)	(0.091)	(0.106)	(0.084)	(0.089)	(0.103)	(0.082)	(0.082)	(0.071)	(0.104)
$\Delta y_{i,t}$	0.0368	0.0264	0.0363	0.0347	0.0689	0.0706	0.0329	0.0239	0.0023	0.0324	0.0622	0.0539	0.0166
	(0.288)	(0.304)	(0.277)	(0.279)	(0.283)	(0.370)	(0.279)	(0.236)	(0.305)	(0.299)	(0.264)	(0.270)	(0.306)
$S_{i,t}$	15.5388	14.6337	15.3970	15.9331	17.2862	15.5348	15.4930	15.7251	14.3472	15.2424	16.5721	15.5811	15.4890
	(1.448)	(1.119)	(1.036)	(1.151)	(1.578)	(1.789)	(1.338)	(1.532)	(1.068)	(1.021)	(1.170)	(1.377)	(1.526)
$I_{i,t}$	0.0629	0.0617	0.0637	0.0639	0.0621	0.0719	0.0617	0.0601	0.0601	0.0635	0.0625	0.0674	0.0575
	(0.081)	(0.085)	(0.082)	(0.079)	(0.075)	(0.094)	(0.078)	(0.081)	(0.084)	(0.080)	(0.080)	(0.082)	(0.080)
$\Delta NWC_{i,t}$	-0.0478	-0.0415	-0.0465	-0.0530	-0.0551	-0.0535	-0.0459	-0.0506	-0.0537	-0.0444	-0.0440	-0.0430	-0.0534
	(0.166)	(0.178)	(0.164)	(0.159)	(0.155)	(0.195)	(0.162)	(0.154)	(0.187)	(0.164)	(0.151)	(0.148)	(0.185)
$ISS_{i,t}$	0.0349	0.0326	0.0362	0.0325	0.0431	0.0304	0.0366	0.0317	0.0237	0.0309	0.0453	0.0412	0.0274
	(0.209)	(0.214)	(0.206)	(0.209)	(0.203)	(0.246)	(0.205)	(0.193)	(0.206)	(0.204)	(0.214)	(0.192)	(0.228)
$\Delta INT_{i,t}$	-0.0005	-0.0007	-0.0006	-0.0005	-0.0003	-0.0005	-0.0006	-0.0005	-0.0008	-0.0006	-0.0003	-0.0002	-0.0009
	(0.007)	(0.008)	(0.007)	(0.007)	(0.007)	(0.009)	(0.007)	(0.007)	(0.008)	(0.007)	(0.007)	(0.007)	(0.008)
$FinI_{i,t}$	0.0391	0.0262	0.0344	0.0442	0.0705	0.0277	0.0387	0.0502	0.0262	0.0324	0.0542	0.0418	0.0359
	(0.088)	(0.076)	(0.082)	(0.089)	(0.116)	(0.081)	(0.087)	(0.100)	(0.071)	(0.081)	(0.102)	(0.090)	(0.086)
Observations	17,283	5,688	4,549	4,817	2,229	2,480	11,837	2,966	4,537	5,359	7,003	9,351	7,932
Number of firms	4,771	1,591	1,289	1,292	599	689	3,259	823	1,254	1,509	1,949	2,670	1,864

Notes: Both total sample and subsamples' mean values of the main variables used to estimate equation (2) are reported. Standard deviations are given in parenthesis.

Tables 3 and 4 present the correlations and its significance levels across the main variables used for the ICFS and CCFS estimations, respectively. It is possible to observe that correlations are significant for most variables used in both Model (1) and (2). Exceptions are the small and non-significant correlations between cash stock variation and both size (total assets) and variation of interest paid for Model (2). Still for the same model, negative correlations between cash stock variation and both investment and non-cash net working capital are as expected as they are demands and not sources of cash. Finally, the correlation between cash-flow and debt and equity issuances is negative possibly indicating that either when there is a shortage in internal funds, firms resort to issuances or, on the contrary, when firms have large cash flows they use them to reduce debt.

Table V.3. Correlation matrix of Model (1) variables

Variables	$I_{i,t}/K_{i,t-1}$	$I_{i,t-1}/K_{i,t-2}$	$\Delta y_{i,t}$	$\Delta y_{i,t-1}$	$CF_{i,t}/K_{i,t-1}$	$CF_{i,t-1}/K_{i,t-2}$
$I_{i,t}/K_{i,t-1}$	1.0000					
$I_{i,t-1}/K_{i,t-2}$	0.4763***	1.0000				
$\Delta y_{i,t}$	0.1558***	0.1138***	1.0000			
$\Delta y_{i,t-1}$	0.1373***	0.1434***	0.1537***	1.0000		
$CF_{i,t}/K_{i,t-1}$	0.3234***	0.3066***	0.2420***	0.1941***	1.0000	
$CF_{i,t-1}/K_{i,t-2}$	0.3347***	0.3160***	0.0676***	0.2172***	0.7632***	1.0000

Notes: Spearman rank correlation coefficients with Sidak-adjusted significance level. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively.

Table V.4. Correlation matrix of Model (2) variables

Variables	$\Delta CS_{i,t}$	$CF_{i,t}$	$\Delta y_{i,t}$	$S_{i,t}$	$I_{i,t}$	$\Delta NWC_{i,t}$	$ISS_{i,t}$	$\Delta INT_{i,t}$	$FinI_{i,t}$
$\Delta CS_{i,t}$	1.0000								
$CF_{i,t}$	0.0829***	1.0000							
$\Delta y_{i,t}$	0.1181***	0.2393***	1.0000						
$S_{i,t}$	-0.0017	-0.0546***	0.0389***	1.0000					
$I_{i,t}$	-0.0276***	0.3203***	0.1594***	-0.0189	1.0000				
$\Delta NWC_{i,t}$	-0.2525***	0.0052	0.0246***	0.0523***	-0.2827***	1.0000			
$ISS_{i,t}$	0.1107***	-0.1438***	0.1739***	0.0440***	0.2041***	0.0355***	1.0000		
$\Delta INT_{i,t}$	-0.0087	-0.0745***	0.1245***	0.0163	0.0874***	-0.0135	0.2126***	1.0000	
$FinI_{i,t}$	-0.0221***	-0.0740***	-0.0322***	0.4047***	-0.0407***	0.0027	0.0067	-0.0017	1.0000

Notes: Spearman rank correlation coefficients with Sidak-adjusted significance level. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively.

4.2. Overall sample estimation

The regression of Model (1) reports a high sensitivity of investment to cash flow (0.32), significant at the 5% level, as it is shown in Table 5. This means that Portuguese firms, on average, increase their investment in 32 cents for each euro of extra cash flow, illustrative of the financial distress faced by such firms. We test for the overall significance of the regression obtaining a highly significant Wald test statistic (309.7). For the purpose of comparison, just as mere examples since such estimates result from different sample types—e.g. quoted or non-quoted firms, firms with more than 100 or 250 employees, *inter alia*—and different economic realities, Harhoff (1998) for Germany obtains a 0.314 estimate on ICFS, while Bond et al., find ICFS of -0.055, -0.033, 0.180 and 0.520 for Belgium, France, Germany and UK, respectively.

Meanwhile, as expected, the regression of Model (2) reports positive and significant sensitivities of cash to cash-flow confirming that, in general, Portuguese firms face financial constraints. As it is shown in Table 6, coefficients reported on cash flow are significantly different from zero at the 1% level for the total sample. The reported R-squared (0.18) is within the usual in these models. The estimated CCFS is 0.1843, meaning that Portuguese firms, on average, save 18 cents out of each euro of extra cash flow which is symptomatic of the presence of financial constraints. As an example of benchmark CCFS values, ACW, for a sample of COMPUSTAT manufacturing firms and based on size as a-priori classification, find CCFS estimates of 0.3836 for constrained firms and 0.0364 for unconstrained ones. With respect to firm age, Lin (2007), for Taiwan, finds that coefficients vary from 0.197 to 0.409 for constrained firms and from -0.104 to -0.026 for unconstrained ones, depending on the regression technique.

Table V.5. Model 1-Investment-Cash Flow Sensitivity estimation

	Total	Size classes				Age classes			SA index			Dividend payment	
Variables		[20;50[	[50;100[	[100;250[	[250;+∞[	[0;10[	[10;40[	[40; +∞ [	1st tercile	2nd terciles	3rd tercile	No	Yes
$I_{i,t-1}/K_{i,t-2}$	0.1388***	0.1239***	0.1334***	0.0903***	0.0758**	0.1288*	0.1224***	0.0452	0.0834**	0.1007***	0.1486***	0.1654***	0.1484***
	(0.015)	(0.032)	(0.029)	(0.026)	(0.034)	(0.077)	(0.021)	(0.040)	(0.033)	(0.026)	(0.027)	(6.089)	(4.340)
$\Delta y_{i,t}$	0.0633**	-0.0122	-0.0103	0.0381	0.0246	0.0858**	0.0377	0.0640	0.0135	0.0059	-0.0242	0.0619	-0.0352
	(0.027)	(0.021)	(0.024)	(0.025)	(0.032)	(0.044)	(0.028)	(0.047)	(0.039)	(0.023)	(0.033)	(1.449)	(-0.895)
$\Delta y_{i,t-1}$	-0.0009	0.0032	-0.0069	0.0038	0.0099	0.0018	-0.0027	-0.0050	0.0021	0.0043	-0.0012	-0.0050	0.0163
	(0.004)	(0.007)	(0.007)	(0.007)	(0.010)	(0.018)	(0.005)	(0.011)	(0.008)	(0.006)	(0.008)	(-0.643)	(1.434)
$CF_{i,t}/K_{i,t-1}$	0.3195**	0.3174*	0.0432	-0.1276	0.1033	0.1580	0.2047	0.4209**	0.5666***	0.1518	0.3028	0.9711***	0.1525
	(0.134)	(0.191)	(0.144)	(0.171)	(0.177)	(0.211)	(0.178)	(0.185)	(0.161)	(0.177)	(0.223)	(3.059)	(1.182)
$CF_{i,t-1}/K_{i,t-2}$	0.0805	0.0102	0.0351	0.1961**	0.0102	-0.0886	0.0094	0.1683	0.0705	-0.0530	0.0659	-0.1712	0.0001
	(0.054)	(0.073)	(0.067)	(0.088)	(0.113)	(0.159)	(0.067)	(0.105)	(0.084)	(0.101)	(0.114)	(-1.097)	(0.001)
Observations	18,359	5,206	4,382	4,831	2,402	1,612	13,373	3,374	4,434	5,088	7,278	7,483	4,562
Number of firms	6,242	2,308	1,726	1,597	751	854	4,652	1,220	1,709	2,056	2,443	3,423	2,399
AR(2) p-value	0.998	0.114	0.426	0.664	0.737	0.770	0.726	0.448	0.387	0.509	0.599	0.752	0.0887
Hansen chi2 p-value	0.395	0.0281	0.934	0.0133	0.908	0.0496	0.0666	0.268	0.187	0.203	0.796	0.725	0.351
Wald Chi2	309.7	26.67	132.9	71.55	99.62	46.02	375.8	34.53	43.26	88.84	223.4	161.5	42.74

Notes: Robust standard errors are in parenthesis. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively. Year dummies are included in all regressions.

Table V.6. Model 2-Cash-Cash Flow Sensitivity estimation

	Total	Size classes				Age classes			SA index			Dividend payment	
Variables		[20;50[	[50;100[	[100;250[	[250;+∞[	[0;10[	[10;40[	[40; +∞ [	1st tercile	2nd terciles	3rd tercile	No	Yes
$CF_{i,t}$	0.1843***	0.2831***	0.1665***	0.1212***	0.1221***	0.1978***	0.1939***	0.1213***	0.2461***	0.2491***	0.0637**	0.2246***	0.1278***
	(0.017)	(0.035)	(0.035)	(0.027)	(0.036)	(0.048)	(0.020)	(0.041)	(0.031)	(0.033)	(0.025)	(0.028)	(0.025)
$\Delta y_{i,t}$	0.0149***	0.0129**	0.0152***	0.0193***	0.0022	0.0177**	0.0113***	0.0283***	0.0242***	0.0109**	0.0072	0.0120***	0.0150***
	(0.003)	(0.005)	(0.006)	(0.005)	(0.007)	(0.008)	(0.003)	(0.008)	(0.005)	(0.005)	(0.005)	(0.004)	(0.006)
$S_{i,t}$	0.0148***	0.0172**	0.0161**	0.0120**	0.0114	0.0126	0.0165***	0.0065	0.0291***	0.0103	0.0083	0.0120**	0.0049
	(0.004)	(0.009)	(0.008)	(0.006)	(0.008)	(0.011)	(0.005)	(0.009)	(0.009)	(0.009)	(0.006)	(0.005)	(0.007)
$I_{i,t}$	-0.2193***	-0.2591***	-0.2051***	-0.1834***	-0.2136***	-0.2126***	-0.2359***	-0.1494***	-0.2363***	-0.2484***	-0.1772***	-0.2995***	-0.1666***
	(0.012)	(0.023)	(0.023)	(0.019)	(0.032)	(0.031)	(0.014)	(0.025)	(0.025)	(0.024)	(0.016)	(0.018)	(0.021)
$\Delta NWC_{i,t}$	-0.1491***	-0.1712***	-0.1252***	-0.1338***	-0.1617***	-0.1386***	-0.1593***	-0.1091***	-0.1667***	-0.1667***	-0.1272***	-0.1949***	-0.0981***
	(0.006)	(0.011)	(0.012)	(0.011)	(0.017)	(0.015)	(0.008)	(0.015)	(0.014)	(0.012)	(0.010)	(0.010)	(0.010)
$ISS_{i,t}$	0.0793***	0.1068***	0.0686***	0.0613***	0.0694***	0.0622***	0.0846***	0.0705***	0.0925***	0.0932***	0.0592***	0.1138***	0.0527***
	(0.004)	(0.008)	(0.009)	(0.007)	(0.010)	(0.011)	(0.005)	(0.009)	(0.009)	(0.009)	(0.006)	(0.007)	(0.007)
$\Delta INT_{i,t}$	-0.2101**	-0.3726**	0.1457	-0.2097	-0.4117	-0.3953	-0.2102*	-0.0472	-0.4096**	-0.0469	-0.1326	-0.1377	-0.1456
	(0.094)	(0.161)	(0.182)	(0.167)	(0.285)	(0.271)	(0.111)	(0.215)	(0.185)	(0.188)	(0.148)	(0.142)	(0.166)
$FinI_{i,t}$	-0.1290***	-0.2685***	-0.1065**	-0.1045***	-0.1096***	-0.0736	-0.1430***	-0.1041***	-0.1353***	-0.2142***	-0.0960***	-0.1284***	-0.1287***
	(0.018)	(0.050)	(0.047)	(0.026)	(0.028)	(0.046)	(0.021)	(0.039)	(0.039)	(0.035)	(0.022)	(0.025)	(0.037)
Observations	15,277	4,586	4,051	4,531	2,109	2,047	10,609	2,621	3,762	4,369	6,241	7,180	4,774
Number of firms	4,771	1,591	1,289	1,292	599	689	3,259	823	1,254	1,509	1,949	2,670	1,864
Hansen chi2 p-value	0.289	0.158	0.246	0.404	0.138	0.663	0.372	0.266	0.760	0.700	0.784	0.145	0.872
R-squared	0.184	0.253	0.154	0.158	0.185	0.175	0.203	0.141	0.229	0.207	0.140	0.251	0.129

Notes: Robust standard errors are in parenthesis. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively. Year dummies are included in all regressions.

Note that quite high coefficients on cash-flow may arise from three different reasons. First, equation (3) used to estimate Model (2) is somewhat close to an accounting identity so sensitivities might be overestimated. Second, for both Models, due to the relative underdevelopment of Portuguese financial markets, one would expect that firms operating in Portugal would face severe financial constraints. Finally, sales growth might not be capturing investment opportunities, since its use as a proxy is questionable. As a result, especially for Model (1), coefficients on cash-flow may possibly be overestimated.

4.3. Classification schemes

4.3.1. Size

Both estimators used to measure financial constraints provide evidence that there is an inverse relationship between firm size and financial constraints. With respect to ICFS analysis, as it is shown in Table 5 (columns 2-5), those seem to affect only the smallest firms (with less than 50 employees), that invest 32 cents out of an extra euro of cash flow (significant at the 10% level). On the other hand, the estimates on ICFS for larger firms are not statistically different from zero, indicating that such firms do not suffer from financial distress. As to CCFS analysis (see columns 2-5 of Table 6), besides reporting a descending trend, coefficients on cash-flow for the subsamples of firms with less than 50 employees, between 50 and 100 employees and between 100 and 250 employees (0.28, 0.17 and 0.12, respectively) are all significant at the 1% level. This indicates that we might be in presence of a negative relationship between size and financial constraints. Note that there is a potential bias caused by the correlation between DIM (classes of firms by employees) and the covariate S (log total assets). We tested an alternative regression excluding S but the interpretation of results remains unchanged.[8]

In order to confirm these findings, we estimated the same regressions of Models (1) and (2), but this time including an interaction term of cash-flow and the variable of interest—Size in this case. Even though we can not interpret the magnitude of the estimates, their sign provides useful information. As we can see from Tables 7 and 8 (column 1), while it is not totally clear that financial constraints are lower for larger firms using ICFS—the interaction term is negative, but not statistically different from zero—, the result is quite straightforward using CCFS—larger firms have significantly lower financial constraints.

[8] With respect to the CCFS estimates, these are slightly lower for the second and third size group (0.1515 and 0.1091, respectively) for the third group. The same coefficient for the top and bottom groups remains unchanged, as do so significance levels for all groupings.

4.3.2. Age

With respect to age, we do not find a clear pattern that links age to financial constraints. Whilst the estimates on ICFS by age groups renders us a puzzle, since we would not expect higher sensitivities for older firms, as we can see in Table 5 (columns 6-8). Additionally, very old firms' investment seems not to react neither to investment opportunities, nor to previous investment, which adds to the argument that possibly these firms are either "inert" or have different objectives. On the other hand, the results for Model (2) regression suggest an inverse relationship between age and constraints, as one can observe in Table 6 (columns 6-8). While for the oldest firms, cash-flow appears to have a relatively small impact on cash stocks (estimated coefficient is 0.12), the opposite is true for young and relatively mature firms, that save 20 and 19 cents out of every euro of extra cash-flow, respectively.

Introducing interaction terms reveals that neither interaction coefficient is statistically different from zero (Tables 7 and 8, column 2). Nevertheless, we should point that while using ICFS the coefficient is positive, in contrast with the negative sign of the corresponding CCFS interaction term. Moreover, we test whether firms that are both small and young (large and old) face higher (lower) financial constraints using another interaction term of cash flow with both Size and Age. While for the ICFS approach, there is no straightforward conclusion due to an insignificant interaction coefficient (Table 7, column 3). the CCFS estimates clearly denote higher constraints for smaller and younger firms (Table 8, column 3)

4.3.3. SA index

Our results appear not to support the findings of Hadlock and Pierce (2010), that present the SA index as way to sort firms by their degree of financial distress. With respect to investment demand, only for the bottom tercile of the SA index, do firms exhibit a statistically significant sensitivity of investment to cash flow (0.57), as it is reported in Table 5 (columns 9-11). This result is counter-intuitive, since we would expect the most constrained firms (top tercile) to exhibit higher and statistically significant ICFS. The same findings are obtained with respect to the framework of demand for liquidity. Albeit all grouping regressions report significant estimates (at the 1% level), estimates on cash-flow sensitivities drop from 0.25 to 0.64 respectively for the bottom and middle to the top tercile, as reported in Table 6 (columns 9-11). The decreasing coefficients reported are against the use of the SA index as a measure of financial constraints, since the results are the exact opposite to the ones expected.[9]

[9] Main issues are not altered by capping age and size (total assets) instead of winsorizing these variables.

Table V.7. Model 1-ICFS estimation with interactions

Variables	X≡log(Size)	X≡log(Age)	X≡log(Size*Age)	X≡SA
	(1)	(2)	(3)	(4)
$I_{i,t-1}/K_{i,t-2}$	0.1278***	0.1073***	0.1343***	0.1372***
	(0.019)	(0.021)	(0.017)	(0.017)
$\Delta y_{i,t}$	0.0813**	0.0710**	0.0565*	0.0515
	(0.037)	(0.030)	(0.032)	(0.037)
$\Delta y_{i,t-1}$	-0.0074	-0.0080	-0.0045	0.0018
	(0.008)	(0.006)	(0.006)	(0.006)
$CF_{i,t}/K_{i,t-1}$	1.3840	-0.5133	0.9846	-0.2963
	(1.147)	(0.811)	(2.057)	(0.463)
$CF_{i,t-1}/K_{i,t-2}$	0.0342	0.0301	0.0522	0.1236*
	(0.066)	(0.076)	(0.080)	(0.066)
$X_{i,t}$	-0.2287	-0.3184*	0.0171 (Size)	0.0553
	(0.244)	(0.174)	(0.044)	(0.089)
			-0.1763 (Age)	
			(0.166)	
$(CF_{i,t}/K_{i,t-1}) * X_{i,t}$	-0.0974	0.2772	-0.0815	-0.2719
	(0.108)	(0.274)	(0.270)	(0.198)
Observations	18,359	17,982	17,982	17,982
Number of firms	6,242	6,031	6,031	6,031
AR(2) p-value	0.657	0.549	0.928	0.475
Hansen chi2 p-value	0.527	0.560	0.403	0.745
Wald Chi2	289.9	457.2	304.0	464.9

Notes: Robust standard errors are in parenthesis. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively. Year dummies are included in all regressions.

Table V.8. Model 2-CCFS estimation with interactions

Variables	X≡log(Size) (1)	X≡log(Age) (2)	X≡log(Size*Age) (3)	X≡SA (4)
$CF_{i,t}$	0.3708***	0.2373***	0.4280***	0.0586
	(0.079)	(0.085)	(0.110)	(0.037)
$X_{i,t}$	-0.0186***	-0.0187	-0.0179*** (Size)	-0.0096
	(0.004)	(0.013)	(0.004)	(0.017)
			-0.0076 (Age)	
			(0.012)	
$CF_{i,t} * X_{i,t}$	-0.0407**	-0.0159	-0.0313**	-0.0558***
	(0.016)	(0.027)	(0.014)	(0.016)
$\Delta y_{i,t}$	0.0149***	0.0141***	0.0142***	0.0143***
	(0.003)	(0.003)	(0.003)	(0.003)
$S_{i,t}$	0.0204***	0.0158***	0.0209***	0.0210**
	(0.004)	(0.004)	(0.004)	(0.010)
$I_{i,t}$	-0.2206***	-0.2168***	-0.2178***	-0.2165***
	(0.012)	(0.012)	(0.012)	(0.012)
$\Delta NWC_{i,t}$	-0.1500***	-0.1499***	-0.1508***	-0.1504***
	(0.006)	(0.006)	(0.006)	(0.006)
$ISS_{i,t}$	0.0779***	0.0782***	0.0770***	0.0790***
	(0.004)	(0.004)	(0.004)	(0.004)
$\Delta INT_{i,t}$	-0.2080**	-0.1824*	-0.1762*	-0.1903**
	(0.094)	(0.095)	(0.096)	(0.095)
$FinI_{i,t}$	-0.1419***	-0.1222***	-0.1337***	-0.1290***
	(0.018)	(0.017)	(0.017)	(0.017)
Observations	15,277	15,008	15,008	15,008
Number of firms	4,771	4,661	4,661	4,661
Hansen chi2 p-value	0.377	0.378	0.449	0.483
R-squared	0.188	0.185	0.188	0.187

Notes: Robust standard errors are in parenthesis. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively. Year dummies are included in all regressions.

Note that there is a potential bias caused by the inclusion of S (log total assets) in both the regression and classification scheme. Still, we tested an alternative regression excluding S but the results do not differ significantly.[10] Nevertheless, these results may be due to the weight of Size^2 in the index being overestimated, meaning that large firms actually manage to get into the top tercile (most constrained firms) due to this positive term, when in fact they are not financially constrained. In fact, while for the bottom tercile mean S (SIZE) is 13.90 (56.12), for the top tercile it is 16.32 (229.32). Furthermore, interaction terms of the index's values with cash-flow carry a negative sign in both ICFS and CCFS regressions (column 4, Tables 7 and 8, respectively), even though it is only statistically significant for case of Model (2). Therefore, the parameters used in the index calculations appear to be extremely sensitive

[10] With respect to the CCFS estimates, these are 0.2452, 0.2348 and 0.0715 for the bottom, middle and top terciles, respectively. The same significance levels remain unchanged for all groupings.

to different economic realities and samples used.[11] Finally, the mixed results found for age subsamples, might also help to explain the inaccurate classification of constraints by the index. As a result, although being very intuitive, care must be taken when using this index. In particular, if data on firm self-assessment of constraints is available, which unfortunately is not our case, then reestimation of the index coefficients is certainly warranted.

4.3.4. Dividend policy

Dividend policy was the main classification scheme, primarily used to distinguish financially constrained from unconstrained firms. Both estimations confirm that dividend policy may be used to sort firms into financially constrained and unconstrained, as it is shown in Tables 5 and 6. First, for Model (1), the pattern is clear since firms that pay no dividends appear to invest 97 cents out of every 1 euro of extra cash-flow while the same estimate for firms that pay dividends is not statistically significant. Second, CCFS are higher for firms that pay no dividends (0.22 against 0.13), both statistically significant and different at the 1% level. However, the differences in ICFS are remarkably large, possibly indicating that financial constraints measured through the former might be overestimated. It may be possible to argue that using ICFS might drive researchers to report firms as financially constrained more often, or at a larger degree than it should be expected.

Overall, firms appear to be financially constrained in Portugal, which might be due to relative underdevelopment of financial markets. However, despite the problems described above associated with the estimation of ICFS and the fact that the CCFS test may be relatively close to an accounting identity, some patters rose from the data indicating a potential inverse relationship between size, dividend policy and financial constraints, while rejecting the use of the SA index as a measure of constraints. As to age, the results are mixed and should be dealt with caution in order to ascertain if they originate from problems associated with the estimations, flawed classification schemes, or even erroneous theoretical assumptions.

[11] While for our sample mean log of inflation adjusted assets (in millions with benchmark 2000) is 17.788 and mean age is 22.494, in Hadlock and Pierce's (2010) sample mean log of inflation adjusted assets (in millions with benchmark 2004 and not 2000, even though the inflation difference is residual) is 782.928 and mean age (number of years listed in stock market) is 13.923. This may explain such biases in the coefficients, especially in size.

5. Concluding remarks

In this Chapter we analyse the financial constraints faced by firms by estimating investment-cash flow sensitivities and cash-cash flow sensitivities upon a large unbalanced panel of Portuguese firms. Additionally we split our sample according to firm's characteristics that are believed to be good proxies for financial constraints (size, age and dividend policy) as well as resorting to a new index of constraints (SA index) in order to test the validity of such classification schemes.

Our results, while supporting previous literature on the inverse relationship between size, dividend policy and financial constraints, they cast some doubts on previously devised relationships between age and the level of constraints. As to the SA index, it is clear that the model should be calibrated according to each economic reality in order to provide correct constraints classification.

This work adds to the discussion over financial constraints both by providing new results on the Portuguese (and perhaps also European) economy and by testing and comparing the results reached using different methodologies used to measure constraints and classify firms by their financial distress.

Finally, this Chapter reveals serious difficulties of firms in resorting to external finance. Therefore, despite a need for particular analysis of such measures, policies should be taken to alleviate firm's financial constraints, in particular, those aimed at firms with smaller size. These policies should be discriminative and specially devised for firms with favourable growth prospects but financially constrained.

CHAPTER VI –DIFFERENCES BETWEEN MANUFACTURING AND SERVICES

1. Introduction

Service firms have been shown to account for an increasing share of economic activity and to greatly contribute to productivity growth (Triplett and Bosworth, 2004). However, although financial constraints appear to influence firm growth (e.g. Oliveira and Fortunato, 2006), to our knowledge, constraints of service firms were never analysed explicitly. Additionally, the recent shortage of financial resources has raised new interest in the impact that such constraints have upon firms. In the presence of an inefficient allocation of funds—that distorts the growth dynamics of firms—and if firms in different sectors (and particularly industries) exhibit different growth potential, then it is certainly important to identify where, within the economic structure, are firms most affected by financial constraints. Moreover, this distinction is particularly relevant for the literature that relies on the classification of certain industries as financially dependent (cf. Rajan and Zingales, 1998).

It is not clear whether we should expect significant differences in financial constraints between and within economic sectors of activity. On one hand, service firms will require, on average, a lower initial investment (lower sunk costs) than manufacturing firms, so we should expect lower constraints for the former. On the other, for most services, the main input is human and not physical capital, at the same time as their output is of an intangible nature, both harder to use as collateral when resorting to external finance. Nevertheless, distinct patters of constraints should emerge from an industry-level analysis of manufacturing and services due to their notable heterogeneity.

Therefore, the goal of this Chapter is to test for differences in financial constraints between and within manufacturing and service sectors. Particularly, it is in the scope of this Chapter to substantiate if previously devised relationships between financial constraints and firm size and age hold for economic sector disaggregation (see Chapter III).

For that purpose, we employ a recently developed technique to measure financial constraints within a framework of demand for cash.[1] This methodology, first developed by Almeida et al. (2004), relies on the analysis of the sensitivity of variations in cash stocks to cash flow (hereafter CCFS) to identify financial constraints. Additionally, we compute an adaptation to CCFS of a recently developed firm-specific index, proposed by Hovakimien

[1] For different methodologies to measure financial constraints, see Chapter V, where we analyse the severity of such constraints for the whole Portuguese economy.

and Hovakimien (2009) (HH index)—compares cash stocks variation time average weighted by cash-flow with time average cash stocks variation—and analyse the distribution for the different sectors and industries as well as its relationship with size and age. To conduct our empirical tests, we use a large unbalanced panel of Portuguese firms covering the period 1996-2004.

We claim that, not only there are clear differences in financial constraints, but most importantly, that size and age relationships to constraints depend on the sector being analysed, which has serious implications both at academic and policymaking levels. Specifically, we find that even though financial constraints are higher for services firms, there is a remarkable heterogeneity at the industry level. Additionally, our results suggest that, contrary to what is commonly accepted, the relationship between financial constraints and either size or age is in general U-shaped, but not robust to sector disaggregation—we only find strong evidence of an inverse relationship when it comes to firm age and for the case of service firms.

This Chapter is the first, as far as we know, to explicitly compare financial constraints between and within manufacturing and service sectors. Importantly, we question commonly accepted inverse relationships between firm size, firm age and financial constraints, as well as the robustness of such relationships to sector disaggregation. Additionally, we combine the recently developed HH index of constraints (has only been applied by Guariglia et al., 2010) with the CCFS framework, which is novel in the literature.

Finally, the importance of this Chapter with respect to policy making seems also worthwhile mentioning. While special public programs designed to alleviate financial constraints (credit lines, subsidies, tax benefits, among others) typically positively discriminate smaller, exporting or new firms, we introduce a new dimension to take into account. Namely, we argue that such policies should also accommodate the fact that financial constraints are distinct between sectors and highly heterogeneous across industries.

The Chapter is organized as follows. Section 2 makes a brief incursion on the existent literature regarding the differences between manufacturing and services, as well as it puts forward some hypothesis with respect to financial constraints. In Section 3 we describe the empirical methodology followed, while Section 4 presents the main results. Finally, in Section 5, we discuss the differences across sectors and industries, while Section 6 pulls the pieces together and concludes.

2. Recent developments and main hypothesis

2.1. Services and firms' financial constraints

In the last decade, a new wave of empirical research aimed at the study of the service sector has emerged, motivated by the growing size and importance of this sector in modern economies, on one hand, and the new high-quality data that has become available to researchers, on the other. However, there is a lack of research on financial constraints faced by service firms, despite the growing body of empirical literature that compares service to manufacturing sectors in other areas of research, of which innovation and firm growth are just examples. It is argued that a remarkable feature of some service industries is their role in, not only providing support to innovation activities in the manufacturing sector—usually through outsourcing (Merino and Rodríguez, 2007)—, but also working as technology diffusers—see Wong and He (2005) for Singaporean business service firms, Czarnitzki and Spielkamp (2003) for Germany or Tether and Metcalfe (2004) for an overview. Conversely, differences in innovation activity seem to be greater within than between these sectors, as it is shown by Huges and Wood (2000) for the UK or Pires et al. (2008) for Portugal.

Regarding firm growth, contrary to manufacturing sector—where Gibrat's Law is usually found to be violated (eg. Bottazzi and Secchi, 2003 for US and Oliveira and Fortunato, 2008 for Portuguese firms)—for some service industries one can not reject the Law of Proportionate Effect—see Piergiovani et al. (2003) for Italian and Audretsch et al. (2004) for Dutch hospitality services, Vennet (2001) for a OECD sample of the banking industry, or Wilson and Morris (2000) for three out of seven service industries in the UK. The rationale is that, compared to manufacturing, some services do not experience fast small firm growth in order to reach a survival size threshold (efficient scale), but may in fact remain relatively small business (Lotti et al., 2001).[2] If financial constrains are more rigorous in service firms and particularly in industries that are technology-intensive (e.g. Kukuk and Stadler, 2001), then not only firm growth, but also innovation and technological diffusion will be severely affected.

[2] Interestingly, for the Portuguese case, Oliveira and Fortunato (2008) do not corroborate this findings, despite they analyse the aggregate service sector.

From the discussion in Chapter II, it is clear that no consistent measure of financial constraints has yet been developed and the abstract nature of the concept adds to the difficulty in finding such a perfect measure. Keeping this caveat in mind, we attempt to clarify and compare the financing problems of manufacturing and service firms, by resorting to the HH index and the estimation of CCFS upon a large unbalanced panel of Portuguese firms. Inferences using this sample, representative of Portuguese firms, may be made with respect to, at least, the EU economy (cf. Cabral 2007).

2.2. What should we expect?

Firstly, it is not clear whether significant differences in the severity of financial constraints should be found between manufacturing and service sectors. On one hand, service firms will require, on average, a lower initial investment (lower sunk costs) than manufacturing firms, so we should expect lower constraints for the former. On the other, for most services, the main input is human and not physical capital, at the same time as their output is of an intangible nature, both harder to use as collateral when resorting to external finance. Accordingly, we test the following hypothesis:

H1: The level of financial constraints is different between sectors

Secondly, if lenders are not able to correctly assess firms' financial condition through the limited information they have and if other than pure financial dimensions have a role in explaining financial distress (Bottazzi et al. 2011), then we might expect that, besides aggregate sector differences, remarkably distinct industry-level specificities are in line with heterogeneous financial constraints across different industries. Therefore, distinct patters of constraints should emerge from an industry-level analysis of manufacturing and services:

H2: Differences in financial constraints are larger within than between sectors

Finally, in line with empirical literature on financial constraints (Chapter III), we expect that smaller firms face more severe financial constraints, since such firms do not have the reach or visibility that larger firms have, so investors have difficulties in screening the quality of projects. The same type of relationship is expected when it comes to firm age, since over time firms develop relationships with creditors, who build up knowledge on firms' and management quality, reducing information asymmetries. However, differences in the cost structure of manufacturing versus service firms in terms of physical capital (can easily be collateralized) and human capital (may lead to larger benefits from learning processes) intensities might affect this relationship. Specifically, a clearer inverse relationship between size and financial constraints might arise for manufacturing firms in contrast with an inverse age relationship for service firms.

H3: There is an inverse relationship between financial constraints and firm size and age, robust to sector disaggregation

3. Methodology

3.1. CCFS

In order to compare the financial constraints faced by Portuguese manufacturing and service firms we borrow insights from a framework of demand for cash. As we have seen in Chapter I, ACW (Almeida et al., 2004) construct a model of liquidity demand and derive an empirical equation to estimate the sensitivity of cash to cash-flows. They argue that, by being forced to manage liquidity, constrained firms will save cash out of cash-flows, while no systematic relationship should be found for unconstrained firms.

As outlined in Chapter VI, the financial nature of the cash stock variable should, in principle, work as a shield against miss-measurements in Q (sales growth in our case) and investment opportunities hidden in cash-flow because it is not expected that firms will increase their cash stocks if cash-flow signals a new\better investment opportunity, unless they are financially constrained. However, Acharya et al (2007) show that financially constrained firms will tend to use cash to increase cash stocks if their hedging needs are high. Yet, if their hedging needs are low, they will instead use cash to reduce debt. Therefore one might find firms whose propensity to save cash out of cash flow is low, even if they are financially constrained. Consequently, controlling for investment opportunities is necessary. We use sales growth ($\Delta y_{i,t}$) instead of Q as a proxy for investment opportunities (see Chapter IV, Section 3). In order to deal with the potentially problematic use of sales growth as a proxy for investment opportunities we tested the use of forward investment, lead investment and forward sales growth (Table A1 in Appendix). However, results do not change significantly and this modification implies a great loss of observations.[3]

[3] Forward investment is $I_{i,t+1}$, while lead investment is $\left(I_{i,t+1} + I_{i,t+2}\right)/ I_{i,t}$. There is a huge loss of 5583 or 9542 observations corresponding to the loss of 1353 or 2635 firms if using forward or lead investment, respectively. The same applies to the use of future sales growth ($\Delta y_{i,t+1}$).

In addition to the problems associated with proxying investment opportunities, the ACW methodology assumes that cash is the only way to transfer resources across time. In fact, in a subsequent paper (Almeida et al. 2011), they point out that since holding cash is not the only form of inter-temporal allocation of capital—in the ACW paper they assumed that all fixed investment is illiquid—, CCFS may actually be negative for constrained firms (Riddick and Whited 2009) since firms may invest in relatively liquid assets, other than cash. As a result, we try to control for this effect through investment in non-cash net working capital and financial investments.

Keeping these caveats in mind, we implement a slight modification to the ACW baseline empirical equation (as in Chapter V). In the spirit of Lin (2007), we substitute the variation of short term-debt by the sum of net debt and equity issuances ($ISS_{i,t}$) and interest rate variation ($\Delta INT_{i,t}$).Furthermore, we also control for financial investments ($\mathrm{FinI}_{i,t}$), that not only are a demand for cash but may also work as an alternative way to transfer resources across time. The augmented empirical equation is as follows:

$$\Delta \mathrm{CS}_{i,t} = \beta_1 \mathrm{CF}_{i,t} + \beta_2 \Delta \mathrm{y}_{i,t} + \beta_3 \mathrm{S}_{i,t} + \beta_4 \mathrm{I}_{i,t} + \beta_5 \Delta \mathrm{NWC}_{i,t} + \beta_6 \mathrm{ISS}_{i,t} + \beta_7 \Delta \mathrm{INT}_{i,t} + \\ + \beta_8 \mathrm{FinI}_{i,t} + \tau_t + \varepsilon_{i,t}, \qquad \text{(VI. 1)}$$

where $\Delta \mathrm{CS}_{i,t}$ is the variation in cash stocks for firm *i* in period *t*, $\mathrm{CF}_{i,t}$ is cash-flow, $\mathrm{S}_{i,t}$ is log of total assets, $\mathrm{I}_{i,t}$ is investment, $\Delta \mathrm{NWC}_{i,t}$ is the variation of noncash net working capital, τ_t are year dummies and $\varepsilon_{i,t}$ the error term.[4]

The financial and investment covariates are endogenous, so there is a need to estimate the model using instrumental variables (GMM) along with fixed effects to take account of unobserved firm-level heterogeneity and panel-robust standard errors. The set of instruments includes twice lagged cash flow, twice lagged sales growth, lagged investment, lagged variation of noncash net working capital, two-digit industry indicators (for overall samples), size (measured as number of employees), lagged bond issuance, lagged variation in interest payments and lagged financial investments. This specification is particularly useful, since it makes use of variables that, for service firms, are easy to obtain and do not entail significant measurement problems.

[4] With the exception of total assets (*S*), all variables are scaled by total assets

3.2. Size and Age

Additionally, we will test if size and age, that are generally agreed to work as good proxies for financial constraints (Chapter III), are able to provide consistent insights on the degree of financial distress of either manufacturing or service firms.

As in Chapter V, we measure firm size as number of employees instead of either sales or assets. Accordingly, we create four firm size classes, with partitions set at 50, 100 and 250 employees. With respect to firm age, we create three age classes corresponding to those firms younger than 10, between 10 and 40, and over 40 years old—see Chapter V, Section 3.3 for further detail on these thresholds. We should note that there is a problem with size and age sample partition since either we compute the firm mean values and disregard that such firm may move across classes along the time, or we assign the current value which may implicate that the same firm is accounted for the estimation of different classes. We opt for the former. Moreover, we should point that, for the estimation of CCFS upon these subsamples of firms, we drop total assets (*S*) from the specification due to its correlation with number of employees (*SIZE*).

3.3. CCFS with interacted cash-flow

In order to provide further insights on the degree of financial constraints upon different sectors and industries as well as on the relationship between firm size, age and constraints, we test cash-flow interactions with sector, industrial, size class and age class dummies, as well as interactions with *SIZE, SIZE*^{2}, *AGE* and *AGE*^{2}.[5] Therefore we estimate different specifications (corresponding to the different X variables interacted with CF) of the following equation:

$$\Delta \mathrm{CS}_{i,t} = \beta_1 \mathrm{CF}_{i,t} + a_0 \mathrm{X} + a_2 \mathrm{CF}_{i,t} * \mathrm{X} + \beta_2 \Delta \mathrm{y}_{i,t} + \beta_3 \mathrm{I}_{i,t} + \beta_4 \Delta \mathrm{NWC}_{i,t} + \beta_5 \mathrm{ISS}_{i,t} + \beta_6 \Delta \mathrm{INT}_{i,t} + \beta_7 \mathrm{FinI}_{i,t} + \tau_t + \varepsilon_{i,t}, \qquad \text{(VI. 2)}$$

[5] We should note however that when X corresponds to exhaustive sector, industry and class dummies, the term $\beta_1 \mathrm{CF}_{i,t}$ is omitted since for such cases $\sum_k \mathrm{CF}_{i,t} * X_k = \mathrm{CF}_{i,t}$. Additionally, when X corresponds to dummy variables, the term $a_0 \mathrm{X}$ is omitted.

3.4. The HH index

Finally, in order to provide robust findings, we additionally compute the HH index (Hovakimien and Hovakimien 2009) and compare it to CCFS estimates. This is a time averaged, firm-specific measure that, in the spirit of ICFS, compares the time average of investment weighted by cash-flow, against the simple average investment.[6] Accordingly, investment in years when cash-flow is higher receives a higher weight, which means that if a firm invests more (less) in years with higher cash flow, the HH index will turn our positive (negative). The reverse is also true. As a result, this measure captures the sensitivity of investment with respect to variations of cash-flow. However, in order to avoid extreme negative values, all cash-flow observations with negative values are set to zero.[7] The index is constructed in the following way:

$$HH\_I_{\mathrm{i}} = \sum_{\mathrm{t=1}}^{\mathrm{n}} \left(\frac{\left(CF/K \right)_{\mathrm{i,t}}}{\sum_{t=1}^{n} \left(CF/K \right)_{\mathrm{i,t}}} * \left(I/K \right)_{\mathrm{i,t}} \right) - \frac{1}{n} \sum_{t=1}^{n} \left(I/K \right)_{\mathrm{i,t}},$$

where *CF* is cash-flow, *I* is investment, *K* is total assets, *n* the number of annual (*t*) observations for firm *i*. For methodological consistency, we adapt this index to the CCFS framework by substituting investment (I) by variation of cash stocks (ΔCS), which yields:

$$HH_{\mathrm{i}} = \sum_{\mathrm{t=1}}^{\mathrm{n}} \left(\frac{\left(CF/K \right)_{\mathrm{i,t}}}{\sum_{t=1}^{n} \left(CF/K \right)_{\mathrm{i,t}}} * \left(\Delta CS/K \right)_{\mathrm{i,t}} \right) - \frac{1}{n} \sum_{t=1}^{n} \left(\Delta CS/K \right)_{\mathrm{i,t}}, \qquad \text{(VI. 3)}$$

The drawbacks of this measure are on one hand the fact that we are only able to analyse a cross section of firms and therefore need to additionally compute time averages of other variables of interest (such as size and age). On the other hand, this measure does not explore marginal effects and the computed levels of the index disregard investment opportunities (see D'Espallier et al. 2009 for a critic). We assume that firms saving more (less) cash in years of higher cash-flow provides evidence of higher (lower) financial constraints—i.e. CCFS correctly identifies constraints. Keeping these caveats in mind, we analyse the distribution of the index for different sectors, industries, as well as its relationship

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[6] Note that other firm-specific indexes such as for example the KZ index of Lamont et al. (2001) or the SA index of Hadlock and Pierce (2009) require either a self assessed measure of constraints or management reports to estimate coefficients for the computation of the index, therefore being specific to the dataset used. We have no access to such qualitative information.

[7] This is the same procedure as in Hovakimien and Hovakimien (2009).We also remove firms for which investment level is only observed once.

with firm size and age. In particular, we test if there is a non-linear relationship between size, age and financial constraints through an OLS regression upon:

$$HH_i = \beta + \theta_1 \overline{SIZE}_i + \theta_2 \overline{SIZE}_i^2 + \alpha_1 \overline{AGE}_i + \alpha_2 \overline{AGE}_i^2 + e_i, \qquad \text{(VI. 4)}$$

where $\overline{SIZE}_i$ and $\overline{AGE}_i$ are firm time average values of size (number of employees) and age, respectively. The purpose of such analysis is just to capture the relationship between size, age and financial constraints. In fact, this is in line with Hadlock and Pierce (2010) approach to obtain coefficients for their SA index.[8] However, they work with total assets instead of number of employees. Still, due to the stickiness of labour force, number of employees is less correlated with firms' short-term operating activities.

4. Empirical results

4.1. Summary statistics

Table 1.1 reports the summary statistics of the main variables used in the estimation of equations (1)-(2) for the overall sample, as well as for manufacturing and service sectors. A striking contrast between both sectors can be seen in the different mean cash stocks variation—for manufacturing firms, variation in cash stocks is only about 11% of the variation for service firms. Remarkable differences are also found with respect to mean sales growth (higher for service firms), number of employers (service firms are larger), as well as in terms of age (manufacturing firms are older). In fact, both parametric mean and variance equality tests (t and F tests, respectively), as well as the non-parametric two sample Kolmogorov-Smirnov and Fligner-Policello tests for equality of distributions, strongly reject the null hypothesis. Additionally, when we perform these tests for other main variables, only for the case debt and equity issuances, variations of interest paid and financial investments, we are not able to strongly reject (at 1% level) that differences exist between manufacturing and services.[9] When we further disaggregate the samples into manufacturing and service industries (Tables 1.2 and 1.3, respectively), it is notorious the presence of high heterogeneity in terms of all variables analysed, as one might expect due to industrial specificities.

[8] They use a logit specification for their qualitative dependent variable.

[9] The statistics and p-values for the Kolmogorov-Smirnov and Fligner Policello can be found in Table A5 in the Appendix. While the Kolmogorov-Smirnov test does not require normality, the Fligner-Policello test as the advantage of being valid for non-normal distributions with different variances and shape.

Table VI.1.1. Summary statistics

VARIABLES	Overall	Manufacturing	Services
$\Delta CS_{i,t}$	0.0021	0.0002	0.0043
	(0.062)	(0.057)	(0.068)
$CF_{i,t}$	0.0842	0.0856	0.0825
	(0.089)	(0.089)	(0.090)
$\Delta y_{i,t}$	0.0365	0.0185	0.0572
	(0.288)	(0.245)	(0.329)
$S_{i,t}$	15.5066	15.5314	15.4779
	(1.402)	(1.325)	(1.486)
$I_{i,t}$	0.0622	0.0645	0.0596
	(0.081)	(0.079)	(0.084)
$\Delta NWC_{i,t}$	-0.0472	-0.0536	-0.0397
	(0.167)	(0.161)	(0.173)
$ISS_{i,t}$	0.0306	0.0295	0.0320
	(0.157)	(0.150)	(0.164)
$\Delta INT_{i,t}$	-0.0006	-0.0007	-0.0005
	(0.007)	(0.007)	(0.007)
$FinI_{i,t}$	0.0392	0.0366	0.0423
	(0.090)	(0.082)	(0.097)
SIZE	170.1442	157.0521	185.2585
	(490.211)	(265.542)	(660.256)
AGE	26.8550	28.0386	25.4886
	(17.739)	(17.880)	(17.476)
Observations	15,441	8,274	7,167
Number of firms	4,255	2,247	2,006

Notes: Mean values and standard deviations, given in parenthesis, of the main variables used to estimate equations (1)-(2). Both total sample and sector subsamples' statistics are reported.

Table VI.1.2. Summary statistics for manufacturing firms

VARIABLES	DA	DB	DC	DD	DE	DG	DH	DI	DJ	DK	DL	DM	DN
$\Delta CS_{i,t}$	0.0015	-0.0018	0.0023	-0.0006	0.0014	-0.0002	0.0009	-0.0018	0.0019	0.0030	-0.0024	0.0010	-0.0012
	(0.051)	(0.059)	(0.070)	(0.038)	(0.056)	(0.049)	(0.046)	(0.052)	(0.059)	(0.061)	(0.060)	(0.078)	(0.053)
$CF_{i,t}$	0.0766	0.0681	0.0667	0.0653	0.1024	0.0984	0.0971	0.1016	0.0930	0.0907	0.1002	0.0986	0.0939
	(0.075)	(0.097)	(0.089)	(0.069)	(0.100)	(0.082)	(0.092)	(0.087)	(0.088)	(0.077)	(0.083)	(0.110)	(0.089)
$\Delta y_{i,t}$	0.0263	-0.0243	-0.0557	0.0376	0.0318	0.0582	0.0565	0.0102	0.0445	0.0234	0.0196	0.0499	0.0367
	(0.207)	(0.261)	(0.364)	(0.228)	(0.135)	(0.212)	(0.198)	(0.173)	(0.235)	(0.234)	(0.345)	(0.321)	(0.260)
$S_{i,t}$	15.8105	15.2284	15.1314	15.5363	15.7878	16.1085	15.7023	15.7575	15.3760	15.2316	15.5302	15.8377	15.1400
	(1.302)	(1.215)	(1.025)	(1.360)	(1.607)	(1.349)	(1.143)	(1.244)	(1.318)	(1.163)	(1.414)	(1.549)	(1.202)
$I_{i,t}$	0.0638	0.0566	0.0551	0.0579	0.0768	0.0627	0.0788	0.0770	0.0641	0.0585	0.0654	0.0675	0.0708
	(0.078)	(0.072)	(0.068)	(0.079)	(0.096)	(0.078)	(0.084)	(0.094)	(0.072)	(0.072)	(0.075)	(0.074)	(0.086)
$\Delta NWC_{i,t}$	-0.0503	-0.0659	-0.0541	-0.0377	-0.0616	-0.0458	-0.0595	-0.0704	-0.0439	-0.0422	-0.0405	-0.0578	-0.0451
	(0.157)	(0.180)	(0.186)	(0.134)	(0.169)	(0.141)	(0.153)	(0.140)	(0.158)	(0.155)	(0.162)	(0.148)	(0.165)
$ISS_{i,t}$	0.0334	0.0237	0.0114	0.0403	0.0337	0.0351	0.0401	0.0254	0.0323	0.0234	0.0306	0.0305	0.0342
	(0.145)	(0.155)	(0.162)	(0.137)	(0.165)	(0.136)	(0.154)	(0.141)	(0.152)	(0.146)	(0.154)	(0.174)	(0.133)
$\Delta INT_{i,t}$	-0.0004	-0.0009	-0.0009	-0.0002	-0.0004	-0.0003	-0.0007	-0.0010	-0.0007	-0.0006	-0.0013	-0.0010	-0.0003
	(0.006)	(0.008)	(0.008)	(0.008)	(0.007)	(0.006)	(0.007)	(0.007)	(0.008)	(0.007)	(0.008)	(0.007)	(0.008)
$FinI_{i,t}$	0.0427	0.0325	0.0266	0.0377	0.0452	0.0535	0.0434	0.0492	0.0293	0.0326	0.0221	0.0324	0.0211
	(0.090)	(0.075)	(0.058)	(0.095)	(0.092)	(0.101)	(0.082)	(0.098)	(0.066)	(0.075)	(0.065)	(0.086)	(0.068)
SIZE	122.6096	182.1056	211.7662	120.8793	147.1787	128.1222	143.2018	152.3623	122.6628	113.9006	263.7255	291.2023	146.6866
	(165.478)	(185.086)	(336.092)	(141.323)	(202.099)	(135.384)	(191.388)	(166.773)	(124.642)	(143.691)	(715.917)	(558.860)	(245.298)
AGE	34.5270	26.3549	23.1403	26.6466	31.2952	32.9467	26.8735	28.2658	26.6501	25.4725	22.7525	24.4868	24.6866
	(23.412)	(15.596)	(10.938)	(15.628)	(21.184)	(19.655)	(14.351)	(18.482)	(17.430)	(12.070)	(13.813)	(14.127)	(13.310)
Observations	1,368	1,496	385	348	498	450	332	726	866	654	408	341	402
Number of firms	371	426	103	96	139	122	89	186	232	186	116	89	104

Notes: Mean values and standard deviations, given in parenthesis, of the main variables used to estimate equations (1)-(2), disaggregated by manufacturing industries.

Table VI.1.3. Summary statistics for services firms

VARIABLES	G	H	I	K	M	N	O
$\Delta CS_{i,t}$	0.0032	-0.0001	0.0031	0.0102	0.0091	0.0072	0.0030
	(0.059)	(0.079)	(0.062)	(0.086)	(0.109)	(0.073)	(0.061)
$CF_{i,t}$	0.0696	0.0872	0.1051	0.0972	0.1129	0.1108	0.1002
	(0.071)	(0.098)	(0.109)	(0.119)	(0.115)	(0.083)	(0.101)
$\Delta y_{i,t}$	0.0508	0.0343	0.0677	0.0899	0.0544	0.0604	0.0523
	(0.340)	(0.198)	(0.299)	(0.425)	(0.221)	(0.140)	(0.209)
$S_{i,t}$	15.5417	15.8438	16.0435	15.0535	14.2609	14.9290	15.7862
	(1.229)	(1.697)	(1.904)	(1.686)	(1.324)	(1.261)	(1.780)
$I_{i,t}$	0.0442	0.0774	0.0953	0.0598	0.1044	0.0898	0.0926
	(0.063)	(0.110)	(0.105)	(0.085)	(0.120)	(0.087)	(0.111)
$\Delta NWC_{i,t}$	-0.0238	-0.0530	-0.0766	-0.0449	-0.0827	-0.0765	-0.0646
	(0.152)	(0.185)	(0.185)	(0.214)	(0.204)	(0.179)	(0.185)
$ISS_{i,t}$	0.0264	0.0332	0.0403	0.0513	0.0197	0.0285	0.0438
	(0.152)	(0.176)	(0.170)	(0.193)	(0.162)	(0.157)	(0.199)
$\Delta INT_{i,t}$	-0.0008	-0.0003	-0.0005	0.0001	-0.0004	-0.0004	-0.0002
	(0.007)	(0.008)	(0.007)	(0.010)	(0.008)	(0.007)	(0.009)
$FinI_{i,t}$	0.0365	0.0788	0.0565	0.0474	0.0292	0.0472	0.0277
	(0.084)	(0.136)	(0.118)	(0.111)	(0.093)	(0.107)	(0.063)
SIZE	128.0468	302.1312	364.0069	291.5635	119.8056	96.4388	182.5935
	(565.617)	(580.197)	(1,277.360)	(608.387)	(156.967)	(151.820)	(291.911)
AGE	27.0594	24.9253	27.9241	17.5042	23.4796	23.4895	27.8489
	(16.812)	(14.753)	(21.317)	(13.043)	(14.530)	(9.832)	(29.577)
Observations	4,206	442	725	960	319	237	278
Number of firms	1,182	118	206	264	90	66	79

Notes: Mean values and standard deviations, given in parenthesis, of the main variables used to estimate equations (1)-(2), disaggregated by manufacturing industries.

Since most of the variables analysed do not follow a normal distribution, we compute Spearman's rank correlation coefficients and the respective confidence intervals (Table 2). Significance levels were set at the 1% level and results are robust to Kendall's τ. We find that while the association between changes in cash stocks and both cash-flow and sales growth is not different between sectors, the association between the former and investment (as well as financial investments) is only significantly negative for service firms. Nevertheless, the negative correlations between cash stock variation and investment, financial investments as well as variations of non-cash net working capital are as expected—they are demands and not sources of cash. Moreover, the correlation between cash-flow and debt and equity issuances is negative, possibly indicating that either when there is a shortage in internal funds firms resort to issuances or, on the contrary, when firms have large cash flows they use them to reduce debt.

Furthermore, whereas for manufacturing firms there is a strongly significant positive association between total assets and both cash-flow and investment, this associations are negative and strongly significant for the case of services. Additionally, the positive association between cash-flow and investment is stronger for the case of manufacturing firms. Even though these relations are unconditional (and relatively small for the case of total assets), this may well be associated with the different cost structures.

Finally, when it comes to firm size and age, we should note that even though we find a positive and significant correlation coefficient for manufacturing firms, this is not the case for service firms. Interestingly, we find no statistical significant association between these variables and variation of cash stocks, except for the case of age in the overall sample. Surprisingly, while cash-flow is always positively related to size, it is strongly negatively related to firm age.

Table VI.2. Spearman's rank correlation matrixes for manufacturing and services

VARIABLES	$\Delta CS_{i.t}$	$CF_{i.t}$	$\Delta y_{i.t}$	$S_{i.t}$	$I_{i.t}$	$\Delta NWC_{i.t}$	$ISS_{i.t}$	$\Delta INT_{i.t}$	$FinI_{i.t}$	$SIZE_{i.t}$	$AGE_{i.t}$
Overall											
$\Delta CS_{i.t}$	1.00										
$CF_{i.t}$	0.0831*	1.00									
$\Delta y_{i.t}$	0.1178*	0.2494*	1.00								
$S_{i.t}$	0.0009	-0.0292*	0.0464*	1.00							
$I_{i.t}$	-0.0291*	0.3091*	0.1613*	-0.0051	1.00						
$\Delta NWC_{i.t}$	-0.2524*	0.0186	0.0290*	0.0450*	-0.2816*	1.00					
$ISS_{i.t}$	0.1260*	-0.1668*	0.2028*	0.0519*	0.2288*	-0.1576*	1.00				
$\Delta INT_{i.t}$	-0.0088	-0.0805*	0.1189*	0.0141	0.0847*	-0.0181	0.2268*	1.00			
$FinI_{i.t}$	-0.0222	-0.0629*	-0.0335*	0.3945*	-0.0268*	-0.0054	0.0045	-0.0011	1.00		
$SIZE_{i.t}$	0.0003	0.0659*	0.0728*	0.5852*	0.1069*	-0.0486*	0.0245*	0.0079	0.2434*	1.00	
$AGE_{i.t}$	-0.0243*	-0.0929*	-0.1183*	0.1231*	-0.0697*	0.0191	-0.0456*	-0.0186	0.2417*	0.0647*	1.00
Manufacturing											
$\Delta CS_{i.t}$	1.00										
$CF_{i.t}$	0.0834*	1.00									
$\Delta y_{i.t}$	0.1173*	0.2782*	1.00								
$S_{i.t}$	0.0082	0.0520*	0.0648*	1.00							
$I_{i.t}$	-0.0068	0.3291*	0.1883*	0.0362*	1.00						
$\Delta NWC_{i.t}$	-0.2242*	0.0175	0.0372*	0.0423*	-0.2779*	1.00					
$ISS_{i.t}$	0.1049*	-0.1712*	0.1735*	0.0228	0.2471*	-0.1407*	1.00				
$\Delta INT_{i.t}$	-0.0074	-0.0760*	0.1230*	0.0005	0.0836*	-0.0099	0.2250*	1.00			
$FinI_{i.t}$	0.0007	-0.0462*	-0.0136	0.4364*	-0.0243	-0.0077	0.0096	-0.0086	1.00		
$SIZE_{i.t}$	-0.0041	0.0672*	0.0347*	0.6782*	0.0629*	-0.0247	-0.0143	-0.0111	0.3225*	1.00	
$AGE_{i.t}$	-0.0255	-0.1146*	-0.1057*	0.1347*	-0.0948*	0.0167	-0.0418*	-0.0182	0.2394*	0.1248*	1.00
Services											
$\Delta CS_{i.t}$	1.00										
$CF_{i.t}$	0.0862*	1.00									
$\Delta y_{i.t}$	0.1153*	0.2324*	1.00								
$S_{i.t}$	-0.0074	-0.1119*	0.0293	1.00							
$I_{i.t}$	-0.0431*	0.2749*	0.1541*	-0.0534*	1.00						
$\Delta NWC_{i.t}$	-0.2860*	0.0302	0.0139	0.0492*	-0.2731*	1.00					
$ISS_{i.t}$	0.1447*	-0.1619*	0.2292*	0.0805*	0.2159*	-0.1755*	1.00				
$\Delta INT_{i.t}$	-0.0111	-0.0840*	0.1131*	0.0293	0.0911*	-0.0295	0.2284*	1.00			
$FinI_{i.t}$	-0.0448*	-0.0812*	-0.0529*	0.3537*	-0.0322*	-0.0028	-0.0002	0.0068	1.00		
$SIZE_{i.t}$	0.0124	0.0503*	0.1330*	0.5004*	0.1161*	-0.0494*	0.0624*	0.0330*	0.1709*	1.00	
$AGE_{i.t}$	-0.0204	-0.0828*	-0.1171*	0.1151*	-0.0673*	0.0355*	-0.0486*	-0.0155	0.2477*	-0.0216	1.00

Notes: Rank correlation coefficients were calculated using Sidak's adjustment. * denotes statistical significance at the .01 level.

4.2. Aggregate Manufacturing and Services

As expected, the regression of equation (1) reports positive and significant sensitivities of cash to cash-flow. As it is shown in Table 3 (column 1), coefficients reported on cash flow are significantly different from zero at the 1% level for the overall sample. The estimated CCFS is 0.154, meaning that Portuguese firms save, on average, 15.4 cents out of each euro of cash flow, which is symptomatic of the presence of severe financial constraints. Note that quite high coefficients on cash-flow may arise from two different reasons. First, equation (1) is somewhat close to an accounting identity so sensitivities might be overestimated. Second, due to the relative underdevelopment of Portuguese financial markets, one would expect that firms operating in Portugal would face severe financial constraints.

The comparison between aggregate manufacturing and service sectors (columns 2 and 3) indicates that firms operating in the former are not as severely affected by financial constraints as firms in the latter. In fact, while manufacturing firms save, on average, 10 cents out of each euro of extra cash flow, service firms save 23 cents out of each euro of extra cash flow. These estimates are both significant at the 1% level and statistically different at the 1% level.[10] Another striking difference can be found on the impact of size (assets) on firms' cash policy, since only for service firms it is not significant at the 1% level. This may be due to the fact that manufacturing firms have an higher minimum efficiency scale and incur in significant sunk costs in initial (and subsequent) investment, when compared to service firms. Accordingly, the liquidity needs of the former firms are larger. Finally, except for sales growth, the impact of the remaining explanatory variables is greater for the case of services, meaning that these firms are, in general more cautious with their cash policy than manufacturing firms.

[10] The reported R-squared statistics are within the usual in these models. See Chapter V for a few benchmark CCFS estimates from other studies.

Table VI.3. Cash-Cash Flow Sensitivity estimation for manufacturing and services

VARIABLES	Overall (1)	Manufacturing (2)	Services (3)	Overall (4)	Manufacturing (5)	Services (6)	Overall (7)	Manufacturing (8)	Services (9)
$CF_{i,t}$	0.154***	0.096***	0.227***	0.159***	0.107***	0.226***	0.160***	0.108***	0.228***
	(0.018)	(0.020)	(0.032)	(0.018)	(0.021)	(0.032)	(0.018)	(0.020)	(0.032)
	[0.119;0.189]	[0.056;0.135]	[0.165;0.290]	[0.124;0.194]	[0.067;0.147]	[0.164;0.288]	[0.124;0.195]	[0.068;0.148]	[0.166;0.291]
$\Delta y_{i,t}$	0.013***	0.016***	0.011**	0.014***	0.018***	0.011**	0.015***	0.018***	0.011**
	(0.003)	(0.004)	(0.004)	(0.003)	(0.004)	(0.005)	(0.003)	(0.004)	(0.005)
	[0.007;0.019]	[0.007;0.024]	[0.002;0.019]	[0.008;0.021]	[0.009;0.026]	[0.002;0.020]	[0.008;0.021]	[0.009;0.026]	[0.002;0.020]
$S_{i,t}$	0.018***	0.022***	0.015**	0.016***	0.019***	0.016**	0.016***	0.019***	0.016**
	(0.004)	(0.005)	(0.006)	(0.004)	(0.005)	(0.007)	(0.004)	(0.005)	(0.007)
	[0.010;0.026]	[0.012;0.032]	[0.003;0.027]	[0.008;0.025]	[0.009;0.030]	[0.003;0.029]	[0.008;0.025]	[0.009;0.030]	[0.003;0.029]
$I_{i,t}$	-0.205***	-0.150***	-0.269***	-0.202***	-0.143***	-0.270***	-0.202***	-0.142***	-0.270***
	(0.012)	(0.014)	(0.020)	(0.012)	(0.014)	(0.020)	(0.012)	(0.014)	(0.020)
	[-0.228;-0.181]	[-0.177;-0.123]	[-0.308;-0.230]	[-0.225;-0.178]	[-0.170;-0.115]	[-0.309;-0.231]	[-0.225;-0.178]	[-0.170;-0.115]	[-0.309;-0.230]
$\Delta NWC_{i,t}$	-0.124***	-0.109***	-0.140***	-0.124***	-0.109***	-0.140***	-0.124***	-0.109***	-0.139***
	(0.006)	(0.008)	(0.009)	(0.006)	(0.008)	(0.009)	(0.006)	(0.008)	(0.009)
	[-0.136;-0.112]	[-0.124;-0.094]	[-0.159;-0.122]	[-0.136;-0.112]	[-0.124;-0.094]	[-0.158;-0.121]	[-0.135;-0.112]	[-0.124;-0.094]	[-0.157;-0.121]
$ISS_{i,t}$	0.076***	0.059***	0.095***	0.078***	0.063***	0.094***	0.078***	0.063***	0.095***
	(0.006)	(0.008)	(0.010)	(0.006)	(0.008)	(0.010)	(0.006)	(0.008)	(0.010)
	[0.064;0.089]	[0.044;0.074]	[0.076;0.114]	[0.066;0.091]	[0.048;0.078]	[0.075;0.114]	[0.066;0.091]	[0.048;0.078]	[0.075;0.114]
$\Delta INT_{i,t}$	-0.260***	-0.215*	-0.331**	-0.126	-0.054	-0.220	-0.126	-0.057	-0.215
	(0.097)	(0.120)	(0.155)	(0.104)	(0.130)	(0.166)	(0.104)	(0.130)	(0.166)
	[-0.450;-0.071]	[-0.450;0.021]	[-0.635;-0.026]	[-0.329;0.077]	[-0.308;0.201]	[-0.544;0.105]	[-0.329;0.077]	[-0.311;0.197]	[-0.540;0.110]
$FinI_{i,t}$	-0.123***	-0.088***	-0.157***	-0.125***	-0.093***	-0.159***	-0.126***	-0.091***	-0.161***
	(0.019)	(0.025)	(0.028)	(0.018)	(0.025)	(0.027)	(0.018)	(0.024)	(0.027)
	[-0.159;-0.086]	[-0.136;-0.039]	[-0.211;-0.103]	[-0.161;-0.089]	[-0.141;-0.045]	[-0.212;-0.105]	[-0.162;-0.090]	[-0.139;-0.044]	[-0.215;-0.107]
Dummies									
Year	NO	NO	NO	YES	YES	YES	YES	YES	YES
Industry	NO	NO	NO	NO	NO	NO	YES	YES	YES
Observations	13,874	7,590	6,256	13,874	7,590	6,256	13,874	7,590	6,256
No. of firms	4,322	2,277	2,043	4,322	2,277	2,043	4,322	2,277	2,043
Hansen p-val.	0.368	0.206	0.819	0.463	0.430	0.751	0.560	0.455	0.830
R-squared	0.155	0.125	0.193	0.158	0.131	0.195	0.159	0.132	0.195

Notes: Regression of equation (1). Robust standard errors in parenthesis; 95% confidence intervals in brackets. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively. Results do not change significantly with different proxies for investment opportunities (Table A1).

These results are robust to the introduction of year and industry dummies (Table 3, columns 4-9). Furthermore, using different proxies for investment opportunities (Table A1 in Appendix) results do not change significantly and we still find that the CCFS of manufacturing firms is lower than that of services (even though these estimates are statistically different only at the 90% level). Moreover, when we test interactions of cash-flow with sector dummies (equation 2), we also find that both manufacturing and service sectors coefficients are positive, significant and larger for services (Table A3 in Appendix, column 2). Alternatively, we compute the HH index as in equation (3) and compare the distribution for the different sectors (Table 4).[11] Firstly, the median and mean are higher for the services sample, even though there is larger variation (columns 2-3, line 5 and columns 5-6, lines 2-3, respectively). Secondly, service firms' HH distribution is more skewed to the right, as well as there is an higher percentage of observations above zero—within the CCFS interpretation, firms that save more cash in years of higher cash-flows are financially constrained—of 54.2% against 52.7% in manufacturing (columns 5-6, lines 4 and 7, respectively). Thirdly, even though a formal Mann–Whitney test indicates that manufacturing and services medians are not statistically different at any level smaller than 12.54%, Kolmogorov-Smirnov and Fligner-Policello tests reject the equality of distributions (column 4, lines 10, 9 and 11, respectively).[12] Finally, a quantile-quantile plot of the HH index values for each sector (Figure 1) indicates that the HH distribution for services is more dispersed, skewed and, most importantly, it reveals that for positive values of the index (i.e. firms that are financially constrained), services' HH distribution seems to dominate the manufacturing's HH distribution. On the whole, the comparison of the HH index between these sectors suggests that, when present, financial constraints are higher for service firms.

Overall, these results provide robust evidence that financial constraints are different between manufacturing and service sectors—hypothesis *H1* should not be rejected. In fact, these constraints are higher for service than for manufacturing firms.

[11] We validate the use of the adapted HH index to the cash management perspective by testing if, using equation (1), CCFS estimation yields higher cash-flow estimates for higher HH levels. There is a clear increase in CCFS when we move from lower to higher quartiles of the index (Table A2 in Appendix). Accordingly, we conclude that this version of the index correctly identifies CCFS.

[12] Note that the Fligner-Policello test statistic is 1.532 and the rejection is only at the 10% level.

Table VI.4. HH index distribution

Percentiles	Overall (1)	Manufacturing (2)	Services (3)	Statistics	Overall (4)	Manufacturing (5)	Services (6)
Min	-0.1618	-0.1270	-0.1618	Obs.	9112	4406	4706
1	-0.0226	-0.0180	-0.0251	Mean	0.0006	0.0005	0.0007
5	-0.0065	-0.0051	-0.0078	$S.D.$	0.0088	0.0071	0.0102
10	-0.0030	-0.0023	-0.0037	Skew.	2.3606	1.4108	2.5207
25	-0.0006	-0.0005	-0.0007	Kurt.	82.5336	74.9682	73.7531
50	0.0000	0.0000	0.0001				
75	0.0010	0.0008	0.0012	%Obs.>0	53.48%	52.70%	54.21%
90	0.0047	0.0037	0.0054				
95	0.0094	0.0077	0.0108	K-S p.	0.000		
99	0.0286	0.0267	0.0313	M-W p.	0.1254	P(Manuf.>Serv.)=0.491	
Max	0.1632	0.1270	0.1632	F-P p.	0.0628		

Notes: Distribution of the HH index, as in equation (3), for the overall manufacturing and services samples. We report the minimum and maximum values (Min and Max, respectively), the mean (Mean), standard deviations (S.D.), skewness (Skew.), kurtosis (Kurt.), the percentage of observations above zero (%Obs.>0), as well as the p-values for the following non-parametric tests: Kolmogorov-Smirnov for equality of distribution (K-S p.), Mann–Whitney adjusted for ties (M-W p.), Fligner-Policello test (F-P p.) and the probability that manufacturing HH values are larger than services values (P(Manuf.>Serv.)).

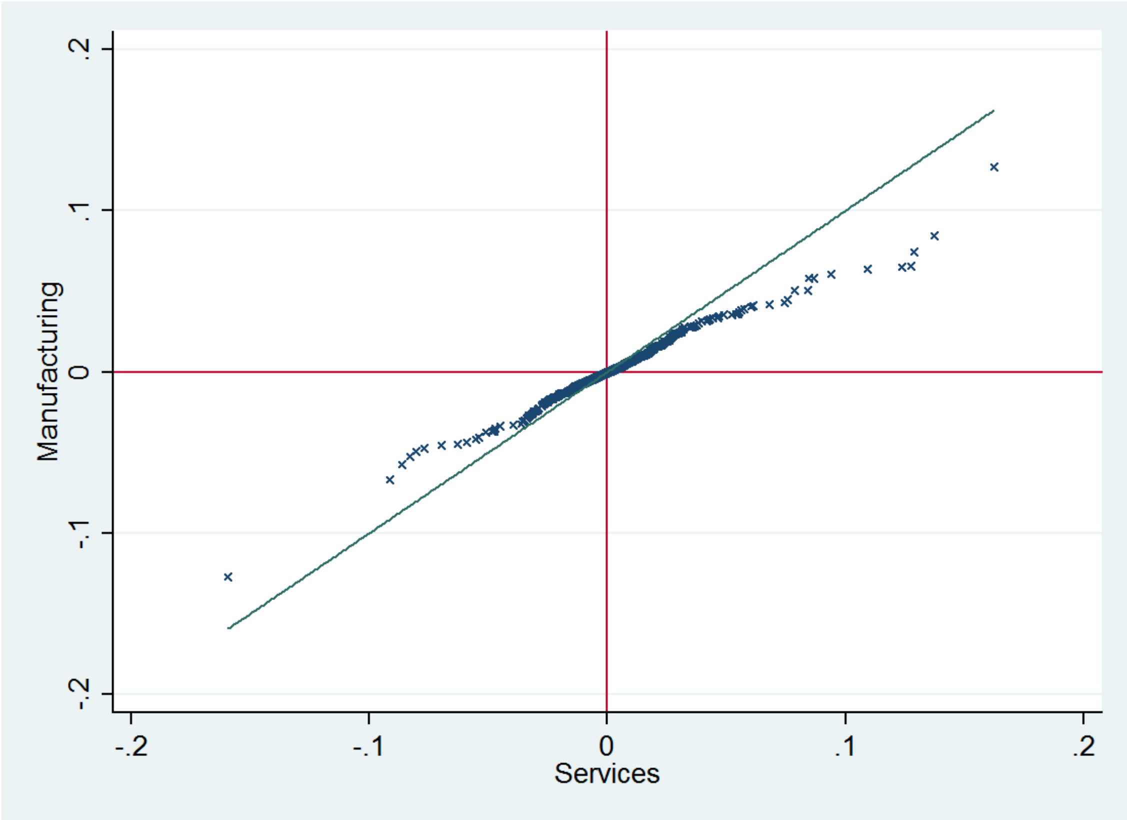

Figure VI.1. Quantile-Quantile plot of the HH index for different sectors

Notes: We plot the quantiles of the HH index distribution (computed as in equation 3), for Manufacturing against those of Services firms (vertically and horizontaly, respectively). Values above the vertical (horizontal) lines at HH=0 indicate that services (manufacturing) firms save more cash in years of higher cash-flow, suggesting the presence of financial constraints. Values above (under) the symmetry line (y=x) indicate higher HH values for manufacturing (services) firms.

4.3. Differences across industries

Table 5 presents the estimates for manufacturing industries. A noticeable outcome of the estimation of CCFS is the relatively lower estimates obtained when compared with the overall and aggregate service sample. The machinery manufacture industry (DK) is the only case for which financial constraints are higher than the overall sample (0.1629). Still, the degree of financial distress in the aggregate service sector is substantially higher. Additionally, only firms that produce food, beverages and tobacco (DA), wood and furniture (DD), paper (DE), or chemicals (DG) appear to be financially constrained, while in the remaining industries firms do not suffer from such constraints. The severity of these constraints varies from the chemicals industry (DG), the least constrained (firms save, on average 10 cents out of each extra euro of cash-flow), to the machinery manufacture industry (DK), the most constrained. For these particular cases, while the former industry is mature and highly spatially concentrated, firms in the latter face significant sunk costs, which might help to explain the differences in constraints.

Table 6 reports the estimation results for service industries. Depending on industry, the coefficient on cash flow ranges from not statistically significant—health (N) and other service industries (O)—to remarkable values of 0.53 and 0.43 for firms in the education (M) and hospitality (H) industries, respectively. In fact, firms in these industries are extremely constrained as they save more than 40% of their cash flows. Additionally, it is possible to find both high and low levels of constraints in other industries. Namely, while for wholesale (G) the severity of such constraints is high (0.2016), for transport and communications (I) and rentals and business services (K) industries, the CCFS (0.1618 and 0.1494, respectively) are relatively low when compared to other service industries, but still near the overall sample average. Still, lower constraints for business services firms (K), for example, might result from their subcontracting relationships with manufacturing firms, since interaction between firms and establishment of credit links in form of, for example, trade credit may reduce financial constraints for the subcontracted firms. Overall, the differences in constraints tend to be larger within than between manufacturing and services. In fact, the analysis at the industry level, reveals that while in some industries firms are clearly not financially constrained, for industries whose firms are found to be constrained, the degree of constrains varies in a wide range—firms tend to save, on average, from 10% to 49% of their cash flow, depending on industry.

Table VI.5. Cash-Cash Flow Sensitivity estimation for manufacturing industries

VARIABLES	DA	DB	DC	DD	DE	DG	DH	DI	DJ	DK	DL	DM	DN
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
$CF_{i,t}$	0.126**	0.070	0.059	0.129*	0.133***	0.102*	0.182	0.040	0.113	0.163**	0.082	0.022	-0.016
	(0.050)	(0.050)	(0.086)	(0.074)	(0.051)	(0.058)	(0.135)	(0.053)	(0.077)	(0.073)	(0.074)	(0.086)	(0.064)
$\Delta y_{i,t}$	0.013	0.017*	0.019	-0.015	-0.026	0.013	0.003	0.047**	0.016	0.041***	0.025**	0.006	0.045***
	(0.010)	(0.009)	(0.015)	(0.012)	(0.023)	(0.014)	(0.024)	(0.021)	(0.014)	(0.015)	(0.011)	(0.016)	(0.015)
$S_{i,t}$	0.027**	0.017	-0.024	0.024*	-0.003	0.020	0.053	0.025	0.013	0.050**	0.002	0.040	0.006
	(0.011)	(0.013)	(0.028)	(0.013)	(0.017)	(0.017)	(0.033)	(0.016)	(0.016)	(0.021)	(0.023)	(0.025)	(0.017)
$I_{i,t}$	-0.137***	-0.160***	-0.217***	-0.085**	-0.204***	-0.052	-0.080*	-0.135***	-0.161***	-0.193***	-0.146**	-0.217***	-0.056
	(0.031)	(0.038)	(0.064)	(0.034)	(0.048)	(0.038)	(0.047)	(0.045)	(0.041)	(0.046)	(0.060)	(0.064)	(0.035)
$\Delta NWC_{i,t}$	-0.084***	-0.115***	-0.123***	-0.113***	-0.081***	-0.064**	-0.034*	-0.114***	-0.142***	-0.158***	-0.117***	-0.129**	-0.039*
	(0.014)	(0.017)	(0.032)	(0.034)	(0.025)	(0.027)	(0.019)	(0.026)	(0.025)	(0.034)	(0.036)	(0.051)	(0.022)
$ISS_{i,t}$	0.065***	0.034	0.082**	0.017	0.131***	0.033	0.018	0.084***	0.065***	0.056**	0.026	0.048	0.090***
	(0.016)	(0.021)	(0.035)	(0.019)	(0.029)	(0.023)	(0.032)	(0.029)	(0.022)	(0.025)	(0.029)	(0.038)	(0.033)
$\Delta INT_{i,t}$	-0.400	0.036	-0.312	0.134	-1.142***	0.003	-0.148	-0.594	-0.142	-0.300	0.408	-0.658	-0.046
	(0.335)	(0.246)	(0.771)	(0.248)	(0.411)	(0.369)	(0.388)	(0.380)	(0.295)	(0.448)	(0.531)	(0.625)	(0.351)
$FinI_{i,t}$	-0.090*	-0.063	0.042	-0.008	0.073	-0.197***	0.068	-0.151*	-0.116	-0.138	-0.795***	-0.170**	0.194
	(0.052)	(0.057)	(0.084)	(0.039)	(0.064)	(0.075)	(0.102)	(0.079)	(0.091)	(0.106)	(0.255)	(0.079)	(0.236)
Observations	1,277	1,346	353	306	463	419	301	661	797	595	376	302	367
No. of firms	377	432	103	100	141	122	89	189	237	188	117	89	105
Hansen p-val.	0.657	0.920	0.358	0.375	0.170	0.388	0.887	0.0329	0.226	0.415	0.185	0.0804	0.443
R-squared	0.126	0.105	0.164	0.119	0.226	0.121	0.082	0.171	0.153	0.211	0.137	0.138	0.134

Notes: Regression of equation (1). These estimations also include year dummies. Robust standard errors in parenthesis. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively. Further test statistics available from the authors on request. Industry key: (DA) food, beverages and tobacco; (DB) textiles; (DC) tanning; (DD) wood and furniture; (DE) paper; (DG) chemicals; (DH) plastics; (DI) non-metallic mineral products; (DJ) metal, except machinery; (DK) machinery; (DL) electric, optic and other equipment ; (DM) vehicles and transports; (DN) furniture and recycling. See Chapter IV for further detail.

Most of these results are confirmed by the estimation of equation (2) with industry dummy interactions with cash-flow as an alternative to the partition-wise approach (Table A3 in Appendix, column 2). However, for the case of textiles (DB), plastics (DH) and electric, optic and other equipment (DL), the interaction term is positive and statistically significant, meaning that possibly, in these industries, firms are also financially constrained.

Nevertheless, it remains clear that there is a huge heterogeneity within sectors when it comes to the level of financial constraints. In fact, computing the HH index and comparing mean and median values (absolute and relative values with respect to the overall sample), as well as the percentage of positive observations (Table A3 in Appendix, columns 3-5), it is clear that such heterogeneity is very much present, as one would expect (if not from the industry-level summary statistics presented in Section 5.1). These results implicate that usual measures that rely on sample averages fail to capture such heterogeneity, therefore assigning firms incorrectly as constrained or not.

Overall, when we disaggregate service and manufacturing sectors into industries, we find a remarkable heterogeneity of financial constraints. Therefore, the hypothesis that differences in such constraints are larger within than between sectors (hypothesis *H2*) should not be rejected.

4.4. Differences across firms' size and age

We find that while for the case of age, in line with previous literature, the estimated interaction coefficients are always lower for older firms (Table 7 columns 2, 4 and 6), this is not the case for of size-cash flow interactions. In fact, for service firms, we do not find the expected inverse relationship between size and constraints, since the estimated interaction coefficients decrease until size class 3 ([100;250[employees) and then increases for firms with more than 250 employees (column 5). This suggests that, for the case of services, a non-monotonic (U-shaped) relationship between firm size and financial constraints might be present.

Also using equation (2), we further investigate these relationships by testing the inclusion of size and age interactions (as well as its quadratic terms) with cash-flow (Table 8). We find that, for the case of size and both the overall sample and manufacturing firms (columns 1 and 2, lines 6 and 8), estimates indicate the presence of an U-shaped relationship to financial constraints. All remaining interaction terms are not statistically different from zero. These results cast some doubts on previously devised monotonic relationships between firm size and financial constraints.

Table VI.6. Cash-Cash Flow Sensitivity estimation for services industries

VARIABLES	G	H	I	K	M	N	O
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$CF_{i,t}$	0.202***	0.431***	0.162**	0.149**	0.528***	0.133	0.070
	(0.045)	(0.127)	(0.068)	(0.062)	(0.128)	(0.160)	(0.108)
$\Delta y_{i,t}$	0.002	0.040	0.022	0.030***	0.049	-0.081	-0.028
	(0.005)	(0.035)	(0.015)	(0.011)	(0.036)	(0.051)	(0.042)
$S_{i,t}$	0.012	0.007	-0.000	0.040***	0.069*	-0.004	-0.011
	(0.008)	(0.020)	(0.012)	(0.015)	(0.036)	(0.019)	(0.020)
$I_{i,t}$	-0.234***	-0.367***	-0.142***	-0.278***	-0.561***	-0.363***	-0.093
	(0.026)	(0.059)	(0.049)	(0.052)	(0.074)	(0.083)	(0.065)
$\Delta NWC_{i,t}$	-0.129***	-0.146***	-0.069***	-0.192***	-0.168***	-0.221***	-0.109**
	(0.011)	(0.029)	(0.021)	(0.023)	(0.046)	(0.051)	(0.043)
$ISS_{i,t}$	0.096***	0.188***	0.073**	0.035	0.323***	0.063	0.075*
	(0.011)	(0.043)	(0.029)	(0.025)	(0.060)	(0.045)	(0.038)
$\Delta INT_{i,t}$	-0.555***	0.426	0.043	-0.609	1.266*	0.400	-0.872*
	(0.176)	(0.460)	(0.415)	(0.403)	(0.753)	(0.776)	(0.523)
$FinI_{i,t}$	-0.133***	-0.126**	-0.029	-0.056	-0.375**	-0.422***	-0.227**
	(0.037)	(0.052)	(0.054)	(0.064)	(0.168)	(0.128)	(0.103)
Observations	3,630	427	636	786	297	222	250
Number of firms	1,196	131	208	266	95	67	79
Hansen p-value	0.963	0.555	0.336	0.454	0.523	0.312	0.794
R-squared	0.183	0.323	0.105	0.249	0.378	0.321	0.158

Notes: Regression of equation (1). These estimations also include year dummies. Robust standard errors in parenthesis. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively. Further test statistics available from the authors on request. Industry key: (G) wholesale; (H) hospitality; (I) transport and communications; (K) rentals and business services industry; (M) education; (N) health; (O) other services. See Chapter IV for further detail.

Alternatively, we look at the relationship between the HH index and either size or age for the different sectors. We find that, in some cases, one might expect a non-monotonic relationship (namely U-shaped) between these variables. Firstly, the spearman correlation coefficients yield negative but not statistically significant correlations between the HH index and both size and age (available from authors). Secondly, the results from a simple OLS regression of equation (4) report an inverse relationship and a U-shaped relationship between size and constraints for the overall and manufacturing samples, respectively (Table 9, columns 1-3).[13] Oddly, neither of the coefficients is statistically significant for service firms and results point towards a direct relationship between age and constraints for manufacturing firms. However, if we restrict our sample to positive HH values (only those firms that are financially constrained), we find a U-shaped relationship between constraints and firm size for all subsamples (columns 4-6) and an inverse relationship between age and constraints both for the overall and services subsamples. Interestingly, the coefficients on firm age for manufacturing firms are not statistically significant. If we estimate a simultaneous quantile regression of equation (4), results show that while for lower quantiles there is an inverted U-shaped relationship between constraints and both size and age, for higher quantiles, this relationship changes to a U-shaped one.[14]

Overall, size and age interplay with financial constraints in a rather non-trivial way. On one hand, the relationship between size and constraints is non-monotonic for the case of services and, even though we find some evidence suggesting an inverse relationship for manufacturing firms, this finding is not robust to all approaches. On the other, the relationship between age and constraints, in fact, appears to be inverse for the case of services. However, this is not the case for manufacturing firms, for whom we have mixed evidence. Consequently, these results indicate that the hypothesis (*H3*) should be rejected. Accordingly, the rather odd possibility of the relationship between size, age and constraints being of an U-shaped form opens for further discussion both at the theoretical and empirical levels.

[13] Note that this regression is done upon a cross section that results from the computation of average time values of the variables of interest, since the HH index is a time average itself. Furthermore, zero but statistically significant coefficients arise due to the scale of size and age variables with respect to HH values (see Table 1.1).
[14] Simultaneous quantile regression, with 499 bootstrap replications, for the following quantiles: 5; 10; 15; 20; 25; 30; 35; 40; 45; 50; 55; 60; 65; 70; 75; 80; 85; 90 and 95—Tables A6, A7 and A8 in the Appendix.

Table VI.7. CCFS with size and age classes interactions

VARIABLES	Overall		Manufacturing		Services	
	Size	Age	Size	Age	Size	Age
	(1)	(2)	(3)	(4)	(5)	(6)
$CF_{i,t} * \overline{SIZE_i}$						
[20;50[	0.230***		0.164***		0.297***	
	(0.030)		(0.038)		(0.045)	
[50;100[	0.163***		0.147***		0.185***	
	(0.028)		(0.032)		(0.046)	
[100;250[	0.114***		0.084***		0.149***	
	(0.023)		(0.026)		(0.050)	
[250;+∞[	0.132***		0.047		0.241***	
	(0.030)		(0.037)		(0.050)	
$CF_{i,t} * \overline{AGE_i}$:						
[0;10[		0.179***		0.132***		0.247***
		(0.038)		(0.045)		(0.061)
[10;40[		0.169***		0.114***		0.238***
		(0.019)		(0.022)		(0.034)
[40;+∞[		0.125***		0.089**		0.168**
		(0.034)		(0.037)		(0.068)
$\Delta y_{i,t}$	0.015***	0.015***	0.020***	0.020***	0.011**	0.011**
	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)
$I_{i,t}$	-0.201***	-0.201***	-0.141***	-0.140***	-0.271***	-0.271***
	(0.012)	(0.012)	(0.014)	(0.014)	(0.020)	(0.020)
$\Delta NWC_{i,t}$	-0.123***	-0.122***	-0.106***	-0.106***	-0.141***	-0.140***
	(0.006)	(0.006)	(0.008)	(0.008)	(0.009)	(0.009)
$ISS_{i,t}$	0.086***	0.086***	0.071***	0.071***	0.103***	0.102***
	(0.006)	(0.006)	(0.008)	(0.007)	(0.010)	(0.010)
$\Delta INT_{i,t}$	-0.091	-0.097	-0.011	-0.015	-0.180	-0.195
	(0.103)	(0.104)	(0.130)	(0.130)	(0.165)	(0.166)
$FinI_{i,t}$	-0.118***	-0.116***	-0.083***	-0.079***	-0.148***	-0.148***
	(0.018)	(0.018)	(0.024)	(0.024)	(0.027)	(0.027)
Observations	13,874	13,874	7,590	7,590	6,256	6,256
Number of firms	4,322	4,322	2,277	2,277	2,043	2,043
Hansen chi2 p-value	0.473	0.364	0.533	0.499	0.277	0.308
R-squared	0.158	0.156	0.129	0.127	0.196	0.193

Notes: Regression of equation (2), where X corresponds to either size or age classes dummies. These estimations also include year dummies. Robust standard errors in parenthesis. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively.

Table VI.8. CCFS with size and age interactions

VARIABLES	Overall (1)	Manufacturing (2)	Services (3)
$CF_{i,t}$	0.157***	0.104*	0.217***
	(0.047)	(0.057)	(0.076)
$SIZE_{i,t}$	-0.000**	-0.000	-0.000*
	(0.000)	(0.000)	(0.000)
$CF_{i,t} * SIZE_{i,t}$	-0.000*	-0.000**	-0.000
	(0.000)	(0.000)	(0.000)
$CF_{i,t} * SIZE^2{}_{i,t}$	0.000***	0.000**	0.000
	(0.000)	(0.000)	(0.000)
$AGE_{i,t}$	0.000	0.001	-0.001
	(0.002)	(0.002)	(0.002)
$CF_{i,t} * AGE_{i,t}$	0.003	0.004	0.002
	(0.002)	(0.003)	(0.004)
$CF_{i,t} * AGE^2{}_{i,t}$	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)
$\Delta y_{i,t}$	0.015***	0.020***	0.011**
	(0.003)	(0.004)	(0.005)
$I_{i,t}$	-0.196***	-0.139***	-0.262***
	(0.012)	(0.014)	(0.020)
$\Delta NWC_{i,t}$	-0.122***	-0.106***	-0.138***
	(0.006)	(0.008)	(0.009)
$ISS_{i,t}$	0.084***	0.070***	0.100***
	(0.006)	(0.007)	(0.010)
$\Delta INT_{i,t}$	-0.061	0.029	-0.173
	(0.105)	(0.132)	(0.169)
$FinI_{i,t}$	-0.116***	-0.081***	-0.150***
	(0.018)	(0.024)	(0.028)
Observations	13,724	7,527	6,169
Number of firms	4,255	2,247	2,006
Hansen chi2 p-value	0.882	0.380	0.970
R-squared	0.157	0.132	0.193

Notes: Regression of equation (2), where X corresponds to size, age and its square values. These estimations also include year dummies. Robust standard errors in parenthesis. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively.

Table VI.9. Relationship of size and age with the HH index

VARIABLES	All HH values			HH>0 subsample		
	Overall	Manuf.	Services	Overall	Manuf.	Services
	(1)	(2)	(3)	(4)	(5)	(6)
$\overline{SIZE_i}$	-0.000**	-0.000**	-0.000	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$\overline{SIZE}_i^2$	0.000	0.000**	0.000	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$\overline{AGE}_i$	0.000	0.000***	-0.000	-0.000***	0.000	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$\overline{AGE}_i^2$	-0.000	-0.000	-0.000	0.000*	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.001**	0.000	0.001**	0.005***	0.003***	0.006***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Observations	8,841	4,298	4,543	4,745	2,264	2,481
R-squared	0.000	0.002	0.000	0.006	0.009	0.008

Notes: Regression of equation (4) to test for the relationship between size, age and financial constraints, measured by the HH index. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively. The zero, but statistically significant coefficients, arise due to the scale of the variables Size and Age—see Table 1.1.

5. Discussion

The results show that the level of firms' financial constraints is heterogeneous across different sectors and industries. Therefore, for an accurate analysis of constraints, the decomposition of the structure of the economy should definitely be taken into account. In fact, common measures of financial constraints do not take into account potential heterogeneity stemming from sectoral and industrial specificities. For the case of CCFS and other indirect measures of financial constraints, the use of industry dummies is not enough to capture this heterogeneity because the dependent variable is not financial constraints. Instead, these are captured by the parameter estimate of the sensitivity of cash to cash-flow (this is similar for the case of ICFS). When it comes to indexes of constraints (e.g. Lamont et al. 2001; Hadlock and Pierce 2010) this heterogeneity is usually not taken into account, with the exceptions of Whited and Wu (2006) (includes industry sales growth) and Musso and Schiavo (2008) (a score based on the values of seven different variables for each firm-year relative to the respective industry average). Therefore future analysis of firms' financial constraints should also take into account this dimension.

Furthermore, not rejecting (*H1*) and (*H2*) implies that the heterogeneous financing problems of firms across different industries and economic sectors, by imposing distinct barriers to firm growth, will have a crucial impact upon the composition of the economy. Accordingly, different degrees of financial constraints will undoubtedly affect the dynamics of structural change and thus economic growth (cf. Saviotti and Pika 2004). Moreover, the extent to which the notion of financial constraints should be extended to the industry and sector levels should be further explored. In fact, the high degree of heterogeneity found at the sectoral and particularly the industrial level, suggests that aggregated analysis may well hide a number of specificities that might affect the extent to which firms are financially constrained. Therefore, this work is particularly useful to the literature that attempts to classify sectors and industries as financially constrained.[15]

On the other hand, the distinct results obtained between manufacturing and services with respect to firm size and age (rejection of *H3*) cast serious doubts on previous relationships between these variables and financial constraints, found for aggregated samples of firms. While for samples that include all sectors of economic activity, previous empirical literature identifies an inverse relationship between both size and age and constraints, this research shows that such findings are not robust to sector and industry disaggregation. Still,

[15] This classification is specifically used in the literature on financial development at the regional and country levels since Rajan and Zingales (1998).

this is a somewhat expected result, since the characteristics of different economic activities might have a significant impact on financial constraints. In particular, manufacturing firms, on average, require a larger initial investment, have a larger portion of sunk-costs and have to attain a higher minimum efficient scale than service firms. Accordingly, size is more important for manufacturing than for service firms, explaining the linear coefficient on size carrying a negative sign in all estimations for the former and the U-shaped relationship found for the latter. Conversely, service firms, for whom human capital is preponderant, may draw larger benefits from a learning process than do manufacturing firms. Therefore, age has a decisive and clear impact on the constraints faced by services, that contrasts with the mixed evidence found for manufacturing.

These results have important implications. In particular, when it comes to empirical research that relies on (either one or both) size and age as proxies of financial constraints. Firstly, it is not totally clear that, for aggregated samples, there is an inverse relationship between such constraints and size or age. Secondly, our findings suggest that, depending on the sector being analysed, size or age may work as better proxies of financial constraints.

As a consequence, these findings put into perspective widely accepted results on financial constraints and firm size and age. Additionally, measures and indexes of constraints that are based on either one or both of these variables must be checked for its robustness. The most notorious example is the SA index (see Hadlock and Pierce 2010) that is based solely on these variables.

Finally, the effects of size and age, as well as other firm characteristics, on financial constraints are most probably distinct across different industries. Despite being extremely interesting, due to the lack of observations we were unable to carry out such analysis.

6. Concluding remarks

In this Chapter, we analyse the differences in financial constraints between and within manufacturing and service sectors, by estimating cash-cash flow sensitivities upon a large unbalanced panel of Portuguese firms. Moreover, we split our sample according to exogenous firm characteristics that are believed to be good proxies for financial constraints (size and age) in order to test the validity of such classification schemes in different sectors of economic activity. As robustness tests, we additionally interact size and age with cash-flow and make use of the HH index.

This work adds to the discussion over firms' financial constraints as well as it contributes to a better understanding of the differences between manufacturing and services and the heterogeneity within these sectors.

On the whole, our results clearly show that financial constraints is a serious problem affecting the dynamics of Portuguese firms. Furthermore, we verify that such constraints are more severe for service than for manufacturing firms. With respect to industry analysis, despite the considerable differences between the severity of financial constraints in the aggregate manufacturing and service sectors, we find a striking heterogeneity of access to external finance. Moreover, regarding firm size and age, distinct patterns arise between those sectors, indicating that size or age work as better proxies of financial distress, depending on firms' economic sector of activity. This result has serious implications on the interpretation of previous findings.

These results are relevant for policymaking purposes. Public financial support, that typically positively discriminates smaller, exporting or new firms, should to take into account a new dimension. Namely, we argue that such policies should also accommodate the fact that financial constraints are distinct between sectors and highly heterogeneous across industries.

Finally, the severity of financial constraints in services that are fundamental for economic development (e.g. education) or are main technology diffusers (e.g. some business services) calls for policies that help to mitigate these constraints.

Appendix

Table VI.A1. CCFS with different proxies for investment opportunities

VARIABLES	Forward investment			Lead investment			Forward sales growth		
	Overall	Manufacturing	Services	Overall	Manufacturing	Services	Overall	Manufacturing	Services
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$CF_{i\,t}$	0.141***	0.096***	0.204***	0.122***	0.097***	0.168***	0.137***	0.107***	0.173***
	[0.099;0.184]	[0.051;0.141]	[0.125;0.282]	[0.070;0.175]	[0.037;0.157]	[0.083;0.253]	[0.103;0.172]	[0.069;0.145]	[0.111;0.234]
$I_{i.t+1}$	0.014	0.021	0.014						
	[-0.014;0.041]	[-0.010;0.052]	[-0.035;0.062]						
$\frac{I_{i,t+2}+I_{i,t+1}}{I_{i,t}}$				0.000**	0.000	0.000**			
				[0.000;0.000]	[-0.000;0.000]	[0.000;0.000]			
$\Delta y_{i.t+1}$							-0.012***	-0.011**	-0.012**
							[-0.018;-0.006]	[-0.020;-0.003]	[-0.020;-0.003]
$\Delta y_{i.t}$	0.017***	0.020***	0.014**	0.020***	0.014*	0.030***	0.011***	0.016***	0.006
	[0.010;0.025]	[0.011;0.030]	[0.002;0.026]	[0.009;0.031]	[0.002;0.025]	[0.013;0.047]	[0.005;0.017]	[0.008;0.024]	[-0.003;0.015]
$S_{i.t}$	0.022***	0.024***	0.025**	0.007	0.015	0.004	0.016***	0.020***	0.014*
	[0.011;0.033]	[0.012;0.037]	[0.007;0.042]	[-0.008;0.022]	[-0.003;0.033]	[-0.020;0.028]	[0.007;0.025]	[0.009;0.031]	[0.000;0.027]
$I_{i.t}$	-0.222***	-0.171***	-0.279***	-0.265***	-0.221***	-0.331***	-0.210***	-0.165***	-0.260***
	[-0.250;-0.194]	[-0.203;-0.139]	[-0.326;-0.233]	[-0.304;-0.225]	[-0.267;-0.176]	[-0.400;-0.263]	[-0.233;-0.186]	[-0.193;-0.138]	[-0.298;-0.222]
$\Delta NWC_{i.t}$	-0.132***	-0.116***	-0.149***	-0.143***	-0.115***	-0.185***	-0.125***	-0.111***	-0.137***
	[-0.145;-0.118]	[-0.133;-0.100]	[-0.171;-0.127]	[-0.163;-0.123]	[-0.137;-0.093]	[-0.218;-0.151]	[-0.137;-0.114]	[-0.126;-0.097]	[-0.154;-0.120]
$ISS_{i.t}$	0.085***	0.075***	0.093***	0.101***	0.093***	0.108***	0.080***	0.071***	0.088***
	[0.070;0.099]	[0.057;0.092]	[0.071;0.115]	[0.079;0.122]	[0.066;0.119]	[0.074;0.141]	[0.068;0.092]	[0.056;0.087]	[0.069;0.107]
$\Delta INT_{i.t}$	0.096	-0.163	0.323	0.124	0.119	0.099	0.048	-0.006	0.074
	[-0.148;0.339]	[-0.466;0.141]	[-0.064;0.710]	[-0.216;0.465]	[-0.328;0.567]	[-0.411;0.608]	[-0.147;0.244]	[-0.260;0.247]	[-0.224;0.373]
$FinI_{i.t}$	-0.118***	-0.090***	-0.144***	-0.129***	-0.091*	-0.158***	-0.115***	-0.073***	-0.158***
	[-0.160;-0.076]	[-0.144;-0.036]	[-0.209;-0.080]	[-0.190;-0.068]	[-0.170;-0.013]	[-0.249;-0.067]	[-0.149;-0.080]	[-0.118;-0.028]	[-0.210;-0.105]
Dummies									
Year	YES	YES	YES	YES	YES	YES	YES	YES	YES
Industry	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	13,874	7,590	6,256	13,874	7,590	6,256	13,874	7,590	6,256
No. of firms	4,322	2,277	2,043	4,322	2,277	2,043	4,322	2,277	2,043
Hansen p-val.	0.368	0.206	0.819	0.463	0.430	0.751	0.560	0.455	0.830
R-squared	0.155	0.125	0.193	0.158	0.131	0.195	0.159	0.132	0.195

Notes: Regression of equation (1) with forward investment ($I_{i,t+1}$), sales growth ($\Delta y_{i,t+1}$) and lead investment ($I_{i,t+2}+I_{i,t+1}/I_{i,t}$) as alternative proxies for investment opportunities. We report 90% confidence intervals in brackets. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively. Further test statistics available from the authors on request.

Table VI.A2. Validation of HH index

VARIABLES	HH index quartiles			
	Q1	Q2	Q3	Q4
$CF_{i,t}$	-0.2113***	-0.0499***	0.1467***	0.4843***
	(0.041)	(0.019)	(0.022)	(0.037)
$\Delta y_{i,t}$	0.0077	0.0050	0.0032	0.0259***
	(0.007)	(0.004)	(0.004)	(0.007)
$I_{i,t}$	-0.2563***	-0.0742***	-0.1491***	-0.2730***
	(0.030)	(0.014)	(0.018)	(0.029)
$\Delta NWC_{i,t}$	-0.1250***	-0.0552***	-0.0859***	-0.1992***
	(0.014)	(0.007)	(0.009)	(0.015)
$ISS_{i,t}$	0.1297***	0.0377***	0.0478***	0.0963***
	(0.014)	(0.007)	(0.009)	(0.016)
$\Delta INT_{i,t}$	-0.0349	-0.1315	-0.2509**	-0.4780*
	(0.257)	(0.109)	(0.112)	(0.244)
$FinI_{i,t}$	-0.2613***	-0.0331**	-0.0715***	-0.1465***
	(0.058)	(0.014)	(0.025)	(0.054)
Observations	2,633	4,443	4,184	2,614
Number of firms	893	1,274	1,255	900
Hansen chi2 p-value	0.063	0.174	0.009	0.135
R-squared	0.261	0.064	0.105	0.310

Notes: Regression of equation (1) by quartiles of the HH index. We should note that using interactions, as in equation (3), would result in collinearity problems, by construction of the index. Robust standard errors in parenthesis. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively. Further test statistics available from the authors on request.

Table VI.A3. Summary of results on CCFS and HH index by sector and industry

CAE	TEXT	CCFS	CCFS INTERACT	HH	HH norm.	Median %HH>0
		(1)	(2)	(3)	(4)	(5)
ALL	Overall Sample	0.153***	N.A.	0.0006	0	0.0000
		[0.118;0.188]	N.A.	(0.0088)	(1)	53.48%
MANUF	Manufacturing firms	0.093***	0.129***	0.0005	-0.011	0.0000
		[0.054;0.132]	[0.091;0.168]	(0.0071)	0.806)	52.70%
DA	Food, beverages & tobacco	0.1263**	0.146***	0.0006	0.001	0.0001
		[0.028;0.224]	[0.053;0.238]	(0.0058)	(0.653)	53.95%
DB	Textiles	0.0702	0.117***	0.0003	-0.035	0.0000
		[-0.027;0.168]	[0.035;0.198]	(0.0089)	(1.009)	51.35%
DC	Tanning	0.0585	0.110	0.0009	0.029	0.0000
		[-0.111;0.228]	[-0.054;0.274]	(0.0062)	(0.699)	55.02%
DD	Wood	0.1295*	0.127*	0.0004	-0.021	0.0000
		[-0.016;0.275]	[-0.024;0.278]	(0.0057)	(0.648)	45.49%
DE	Paper	0.1331***	0.115**	0.0002	-0.050	0.0001
		[0.033;0.233]	[0.006;0.224]	(0.0043)	(0.489)	57.54%
DG	Chemicals	0.1019*	0.121**	-0.0001	-0.075	0.0000
		[-0.011;0.215]	[0.014;0.228]	(0.0063)	(0.708)	51.47%
DH	Plastics	0.1825	0.235**	0.0003	-0.035	0.0000
		[-0.083;0.448]	[0.000;0.469]	(0.0042)	(0.476)	53.21%
DI	Non-metallic mineral products	0.0397	0.077	0.0006	-0.002	0.0000
		[-0.064;0.143]	[-0.028;0.183]	(0.0063)	(0.710)	51.61%
DJ	Metal, except machinery	0.1130	0.194***	0.0006	-0.005	0.0000
		[-0.037;0.263]	[0.068;0.320]	(0.0052)	(0.589)	53.11%
DK	Machinery	0.1629**	0.176***	0.0004	-0.019	0.0000
		[0.020;0.306]	[0.056;0.295]	(0.0077)	(0.872)	52.20%
DL	Electric, optic & other equipment	0.0823	0.166**	0.0009	0.039	0.0000
		[-0.062;0.227]	[0.021;0.311]	(0.0069)	(0.783)	58.08%
DM	Vehicles & transports	0.0222	0.085	0.0012	0.071	0.0000
		[-0.146;0.191]	[-0.055;0.224]	(0.0100)	(1.130)	52.33%
DN	Furniture & recycling	-0.0156	0.063	0.0007	0.013	0.0000
		[-0.142;0.111]	[-0.097;0.223]	(0.0104)	(1.179)	53.20%
SERV	Services firms	0.227***	0.211***	0.0007	0.011	0.0001
		[0.165;0.289]	[0.152;0.271]	(0.0102)	(1.152)	54.21%
G	Wholesale	0.2016***	0.169***	0.0003	-0.033	0.0000
		[0.113;0.290]	[0.086;0.252]	(0.0072)	(0.810)	53.56%
H	Hospitality	0.4311***	0.358***	0.0004	-0.026	0.0001
		[0.183;0.680]	[0.133;0.584]	(0.0090)	(1.017)	54.42%
I	Transport and communications	0.1618**	0.164***	0.0005	-0.015	0.0000
		[0.028;0.296]	[0.044;0.284]	(0.0089)	(1.006)	52.78%
K	Rentals & business services	0.1494**	0.189***	0.0009	0.038	0.0001
		[0.028;0.271]	[0.064;0.315]	(0.0146)	(1.649)	54.01%
M	Education	0.5281***	0.408***	0.0050	0.495	0.0004
		[0.278;0.778]	[0.167;0.648]	(0.0207)	(2.347)	64.29%
N	Health	0.1332	0.074	0.0024	0.200	0.0001
		[-0.181;0.447]	[-0.290;0.438]	(0.0165)	(1.864)	56.25%
O	Other services	0.0697	0.097	0.0007	0.007	0.0001
		[-0.142;0.281]	[-0.103;0.297]	(0.0063)	(0.712)	55.00%

Notes: Results on financial constraints, for different sectors and industries, through different approaches: Column (1) reports the estimation results for equation (1) upon the different subsamples; Column (2) those of equation (2) with industry dummies; Column (3) the means and standard deviations of the HH index as in equation (3); Column (5) the median of the index and the percentage of observations above zero (financially constrained). For easier interpretation, we report adjusted HH distributions: $HH^a = \frac{x-\mu}{\sigma}$, where x is the HH original value, μ the overall sample mean and σ the overall sample standard deviations (column 4). Interpretation is with reference to the overall sample distribution that is set to have zero mean and unit standard deviation. Robust standard deviations in parenthesis and 95% level confidence intervals in brackets. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively.

Table VI.A4: Summary of size and age relationships with financial constraints

	Overall		Manufacturing		Services	
SIZE	-	U	-	U	U	U
	U	-	U	U	N	N
AGE	-	U	-	N	-	-
	N	N	N	+	N	N

Key for the estimation used

CCFS	HH fit for HH>0
CCFS interactions	HH fit

Notes: This table shows what type of relationship one might expect, given the results obtained with the estimation of: a) CCFS upon different subsamples and size and age classes interactions with cash-flow (Table 7); b) CCFS with size and age cash-flow interactions (Table 8); c) a quadratic fit of the HH index on size and age (Table 9, columns 1-3); d) the same quadratic fit for the subsample of firms that are found to be financially constrained using the HH index—values above zero—(Table 11, columns 4-6). The signs (+) and (-) denote a possible direct and inverse relationship, respectively. Additionally, (U) denotes a possible U-shaped relationship and N that no clear relationship was found.

Table VI.A5. Main variables in Services against Manufacturing

VARIABLES	K-S test	F-P test
	(1)	(2)
$\Delta CS_{i,t}$	0.0644	-4.872
p-val	0.000	0.000
$CF_{i,t}$	0.0795	7.953
p-val	0.000	0.000
$\Delta y_{i,t}$	0.0788	-9.704
p-val	0.000	0.000
$S_{i,t}$	0.0485	4.534
p-val	0.000	0.000
$I_{i,t}$	0.0956	10.805
p-val	0.000	0.000
$\Delta NWC_{i,t}$	0.0704	-7.682
p-val	0.000	0.000
$ISS_{i,t}$	0.0262	-1.006
p-val	0.009	0.314
$\Delta INT_{i,t}$	0.0227	-1.408
p-val	0.036	0.159
$FinI_{i,t}$	0.0505	1.575
p-val	0.000	0.115
SIZE	0.1771	20.045
p-val	0.000	0.000
AGE	0.0906	12.195
p-val	0.000	0.000

Notes: We report the statistics and p-values of a Kolmogorov-Smirnov and a Fligner-Policello test for comparing the distributions of main variables between services (1) against manufacturing (0) samples.

Table VI.A6. Quantile regression for the Overall sample

Variables	(1) q05	(2) q10	(3) q15	(4) q20	(5) q25	(6) q30	(7) q35	(8) q40	(9) q45	(10) q50
Size	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***	0.0000**	0.0000	-0.0000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Size2	-0.0000*	-0.0000	-0.0000*	-0.0000	-0.0000	-0.0000	-0.0000**	-0.0000	-0.0000	-0.0000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age	0.0002***	0.0001***	0.0001***	0.0000***	0.0000***	0.0000*	0.0000	0.0000	-0.0000	-0.0000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age2	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000*	-0.0000	-0.0000	0.0000	0.0000	0.0000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	-0.0102***	-0.0048***	-0.0026***	-0.0016***	-0.0009***	-0.0005***	-0.0002***	-0.0001***	-0.0000	0.0001**
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	8,841	8,841	8,841	8,841	8,841	8,841	8,841	8,841	8,841	8,841

Variables	(11) q55	(12) q60	(13) q65	(14) q70	(15) q75	(16) q80	(17) q85	(18) q90	(19) q95
Size	-0.0000	-0.0000**	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Size2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000*	0.0000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age	-0.0000*	-0.0000*	-0.0000**	-0.0000***	-0.0000***	-0.0000***	-0.0001***	-0.0001***	-0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age2	0.0000	0.0000	0.0000**	0.0000*	0.0000**	0.0000***	0.0000***	0.0000*	0.0000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.0002***	0.0003***	0.0006***	0.0009***	0.0015***	0.0024***	0.0038***	0.0065***	0.0118***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Observations	8,841	8,841	8,841	8,841	8,841	8,841	8,841	8,841	8,841

Notes: Quantile regression results for the quantiles (q#) of the HH index. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively. The zero, but statistically significant coefficients, arise due to the scale of the variables Size and Age—see Chapter VI, Table 1.1.

Table VI.A7. Quantile regression for the Manufacturing sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Variables	q05	q10	q15	q20	q25	q30	q35	q40	q45	q50
Size	0.0000**	0.0000**	0.0000**	0.0000**	0.0000	0.0000	0.0000	0.0000	-0.0000	-0.0000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Size2	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0000	0.0000	0.0000	0.0000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age	0.0001***	0.0001***	0.0000***	0.0000**	0.0000**	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age2	-0.0000*	-0.0000**	-0.0000**	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0000	-0.0000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	-0.0079***	-0.0037***	-0.0022***	-0.0013***	-0.0008***	-0.0005***	-0.0002***	-0.0001***	-0.0000	0.0000
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	4,298	4,298	4,298	4,298	4,298	4,298	4,298	4,298	4,298	4,298

	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Variables	q55	q60	q65	q70	q75	q80	q85	q90	q95
Size	-0.0000**	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Size2	0.0000	0.0000***	0.0000***	0.0000***	0.0000***	0.0000**	0.0000	0.0000	0.0000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age	0.0000	0.0000	0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000	-0.0000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.0001***	0.0002***	0.0004***	0.0006***	0.0009***	0.0015***	0.0026***	0.0045***	0.0093***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Observations	4,298	4,298	4,298	4,298	4,298	4,298	4,298	4,298	4,298

Notes: Quantile regression results for the quantiles (q#) of the HH index. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively. The zero, but statistically significant coefficients, arise due to the scale of the variables Size and Age—see Chapter VI, Table 1.1.

Table VI.A8. Quantile regression for the Services sample

Variables	(1) q05	(2) q10	(3) q15	(4) q20	(5) q25	(6) q30	(7) q35	(8) q40	(9) q45	(10) q50
Size	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***	0.0000**	0.0000	0.0000	-0.0000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Size2	-0.0000	-0.0000	-0.0000*	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age	0.0003***	0.0001***	0.0001***	0.0000***	0.0000***	0.0000*	0.0000	0.0000	-0.0000	-0.0000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age2	-0.0000**	-0.0000**	-0.0000**	-0.0000***	-0.0000***	-0.0000	-0.0000	-0.0000	0.0000	0.0000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	-0.0124***	-0.0059***	-0.0033***	-0.0018***	-0.0011***	-0.0006***	-0.0002***	-0.0001*	0.0000	0.0001***
	(0.002)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	4,543	4,543	4,543	4,543	4,543	4,543	4,543	4,543	4,543	4,543

Variables	(11) q55	(12) q60	(13) q65	(14) q70	(15) q75	(16) q80	(17) q85	(18) q90	(19) q95
Size	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000***	-0.0000**	-0.0000***	-0.0000***	-0.0000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Size2	0.0000	0.0000	0.0000	0.0000	0.0000*	0.0000	0.0000**	0.0000**	0.0000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age	-0.0000*	-0.0000**	-0.0000***	-0.0000***	-0.0001***	-0.0001***	-0.0001***	-0.0001***	-0.0002**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age2	0.0000	0.0000	0.0000***	0.0000***	0.0000***	0.0000***	0.0000**	0.0000*	0.0000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.0003***	0.0006***	0.0010***	0.0014***	0.0021***	0.0031***	0.0049***	0.0081***	0.0149***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.002)
Observations	4,543	4,543	4,543	4,543	4,543	4,543	4,543	4,543	4,543

Notes: Quantile regression results for the quantiles (q#) of the HH index. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively. The zero, but statistically significant coefficients, arise due to the scale of the variables Size and Age—see Chapter VI, Table 1.1.

CHAPTER VII – OPENNESS, EXPORTS AND THE EUROPEAN MONETARY INTEGRATION

1. Introduction

The causality flow between financial constraints and openness to foreign markets is rather unclear. On one hand, open firms may have access to foreign finance and, especially if they are strong exporters, see their domestic credit conditions improve. On the other, these firms may only export because they were able to overcome the financial constraints barrier. Effectively, there are additional costs to explore foreign markets and the required investment may be financially constrained. As a result, only firms that are not financially constrained are able to export.

This Chapter explores how financial constraints relate to the openness of firms to foreign markets, in particular to their exporting and importing activities. Additionally, it evaluates the changes in firms' levels of constraints driven by a monetary integration process (the European Common Currency). While we find an inverse relationship between export intensity and financial constraints, we cast some doubts on the argument stating that only unconstrained firms self-select into export behaviour. In fact, a priori constrained firms are also able to export and there are significant improvements in firms' ability to raise external funds once they start exporting. Furthermore, we argue that while in general the monetary integration reduced the constraints faced by Portuguese firms, these were affected differently depending on their importing and exporting activities.

After the accession to the European Economic Communities (now the European Union, EU) in 1986, Portugal experienced not only the creation of the Common Market in 1992, but most of all the introduction of the Common Currency in 2001. The monetary integration that culminated in the Euro brought several changes, of which we should point out the reduction of interest rates (annualised benchmark interest rate fell from 7.2% in 1996 to 2.1% in 2004)[1] and the promotion of deeper integration of financial markets within the Euro area. Not only could economic agents obtain finance in the Euro area cheaper and in an easier manner, but also the

[1] Annualised Euribor and Lisbor at 3 months with adjusted Lisbor by the mean difference in common years—see Chapter IV, Section 3 for details.

adoption of a stronger currency has eased the access of Portuguese firms to foreign finance.

This work is the first, to our knowledge, to analyse the effects of the European Monetary Integration on firms' ability to raise external funds. Additionally, along with the recent text of Silva (2011b), it is the first to analyse the relationship between openness to foreign markets, exports and firms' constraints for Portugal. Furthermore the relatively large time span of our unique dataset (see Chapter IV) allows us to compare two distinct periods (before and after monetary integration), which, as far as we know, is novel in the analysis of financial constraints at the firm level.[2]

The importance of this research with respect to policy making seems also worthwhile mentioning. On one hand, it provides insights on the effects that monetary integrations have upon firms financial constraints, which is relevant not only to understand the subsequent behaviour of Portuguese firms after the introduction of the Euro, but also for policymakers in countries now joining the Common Currency. On the other, the clarification of the relationship between constraints, degree of openness and, most importantly, export activity, provides further evidence that is crucial to devise the adequate incentives to alleviate constraints and ultimately foster exports.

The Chapter is organized as follows. Section 2 makes a brief discussion of the literature on financial constraints, firms' exports and monetary integration. In Section 3 we describe our empirical methodology, while Section 4 presents the main results. Finally, Section 5 pulls the pieces together and concludes.

2. Financial constraints, trade and monetary integration

Financial constraints seem to be an important factor to take into account when analysing international trade, as suggested, for example, by the theoretical models of Chaney (2005), Manova (2010) and Broll and Wahl (2011). These models are based on Melitz (2003), that already recognizes the importance of fixed costs when firms decide to export. However, in such models, financial constraints are seen as an exogenous barrier to export, even though we provide evidence that firms that start exporting experience a reduction in constraints. Shipping goods

[2] Focusing on firm size issues and using different datasets, Cabral and Mata (2003) and Oliveira and Fortunato (2006) have also analyzed the role of financial constraints. The former use entrepreneurs' age as a proxy for wealth (ultimately for financial constraints) to analyse the evolution of firm size distribution; the latter estimate the impact of cash-flow upon firm employment growth (significant cash-flow coefficients are usually regarded as indicating the presence of financial constraints)

across countries may entail significant additional costs than selling them in the domestic market, not to mention jurisdiction differences between countries (Bekaert and Hodrick, 2008). Even though one should expect a negative relationship between financial constraints and exports, it is not clear whether exporting reduces financial constraints or unconstrained firms self-select into exporting. On one hand, start exporting may lead to more stable cash-flows due to sales diversification, that hedge against demand side shocks (Bridges and Guariglia, 2008). Moreover, exporting may signal efficiency to investors (Ganesh-Kumar et al., 2001), not to mention that such firms may additionally gain access to foreign finance. On the other hand, firms face significant sunk costs when they start exporting, thus financial constraints may work as a major barrier to export activity. In fact, Bellone et al. (2010), for French firms, find that financial constraints work as an *ex-ante* barrier to export, since less constrained firms self-select into exporting behaviour. Examples of this self-selection effect can also be found in Greenway et al. (2007) for the UK, Manole and Spatareanu (2010) for the case of Czech firms, Forlani (2010) and Minetti and Zhu (2011) for Italian firms or in Berman and Hericourt (2010) for 9 developing and emerging economies. Therefore, if financial constraints work as a major barrier to export then, in order to foster exports, incentives particularly designed to alleviate such constraints are certainly warranted.[3] Recently, for the Portuguese case, Silva (2011b) analyses firms financial condition prior to export and uses an index of constraints based on Bellone et al. (2010) as dependent variable for treatment effects estimation of the impact of exports upon financial constraints. His results support that not only there is a self-selection effect, but also that such constraints are reduced once firms engage in exporting activity.

When it comes to financial development and integration, while previous empirical literature, in general, found that it alleviates firms' financial constraints (see Chapter III), recent studies analysing the impacts of financial crises, put these results into perspective. As an example, Popov and Ongena (2011), comparing both Western and Central with Eastern European countries, find that interbank market integration has reduced the level of constraints, especially in highly competitive banking sector markets. However, there were significant risks of overleveraging when integration took place at an accelerated pace. Nonetheless, Amiti and Weinstein (2009), for Japan, find that financial constraints severely affect exporting activity

[3] Note that, for the Portuguese case, Silva (2011a) finds that production subsidies neither significantly increase the probability that firms start to export nor increase their export intensity, even though production subsidies may not be particularly designed to foster exports, as the author argues.

during financial crisis, while Chor and Manova (2011), using US imports data find that, during the recent financial crisis, higher interbank interest rates led to lower exports especially for firms in more financially constrained sectors. For the European case, we should also stress that monetary integration came along, among others, with the loss monetary policy instruments. Still, the levels of financial constraints seem to be lower in bank-based systems (see Chapter III for a survey or Hernández-Cánovas and Martínez-Solano, 2010 for an example), especially for short-term finance (Kunt and Maksimovic, 2002). Gorg and Spaliara (2009), comparing firms operating in the UK and France, find that firm failure is more sensible to financial variables for firms in the "market-oriented system" of the UK. Additionally, they find that continuous export behaviour increases firm survival.

Overall, not only there is still much to be said with respect to the causality flows between financial constraints and degree of openness, but also the real benefits of the European monetary integration process are, still nowadays, rather unclear and very debatable. Specifically, despite the extensive literature on firm's financial constraints, the consequences of such processes upon the ability of firms to raise the necessary amounts to invest, grow and export are still to be fully explored. Keeping in mind that no fully consistent measure of financial constraints has yet been developed (see Chapter II), we test the following hypothesis:

H1) Monetary integration alleviates financial constraints and benefits mostly open firms

H2) Financially unconstrained firms self-select into exporting activity

3. Methodology

As described in previous Chapters, ACW (Almeida et al., 2004) construct an alternative model of liquidity demand and derive an empirical equation to estimate CCFS. Even though the financial nature of the cash stock variable avoids measurement problems in Tobin's Q and investment opportunities hidden in cash-flow (see Chapter II), as pointed by Acharya et al (2007), financially constrained firms will only use cash to increase cash stocks if hedging needs are high (investment opportunities). Therefore, we control both for debt issuances as well as for investment opportunities. Additionally, as pointed by Almeida et al. (2011), firms may invest in relatively liquid assets, other than cash, to transfer resources across time. As a result, we control for this effect through investment in non-cash net working capital ($\Delta NWC_{i,t}$) and financial investments ($FinI_{i,t}$). Furthermore, we follow of Lin (2007) and use the sum of net debt and equity issuances ($ISS_{i,t}$), as well as variations of interest paid ($\Delta INT_{i,t}$), for reasons outlined in Chapter V. In this specification, all variables are scaled by total assets (except the control for firm size). As a result, we have the following empirical specification:

$$\Delta CS_{i,t} = \beta_0 + \beta_1 CF_{i,t} + \beta_2 \Delta y_{i,t} + \beta_3 S_{i,t} + \beta_4 I_{i,t} + \beta_5 \Delta NWC_{i,t} + \beta_6 ISS_{i,t} + \beta_7 \Delta INT_{i,t} + \beta_8 FinI_{i,t} + d_k + \varepsilon_{i,t}, \quad \text{(VII. 1)}$$

where $\Delta CS_{i,t}$ is the variation in cash stocks of firm i in period t, $CF_{i,t}$ the cash-flow, $S_{i,t}$ is a control for firm size (log of total assets), $I_{i,t}$ investment, d_k are two-digit industry dummies (CAE rev. 2.1) and $\varepsilon_{i,t}$ the error term. We do not have financial markets information that would allow us to compute Tobin's Q. Therefore, we use sales growth ($\Delta y_{i,t}$) to proxy investment opportunities (see Chapter IV, Section 3 for a discussion).

The financial and investment covariates are endogenous, so we estimate the model using instrumental variables (GMM) with fixed effects to take account of unobserved firm-level heterogeneity and panel-robust standard errors. The set of instruments includes twice lagged cash flow, twice lagged sales growth, lagged investment, lagged variation of noncash net working capital, number of employees, lagged bond issuance and lagged variation in interest payments.[4]

In an attempt to capture the effects of monetary and financial integration, we split our sample into two major periods, before and after integration—i.e. up to 2000 and from 2001 onwards. Even though the integration processes is continuous, we pick this breakpoint for two main reasons. First, we only have access to the period 1996-2004, consequently, to guarantee a consistent estimation that takes advantage of lagged variables, we must guarantee that the subpanels have at least a 3 year depth (preferably 4 year to have a larger number of observations for a more efficient estimation).[5] Accordingly, our breakpoint should be either on 1999 or 2000. Second, since the Euro was introduced on the 1st January 2001, a landmark for the monetary integration process, we expect that the possible benefits would be observed from 2001 onwards.

[4] Note that if the methodology is applied to a large number of observations, coefficients are usually found to be statistically significant, since the precision of the estimate is higher. However, one should still expect that such coefficients are higher for financially constrained groups of firms. Comparison of CCFS estimates with other studies can be found in Chapter V.

[5] The limitations of the period of analysis (1996-2004) are due to methodological changes on the collection of data by INE—see Chapter IV.

Additionally, it is reasonable to expect that the real effects of the potential benefits from the ongoing integration process before 2001 would be subject to a "policy lag", therefore only having a significant impact on firms during the subsequent period. As a result, we expect that the bulk impact of the integration process would be felt during the period 2001-2004.[6]

In order to capture the effects of integration upon financial constraints by different classes of firms, according to their degree of openness to foreign markets, we construct a score that identifies firms as closed, open and, within open firms, those with low and high levels of openness (see Chapter IV, Section 3 for further detail). Consequently, we obtain different subsamples of firms depending on their exposure to European markets. Over the period, the EU, on average, accounts for 75% of the total exports and 89% of imports. As a result, we focus mainly on the degree of openness towards the EU. In fact, the results using a broader definition that covers total exports and imports remain unchanged.[7] The same procedure is made with respect to exports and imports, that we then classify as levels of export and import intensity, respectively. With the purpose of comparing the CCFS estimates across subsamples, we perform formal significance tests. The robustness of the inverse relationship between financial constraints, degree of openness, export and import intensities is checked by introducing interaction terms between cash-flow and these variables (Table A2 in Appendix).

Finally, in order to compare firms' constraints before and after shifting into open, exporting or importing activity, we group firms that moved from closed to open, started exporting and importing, respectively. We further divide the period of time, for each firm, according to the moment they shifted.

[6] Note that this second period not only captures a downward economic cycle, but it also corresponds to higher bilateral exchange rates (convergence was before 2001 but effects might be time lagged) which affects the capacity of firms to export and import (although very debatable, degree of openness should account for this inverse sign effects). Conversely, the previous period, not only captures an economic expansion period, but also carries the effects of the implementation of the Common market in 1992. This latter effect is, however, expected to be transversal to the whole period.

[7] For an example, compare the results of Table A3, columns 1-2 with those of Table 3, columns 8-9.

4. Empirical results

4.1. Summary statistics

Table 1.1 allows us to compare mean values, before and after monetary integration as well as by degree of openness, of the main variables used in the estimation. It is clear that after monetary integration mean variation of cash stocks and size (total assets) increased during the period, while mean cash-flow, sales growth, investment, debt and equity issuances, benchmark interest rate and degree of openness decreased (columns 2 and 3).[8] Additionally, while firms faced a mean decrease in interest paid, the mean variation in non cash net working capital increased. If instead we compare different levels of openness, it is possible to see that, for the whole period, differences between less open and highly open firms (columns 5 and 6) are, in general, larger than differences between closed and slightly open firms (columns 4 and 5). This indicates that firms with no or a low level of openness appear to be quite similar. However, when we further distinguish between levels of export and import intensity (Table 1.2 columns 1-3 and 4-6, respectively), this pattern is not as clear. While firms with higher levels of both import and export intensity are larger and face both lower cash stock variation and higher cash-flows (which should be expected at least for heavy exporters and might be a sign of lower constraints), intensive exporters are distinct from intensive importers when it comes to sales growth. In fact, while for higher levels of export intensity firms face lower sales growth, the opposite is true for higher levels of import intensity. This is rather puzzling, in particular for the case of exporters, since we would expect that sales would increase with higher levels of export intensity, even though it may well depend upon economic growth abroad. This odd result is also evident when we compare firms before and after they shifted into exporting or importing (columns 7-10).[9] In addition, for both of these groups of firms, they face larger cash stocks variation and lower cash-flows, once they shifted, which is in contrast with the statistics found for different intensities.[10]

[8] We should note that the economic downturn that came after 2001 may be affecting, to a larger extent some of these variables (e.g. exports or sales growth).

[9] Nevertheless, this is in line with the downward economic cycle that came after 2001, which, for the Portuguese case, is clear from the reduction in sales growth in the second major period of analysis (Table 1.1).

[10] See Table A1 for non-parametric tests comparing the distribution of main variables between different subsamples.

Table VII.1.1. Summary Statistics 1

VARIABLES	Period			Degree of Openness		
	1996-2004	1996-2000	2001-2004	NO	LOW	HIGH
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta CS_{i,t}$	0.002	0.001	0.003	0.003	0.003	0.001
	(0.062)	(0.064)	(0.061)	(0.070)	(0.055)	(0.059)
$CF_{i,t}$	0.085	0.091	0.081	0.083	0.082	0.089
	(0.089)	(0.089)	(0.088)	(0.098)	(0.085)	(0.083)
$\Delta y_{i,t}$	0.037	0.073	0.015	0.040	0.041	0.030
	(0.288)	(0.280)	(0.290)	(0.326)	(0.269)	(0.264)
$S_{i,t}$	15.539	15.441	15.599	15.074	15.698	15.840
	(1.448)	(1.508)	(1.406)	(1.508)	(1.476)	(1.237)
$I_{i,t}$	0.063	0.077	0.054	0.068	0.061	0.060
	(0.081)	(0.091)	(0.074)	(0.090)	(0.077)	(0.076)
$\Delta NWC_{i,t}$	-0.048	-0.060	-0.040	-0.051	-0.046	-0.047
	(0.166)	(0.179)	(0.157)	(0.189)	(0.155)	(0.152)
$ISS_{i,t}$	0.035	0.058	0.021	0.036	0.037	0.032
	(0.209)	(0.218)	(0.203)	(0.227)	(0.201)	(0.198)
$FinI_{i,t}$	0.039	0.038	0.040	0.039	0.042	0.036
	(0.088)	(0.086)	(0.090)	(0.096)	(0.090)	(0.079)
$\Delta INT_{i,t}$	-0.001	0.000	-0.001	-0.000	-0.000	-0.001
	(0.007)	(0.008)	(0.007)	(0.008)	(0.007)	(0.007)
R	0.030	0.037	0.026			
	(0.008)	(0.007)	(0.005)			
OPEN	0.125	0.134	0.119			
	(0.175)	(0.180)	(0.171)			
Observations	17,283	6,600	10,683	5,757	5,444	6,066
N. of firms	4,771	2,606	3,333	1,537	1,462	1,632

Notes: Mean values and standard deviations, given in parentheses, of the main variables used in the estimations.

Table VII.1.2. Summary Statistics 2

VARIABLES	Export intensity NO (1)	Export intensity LOW (2)	Export intensity HIGH (3)	Import intensity NO (4)	Import intensity LOW (5)	Import intensity HIGH (6)	Export shifting Before (7)	Export shifting After (8)	Import shifting Before (9)	Import shifting After (10)
$\Delta CS_{i,t}$	0.004	0.003	0.000	0.003	0.002	0.002	0.001	0.003	0.000	0.003
	(0.067)	(0.055)	(0.058)	(0.069)	(0.057)	(0.058)	(0.057)	(0.055)	(0.058)	(0.056)
$CF_{i,t}$	0.083	0.085	0.088	0.081	0.083	0.091	0.094	0.085	0.089	0.081
	(0.095)	(0.081)	(0.084)	(0.096)	(0.085)	(0.082)	(0.086)	(0.084)	(0.084)	(0.084)
$\Delta y_{i,t}$	0.045	0.033	0.027	0.036	0.037	0.038	0.066	0.035	0.051	0.024
	(0.313)	(0.261)	(0.266)	(0.323)	(0.271)	(0.256)	(0.292)	(0.271)	(0.272)	(0.279)
$S_{i,t}$	15.226	15.817	15.809	15.106	15.663	15.947	15.724	15.818	15.827	15.793
	(1.540)	(1.302)	(1.301)	(1.496)	(1.450)	(1.229)	(1.413)	(1.414)	(1.469)	(1.434)
$I_{i,t}$	0.067	0.056	0.062	0.066	0.060	0.062	0.074	0.054	0.067	0.056
	(0.089)	(0.075)	(0.074)	(0.088)	(0.076)	(0.077)	(0.092)	(0.072)	(0.079)	(0.079)
$\Delta NWC_{i,t}$	-0.050	-0.039	-0.051	-0.050	-0.049	-0.044	-0.053	-0.039	-0.048	-0.047
	(0.181)	(0.148)	(0.154)	(0.187)	(0.154)	(0.149)	(0.175)	(0.168)	(0.169)	(0.167)
$ISS_{i,t}$	0.040	0.034	0.028	0.035	0.033	0.037	0.060	0.026	0.044	0.024
	(0.222)	(0.194)	(0.200)	(0.226)	(0.202)	(0.194)	(0.222)	(0.197)	(0.230)	(0.197)
$\Delta INT_{i,t}$	-0.000	-0.001	-0.001	-0.000	-0.001	-0.001	-0.000	-0.000	-0.000	-0.001
	(0.008)	(0.007)	(0.007)	(0.008)	(0.007)	(0.006)	(0.008)	(0.007)	(0.008)	(0.006)
$FinI_{i,t}$	0.040	0.037	0.040	0.039	0.043	0.036	0.042	0.049	0.048	0.049
	(0.094)	(0.082)	(0.084)	(0.094)	(0.091)	(0.078)	(0.092)	(0.105)	(0.100)	(0.108)
Observations	8,039	4,315	4,913	6,652	5,066	5,550	990	990	1,302	1,302
N. of firms	2,210	1,144	1,333	1,782	1,374	1,523	300	300	397	397

Notes: Mean values and standard deviations, given in parentheses, of the main variables used in the estimations.

Table 1.3 reports the Spearman's correlation coefficients for the main variables used and by different sub-periods.[11] Firstly, we should point that the positive association between cash-flow and both changes in cash stocks and investment is slightly larger for the first period, which may provide the first insights on possible differences in CCFS (as well as ICFS).[12] Secondly, we should highlight that whereas in the first period there is a significant positive correlation between the benchmark interest rate and sales growth, this association is negative and significant in the second period (which may well result from the economic cycle). Meanwhile, the correlation between benchmark interest rate and cash-stock variation is only significantly negative for the first period. This latter pattern is also verified when it comes to the correlation between exports and both cash stock variation and sales growth. Additionally, there is a strong positive association between size and both export and import intensity, suggesting that larger firms are those that export and import the most, which is not unexpected.[13] Furthermore, the extremely high and significant correlation between import and export intensities is also as expected and indicates that defining degree of openness as the combination of both is sensible. Finally, the positive correlation between cash-flow and both export and import intensity is higher and strongly significant for the second period, pointing to potentially larger benefits for international firms after the Monetary integration.

[11] We avoid using Pearson's correlation coefficients due to the non-normality of a large number of variables.

[12] We test the alternative ICFS methodology and in fact results point to larger sensitivities in the first period (0.61 against 0.23, significant at 5% level).

[13] In fact, the correlation between size (total assets) and degree of openness is positive, high and statistically significant. The same is true if instead of total assets we use number of employees as a measure of size (spearman's rho is 0.23*). Furthermore, for different size classes (with thresholds at 50, 100 and 250 employees) the mean degree of openness is 0.07, 0.11, 0.16 and 0.17 for small, medium-small, medium-large and large firms, respectively.

Table VII.1.3. Spearman's rank correlation coefficients for the different periods

1996-2004	ΔCS	CF	ΔY	S	I	ΔNWC	ISS	ΔINT	$FinI_{i,t}$	R	EXPORT	IMPORT	OPEN
ΔCS	1.000												
CF	0.0830*	1.000											
ΔY	0.1185*	0.2395*	1.000										
S	-0.0012	-0.0539*	0.0386*	1.000									
I	-0.0274*	0.3205*	0.1594*	-0.0189	1.000								
ΔNWC	-0.2525*	0.0051	0.0248*	0.0518*	-0.2827*	1.000							
ISS	0.1105*	-0.1433*	0.1740*	0.0437*	0.2043*	0.003	1.000						
ΔINT	-0.0089	-0.0742*	0.1246*	0.0164	0.0876*	0.0354*	0.2125*	1.000					
$FinI_{i,t}$	-0.0218*	-0.0736*	-0.0324*	0.4043*	-0.0404*	-0.0135	0.0065	-0.0019	1.000				
R	-0.0307*	0.0360*	0.0888*	-0.0514*	0.1318*	-0.0377*	0.0598*	0.1180*	-0.0054	1.000			
EXPORT	-0.0202	0.0492*	-0.0254*	0.2135*	0.0260*	-0.0028	-0.0188	-0.0340*	0.0817*	0.0121	1.000		
IMPORT	-0.0101	0.0507*	0.0131	0.2876*	0.0130	0.0303*	0.0009	-0.0199	0.0819*	0.0232*	0.5501*	1.000	
OPEN	-0.0170	0.0477*	-0.0092	0.2581*	0.0145	0.0175	-0.0083	-0.0281*	0.0761*	0.0239*	0.8256*	0.8619*	1.000
1996-2000													
ΔCS	1.000												
CF	0.0896*	1.000											
ΔY	0.1277*	0.2170*	1.000										
S	-0.0158	-0.0619*	0.0426*	1.000									
I	-0.0170	0.3496*	0.1211*	-0.0216	1.000								
ΔNWC	-0.2372*	-0.0336*	0.0284	0.0671*	-0.3055*	1.000							
ISS	0.1087*	-0.1491*	0.1596*	0.0736*	0.1926*	0.0616*	1.000						
ΔINT	-0.0196	-0.0828*	0.1289*	0.0327*	0.0727*	-0.0073	0.2039*	1.000					
$FinI_{i,t}$	-0.0192	-0.0599*	-0.0265	0.4242*	-0.0338*	0.0030	0.0189	0.0064	1.000				
R	-0.0700*	-0.0241	0.0564*	0.0202	-0.0244	0.0549*	0.0073	0.3142*	0.0005	1.000			
EXPORT	-0.0386*	0.0374*	-0.0544*	0.2311*	0.0341*	0.0018	-0.0128	-0.0258	0.0653*	-0.0178	1.000		
IMPORT	-0.0254	0.0248	0.0062	0.3251*	0.0099	0.0445*	0.0158	-0.0013	0.0925*	0.0004	0.5372*	1.000	
OPEN	-0.0386*	0.0245	-0.0334*	0.2862*	0.0128	0.0286	0.0014	-0.0149	0.0720*	-0.0091	0.8264*	0.8536*	1.000
2001-2004													
ΔCS	1.000												
CF	0.0766*	1.000											
ΔY	0.1115*	0.2462*	1.000										
S	0.0131	-0.0372*	0.0587*	1.000									
I	-0.0362*	0.2822*	0.1487*	0.0098	1.000								
ΔNWC	-0.2698*	0.0540*	0.0419*	0.0270	-0.2460*	1.000							
ISS	0.1135*	-0.1520*	0.1671*	0.0285	0.1892*	0.0215	1.000						
ΔINT	0.0055	-0.0747*	0.1088*	0.0065	0.0872*	-0.0144	0.2191*	1.000					
$FinI_{i,t}$	-0.0243	-0.0850*	-0.0349*	0.3846*	-0.0442*	0.0009	-0.0030	-0.0086	1.000				
R	-0.0207	-0.0143	-0.1026*	-0.0165	0.0263	-0.0287	-0.0152	-0.0829*	0.0113	1.000			
EXPORT	-0.0015	0.0573*	-0.0050	0.2009*	0.0101	-0.0032	-0.0308*	-0.0458*	0.0984*	-0.0013	1.000		
IMPORT	0.0049	0.0717*	0.0138	0.2550*	0.0065	0.0194	-0.0185	-0.0416*	0.0724*	0.0208	0.5619*	1.000	
OPEN	0.0044	0.0658*	0.0057	0.2361*	0.0051	0.0106	-0.0245	-0.0450*	0.0809*	0.0161	0.8248*	0.8693*	1.000

Notes: Rank correlation coefficients were calculated using Sidak's adjustment. * denotes statistical significance at the .01 level.

4.2. Monetary integration

Portuguese firms, during the period 1996-2004 were, on average, financially constrained. Table 2 shows that before monetary integration firms saved, on average, 25 cents out of each euro of cash flow, meanwhile after integration the CCFS was reduced to 0.183 (first line of columns 2 and 3, respectively).[14] A formal Wald test rejects the hypothesis that the CCFS coefficient after integration is the same as before integration, at the 95% level. If we abstain from controlling for the money market, the difference in CCFS is also large and statistically significant (columns 6 and 7).[15] Noteworthy differences are also found with respect to the impact of sales growth, size, debt and equity issuances and interest payments variations in the cash policy of firms. The Euro landmark is further emphasized if year dummies are introduced (column 1). Even though a comparison between the two periods with year dummies is not econometrically feasible, in a regression over the whole period 1996-2004, only the dummy corresponding to 2000 is statistically significant.[16] This may indicate that, in this particular year, there were changes that significantly affected firms' cash policy. Alternatively, if we control for the evolution of the benchmark interest rate (columns 4 and 5), it is possible to observe that not only the CCFS difference between periods is much lower (and not statistically significant), but also that there is a huge difference in the impact of the benchmark interest rate between periods (negative for the first period and not different from zero in the second).[17] This result indicates that the evolution of interest rates (fell from 7.2% in 1996 to 2.1% in 2004), that mirrors the integration process, were an important determinant of firms' cash policy. Therefore, even if firms anticipated this effect, it helps in explaining the differences in CCFS between periods (columns 2-3 and 6-7) and supports the analysis distinguishing each period.

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[14] Results using ICFS approach (see Chapter V) yield 0.710*** and 0.326** estimates for the periods 1996-2000 and 2001-2004, respectively.

[15] Chapter V refers to a few benchmark CCFS coefficients from other studies.

[16] The use of lagged variables both as independent\endogenous variables and instruments imposes that a number of year dummies must be dropped due to collinearity. However, we tested simpler regressions and results do not differ substantially. Namely, either d5 (2000) is the only significant dummy (always at 1% level) or dummies corresponding to previous years are slightly significant (at either 5% or 10% levels), while 2000 remains the most significant.

[17] Note that the introduction of the benchmark interest rate, that is common to all firms—even though in practice firms are able to negotiate with banks\lenders their own interest rate (the reason to use interest paid)—implies that neither year dummies nor interest paid can be used in the estimation.

Table VII.2: CCFS estimation with different controls for money market

	Dummies	Baseline estimation		Benchmark interest rate		No controls	
VARIABLES	1996-2004	1996-2000	2001-2004	1996-2000	2001-2004	1996-2000	2001-2004
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$CF_{i,t}$	0.185***	0.245***	0.184***	0.221***	0.190***	0.245***	0.188***
	(0.017)	(0.037)	(0.027)	(0.037)	(0.027)	(0.037)	(0.027)
$\Delta y_{i,t}$	0.015***	0.020***	0.011**	0.021***	0.010**	0.019***	0.010**
	(0.003)	(0.007)	(0.004)	(0.007)	(0.004)	(0.007)	(0.004)
$S_{i,t}$	0.015***	0.028**	0.043***	0.042***	0.040***	0.023*	0.040***
	(0.004)	(0.012)	(0.008)	(0.013)	(0.008)	(0.012)	(0.008)
$I_{i,t}$	-0.220***	-0.241***	-0.241***	-0.244***	-0.242***	-0.237***	-0.243***
	(0.012)	(0.022)	(0.017)	(0.022)	(0.017)	(0.022)	(0.017)
$\Delta NWC_{i,t}$	-0.149***	-0.155***	-0.159***	-0.148***	-0.161***	-0.151***	-0.161***
	(0.006)	(0.012)	(0.009)	(0.012)	(0.009)	(0.012)	(0.009)
$ISS_{i,t}$	0.079***	0.103***	0.071***	0.095***	0.071***	0.102***	0.071***
	(0.004)	(0.009)	(0.006)	(0.009)	(0.006)	(0.009)	(0.006)
$FinI_{i,t}$	-0.130***	-0.252***	-0.235***	-0.241***	-0.237***	-0.243***	-0.237***
	(0.017)	(0.048)	(0.030)	(0.047)	(0.030)	(0.048)	(0.030)
$\Delta INT_{i,t}$	-0.214**	-0.205	-0.364**				
	(0.094)	(0.157)	(0.143)				
R				-0.734***	-0.100		
				(0.129)	(0.128)		
1999	-0.002						
	(0.002)						
2000	-0.009***						
	(0.002)						
2002	-0.001						
	(0.002)						
2003	0.001						
	(0.002)						
Observations	15,277	5,212	8,756	5,212	8,756	5,212	8,756
N. of firms	4,771	2,606	3,333	2,606	3,333	2,606	3,333
R-squared	0.184	0.212	0.201	0.224	0.199	0.211	0.199
Hansen p-val.	0.289	0.393	0.134	0.282	0.0976	0.312	0.0912

Notes: Regression of equation (1) as baseline estimation (columns 2 and 3). In column (1) we introduce year dummies, while in columns (4) and (5) we use the benchmark interest rate (R). In columns (6) and (7) we omit both $\Delta INT_{i,t}$ and R. All regressions include two-digit industry dummies (CAE rev.2.1). Robust standard errors in parentheses. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively.

4.3. Exporting and importing

As expected, Table 3 shows that there might be an inverse relationship between the degree of openness to foreign markets and financial constraints since, for the whole period, the higher the openness, the lower is the CCFS—columns 1-3 report the CCFS estimates that are all statistically different. This result may arise either because more open firms may have better access to foreign finance or only unconstrained firms are able to exploit foreign markets.

Interestingly, when we split the sample by the two major periods, we find a reduction in constraints for open firms (columns 6 and 7), while the level of financial distress of closed firms remains mostly unchanged (columns 4 and 5). However, depending on the degree of openness, firms' financial constraints were either reduced (columns 10 and 11) or, if not equal (estimates in columns 8 and 9 are not statistically different), were amplified. This is a puzzling result since we would expect, *a priori*, that even though the reduction in constraints should be larger for highly open firms, firms with lower levels of openness should also exhibit a reduction in constraints, given that monetary integration should benefit mostly those firms that also have businesses overseas—through exchange rate stability and access to both foreign banks and financial markets. Additional differences arise between firms with low and high levels of openness with respect to the impacts of sales growth, investment and variation of interest paid. We also tested the inclusion of real GDP growth or unemployment, in order to capture possible influences of the economic cycle, nevertheless the results remain very similar. Results remain unchanged if we additionally control for the benchmark interest rate, or even if, instead of degree of openness-EU, we use total degree of openness (see Table A3, in the Appendix).

These results indicate that while highly open firms benefited the most with the integration, closed firms experienced no changes with respect to constraints and, most interestingly, slightly open firms faced, if not the same, higher constraints in the second period. This odd result arises for firms that have very small degrees of openness—smaller than 0.5%, while for firms between 0.5% and 1% the results are as previously hypothesised. This might, however, be associated with larger competition for funds in the integrated markets, since firms with low degrees of openness might not be as visible abroad as they would be in the domestic market, while at the same time, losing their advantage on the domestic market, where lenders will then opt to finance domestic or even foreign firms with better prospects. In fact, if we compare the level of constraints of these firms with those of closed firms, the difference in CCFS estimates is larger for the initial period than for the second period. One could argue that lenders would no longer distinguish between slightly open and closed firms.

If instead we look at firm export and import activity separately, we see that firms with higher export or import intensities are less financially constrained, as expected, even though the pattern is clearer for the case of exports—while for exports (Table 4, columns 1-3) all estimates are statistically different, for the case of imports (Table 5, columns 1-3), high intensity estimates are not statistically different from those of lower intensity. However, when we compare the levels of constraints before and after monetary integration, distinct patterns arise. While no significant differences between periods are found for firms that either imported or not (Table 5, columns 4-7), firms that either exported or not (Table 4, columns 4-7) seem to have experienced a slight reduction in constraints with integration (a formal Wald test only rejects that the coefficients are statistically equal at the 90% level). Nevertheless, the levels of constraints for non-exporting firms in the second period is much larger than those of exporting firms in the first period (Table 4, columns 5 and 6, respectively).[18]

If we further distinguish between low and high levels of export and import intensities, we find a clear contrast between these firms. Whereas for high export intensity firms, financial constraints levels remain unchanged at low levels (estimates in columns 10 and 11 of Table 4 are not statistically different), high intensity importers experienced a clear reduction in constraints (Table 5, columns 10 and 11). These results suggest that firms that rely mostly on imports accrued larger benefits from integration than did export driven firms. This may arise because the former saw their credit conditions improved overseas, while the latter already benefited from a privileged position before integration, corroborated by the CCFS estimates for the first period (Table 5, column 10). Conversely, while there is

[18] Note that the reduction in constraints for non-exporting firms, even though apparently unexpected, goes in line with the general findings in section 5.2.

a clear increase in financial constraints for firms with lower import intensities (Table 5, columns 8 and 9), the level of constraints for firms with low export intensity, if not lower, remains practically unchanged in the second period (Table 4, columns 8 and 9 report CCFS estimates that are not statistically different). This result clarifies the higher CCFS, after integration, found for firms with lower degree of openness, provided it is due to a higher contribution of importing firms rather than exporting ones.

In order to verify if firms' constraints were actually reduced with shifting, there is no longer a point in analysing firm openness, since if a firm starts importing, even though there might be a constraints alleviating effect due to relationships established abroad, the opposite effect might be larger due to a possible necessity of importing goods (either machinery or raw materials) that boosts the demand for cash (this pattern is clear from the comparison of columns 5 and 6 in Table 6). However, if we look at firms that started exporting, it is clear that the self-selection effect (financial constraints barrier) is not as large as the benefits accruing from access to better finance either abroad or at home, as we can see from the comparison of the estimates from columns 4 and 5 (CCFS coefficients dropped from 0.265 to 0.145 and are statistically different). If instead estimates on CCFS before and after starting to export would be similar, then this would suggest that less constrained firms would self-select into exporting.[19] These results are confirmed if, instead of splitting the sample, we interact cash-flow with a binary indicator for the shifting status—before and after shifting (Table A1 in appendix). Nevertheless, even after starting to export, these firms still face significant constraints as they save, on average, 15 cents out of each extra euro of cash-flow. Finally, the fact that, on average, firms before starting to export present high CCFS (they save 27 cents out of each euro of extra cash-flow), casts serious doubts on the hypothesis that only unconstrained firms self-select into exporting activity.

[19] We should note that there is a significant reduction in the number of firms from the samples corresponding to the periods before shifting to those after shifting, which results from the estimator used, that requires at least 3 periods of observations for consistent estimation. This means that if a firm shifted in 1997 we will not have sufficient years to estimate the CCFS "before shifting", while such firm will appear in the "after shifting" CCFS estimation. To tackle this issue, we only estimate "after shifting" CCFS for those firms whose "before shifting" CCFS was feasible. Accordingly we have a smaller subsample of firms for which results are indeed comparable.

Table VII.3: CCFS estimation by openness towards the EU

Openness	NO	LOW	HIGH	NO		YES		LOW		HIGH	
	1996-2004	1996-2000	2001-2004	1996-2000	2001-2004	1996-2000	2001-2004	1996-2000	2001-2004	1996-2000	2001-2004
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
$CF_{i,t}$	0.269***	0.173***	0.107***	0.284***	0.272***	0.208***	0.151***	0.167**	0.221***	0.240***	0.110***
	(0.035)	(0.030)	(0.027)	(0.062)	(0.056)	(0.047)	(0.032)	(0.068)	(0.049)	(0.065)	(0.043)
$\Delta y_{i,t}$	0.018***	0.011**	0.014***	0.031**	0.012*	0.015*	0.008	0.022*	0.004	0.009	0.013*
	(0.005)	(0.005)	(0.005)	(0.013)	(0.007)	(0.008)	(0.005)	(0.012)	(0.008)	(0.011)	(0.007)
$S_{i,t}$	0.018**	0.018***	0.025***	0.025	0.032**	0.026*	0.059***	-0.010	0.055***	0.048**	0.070***
	(0.008)	(0.006)	(0.007)	(0.024)	(0.014)	(0.015)	(0.009)	(0.022)	(0.014)	(0.021)	(0.012)
$I_{i,t}$	-0.252***	-0.200***	-0.222***	-0.263***	-0.266***	-0.224***	-0.243***	-0.161***	-0.234***	-0.251***	-0.260***
	(0.023)	(0.022)	(0.019)	(0.042)	(0.032)	(0.029)	(0.020)	(0.044)	(0.036)	(0.040)	(0.027)
$\Delta NWC_{i,t}$	-0.166***	-0.134***	-0.161***	-0.168***	-0.177***	-0.148***	-0.163***	-0.137***	-0.150***	-0.166***	-0.182***
	(0.012)	(0.011)	(0.011)	(0.025)	(0.018)	(0.014)	(0.011)	(0.022)	(0.018)	(0.019)	(0.017)
$ISS_{i,t}$	0.080***	0.078***	0.076***	0.108***	0.069***	0.098***	0.075***	0.107***	0.076***	0.092***	0.067***
	(0.008)	(0.008)	(0.008)	(0.018)	(0.012)	(0.011)	(0.008)	(0.015)	(0.012)	(0.016)	(0.011)
$\Delta INT_{i,t}$	-0.484***	-0.081	-0.552***	-0.082	-0.685**	-0.301	-0.196	0.186	0.071	-0.704**	-0.492**
	(0.177)	(0.144)	(0.168)	(0.306)	(0.285)	(0.202)	(0.156)	(0.266)	(0.218)	(0.312)	(0.229)
$FinI_{i,t}$	-0.198***	-0.116***	-0.107***	-0.404***	-0.286***	-0.246***	-0.242***	-0.215***	-0.264***	-0.305***	-0.221***
	(0.046)	(0.030)	(0.030)	(0.100)	(0.083)	(0.055)	(0.033)	(0.077)	(0.062)	(0.081)	(0.037)
Observations	4,299	4,163	5,173	1,274	2,497	3,400	5,502	1,282	2,340	1,802	2,789
N. of firms	1,537	1,462	1,632	637	1,008	1,700	2,160	641	960	901	1,093
R-squared	0.221	0.180	0.180	0.265	0.235	0.199	0.211	0.202	0.207	0.212	0.236
Hansen p.	0.251	0.200	0.729	0.268	0.182	0.930	0.514	0.986	0.540	0.621	0.477

Notes: Regression of equation (1). Firms' openness score definition in Appendix. All regressions include two-digit industry dummies (CAE rev.2.1). Robust standard errors in parentheses. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively.

Table VII.4:CCFS estimation by export intensity-EU

Openness	NO	LOW	HIGH	NO		YES		LOW		HIGH	
	1996-2004	1996-2000	2001-2004	1996-2000	2001-2004	1996-2000	2001-2004	1996-2000	2001-2004	1996-2000	2001-2004
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
$CF_{i,t}$	0.271***	0.135***	0.062**	0.313***	0.269***	0.151***	0.099***	0.186*	0.119**	0.130**	0.098**
	(0.027)	(0.036)	(0.027)	(0.059)	(0.041)	(0.047)	(0.035)	(0.106)	(0.056)	(0.051)	(0.045)
$\Delta y_{i,t}$	0.014***	0.010	0.015***	0.030***	0.009	0.017**	0.015***	0.030**	0.005	0.006	0.021***
	(0.004)	(0.006)	(0.005)	(0.011)	(0.006)	(0.008)	(0.006)	(0.014)	(0.008)	(0.010)	(0.008)
$S_{i,t}$	0.016***	0.021**	0.019***	0.013	0.043***	0.040**	0.042***	0.077***	0.014	0.044**	0.052***
	(0.006)	(0.008)	(0.007)	(0.019)	(0.012)	(0.016)	(0.011)	(0.024)	(0.016)	(0.021)	(0.015)
$I_{i,t}$	-0.253***	-0.210***	-0.174***	-0.253***	-0.271***	-0.235***	-0.203***	-0.275***	-0.211***	-0.212***	-0.200***
	(0.018)	(0.024)	(0.020)	(0.036)	(0.026)	(0.031)	(0.021)	(0.048)	(0.032)	(0.039)	(0.028)
$\Delta NWC_{i,t}$	-0.158***	-0.155***	-0.142***	-0.158***	-0.167***	-0.159***	-0.156***	-0.164***	-0.170***	-0.156***	-0.156***
	(0.010)	(0.013)	(0.011)	(0.020)	(0.014)	(0.015)	(0.013)	(0.026)	(0.020)	(0.019)	(0.017)
$ISS_{i,t}$	0.086***	0.087***	0.063***	0.111***	0.079***	0.100***	0.064***	0.109***	0.081***	0.087***	0.047***
	(0.007)	(0.008)	(0.008)	(0.015)	(0.009)	(0.012)	(0.008)	(0.017)	(0.012)	(0.016)	(0.011)
$\Delta INT_{i,t}$	-0.420***	-0.385**	-0.359**	-0.039	-0.553**	-0.381*	-0.449**	-0.748**	-0.373	-0.258	-0.333
	(0.139)	(0.186)	(0.169)	(0.241)	(0.223)	(0.222)	(0.177)	(0.352)	(0.254)	(0.292)	(0.235)
$FinI_{i,t}$	-0.162***	-0.161***	-0.079**	-0.241***	-0.321***	-0.322***	-0.190***	-0.369***	-0.207***	-0.294***	-0.181***
	(0.032)	(0.035)	(0.032)	(0.075)	(0.061)	(0.071)	(0.030)	(0.088)	(0.049)	(0.101)	(0.042)
Observations	6,475	3,293	4,299	1,984	3,804	2,762	4,333	1,022	1,833	1,580	2,280
N. of firms	2,210	1,144	1,333	992	1,500	1,381	1,689	511	742	790	884
R-squared	0.212	0.210	0.154	0.241	0.231	0.225	0.194	0.282	0.218	0.202	0.188
Hansen p.	0.228	0.509	0.728	0.173	0.665	0.875	0.633	0.791	0.237	0.782	0.819

Notes: Regression of equation (1). Firms' export intensity scores definition in Appendix. All regressions include two-digit industry dummies (CAE rev.2.1). Robust standard errors in parentheses. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively.

Table VII.5:CCFS estimation by import intensity-EU

Openness	NO	LOW	HIGH	NO		YES		LOW		HIGH	
	1996-2004	1996-2000	2001-2004	1996-2000	2001-2004	1996-2000	2001-2004	1996-2000	2001-2004	1996-2000	2001-2004
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
$CF_{i,t}$	0.259***	0.142***	0.118***	0.278***	0.271***	0.192***	0.168***	0.078	0.211***	0.307***	0.126***
	(0.033)	(0.032)	(0.030)	(0.061)	(0.053)	(0.051)	(0.034)	(0.066)	(0.053)	(0.092)	(0.047)
$\Delta y_{i,t}$	0.017***	0.014**	0.005	0.033***	0.010	0.016*	0.008	0.017	0.008	0.009	0.003
	(0.005)	(0.006)	(0.005)	(0.012)	(0.007)	(0.009)	(0.006)	(0.012)	(0.009)	(0.014)	(0.008)
$S_{i,t}$	0.017**	0.018***	0.020***	0.017	0.032**	0.032**	0.061***	0.009	0.054***	0.071***	0.052***
	(0.007)	(0.007)	(0.007)	(0.023)	(0.013)	(0.016)	(0.010)	(0.023)	(0.013)	(0.024)	(0.015)
$I_{i,t}$	-0.248***	-0.176***	-0.253***	-0.238***	-0.264***	-0.245***	-0.242***	-0.135***	-0.251***	-0.280***	-0.263***
	(0.022)	(0.024)	(0.019)	(0.041)	(0.030)	(0.032)	(0.022)	(0.049)	(0.041)	(0.040)	(0.028)
$\Delta NWC_{i,t}$	-0.159***	-0.132***	-0.167***	-0.165***	-0.172***	-0.150***	-0.168***	-0.145***	-0.143***	-0.147***	-0.192***
	(0.011)	(0.013)	(0.012)	(0.023)	(0.016)	(0.014)	(0.013)	(0.023)	(0.020)	(0.021)	(0.018)
$ISS_{i,t}$	0.077***	0.066***	0.091***	0.103***	0.067***	0.095***	0.075***	0.098***	0.067***	0.095***	0.095***
	(0.008)	(0.008)	(0.008)	(0.016)	(0.011)	(0.012)	(0.009)	(0.020)	(0.013)	(0.018)	(0.012)
$\Delta INT_{i,t}$	-0.483***	-0.166	-0.267	-0.118	-0.623**	-0.369*	-0.273	-0.044	-0.041	-0.663*	-0.216
	(0.165)	(0.151)	(0.177)	(0.290)	(0.266)	(0.219)	(0.167)	(0.254)	(0.238)	(0.382)	(0.257)
$FinI_{i,t}$	-0.188***	-0.102***	-0.117***	-0.305***	-0.272***	-0.267***	-0.232***	-0.172***	-0.257***	-0.379***	-0.204***
	(0.042)	(0.031)	(0.031)	(0.104)	(0.070)	(0.058)	(0.035)	(0.066)	(0.066)	(0.084)	(0.038)
Observations	4,925	3,865	4,614	1,426	2,845	3,076	4,977	1,142	2,109	1,532	2,461
N. of firms	1,782	1,374	1,523	713	1,156	1,538	1,967	571	871	766	984
R-squared	0.212	0.155	0.192	0.250	0.225	0.194	0.211	0.182	0.193	0.240	0.231
Hansen p.	0.341	0.241	0.857	0.337	0.209	0.999	0.531	0.632	0.988	0.479	0.126

Notes: Regression of equation (1). Firms' import intensity scores definition in Appendix. All regressions include two-digit industry dummies (CAE rev.2.1). Robust standard errors in parentheses. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively.

Table VII.6:CCFS for shifting firms

	OPEN		EXPORT		IMPORT	
VARIABLES	Before	After	Before	After	Before	After
	(1)	(2)	(3)	(4)	(5)	(6)
$CF_{i,t}$	0.155*	0.178**	0.265***	0.145**	0.060	0.211***
	(0.090)	(0.074)	(0.094)	(0.063)	(0.061)	(0.062)
$\Delta y_{i,t}$	0.025*	0.015	0.018	0.013	0.011	0.016*
	(0.013)	(0.011)	(0.013)	(0.010)	(0.011)	(0.009)
$S_{i,t}$	0.024	0.004	0.013	0.025	0.010	-0.002
	(0.017)	(0.018)	(0.015)	(0.020)	(0.013)	(0.015)
$I_{i,t}$	-0.201***	-0.182***	-0.222***	-0.186***	-0.198***	-0.189***
	(0.050)	(0.038)	(0.044)	(0.041)	(0.044)	(0.036)
$\Delta NWC_{i,t}$	-0.130***	-0.138***	-0.152***	-0.137***	-0.135***	-0.153***
	(0.028)	(0.021)	(0.025)	(0.022)	(0.026)	(0.021)
$ISS_{i,t}$	0.036**	0.088***	0.083***	0.070***	0.043***	0.087***
	(0.016)	(0.018)	(0.016)	(0.017)	(0.014)	(0.016)
$\Delta INT_{i,t}$	-0.145	-0.221	0.072	-0.023	0.036	0.098
	(0.294)	(0.392)	(0.279)	(0.393)	(0.287)	(0.367)
$FinI_{i,t}$	-0.160***	-0.198**	-0.152***	-0.219**	-0.171**	-0.116
	(0.059)	(0.101)	(0.041)	(0.087)	(0.068)	(0.090)
Observations	788	788	731	731	942	942
N. of firms	330	330	300	300	397	397
R-squared	0.183	0.215	0.222	0.214	0.179	0.233
Hansen p-val.	0.528	0.887	0.947	0.493	0.636	0.985

Notes: Regression of equation (1) for groups of firms that moved from closed to open, started exporting those that started importing. All regressions include two-digit industry dummies (CAE rev.2.1). Robust standard errors in parentheses. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively.

5. Concluding Remarks

In this Chapter we investigate the extent to which the European monetary integration has influenced firms' financial distress, as well as the impact of financial constraints upon firms with different exporting and importing activities.

Our main findings suggest that firms with higher degrees of openness and particularly those with higher export intensities face much lower financial constraints. Additionally, while we cast some doubts on the argument that only unconstrained firms self-select into exporting activity, we show that firms face lower constraints once they start exporting.

Furthermore, we find that financial and monetary integration has helped in reducing firms' financial constraints. Only for low intensity importers did the level of constraints increase. While this process benefited mostly firms that were highly open, there was no substantial effect upon firms that relied solely on their domestic market. Overall, these results show that these integration processes alleviate firms' financial constraints by easing their access to finance abroad and reducing the price of money in domestic markets.

Further research should aim at extending this analysis to a wider time span, particularly covering the recent financial crisis, as well as at comparing the level of constraints for exporting firms across different economies.

Appendix

Table A1. Non-parametric tests comparing different subsamples

VARS.	i) Integration		ii) Openness		iii) Export		iv) Shifting	
	K-S test (1)	F-P test (2)	K-S test (1)	F-P test (2)	K-S test (1)	F-P test (2)	K-S test (1)	F-P test (2)
$\Delta CS_{i,t}$	0.0317	-2.807	0.0484	1.536	0.0664	2.751	0.0664	-1.110
p-val	0.001	0.005	0.000	0.125	0.033	0.006	0.033	0.267
$CF_{i,t}$	0.0680	9.112	0.0520	-3.345	0.0731	-3.697	0.0731	2.745
p-val	0.000	0.000	0.000	0.001	0.014	0.000	0.014	0.006
$\Delta y_{i,t}$	0.1148	15.813	0.0402	1.781	0.0698	3.525	0.0698	2.585
p-val	0.000	0.000	0.000	0.075	0.021	0.000	0.021	0.010
$S_{i,t}$	0.0644	-6.809	0.2241	-31.637	0.0507	-30.613	0.0507	-0.990
p-val	0.000	0.000	0.000	0.000	0.180	0.000	0.180	0.322
$I_{i,t}$	0.1367	20.755	0.0396	0.184	0.1273	1.658	0.1273	5.779
p-val	0.000	0.000	0.000	0.854	0.000	0.0972	0.000	0.000
$\Delta NWC_{i,t}$	0.0907	-8.787	0.0502	-1.293	0.0800	-1.747	0.0800	-2.477
p-val	0.000	0.000	0.000	0.196	0.005	0.081	0.005	0.0132
$ISS_{i,t}$	0.0992	13.017	0.0238	0.359	0.1090	2.515	0.1090	4.070
p-val	0.000	0.000	0.024	0.720	0.000	0.011	0.000	0.001
$\Delta INT_{i,t}$	0.1173	12.044	0.0494	2.850	0.0763	4.093	0.0763	1.279
p-val	0.000	0.000	0.000	0.004	0.009	0.000	0.009	0.201
$FinI_{i,t}$	0.0140	-1.396	0.1235	-11.430	0.0550	-10.180	0.0550	-1.121
p-val	0.392	0.163	0.000	0.000	0.119	0.000	0.119	0.262
OPEN	0.0521	6.178						
p-val	0.000	0.000						

Notes: We report the statistics and p-values of a Kolmogorov-Smirnov and a Fligner-Policello test for comparing the distributions of main variables between: i) Before (1) against After (0) integration; ii) Open (1) against Closed (0); iii) Exporters (1) against Domestic (0); iv) Before (1) against After shifting to export (0).

Table VII.A2. Relationship between openness, exports, imports and financial constraints using interactions

VARIABLES	Open (1)	Export (2)	Import (3)	Export shift (4)
$CF_{i,t}$	0.207***	0.207***	0.198***	0.238***
	(0.020)	(0.019)	(0.019)	(0.049)
$Open_{i,t}$	0.001			
	(0.011)			
$CF_{i,t} * Open_{i,t}$	-0.249***			
	(0.074)			
$Export_{i,t}$		0.006		
		(0.007)		
$CF_{i,t} * Export_{i,t}$		-0.159***		
		(0.043)		
$Import_{i,t}$			0.001	
			(0.008)	
$CF_{i,t} * Import_{i,t}$			-0.199***	
			(0.066)	
$Shift_{i,t}$				0.014***
				(0.005)
$CF_{i,t} * Shift_{i,t}$				-0.113***
				(0.039)
$\Delta y_{i,t}$	0.014***	0.014***	0.014***	0.010
	(0.003)	(0.003)	(0.003)	(0.007)
$S_{i,t}$	0.017***	0.017***	0.017***	0.013
	(0.004)	(0.004)	(0.004)	(0.008)
$I_{i,t}$	-0.222***	-0.223***	-0.221***	-0.194***
	(0.012)	(0.012)	(0.012)	(0.026)
$\Delta NWC_{i,t}$	-0.150***	-0.150***	-0.150***	-0.128***
	(0.006)	(0.006)	(0.006)	(0.015)
$ISS_{i,t}$	0.078***	0.078***	0.078***	0.069***
	(0.004)	(0.004)	(0.004)	(0.010)
$\Delta INT_{i,t}$	-0.338***	-0.336***	-0.333***	0.065
	(0.088)	(0.088)	(0.088)	(0.188)
$FinI_{i,t}$	-0.129***	-0.129***	-0.128***	-0.104***
	(0.018)	(0.018)	(0.018)	(0.031)
Observations	15,259	15,259	15,260	1,773
N. of firms	4,765	4,765	4,765	514
R-squared	0.183	0.183	0.183	0.170
Hansen p-val.	0.218	0.229	0.222	0.534

Notes: Regression of equation (1) with interaction terms for cash-flow and degree of openness, export intensity and import intensity (columns 1-3, respectively), as well as with a binary indicator for firms before and after shifting to export activity (column 4). All regressions include industry dummies (2-digit CAE rev.2.1). Robust standard errors in parentheses. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively.

Table VII.A3. CCFS changes with monetary integration for firms with low degree of openness

VARIABLES	Open World		X≡GDP		X≡R		X≡U	
	1996-2000	2001-2004	1996-2000	2001-2004	1996-2000	2001-2004	1996-2000	2001-2004
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
$CF_{i,t}$	0.167**	0.221***	0.164**	0.223***	0.164**	0.227***	0.164**	0.227***
	(0.068)	(0.049)	(0.069)	(0.049)	(0.069)	(0.049)	(0.069)	(0.049)
$\Delta y_{i,t}$	0.022*	0.004	0.022*	0.003	0.022*	0.004	0.022*	0.003
	(0.012)	(0.008)	(0.012)	(0.008)	(0.012)	(0.008)	(0.012)	(0.008)
$S_{i,t}$	-0.010	0.055***	-0.005	0.054***	-0.005	0.050***	-0.005	0.050***
	(0.022)	(0.014)	(0.024)	(0.014)	(0.024)	(0.015)	(0.024)	(0.015)
$I_{i,t}$	-0.161***	-0.234***	-0.163***	-0.233***	-0.163***	-0.232***	-0.163***	-0.232***
	(0.044)	(0.036)	(0.045)	(0.036)	(0.045)	(0.036)	(0.045)	(0.036)
$\Delta NWC_{i,t}$	-0.137***	-0.150***	-0.136***	-0.150***	-0.136***	-0.151***	-0.136***	-0.151***
	(0.022)	(0.018)	(0.022)	(0.018)	(0.022)	(0.018)	(0.022)	(0.018)
$ISS_{i,t}$	0.107***	0.076***	0.104***	0.076***	0.104***	0.077***	0.104***	0.077***
	(0.015)	(0.012)	(0.015)	(0.012)	(0.015)	(0.012)	(0.015)	(0.012)
$\Delta INT_{i,t}$	0.186	0.071	0.267	0.055	0.267	0.067	0.267	0.056
	(0.266)	(0.218)	(0.283)	(0.219)	(0.283)	(0.217)	(0.283)	(0.218)
$FinI_{i,t}$	-0.215***	-0.264***	-0.212***	-0.265***	-0.212***	-0.265***	-0.212***	-0.265***
	(0.077)	(0.062)	(0.075)	(0.062)	(0.075)	(0.062)	(0.075)	(0.062)
X			-0.003	0.001	-0.174	-0.418*	0.003	0.009*
			(0.004)	(0.002)	(0.253)	(0.220)	(0.004)	(0.005)
Observations	1,282	2,340	1,282	2,340	1,282	2,340	1,282	2,340
N. of firms	641	960	641	960	641	960	641	960
Hansen p-val.	0.986	0.540	0.972	0.569	0.972	0.566	0.972	0.582
R-squared	0.202	0.207	0.203	0.207	0.203	0.209	0.203	0.209

Notes: Regression of equation (1). Firms' openness score definition in Chapter IV. The following variables are tested: Gross domestic product (GDP), benchmark interest rate (R) and Unemployment (U). Column (1) also reports estimates using a broader definition of openness—exports and imports to and from any foreign country. All regressions include two-digit industry dummies (CAE rev.2.1). Robust standard errors in parentheses. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively.

CHAPTER VIII – R&D INVESTMENT, INNOVATION AND SUBSIDIES

1. Introduction

The recent shortage of financial resources has raised new interest on the role of financial constraints in firm dynamics. As a consequence, it is crucial to verify and quantify the extent to which R&D investment and ultimately innovation is affected by these constraints. If innovation is to be one of the main drivers of economic growth and if indeed such constraints are present, hindering firms' ability to work as main drivers of innovation and distorting the selection process, then financial constraints and policies to mitigate them, must be a priority in microeconomic research.

Accordingly, the goal of this Chapter is to broadly analyse the financing problems of the innovation process. In particular, we investigate the impact of financial constraints upon R&D investment and innovation, as well as the role of public financial support in alleviating such constraints. In order to provide robust findings, we use different approaches and both direct and indirect measures of constraints. For this purpose, we construct an unique dataset that contains firms' characteristics, balance sheets, information on innovation activity and a direct (self-assessed) measure of financial constraints. Upon this data, we first estimate the cash-flow sensitivity of cash (CCFS), by distinguishing different subsamples of firms that either or not innovate, invest in R&D and receive public financial support. Secondly, to investigate the impact of financial constraints upon R&D investment, we test different specifications, controlling for selection and endogeneity. Thirdly, in order to account for endogeneity of financial constraints on innovation, we specify a simultaneous equations probit model that we further extend to the ordered probit case. Finally, we explore the impact of public financial support (subsidies) upon firms' perception of constraints, through both a probit and a simultaneous equations probit (and ordered probit) specifications.

Our findings suggest that firms that do not innovate (but are potential innovators), those that do not invest in R&D, and those that do not receive public funding are financially constrained. Moreover, controlling for endogeneity, we find that financial constraints severely reduce the amounts invested in R&D and seriously hamper innovation. Finally, we question the extent to which subsidies effectively alleviate firms' financial constraints.

This work is the first, as far as we know, to combine different methodologies to evaluate the role of financial constraints on the innovation activity of firms. More importantly, it contributes to the extant innovation literature by being the first, to our knowledge, to explicitly analyse the nexus between financial constraints and public financial support, bridging two closely related lines of research within innovation studies. Finally, we make use of an unique dataset that covers the period 1996-2004 and combines firms' characteristics with both balance sheet data and information on the innovation activities of firms, drawn from three different waves of Community Innovation Surveys (CISs II, III and IV). This has barely been done and is a novelty with respect to Portugal.

The Chapter is organized as follows. Section 2 makes a brief incursion on the empirical literature concerning financial constraints, innovation and public financial support, as well as it puts forward the main hypothesis to be tested. In Section 3 we describe the empirical methodology followed. Section 4 presents the main results, that are followed by a discussion in Section 5. Finally Section 6 pulls the pieces together and concludes.

2. Financing problems of the innovation process

2.1. Financial constraints, R&D investment and innovation

As we have seen in Chapter III, *Stylized Result 6*, when it comes to R&D investment and innovation—assuming that the effort to innovate draws from the capacity that firms have to invest in R&D (input for innovation)—this type of investments is expected to be more financially constrained than investment in physical capital. The rational is that R&D, in opposition to physical capital is not only harder to use as collateral (possible credit multiplier effects), but is also of a riskier nature and entails significant information asymmetry problems (Hall and Lerner, 2010). In particular, these information asymmetries may be further amplified if firms try to conceal their R&D projects, fearing any leak of information to competitors, that could prove to be fatal in their attempt to innovate.[1]

Notwithstanding, empirical literature on the impact of financial constraints upon innovation has mostly relied on datasets composed mainly of firms' financial information, patents and R&D expenses (e.g. Bond, et al., 2003b, Scellato, 2007 or Brown and Petersen, 2011) that are not as specific as for example (for the European case) the Community Innovations Surveys (CISs), that are particularly designed to evaluate the innovation activity of firms—see Mairesse and Mohnen, 2010 for a survey of findings using CIS. Additionally, they also include extremely useful information on firms' perception of financial constraints.

[1] We should note, however, that besides the usual, but distinct, forms to raise external finance (see Majumdar, 2011 for heterogeneous impacts of different debt types in R&D investment)—such as bank lending, issuing debt and equity in capital markets or even trade credit—business angels and, notoriously, venture capital play a central role when it comes to innovation (see Hall and Lerner, 2010 for an overview). Nevertheless, an analysis of the role of venture capital on the financing of innovation is not in the scope of this work. Effectively, we do not have information on start-ups and very young firms due to the CIS sample design.

To our knowledge, only a reduced number of tests have been performed with a combined dataset of CIS (or other specific innovation survey) and financial information, of which Mueller and Zimmermann (2006), Savignac (2008), Gorodnichenko and Schnitzer (2010) and Czarnitzki and Hottenrott (2011a) are examples.

While initial results using CISs found that the impact of obstacles on the innovation activity of firms was positive, subsequent literature has found that, after controlling for endogenous variables, such as financial constraints, the reported estimates on the impact of obstacles were found to be negative, as expected (e.g. Savignac, 2008, Tiwari et al., 2008). This endogeneity, for the specific case of financial constraints, results from unobservables that correlate both with financial constraints and innovation\R&D investment. This is the case of firm-specific R&D investment project uncertainty, duration and confidentiality (see Savignac, 2008). We should also note that innovators might be expected to face lower constraints due to a better financial position associated with a possibly better economic performance, which further adds to the endogeneity problem. Moreover, the decision to apply for credit and the probability of credit approval, may well depend upon firms' R&D intensity (Guiso, 1998; Azteni and Piga, 2005).[2] Therefore, once endogeneity is taken into account, we expect that:[3]

H1) Financial constraints reduce the amounts invested in R&D

H2) The probability that a firm innovates is negatively affected by financial constraints

2.2. Pubic financial support

Financial constraints and subsidies are two closely related lines of research within innovation studies. On one hand, as previously discussed, researchers have strived to measure the impact of financial constraints upon R&D investment and innovation. On the other hand, the effects of public policy, and specifically subsidies, on R&D spending and innovation performance, have been given particular attention in recent years (e.g. Bloom et al., 2002; Almus and Czarnitzki, 2003; Aerts and Schmidt, 2008; Schneider and Veugelers, 2010). However, as far

[2] Not to mention the possible endogeneity stemming from the survey-based financial constraints variable we use, since the probability that a firm reports as constrained might well increase as it is committed to more innovation projects. Additionally, more innovative firms are also more aware of such constraints (e.g. Tiwari et al., 2008; Savignac, 2008).

[3] Even though it is not the purpose of this work to explore such effects, we should note that innovation may also be hampered by other constraints that relate to the ability of firms to absorb new technology (Cohen and Levinthal, 1990) and enhance competitiveness (e.g. Teece et al., 1997). Namely, a set of resources and capabilities at the human, organizational, networking and legislatory levels, as argued by the resource-based literature, may significantly constrain innovation (e.g. Hewitt-Dundas, 2006).

as we know, the role of public financial support to R&D investment and innovation (hereafter subsidies for simplicity purposes) in alleviating firms' financial constraints has never been analysed explicitly (see Chapter III, *Stylized Result 6*).[4]

Subsidising private R&D and innovation activities is generally agreed by researchers to be desirable in order to foster economic growth, as well as it is in the agenda of several policymakers. The main theoretical argument for public support of R&D and innovation activities resides in higher social than private returns to R&D investment, due to incomplete appropriability and knowledge spillovers (Hall and Lerner, 2010). In this line, the main empirical issue is whether subsidies stimulate or replace R&D spending (David et al., 2000). Recent empirical literature suggests that the former hypothesis holds—subsidies have a significant additionality effect on R&D spending (e.g. Aerts and Schmidt, 2008; Czarnitzki and Bento, 2011). This effect seems to be particularly relevant for research activity in comparison to development, where subsidies appear to have a "crowding out" effect (Clausen, 2009). This distinction—in line with the findings that point that the former is more prone to financial constraints than the latter (Czarnitzki et al., 2011)—suggests that subsidies may prove to be particularly efficient when aimed at financially constrained firms.

Accordingly, besides the market inefficiencies argument, associated with the "public good" nature of knowledge, the existence of financial market frictions (financial constraints) might also be ground for public intervention. Therefore, the question of interest is whether public financial support effectively reduces financial constraints? It is apparent that subsidies directly increase firms' financial capacity. However, when it comes to information asymmetries and firm access to external funds, the effect is not as clear—except for other public intervention forms such as special credit lines and backed debt policies. Nevertheless, provided that subsidies are specifically designed and correctly allocated to financially constrained firms, they signal favourable growth (innovation, in this particular context) prospects to investors. Additionally, such subsidies in the current period, may enhance current economic performance and therefore reduce financial constraints in the future. As a consequence, we expect that:

H3) Subsidies reduce the extent to which R&D investment\innovation is financially constrained

[4] We should note that the impact of public intervention upon financial constraints, that are not specific to the innovation process, has been previously analysed, even though with different methodologies (e.g. Zecchini and Ventura, 2009).

Overall, the analysis of the impact of financial constraints upon the innovation process usually relies on either subjective self-assessed measures or on methodologies that can be questionable on theoretical and empirical grounds. In fact, there appears to be no consistent measure of financial constraints, even though strong policy implications are drawn from investigations using a sole measure of such constraints with strong underlying assumptions (Coad, 2010a). Keeping this caveat in mind, and resorting to different measures, we attempt to contribute to the clarification of the financing problems (and possible remedies) of the innovation process.

3. Methodology

3.1. Model A: Measuring financial constraints using CCFS

As we have seen in previous Chapters, ACW (Almeida et al., 2004) suggest that firms' financial constraints can be measured by the sensitivity of cash to cash-flows (CCFS). They argue that, by being forced to manage liquidity, constrained firms will save cash out of cash-flows, while no systematic relationship should be found for unconstrained firms. In line with the discussion of this approach in Chapters II and V, while the financial nature of cash stocks avoids measurements problems in Q, recent literature pointed that cash may alternatively be used to reduce debt if hedging needs are low (Acharya et al, 2007) and that firms' intertemporal transfers of resources can also be done using relatively liquid assets, rather than only through cash (Almeida et al., 2011). Keeping these caveats in mind, we have the following empirical specification:

$$\Delta CS_{i,t} = \beta_1 CF_{i,t} + \beta_2 \Delta y_{i,t} + \beta_3 S_{i,t} + \beta_4 I_{i,t} + \beta_5 \Delta NWC_{i,t} + \beta_6 ISS_{i,t} + \\ + \beta_7 \Delta INT_{i,t} + \beta_8 FinI_{i,t} + \varepsilon_{i,t} \quad \text{(VIII. A1)}$$

where $\Delta CS_{i,t}$ is the variation in cash stocks for firm i in year t, $CF_{i,t}$ is cash-flow, $S_{i,t}$ is a control for firm size (log of total assets), $I_{i,t}$ is investment, $\Delta NWC_{i,t}$ is the variation of noncash net working capital and $\varepsilon_{i,t}$ the error term. We shall use sales growth ($\Delta y_{i,t}$) instead of Q as a proxy for investment opportunities (see Chapter V). Additionally, we implement a slight modification to the original model. In the spirit of Lin (2007), we substitute the variation of short term-debt by the sum of net debt and equity issuances ($ISS_{i,t}$) and changes in interest paid ($\Delta INT_{i,t}$). The former modification is due to the fact that debt and equity issuances, while being a signal of easier access to external funds, might have a significant impact upon cash stocks (by accounting procedures), so we control for such effect. With respect to the latter, firms may decide to reduce their borrowings or pay back debt according to expected interest expenses. However, instead of benchmark interest rate variations, we use variations of interest paid, which allows for firm variation and thus can also be seen as a form of credit rating. Furthermore, we also control for financial investments ($FinI_{i,t}$), that not only are a demand for cash but may also work as an alternative way to transfer resources across time.[5] The above mentioned variables (except *S*) are scaled by total assets.

The financial and investment covariates are endogenous, so there is a need to estimate the model using instrumental variables, along with fixed effects to take account of unobserved firm-level heterogeneity and panel-robust standard errors. The cross-sectional nature of the different CIS waves (1997, 2000 and 2004) entails significant problems for the estimation of CCFS. The endogeneity of the financial covariates recommends the use of instrumental variables. However, the most appropriate instruments would be lagged—in some cases twice and further lagged because of the exogeneity condition, in order to provide consistent estimates—values of these variables. Unfortunately, the use of lagged values—particularly those of variables built upon differenced values—will require at least 2 periods of data to be lost, meaning that the first wave of CIS (1997) would not be taken into account.[6] Therefore, for this model, we assume that the CIS information represents averages for the corresponding wave span and make use of the full length of the panel.

In order to compare financial constraints across different types of firms, we split our sample into subsamples of firms that: (i) innovated (*INNOV*=1) and those that did not (*INNOV*=1); (ii) decided to invest in R&D (*RD*=1) and those that did not (*RD*=0); (iii) received public financial support (SUB=1) and those that did not (SUB=1). For the case of investment in R&D, we additionally estimate an interaction of total R&D expenditures (I_RD) with cash-flow of the form:

$$\Delta CS_{i,t} = \beta_1 CF_{i,t} + \alpha_0 I\_RD_{i,t} + \alpha_1 CF_{i,t} * I\_RD_{i,t} + \beta_2 \Delta y_{i,t} + \beta_4 I_{i,t} + \beta_5 \Delta NWC_{i,t} + \beta_6 ISS_{i,t} + + \beta_7 \Delta INT_{i,t} + \beta_8 FinI_{i,t} + \varepsilon_{i,t} \quad \text{(VIII. A2)}$$

[5] We test the different specifications departing from Almeida et a. (2004). CCFS estimates range from 0.1 to 0.26, where major differences are driven by the replacement of short-term debt by equity and debt issuances and interest payments. The inclusion of financial investments (always strongly significant) leads to a slight reduction of CCFS estimates, possibly capturing the effect (for financially constrained firms) of the use of these investments to allocate present resources (cash-flows) to future states as an alternative to cash holdings (see Table A1 in Appendix).

[6] The set of instruments includes profitability, percentage of sales of innovated products, lagged net working capital two-digit industry indicators, lagged bond issuance, leverage and self assessed financial constraints.

3.2.Model B: Sample selection in R&D investment, with endogenous financial constraints

In addition to the possible endogeneity of FC for reasons presented in Section 2.2, our R&D investment variable has an excess of zeroes and is highly skewed.[7] Accordingly, we assume that the R&D investment process encompasses two decisions. While the first is firms' decision either to invest or not in R&D, the second is the decision of the amounts that should be invested. However, these are not independent (the errors from two-step equations are correlated, which we confirm further on) and therefore a joint specification is needed. Consequently, this setup falls into the selection models category.[8]

As a result, to evaluate the impact of financial constraints, as well as other firms' characteristics, on the amounts spent in R&D we build up a model that takes into account both selection and the endogenous nature of the financial constraint variable. The model is described as:

$$RD\_I = Z_1\beta_1 + \alpha FC + \varepsilon \qquad \text{(VIII. B1)}$$

$$FC^* = X\beta_2 + u \qquad \text{(VIII. B2)}$$

$$RD = 1(Z\beta_3 + v > 0) \quad , \qquad v \sim N(0,1) \qquad \text{(VIII. B3)}$$

where (B3) describes the selection process, since we only observe the amount invested in R&D (RD_I)—measured in logarithms—when firms decide to invest in R&D ($RD = 1$). This decision is based on a latent variable that can be seen as the propensity to invest ($RD^* = Z\beta_3 + v$). Both Z and RD are always observed. Additionally, self-assessed financial constraints (FC) is also always observed (note that the latent variable FC^* is not), but is an endogenous variable in (B1). Finally, we allow for arbitrary correlation among v, u and ε.

The estimation procedure takes two steps: (a) we estimate a probit model for equation (B3) upon the full sample and obtain the estimated inverse Mills ratios ($\hat{\lambda}_{i3} =$); (b) using that information, we estimate

$$RD\_I_i = Z_{i1}\beta_1 + \alpha FC_i + \gamma\hat{\lambda}_{i3} + e_i \qquad \text{(VIII. B4)}$$

upon the selection sample. So far, this is similar to the traditional Heckit estimator (after Heckman, 1976, 1979). However, the suspected endogeneity of the ordinal FC requires that

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[7] While we have 71% of zeroes, the mean (904324) is much higher than the median (163549).

[8] We recognize the possibility of an alternative specification that relates to the Poisson distribution, usually associated with count data (GLM with a log-link that extends to the GMM version for instrumenting FC). See Nichols (2010) for a reference.

we take into account (B2) (see Wooldridge, 2002 pp. 567-570).[9] Note that at least one covariate in Z must be excluded (Z_i) in the estimating equation (B4) in order to guarantee identification.

In order to obtain correct standard errors we use the bootstrap pairs method, instead of a more complex derivation of the necessary correction of the standard errors. Accordingly, we bootstrap following procedure: 1) estimate a probit of the R&D investment decision; 2) construct the inverse Mills ratio; 3) estimate the volume of R&D investment, taking into account the inverse mills and the endogeneity of financial constraints.

To take into account the endogeneity of financial constraints we use different consistent approaches in the last step, namely: 3.1) Ignore the ordinal nature of FC and estimate a regular optimal GMM; 3.2) Obtain fitted values of FC by resorting to the appropriate ordered probit estimation and then use these as instrument for FC —see Cameron and Trivedi, 2005 pp. 193.

Once again, the data imposes us some constraints in estimating the selection model. Not only the same problem with the inclusion of covariates persists, but there is an additional issue with our dependent variable (expenditures in R&D). If we opt to scale those expenses by either total assets or sales, there is a significant loss of observations (approximately half of initial number of observations). As a result we will work with non-scaled logarithm of total expenditures in R&D. Our full set of variables Z includes: firm size; age; industry dummies; exports *(EXP)*; labour productivity (*LPROD*); investment opportunities to R&D investment (*Y_IN*); investment opportunities *(ΔY)*; percentage of R&D employees (*RD_WORK*), public funding (*SUB*); cooperation with other firms and institutions (*COOP*); leverage; market share (MKTS) and other barriers to innovate (*B_TRAB*, *B_TECH* and *B_MARK*). In the estimating equation (B4) we exclude *MKTS, LPROD,* leverage and other barriers to innovate in order to guarantee identification.[10]

[9] This equation explains financial constraints through the combination of both firms' characteristics and financial variables: firm size (SIZE); firm age (AGE); 2-digit industry dummies (CAE rev 2.1); percentage of public and foreign capital (PUB_K and FOR_K, respectively); investment opportunities *(ΔY);* cash stocks (CS); cash-flow (CF); leverage (LEV); debt and equity issuances (ISS); changes in interest paid (ΔINT); returns on financial investments (R_FIN); exports (EXP); market share (MKTS) and a dummy for firms that received subsidies (SUB). With the exception of PUB_K, FOR_K, ΔY, ISS and ΔNWC, we use the year lag values to account for the wave span.

[10] If Z_1=Z, then β_1 is only identified because of the nonlinearity of the inverse mills ratio. This can lead to multicollinearity problems. As a rule of thumb, at least two variables should not appear in the selected regression.

We compare the estimates with those of a simple OLS, a "hurdle" model and a selection model with no endogeneity, where we should note that, in these cases, non-linear FC can not be used directly in the estimating equation. Accordingly we collapse it into a binary indicator of whether or not a firm reported any financial constraints (FC^c).[11]

3.3. Model C: Impact of financial constraints directly upon innovation

Following Savignac (2008), we estimate the impact of financial constraints directly upon innovation. This is achieved by estimating a simultaneous equations model (specifically a bivariate normal specification of errors within a simultaneous equations probit model) of underlying latent variables—propensity to innovate ($INNOV^*$) and level of financial constraints (FC^{c*})—of the following form:

$$\begin{cases} INNOV^* = X_1\beta_1 + \alpha_1 FC^c + \varepsilon_1 \\ FC^{c*} = X_2\beta_2 + \alpha_2 INNOV + \varepsilon_2 \end{cases} \tag{VIII. C1}$$

For logical consistency purposes we set ($\alpha_2 = 0$) and additionally normalize the variance of the errors:

$$\begin{cases} INNOV^* = X_1\beta_1 + \alpha_1 FC^c + \varepsilon_1 \\ FC^{c*} = X_2\beta_2 + \varepsilon_2 \end{cases}, \quad \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \end{pmatrix} \sim \Phi_2 \begin{bmatrix} 0 \\ 0 \end{bmatrix} \begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix} \tag{VIII. C2}$$

where X_1 includes the investment in R&D (*RD_I*), firm size, age, other barriers to innovate (*B_TRAB*, *B_TECH* and *B_MARK*), subsidies (*SUB*), cooperation with other firms and institutions *(COOP)*, percentage of R&D employees (*RD_WORK*), investment opportunities *(ΔY)* and market share (*MKTS*). In the vector X_2 we include the usual determinants of FC, in accordance to (B2) in Model B. If there are no omitted or unobservable variables that affect simultaneously the probabilities of a firm reporting financial constraints and innovating ($\rho = 0$), these equations can be estimated separately, meaning that FC can be treated as exogenous.

[11] The "hurdle" model is set as a pair of independent equations: a) decision equation, estimated through a probit; b) volume equation, estimated by OLS. We additionally estimate the corresponding two parts model taking into account the endogeneity of FC. For that purpose we estimate the corresponding simultaneous equations and IV regressions that allow us to test for endogeneity, since such tests are rather difficult to compute for the full Model B.

We further extend the model to allow FC outcomes to be ordinal and estimate the corresponding ordered probit model (see Greene and Hensher, 2010 pp. 222 for details and Sajaia, 2008 for STATA implementation).[12] Finally, we discriminate between product and process innovation in order to provide robust results.

3.4. Model D: Subsidies and financial constraints

The last group of estimations in this Chapter attempts to clarify the link between public financial support and financial constraints. Specifically, we estimate the impact of subsidies upon the reported levels of constraints.

There are some reasons to believe that subsidies are endogenous. Firstly, if a firm is financially constrained, there in a higher probability that it applies for subsidies (we do not have data on subsidy requests), as well as it might be seen as a potentially more appropriate target for public policy. Secondly, the possibility of artificial survey positive correlation being present may require that we use balance sheet variables as instruments. Finally, potential correlated unobservables, such as public policy goals and budgets, firms' applications for subsidy programs and the quality of the underlying project (Jaffe, 2002; Schneider and Veugelers, 2010) imply that treating SUB as endogenous should be considered.

Accordingly, as in the previous section, we specify a simultaneous equations probit model (with the corresponding latent variables specification), that we further extend to the ordered probit case in order to fully explore the FC variable. The same logical consistency constraint applies and we also normalize the variance of the errors. Therefore, we simultaneously estimate the following model:

$$\begin{cases} FC^{c*} = X_1\beta_1 + \alpha_1 SUB + u \\ SUB^* = X_2\beta_2 + v \end{cases}, \qquad \begin{pmatrix} u \\ v \end{pmatrix} \sim \Phi_2 \begin{bmatrix} 0 \\ 0 \end{bmatrix} \begin{bmatrix} 1 & \varrho \\ \varrho & 1 \end{bmatrix} \qquad \text{(VIII. D1)}$$

where X_1 includes the following controls: firm size (SIZE); firm age (AGE); 2-digit industry dummies (CAE rev 2.1); percentage of public and foreign capital (PUB_K and FOR_K, respectively); investment opportunities *(ΔY);* cash stocks (CS); cash-flow (CF); leverage (LEV); debt and equity issuances (ISS); changes in interest paid (ΔINT); returns on financial investments (R_FIN); exports (EXP); market share (MKTS). All these variables, are obtained from balance sheets. Therefore, we use the first lag of these variables to account for the CIS

[12] Note that since the estimation of marginal effects in this case are of rather hard computation and above all interpretation we refrain from estimating them.

wave span and reduce artificial survey correlation. Exceptions are PUB_K, FOR_K, ΔY, ISS and ΔNWC, since they either do not have sufficient annual variation, or their construction is based on the previous period (would imply the loss of all CIS2 observations). When it comes to X_2, we include size (SIZE), age (AGE), percentage of R&D employees (RD_WORK), market share ($MKTS$), intangibles (INTANG), exports (EXP), percentage of public (PUB_K) and foreign capital and (FOR_K), cooperation with other firms and institutions (COOP) and share of subsidies by industry (SUB%I) and region (SUB%R). Again, if there are no omitted or unobservable variables that affect simultaneously FC and SUB ($\varrho = 0$), we can estimate the equations separately.

4. Empirical Results

4.1. Summary Statistics

Table 1 reports the means and standard deviations of the main variables used in model (A), by the different subsamples of firms. We should point that mean cash-flow is larger (and less volatile) for firms that innovate, invest in R&D and those that receive subsidies. The same appears to be true with respect to size (total assets) and sales growth.[13]

Table 2 reports the same statistics for the remaining models. As it is clear from columns (2) and (3), firms that invest in R&D are larger (number of employees), older, have a larger percentage of R&D workers and export more. Additionally, while they have higher innovation investment opportunities (percentage sales of new products), they have lower physical capital investment opportunites (sales growth). Moreover, within this group, there is a larger number of firms that report higher financial constraints, receive subsidies and cooperate.

With respect to firms that innovate (columns 5-6), these are found to be larger (number of employees), older, have a higher percentage of R&D workers and higher market shares, but have lower investment opportunities (sales growth). These firms also spend remarkably larger amounts in R&D investment. Furthermore, there is a larger number of firms that innovate and receive subsidies, cooperate, report higher levels of financial constraints as well as other barriers to innovate (except for the case of market barriers).

[13] For each variable of interest, the differences between groups are formally tested through both Mann–Whitney and Fligner-Policello tests, as well as also confirmed by quantile-quantile plots. This applies to all results in Section 5.1.

Finally, firms that receive subsidies (columns 8-9) are larger (number of employees), older, have larger (lower) percentage of public (foreign) capital, lower cash stocks but higher cash-flow, are less leveraged, issue less debt, have larger variation of non-cash working capital, export more and have larger market shares.

Table VIII.1. Summary statistics: Model A.

VARIABLES	Overall	INNOV=1	INNOV=0	RD=1	RD=0	SUB=1	SUB=0
ΔCS	0.003	0.001	0.004	0.002	0.004	0.002	0.003
	(0.060)	(0.057)	(0.064)	(0.054)	(0.065)	(0.048)	(0.061)
CF	0.091	0.097	0.085	0.098	0.084	0.100	0.090
	(0.091)	(0.091)	(0.091)	(0.088)	(0.094)	(0.085)	(0.092)
ΔY	0.033	0.051	0.014	0.048	0.018	0.064	0.030
	(0.270)	(0.260)	(0.278)	(0.254)	(0.284)	(0.189)	(0.277)
S	16.080	16.409	15.740	16.499	15.670	16.670	16.021
	(1.644)	(1.646)	(1.570)	(1.605)	(1.577)	(1.569)	(1.639)
I	0.063	0.064	0.063	0.065	0.061	0.078	0.062
	(0.087)	(0.086)	(0.088)	(0.091)	(0.082)	(0.091)	(0.086)
ΔNWC	-0.048	-0.045	-0.050	-0.048	-0.047	-0.053	-0.047
	(0.157)	(0.146)	(0.167)	(0.145)	(0.168)	(0.131)	(0.159)
ISS	0.022	0.026	0.018	0.027	0.018	0.041	0.021
	(0.161)	(0.154)	(0.167)	(0.144)	(0.175)	(0.128)	(0.163)
ΔINT	-0.001	-0.001	-0.002	-0.001	-0.001	-0.001	-0.001
	(0.007)	(0.007)	(0.008)	(0.007)	(0.008)	(0.006)	(0.008)
$FinI$	0.046	0.052	0.041	0.055	0.038	0.050	0.046
	(0.100)	(0.104)	(0.095)	(0.109)	(0.089)	(0.097)	(0.100)
Observations	3,941	2,003	1,938	1,947	1,994	356	3,585
	100%	51%	49%	49%	51%	9%	91%
Number of firms	1,355	697	658	645	711	116	1,239

Notes: Mean values and standard deviations, given in parenthesis, of the main variables used to estimate equation (A1). Both total sample and subsamples' statistics are reported.

Table VIII.2. Summary statistics: Models B, C and D.

Model B	Total (1)	RD=0 (2)	RD=1 (3)	Model C	Total (4)	INNOV=0 (5)	INNOV=1 (6)	Model D	Total (7)	SUB=0 (8)	SUB=1 (9)
RD_I			12.139	INNOV	0.487			FC	0.903	0.872	1.122
			(2.012)		(0.500)				(1.175)	(1.166)	(1.214)
FC	1.055	1.046	1.064	FC	0.907	0.828	0.991	SUB	0.125		
	(1.195)	(1.185)	(1.206)		(1.175)	(1.153)	(1.191)		(0.331)		
SIZE	4.866	4.640	5.098	RD_I	5.127	0.417	10.091	SIZE	4.845	4.770	5.363
	(1.188)	(1.139)	(1.193)		(6.119)	(2.134)	(4.907)		(1.180)	(1.149)	(1.260)
AGE	3.083	3.061	3.105	SIZE	4.823	4.616	5.041	AGE	3.074	3.065	3.136
	(0.691)	(0.667)	(0.714)		(1.195)	(1.123)	(1.229)		(0.702)	(0.697)	(0.735)
EXP	0.279	0.242	0.317	AGE	3.072	3.057	3.089	PUB_K	4.580	4.064	8.184
	(0.502)	(0.496)	(0.506)		(0.702)	(0.695)	(0.710)		(19.683)	(18.566)	(25.933)
Y_IN	0.113	0.030	0.199	SUB	0.125	0.011	0.246	FOR_K	12.501	12.583	11.928
	(0.256)	(0.135)	(0.317)		(0.331)	(0.103)	(0.431)		(31.176)	(31.470)	(29.072)
ΔY	-0.032	-0.013	-0.052	COOP	0.164	0.011	0.325	ΔY	-0.026	-0.023	-0.049
	(0.289)	(0.307)	(0.268)		(0.370)	(0.106)	(0.469)		(0.259)	(0.263)	(0.227)
RD_WORK	0.006	0.002	0.010	B_TRAB	0.471	0.417	0.528	CS	0.069	0.070	0.055
	(0.032)	(0.015)	(0.043)		(0.499)	(0.493)	(0.499)		(0.101)	(0.103)	(0.083)
SUB	0.149	0.020	0.282	B_TECH	0.426	0.364	0.490	CF	0.091	0.088	0.110
	(0.356)	(0.141)	(0.450)		(0.495)	(0.481)	(0.500)		(0.096)	(0.096)	(0.092)
COOP	0.195	0.038	0.356	B_MARK	0.536	0.508	0.565	LEV	0.663	0.670	0.611
	(0.396)	(0.192)	(0.479)		(0.499)	(0.500)	(0.496)		(0.258)	(0.263)	(0.210)
				RD_WORK	0.005	0.002	0.008	ISS	-0.031	-0.029	-0.049
					(0.030)	(0.018)	(0.039)		(0.157)	(0.158)	(0.151)
				ΔY	-0.026	-0.003	-0.050	ΔNWC	0.001	0.001	0.002
					(0.259)	(0.258)	(0.258)		(0.006)	(0.007)	(0.006)
				MKTS	0.227	0.221	0.234	R_FinI	0.001	0.001	0.001
					(0.270)	(0.268)	(0.273)		(0.003)	(0.003)	(0.002)
								EXP	0.290	0.279	0.369
									(0.521)	(0.520)	(0.518)
								MKTS	0.227	0.225	0.245
									(0.270)	(0.269)	(0.275)
Observations	2,610	1,325	1,285	Observations	3,247	1,666	1,581	Observations	3,208	2,806	402

Notes: Mean values and standard deviations, given in parenthesis, of the main variables used to estimate models B, C and D.

4.2 Results for Model A

Analysing the results on financial constraints to innovation using the CCFS methodology (Table 3), we do not find statistically significant differences in constraints between innovators and non-innovators—the cash-flow coefficients are 0.100 and 0.112, respectively (columns 2-3). However, if we distinguish between non-innovators that are willing to innovate (hampered firms) and those that do not desire to innovate (unwilling to innovate), the figures are different—CCFS of 0.215 against 0.123, respectively (columns 5-6). Please see Chapter IV, Section 3 for definition details.[14]

Evidence on different levels of constraints is clearer if instead of comparing innovators with non-innovators, we distinguish between firms that invested in R&D and those that did not. In fact, as we can see from Table 4, there is a striking difference in CCFS (columns 1-2). While for firms that invested in R&D, the estimated CCFS is not statistically different from zero, firms that did not invest in R&D save, on average, a remarkable amount of 20 cents out of each euro of cash flow. With respect to total R&D expenditures (column 5), the cash-flow interaction term is negative and statically significant (only at 0.1 level), further adding to a potential inverse relationship between financial constraints and R&D investment.

From the estimates in columns 3 and 4, it may be possible to argue that public finance has a positive effect in reducing financial constraints. Firms that do not have public financial support save, on average, 12 cents out of each euro of cash-flow, which contrasts with the group of firms that received funding (the coefficient is not statistically different from zero).[15]

[14] Nevertheless, the former estimate is quite imprecise due to a reduced number of observations and the latter is still statistically significant—possibly capturing firms that are financially constrained with respect to other activities, rather than innovation. We should also note that "hampered firms" include those that either faced financial constraints or any other sort of obstacles to innovate. If we restrict the sample to "hampered firms" that report financial constraints, we obtain 34 firms with the corresponding 75 observations and a CCFS estimate of 0.339** (0.148). Conversely, for the remaining firms (hampered by other obstacles) the CCFS estimate is found to be negative but not statistically different from zero.

[15] However, a test on the difference between estimates is not able to reject the equality of coefficients, even though this is due to the lack of precision stemming from the low number of observations for the SUB=1 subsample.

Table VIII.3. Cash-Cash Flow Sensitivity estimation: Innovators and potential innovators

VARIABLES	(1) Overall	(2) Innovators	(3) Non-Innovators	(4) Potential	(5) Hampered	(6) Unwilling
Potential innovators	Both	Yes	Both	Yes	Yes	No
Innovators	Both	Yes	No	Both	No	No
$CF_{i,t}$	0.117***	0.100*	0.112*	0.103**	0.215*	0.123*
	(0.043)	(0.055)	(0.064)	(0.052)	(0.117)	(0.068)
	[0.046 - 0.189]	[0.009 - 0.190]	[0.007 - 0.218]	[0.017 - 0.189]	[0.023 - 0.407]	[0.012 - 0.235]
$\Delta y_{i.t}$	0.024**	0.019	0.023*	0.018	0.010	0.026*
	(0.010)	(0.012)	(0.013)	(0.011)	(0.012)	(0.014)
	[0.008 - 0.040]	[-0.001 - 0.040]	[0.002 - 0.044]	[-0.000 - 0.036]	[-0.009 - 0.029]	[0.003 - 0.049]
$S_{i.t}$	0.018**	0.021**	0.015	0.019**	-0.004	0.023
	(0.009)	(0.010)	(0.016)	(0.009)	(0.020)	(0.018)
	[0.004 - 0.032]	[0.005 - 0.037]	[-0.012 - 0.042]	[0.004 - 0.033]	[-0.038 - 0.030]	[-0.006 - 0.053]
$I_{i.t}$	-0.143***	-0.152***	-0.131***	-0.162***	-0.188***	-0.112***
	(0.023)	(0.031)	(0.032)	(0.029)	(0.060)	(0.034)
	[-0.180 - -0.105]	[-0.203 - -0.101]	[-0.183 - -0.079]	[-0.209 - -0.115]	[-0.286 - -0.090]	[-0.167 - -0.057]
$\Delta NWC_{i.t}$	-0.154***	-0.123***	-0.178***	-0.124***	-0.073	-0.192***
	(0.018)	(0.020)	(0.026)	(0.019)	(0.045)	(0.027)
	[-0.184 - -0.125]	[-0.157 - -0.090]	[-0.220 - -0.136]	[-0.156 - -0.092]	[-0.147 - 0.000]	[-0.236 - -0.148]
$ISS_{i.t}$	0.035**	0.069***	0.010	0.065***	0.039	0.004
	(0.014)	(0.019)	(0.019)	(0.018)	(0.047)	(0.020)
	[0.011 - 0.058]	[0.038 - 0.100]	[-0.021 - 0.041]	[0.035 - 0.095]	[-0.039 - 0.117]	[-0.028 - 0.036]
$\Delta INT_{i.t}$	-0.090	-0.116	-0.186	-0.072	-0.172	-0.297
	(0.280)	(0.360)	(0.375)	(0.340)	(0.559)	(0.387)
	[-0.551 - 0.370]	[-0.709 - 0.477]	[-0.802 - 0.430]	[-0.631 - 0.487]	[-1.091 - 0.748]	[-0.934 - 0.339]
$FinI_{i.t}$	-0.097***	-0.120***	-0.074	-0.111***	0.527**	-0.092
	(0.034)	(0.032)	(0.090)	(0.032)	(0.266)	(0.093)
	[-0.152 - -0.041]	[-0.173 - -0.067]	[-0.223 - 0.074]	[-0.164 - -0.058]	[0.090 - 0.964]	[-0.245 - 0.060]
Observations	3,320	1,546	1,774	1,674	128	1646
Number of firms	1,458	677	781	727	50	731
Hansen p-value	0.650	0.510	0.194	0.538	0.304	0.218
R-squared	0.167	0.163	0.182	0.156	0.200	0.190

Notes: All regressions use the specification of equation (A1). In column (1) we report the results for the full sample, while columns (2) and (3) report the estimates for firms that innovated and that did not, respectively. Of the non-innovating firms, columns (5) and (6) report the results for potential innovators (hampered) and for those firms that were unwilling to innovate, respectively. Column (4) reports the results for all potential innovators (either effective innovators or not). Robust standard errors in parenthesis and 90% confidence intervals in brackets. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively.

Table VIII.4. Cash-Cash Flow Sensitivity estimation: R&D and Subsidies.

VARIABLES	RD=1 (1)	RD=0 (2)	SUB=1 (3)	SUB=0 (4)	I_RD (5)
$CF_{i\ t}$	0.051	0.204***	0.072	0.123***	0.135***
	(0.056)	(0.068)	(0.141)	(0.045)	(0.045)
	[-0.041 - 0.143]	[0.092 - 0.316]	[-0.160 - 0.304]	[0.049 - 0.196]	
$I\_RD_{i.t}$					0.000
					(0.001)
$CF_{i.t} * I\_RD_{i.t}$					-0.010*
					(0.006)
$\Delta y_{i.t}$	0.020*	0.030**	0.007	0.024**	0.024**
	(0.012)	(0.014)	(0.025)	(0.010)	(0.010)
	[0.001 - 0.039]	[0.006 - 0.053]	[-0.035 - 0.048]	[0.008 - 0.041]	
$S_{i.t}$	0.031***	0.012	0.041	0.017**	0.016*
	(0.012)	(0.018)	(0.031)	(0.009)	(0.009)
	[0.011 - 0.050]	[-0.019 - 0.042]	[-0.010 - 0.092]	[0.003 - 0.032]	
$I_{i.t}$	-0.131***	-0.114***	-0.081	-0.146***	-0.149***
	(0.028)	(0.039)	(0.056)	(0.025)	(0.023)
	[-0.178 - -0.085]	[-0.178 - -0.049]	[-0.174 - 0.011]	[-0.186 - -0.106]	
$\Delta NWC_{i.t}$	-0.110***	-0.194***	-0.089**	-0.158***	-0.154***
	(0.020)	(0.027)	(0.038)	(0.019)	(0.018)
	[-0.143 - -0.077]	[-0.239 - -0.150]	[-0.151 - -0.026]	[-0.189 - -0.127]	
$ISS_{i.t}$	0.048***	0.019	0.014	0.033**	0.038***
	(0.019)	(0.021)	(0.043)	(0.015)	(0.014)
	[0.018 - 0.079]	[-0.015 - 0.053]	[-0.056 - 0.084]	[0.008 - 0.058]	
$\Delta INT_{i.t}$	-0.343	-0.004	0.390	-0.079	-0.059
	(0.354)	(0.404)	(0.851)	(0.288)	(0.284)
	[-0.926 - 0.240]	[-0.670 - 0.661]	[-1.009 - 1.790]	[-0.553 - 0.395]	
$FinI_{i.t}$	-0.136***	-0.019	-0.268**	-0.073**	-0.098***
	(0.035)	(0.126)	(0.131)	(0.033)	(0.034)
	[-0.194 - -0.078]	[-0.227 - 0.189]	[-0.483 - -0.052]	[-0.128 - -0.017]	
Observations	1,500	1,718	255	3,065	3,065
Number of firms	649	815	116	1,342	1,342
Hansen p-value	0.319	0.830	0.637	0.763	0.763
R-squared	0.142	0.214	0.156	0.171	0.171

Notes: Regression of equation (A1) in columns (1-4) and of equation (A2) in column (5). Robust standard errors in parenthesis and 90% confidence intervals in brackets. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively. .

With respect to other variables, we should note that investment and non-cash net working capital are demands for cash. Accordingly, the negative sign is not unexpected. Conversely, the positive impact found for equity and debt issuances reflects the importance of these sources of cash, even though there is an associated cost (interest payments) that reduce cash savings. Finally, financial investments are a demand for cash, but may also be used to transfer resources across time. Therefore, while we find a negative impact for those firms that are not expected to be financially constrained, the same is not true when it comes to constrained ones.[16]

Even though CCFS appear to be able to provide useful insights on the level of financial constraints, this methodology suffers from the fact that it is unable to explore the causality flow between financial constraints (an estimated mean for a given subsample) and R&D investment, innovation or subsidies. Consequently, bearing in mind the subjective nature of such variable, we resort to the reported levels of financial constraints to innovate, as an explanatory variable for these activities in the following sections.

4.3. Results of Model B

In Table 5 we report the estimation results of the selection model with endogenous financial constraints. It can be compared with the Heckman-style estimation of the corresponding model, with an additional treatment of endogeneity. While in column (1) we report the estimates of a simple OLS, columns (2-5) report the estimates of a two-parts specification, where we assume that the amount invested in R&D is independent of the decision to invest in R&D (no selection). In column (6) we estimate a model that accounts for selection but not endogeneity (Heckman) and finally, columns (7-8) report the estimates of the model that accounts for both selection and endogeneity.[17]

[16] Financially constrained firms may redirect cash-flows and present liquidity (cash stocks) to future states, in the form of financial investment (relatively liquid assets) to be used as a source of liquidity in the future. However, we should note that a decrease of financial investments may not necessarily mean an increase in cash stocks. The reason is that since both can be used to finance investment (e.g. R&D investment and innovation investment in general) or face financial distress (e.g. service debt, cover operational losses), it may occur a contemporaneous decrease in cash stocks and financial investments

[17] Since the derivation of the appropriate correction terms for the asymptotic variance is rather complex, we resort to paired bootstrap estimation with 999 replications.

While on one hand the results from columns (2-5) point that endogeneity must be taken into account (statistically significant $\hat{\rho}$ coefficient on the decision equation and a formal endogeneity test on the volume equation), on the other hand, the necessity to account for selection is confirmed by the statistically significant coefficient on $\hat{\lambda}_{i3}$ in columns (6-8). Once both selection and endogeneity are taken into account, we show that an increase in financial constraints leads to a decrease in the amounts invested in R&D.[18] Accordingly, we do not reject *H1*. Additionally, our results suggest that subsidies stimulate R&D investment since, in all specifications, there is a strong positive impact of subsidies upon both the decision to invest and the amounts spent in R&D.

With respect to other variables of interest, we should note the positive impact of size, R&D investment opportunities, percentage of R&D employees and cooperation, which is not unexpected. On the other hand, investment opportunities (sales growth) reduce R&D investment, most probably due to the fact that higher sales growth signal that no innovation efforts are needed since the firm is performing rather well, or alternatively it might suggest that investment in physical capital is warranted.[19] Conversely, a reduction of sales might signal that the firm needs to be innovative and change. Finally, the estimates on firm age are quite unstable. On one hand, the negative signs may indicate that, as firms grow older, they tend to accommodate and invest less in R&D. This can also be related to life cycle of a certain industry and the strength of the selection pressure. On the other hand, the positive signs suggest that as firms age, they increase their knowledge stock and are better suited to pursue R&D activities.

Overall, financial constraints severely affect the amounts invested in R&D once FC are treated as endogenous.

[18] As a check for robustness, we constructed a panel of the 3 wave periods by calculating the averages, over wave period, of financial variables (Table A2, appendix). In this case, there appears to be a reduction in the negative effect of financial constraints on R&D investment along the 3 waves. Additionally, results obtained fitting a Tobit to log(1+R&D investment)—e.g. Czarnitzki and Hottenrott (2011b)—also lead to a negative (but not significant) impact of FC upon R&D investment. The coefficients (standard deviations) are -0.462 (0.953) and -0.021 (1.038) of the ordinal and collapsed binary financial constraints variables, respectively (taking into account endogeneity).

[19] Note that the spearman correlation coefficient of sales growth is positive (0.2411*) and negative (-0.0591*) with respect to physical capital investment (I) and total R&D investment (I_RD), respectively.

Table VIII.5. Investment in R&D.

Estimation procedure	OLS	Two parts "hurdle" Decision	Volume	Two parts with endogeneity Decision	Volume	Selection Heckman	Full Model B last step 3.1)	last step 3.2)
Selection	NO	NO	NO	NO	NO	YES	YES	YES
Endogeneity	NO	NO	NO	YES	YES	NO	YES	YES
Dependent Var.	(1) I_RD	(2) RD	(3) RD_I	(4) RD	(5) RD_I	(6) RD_I	(7) RD_I	(8) RD_I
FC	0.073	0.046	0.395***	-0.505***	-0.561***	-0.150	-0.637***	-0.707***
	(0.303)	(0.086)	(0.152)	(0.055)	(0.142)	(0.115)	(0.238)	(0.271)
SIZE	0.758***	0.101***	1.527***	0.040	0.684***	0.995***	0.871***	0.976***
	(0.109)	(0.031)	(0.055)	(0.029)	(0.065)	(0.049)	(0.059)	(0.069)
AGE	-0.229	-0.045	1.022***	-0.007	-0.217**	0.191**	0.134*	0.273***
	(0.162)	(0.053)	(0.091)	(0.048)	(0.091)	(0.081)	(0.086)	(0.098)
EXP	0.014	-0.008	0.029	-0.045	0.016	0.007	0.021	0.028
	(0.273)	(0.074)	(0.166)	(0.065)	(0.146)	(0.129)	(0.116)	(0.124)
Y_IN	4.618***	1.321***	1.180***	1.076***	0.938***	1.501***	1.243***	1.735***
	(0.612)	(0.236)	(0.313)	(0.195)	(0.244)	(0.233)	(0.315)	(0.348)
ΔY	-1.100***	-0.255**	-1.658***	-0.215**	-0.504*	-0.829***	-0.701***	-0.923***
	(0.406)	(0.113)	(0.436)	(0.098)	(0.273)	(0.213)	(0.215)	(0.251)
RD_WORK	6.834***	2.972	8.122***	2.681	5.018***	5.198***	5.221***	5.579***
	(2.566)	(2.020)	(1.331)	(1.749)	(1.108)	(1.448)	(0.936)	(1.176)
SUB	3.577***	1.051***	0.301*	0.863***	0.593***	1.059***	0.876***	1.203***
	(0.347)	(0.145)	(0.176)	(0.128)	(0.151)	(0.171)	(0.209)	(0.228)
COOP	4.018***	1.120***	0.157	0.872***	0.091	0.874***	0.456**	0.886***
	(0.332)	(0.109)	(0.169)	(0.105)	(0.130)	(0.177)	(0.221)	(0.25)
Endogeneity & Selection tests				0.935***($\hat{\rho}$)	13.439	1.597***($\hat{\gamma}$)	0.827**($\hat{\gamma}$)	1.685***($\hat{\gamma}$)
				(0.151)	0.0002	(0.249)	(0.409)	(0.457)
Observations	2,608	2,608	1,285	2,567	1,270	2,608	1,270	1,270
Chi-squared	0.663 (R2)	339.5	0.966 (R2)	755.2	0.191 (R2)	18987	0.972 (R2)	0.973 (R2)

Notes: Estimates for Model B. Robust standard errors in parenthesis—bootstrapped (999 replications) for columns (7-8). ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively. All regressions include industry dummies. The estimates of the selection variable RD, the dummy variable that represents firms' decision to invest, as well as further test statistics, are available from the authors on request. In this table we omit the controls LPROD, LEV, MKTS and other barriers to innovation (see Section 3.2) in columns (1-2) and (4) for simplicity of presentation. In columns (1-3) and (6) the binary FC^c variable is used instead of ordinal FC. Estimation in columns (4-5) and (8) use the procedure 3.2) of Section 3.2 to take into account FC endogeneity, while in column (7) we use procedure 3.1). Statistically significant $\hat{\rho}$ (column 4) and $\hat{\gamma}$ (columns 6-8) coefficients indicate the presence of endogeneity and selection, respectively, while in column (5) we report a Chi-squared and corresponding p-value of the endogeneity test.

4.4. Results of Model C

When it comes to innovation, Table 6 reports our estimates of the simultaneous equations probit and ordered probit models (columns 2 and 3, respectively), as well as those of a simple univariate probit model (column 1) that does not account for the possibility of endogenous financial constraints. As expected, the rejection of the hypothesis of independent equations (Wald test of whether $\rho = 0$) confirms that FC must be treated endogenously. Once this endogeneity is taken into account, the impact of FC upon innovation becomes negative and statistically significant for both binary and ordinal specifications. Therefore, we are not able to reject *H2*. Additionally, as naturally expected, the amounts spent in R&D positively affect innovation, even though there is no significant impact of subsidies upon the probability that a firm innovates. Nevertheless, if we observe this effect for each wave, we find that while in the first two waves, there is a strong positive impact of subsidies upon innovation, this is not the case when we analyse the last wave (see table A3 in appendix).

With respect to other variables, cooperation and size (for the ordered specification) are found to significantly increase innovation, which is not unexpected—in contrast with the odd positive coefficient for market barriers. We do not find statistically significant coefficients, within the simultaneous equations specifications, for the remaining variables of interest.[20] Finally, we do not find any statistically significant difference (at 0.1 level) between the impact of financial constraints on product and process innovation (see Table A4 in Appendix). Nevertheless, significant differences are found with respect to investment opportunities, that have a significant positive (negative) impact on product (process) innovation, as well as concerning the impact of subsidies—that appears to be only relevant for product innovation.

[20] As for the case of R&D expenditure, when we divide the sample by CIS wave periods (Table A3, Appendix) we find that financial constraints decrease in importance as we move along the CIS waves.

Table VIII.6. Innovation.

VARIABLES	Exogenous FC	Endogenous FC	
	Probit	Probit	Ordered Probit
	(1)	(2)	(3)
FC^c \ FC	-0.066	-0.815***	-0.463***
	(0.092)	(0.303)	(0.125)
RD_I	0.209***	0.193***	0.239***
	(0.008)	(0.015)	(0.017)
SIZE	0.010	0.006	0.092*
	(0.034)	(0.032)	(0.051)
AGE	-0.094*	-0.032	0.037
	(0.052)	(0.059)	(0.073)
SUB	0.237	0.276	0.475
	(0.230)	(0.215)	(0.350)
COOP	0.836***	0.741***	0.547*
	(0.201)	(0.193)	(0.293)
B_TRAB	0.099	0.090	-0.245
	(0.142)	(0.134)	(0.183)
B_TECH	0.152	0.127	0.283
	(0.138)	(0.127)	(0.179)
B_MARK	-0.102	-0.080	0.467***
	(0.107)	(0.097)	(0.135)
ΔY	-0.982	-1.111	1.714
	(1.485)	(1.338)	(1.752)
RD_WORK	-0.166	-0.172	-0.164
	(0.147)	(0.142)	(0.212)
MKTS	-0.021	-0.039	-0.055
	(0.136)	(0.135)	(0.142)
ρ		0.545**	0.348*
		(0.261)	(0.209)
Observations	3,247	3,206	3,206
Chi-squared	852.2	1096	818.5

Notes: Estimates for equation (C2). Robust standard errors in parenthesis. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively. All regressions include industry dummies.

4.5. Results of Model D

The results on the impact of subsidies on financial constraints (Table 7) are quite puzzling. While for regressions that use contemporaneous and lagged balance sheet variables (columns 1, 3 and 4) we find a positive and statistically significant impact of subsidies on financial constraints (regardless of whether we control for endogeneity or not), when we use lagged subsidies and CIS wave variables (columns 2, 5 and 6), the estimated coefficients are not statistically different from zero. Interestingly (but not surprising) when lagged variables are used, one can not reject the null hypothesis that subsidies can be treated as exogenous. With respect to other potential determinants of financial constraints, when significant, they are found to carry the expected sign.

This rather puzzling rejection of $H3$, that contrasts with the expectations of an inverse relationship, as suggested by the findings in Section 4.2, deserves a detailed inspection of both survey variables. Specifically, in Table 8, we report the frequencies of FC and SUB. As expected, the majority of firms do not receive subsidies (88.1%), as well as there is a relatively large percentage of firms that face difficulties in obtaining external funds to finance innovation (43.3%, but increasing in the level of constraints). Additionally, for firms that report financial constraints and receive financial support (6.3%), the percentage of subsidies for those that report minor difficulties (12.5%) is lower than those that report high and very high levels of constraints (21% and 19.1%, respectively).

However, there is a remarkably large number of firms, among those that receive subsidies (11.9%), that reported not to be financially constrained (47.4%). This can either indicate that firms that receive subsidies *ex-ante* do not face significant constraints, or that there is a misallocation of subsidies. We are more inclined towards the second explanation since this value increases to 62.5% if instead of FC_wwe compute the relative frequencies for FC_{w-1}—i.e. 62.5% of firms that received subsidies during one CIS wave, have reported no constraints in the previous wave (Table A5, appendix).[21] Furthermore, if instead of SUB_w we use SUB_{w-1}, one can observe that only 39.3% of firms that received subsidies in one period, report no constraints on the subsequent period. Still, these results may well reflect the idea of "subsidy persistence" (e.g. Hussinger, 2008). In fact, the transition probability of a firm continuing as subsidized is 39.5%, being 40% for firms that report as unconstrained.

[21] The subscript w stands for CIS wave. Additionally, the impact of financial constraints on the probability that a firm receives subsidies (either in the current or subsequent period) is never statistically significant (see Table 6 in the Appendix).

Table VIII.7. Financial constraints: The impact of subsidies.

			SUB treated as endogenous			
Dependent Var.	FC		FC^c	FC	FC^c	FC
CIS wave lag	(1) NO	(2) YES	(3) NO	(4) NO	(5) YES	(6) YES
SUB	0.174**	0.139	0.769***	0.476***	-0.628	-0.064
	(0.074)	(0.135)	(0.297)	(0.175)	(0.571)	(0.860)
SIZE	-0.050**	-0.022	-0.108***	-0.062**	0.037	-0.061
	(0.023)	(0.058)	(0.028)	(0.024)	(0.083)	(0.101)
AGE	0.051	-0.024	0.057	0.048	-0.037	-0.110
	(0.039)	(0.096)	(0.042)	(0.039)	(0.094)	(0.116)
PUB_K	-0.002	-0.003	-0.002	-0.002	-0.003	-0.003
	(0.001)	(0.003)	(0.001)	(0.001)	(0.003)	(0.003)
FOR_K	-0.003***	0.000	-0.004***	-0.003***	-0.000	-0.002
	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
ΔY	-0.121	-0.121	-0.115	-0.115	-0.106	-0.260
	(0.102)	(0.225)	(0.116)	(0.102)	(0.224)	(0.274)
CS	-1.018***	-2.002***	-0.930***	-1.005***	-1.990***	-1.644**
	(0.283)	(0.689)	(0.300)	(0.283)	(0.664)	(0.737)
CF	-0.662**	-0.765	-1.059***	-0.639**	-0.720	-0.908
	(0.318)	(0.726)	(0.345)	(0.317)	(0.734)	(0.836)
LEV	0.226**	0.185	0.493***	0.226**	0.227	0.607*
	(0.108)	(0.259)	(0.123)	(0.107)	(0.254)	(0.311)
ISS	-0.375**	-0.130	-0.296	-0.356**	-0.101	0.101
	(0.170)	(0.356)	(0.200)	(0.169)	(0.350)	(0.445)
ΔINT	12.341***	13.252	10.454**	12.542***	15.049*	15.722
	(3.727)	(8.843)	(4.586)	(3.717)	(8.628)	(12.121)
R_FinI	-11.000	5.257	-16.506	-10.751	6.545	-1.368
	(12.050)	(22.711)	(11.969)	(11.981)	(21.959)	(22.696)
EXP	-0.049	-0.308***	-0.065	-0.056	-0.330***	-0.367***
	(0.060)	(0.105)	(0.065)	(0.060)	(0.106)	(0.131)
MKTS	-0.165	-0.033	-0.159	-0.179*	0.025	0.286
	(0.101)	(0.179)	(0.114)	(0.101)	(0.184)	(0.242)
ϱ			-0.203*	-0.227*	0.390	0.052
			(0.109)	(0.119)	(0.404)	(0.324)
Observations	3,208	556	3,180	3,180	549	549
Log-likelihood	-1701	-377.3	-1222	-2105	-509.9	-320.6

Notes: Columns (1-2) report estimates from an ordered probit regression, columns (3) and (5) those from an instrumental variables probit and columns (4) and (6) report the results for equation (D1). Robust standard errors in parenthesis. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively. All regressions include industry dummies.

These results need further testing, preferably using treatment effects estimation techniques. However, our CIS panel is not sufficiently long and the financial constraints variable is not linear (despite we can do a linear projection), not to mention possible problems associated with the subjective nature of this particular survey variable. In fact, we do not exclude the possibility that there are problems associated with the subjective nature of the FC self-assessed variable.

Table VIII.8. Frequencies of FC and SUB

	FC	SUB 0	SUB 1	Total
Frequency	0	1,781	201	1,982
SUB %		89.86	10.14	100
FC %		56.68	47.41	55.58
Total%		49.94	5.64	55.58
Frequency	1	393	53	446
SUB %		88.12	11.88	100.00
FC %		12.51	12.50	12.51
Total%		11.02	1.49	12.51
Frequency	2	462	89	551
SUB %		83.85	16.15	100.00
FC %		14.70	20.99	15.45
Total%		12.96	2.50	15.45
Frequency	3	506	81	587
SUB %		86.20	13.80	100.00
FC %		16.10	19.10	16.46
Total%		14.19	2.27	16.46
Frequency	YES	1,361	223	1,584
SUB %		85.92	14.08	100.00
FC %		43.32	52.59	16.46
Total%		38.17	6.25	16.46
Frequency	Total	3,142	424	3,566
SUB %		88.11	11.89	100.00
FC %		100.00	100.00	100.00
Total%		88.11	11.89	100.00

Notes: Frequencies of financial constraints (rows) and subsidies (columns). SUB % (FC %) are relative frequencies within rows (columns) of each cell. For the ordinal FC variable, higher values correspond to higher reported constraints (zero for absence of constraints).

5. Discussion

Overall, our results suggest that the innovation process is negatively affected by financial constraints. On one hand, for the case of R&D investment, both our indirect and direct measures point towards a strong negative impact of financial constraints. Indeed, CCFS estimates are much larger for firms that do not invest in R&D (Model A, Section 4.2)—in line with the findings of Bond et al. (2003) for ICFS. This result meets the expectation that only firms that are not financially constrained are able to invest in R&D. Additionally, once endogeneity is taken into account, higher reported levels of constraints reduce the probability that a firm invests in R&D, as well as the R&D investment volume (Model B, Section 4.3). Accordingly, as stated in our hypothesis *H1*, financial constraints reduce the amounts invested in R&D.

When it comes to innovation, even though the CCFS estimates do not allow a straightforward conclusion (Model A), the analysis of Model C (Section 4.4) reveals that, once we take into account endogeneity, financial constraints significantly reduce the probability that a firm innovates, as stated in *H2*. Yet, we should spend some time in trying to understand why we do not find clear-cut results using CCFS. In particular, the extent to which the non-innovators (innovators) group will include some firms that are, a-priori, not constrained (constrained)—one would expect significantly lower (higher) CCFS for firms that do (do not) innovate.

Firstly, this methodology is time-invariant and relies on an *a priori* assignment of firms into distinct groups. Therefore, some lag effects may not be totally captured by the methodology and, notoriously, it does not account for endogeneity. Secondly, regardless of being or not financially constrained, firms might just not be interested in innovating in the first step. For example, it might well be the case in industries where the pace of technological change is rather slow (Marsili and Verspagen, 2002; Castellacci, 2007). This is particularly relevant for our CCFS estimation because the question on self-assessed constraints (FC) is answered by all firms in all CIS waves, whether they innovated or not. Using this information, we identify potential innovators (within non-innovators) that, according to our estimates, seem to be more financially constrained than those firms not willing to innovate. Notwithstanding, the question is asked specifically with respect to innovation barriers. As a result, while it is not expected that firms that do not want to innovate report constraints to innovation (FC), the CCFS measure may also capture the extent to which firms—unwilling to innovate—are financially constrained with respect to their operational and physical capital investment activities (other than innovation). This is probably the reason why we still find significant CCFS for firms unwilling to innovate. Thirdly, non-financially constrained firms may try to innovate, even though they are unsuccessful and therefore will belong to the non-innovators group. Finally, since innovation is measured in a rather broad sense, reasonably financially constrained firms, even without putting too much effort, might be able to innovate. As an example, if we would be able to distinguish between "radical" from "routine" types of investment in R&D and innovations, then we could expect significant differences in the impact of financial constraints (Czarnitzki and Hottenrott, 2011b).

Nevertheless, the combination of both survey and balance sheet information—that allows us to instrument the self-assessed constraints variable—certainly helps to clarify the negative impact that financial constraints have upon R&D investment and ultimately innovation. Consequently, the perverse effect of financial constraints upon the innovation process, calls for policies that help to mitigate such constraints. Accordingly, we evaluate the extent to which public financial support (subsidies) effectively alleviates financial constraints to innovate.

Our first results, using CCFS, suggest an inverse relationship between subsidies and constraints (Section 4.2.). The immediate interpretation is that firms receiving subsidies are not constrained. In this case, even though we would expect the difference to the subsidised group to be significant, there certainly also exist some firms in the non-subsidised group that are not financially constrained. However, this analysis is static. Accordingly, it neither clarifies if there is a causality flowing from subsidized to unconstrained, nor whether subsidies are actually being allocated to financially constrained firms. In fact, even though the results from the CCFS analysis would suggest an inverse relationship between subsidies and constraints, the findings obtained using Model D (Section 4.5) point towards the rejection of the hypothesis that subsidies alleviate financial constraints (*H3*). This rather puzzling result requires further clarification and some explanations, that we summarize as follows:

a) Subsidies are not being allocated correctly. This is one of the two worrisome possible explanations, that is based on our analysis of relative frequencies. In fact, we report a large number of firms that receive subsidies, despite not reporting as financially constrained in current or previous periods. If this is the case, then policymakers should be more cautious in designing incentives and, notoriously, in scrutinizing firms as potential targets. Nevertheless, this hypothesis needs further testing, in particular with information on the specific incentive schemes.

b) Learning and self-selection in applying for subsidies. This is related to point a). We do not know which firms apply for subsidies. However, if certain firms are more engaged in innovation activities and have a better procedural knowledge, it is possible that they obtain subsidies, even if not financially constrained. Therefore, such subsidies will not affect the levels of constraints faced by such firms. We argue that there is a "learning by applying" effect, in which firms—along the time and consecutive applications for funds—learn own to best satisfy the requirements of subsidies programs, as well as they gain insights on the institutional setup behind subsidy allocation. This is in line with the "subsidy persistence" found in our data. If this is the case, firms that regularly apply for subsidies dominate the application process, regardless of the effectiveness of the subsidy (either from a "constraints alleviating" or "innovation enhancing" perspective). Moreover, firms that already have an "application know-how", may discourage applications from firms that apply for the first time, since the latter know in advance that they lack the expertise and therefore have a lower probability of obtaining the subsidy. Consequently, regular applicants will self-select into subsidies. This self-selection effect may also explain the results of Section 4.2., where we do not find significant CCFS for subsidized firms. However, we should note that the extent to which firms learn how to apply for subsidies, may not signify that they also learn how to elaborate a successful project at the eyes of private lenders. This is due to different goals of private (maximize returns with minimal risk of default) and public lenders (deal with market failures by alleviating financial constraints, fostering innovation, or both). Accordingly, we may have constrained firms that will continue to receive subsidies with their levels of financial constraints remaining unchanged.

c) Subsidies do not alleviate financial constraints. In other words, the wedge between external and internal forms of finance remains unchanged after a firm receives a subsidy. This case also requires a serious rethinking of public policy programs. In fact, in addition to our estimation results, the analysis of frequencies using lagged values suggests that there is a significant percentage of firms that, even after receiving subsidies, report high levels of constraints. This may occur mainly for two reasons. On the one hand, such subsidies are strictly designed to foster innovation, regardless of firms' difficulties in raising external funds. This means that there is no "signalling" effect to investors and that ultimately funds are not being allocated to those firms that most need them. On the other hand, subsidies have a "crowding out" effect that does not alter economic performance and subsequent reduction in constraints. However, for a more appropriate causality testing, we would need a dependent variable of financial constraints that is firm-specific (not estimated means), objective, continuous (and not scores) and, most importantly, time varying (in order to allow treatment effects estimation). Unfortunately, to our knowledge, there is no such measure. Moreover, different forms of public incentives (such as special credit lines and backed debt policies), may prove to be more effective in reducing constraints. Regrettably, we do not have sufficient information to distinguish these forms of intervention from subsidies *strictu sensu* (e.g. grants and tax credit).

d) The subjective nature of the survey FC variable. In this particular case, the possible bias would be towards higher reported levels of constraints, since firms would tend to over-report as financially constrained. This would not be a major concern if the bias is transversal and equal to all firms (would only imply a scaling of the effect), which is already a quite strong assumption. However, if this bias is associated with a "subsidy persistence" phenomena, then it is natural to expect that a significant number of firms, that continuously receive subsidies, will still perceive themselves as financially constrained. Nevertheless, this respondent perception problem is not as serious for the other models, since for such cases financial constraints is an explanatory variable that is instrumented with balance sheet data. However interesting, the extent to which firms' self-evaluation of constraints deviates from reality is not in the scope of this Chapter, but is certainly a topic that deserves detailed investigation in the future.

While on one hand it appears that subsidies promote innovation (during the first two waves of our data) and particularly foster R&D investment (Sections 4.4. and 4.3., respectively), on the other our results do not support the idea that this is done *via* a reduction of financial constraints (Section 4.5.). In other words, the rationale for subsidies appears to be solely on the grounds of innovation as a "public good". Accordingly, the allocation of funds to firms that do not suffer financial constraints (if this is the case), may well create inefficiencies, possibly even within a social welfare perspective, since it may reinforce the dominant position of certain firms against other firms (or profitable net present value projects) that either are unable to obtain external finance or do not have the necessary expertise to obtain public financial support—provided explanation c) holds.

On the whole, even though in this Chapter we lack a simultaneous analysis of the different dimensions (which is econometrically extremely complex), it provides a broad view of the effects of financial constraints upon the innovation process. Furthermore, the Chapter raises a number of questions and provides ground for debate regarding the allocation and effectiveness of subsidies in alleviating firms' financial constraints.

6. Conclusion

In this Chapter we broadly analyse the financing problems of the innovation process. Specifically, we explore the impact of financial constraints to R&D investment and innovation, as well as the role of public financial support in alleviating such constraints. Accordingly, we estimate a selection model, simultaneous equations probit models, as well as the sensitivity of cash to cash-flow upon an unique, newly assembled, sample of Portuguese firms.

Using the CCFS methodology to assess the mean level of financial constraints by subsamples of firms, we find that CCFS are larger for firms that do not innovate (but are potential innovators), for those that do not invest in R&D and for firms that do not receive subsidies. This indicates that R&D investment may be financially constrained and subsidies may help in reducing financial constraints. On the other hand, by analysing the impact of a self-assessed measure of constraints upon R&D investment, we show that only when the endogeneity problem associated with this variable is taken into account, do financial constraints significantly decrease the amounts invested in R&D. Furthermore, also resorting to the same direct measure, innovation (in a broad sense) is only found to be significantly hampered by financial constraints once we allow for a joint specification of errors of both equations. However, when we focus on the effect of subsidies upon the reported levels of financial constraints, we do not find evidence supporting the constraints alleviating effect of subsidies. On the contrary, our evidence raises serious concerns regarding the extent to which subsidies reduce financial constraints.

Overall, even though financial constraints analysis usually relies on rather fragile relationships to identify and measure constraints, by adopting different strategies to assess the impact of financial constraints upon the innovation process, we are able to provide compelling evidence that constraints to R&D investment and innovation are binding. Nevertheless, we raise a number of questions regarding the efficiency and effectiveness of policy actions to reduce such constraints—despite they seem to increase innovation activity and, most notoriously, R&D investment. Although such relationship needs further testing, this work opens ground for academic debate on the topic and points towards a reconsideration of corresponding future policy actions.

Appendix

Table VIII.A1. Different specifications of Model A

	Specifications			
VARIABLES	(1)	(2)	(3)	(4)
$CF_{i,t}$	0.101**	0.126***	0.100**	0.117***
	(0.050)	(0.043)	(0.050)	(0.043)
$\Delta y_{i,t}$	0.030***	0.024**	0.030***	0.024**
	(0.010)	(0.010)	(0.010)	(0.010)
$S_{i,t}$	0.033***	0.015*	0.038***	0.018**
	(0.009)	(0.008)	(0.009)	(0.009)
$I_{i,t}$	-0.128***	-0.138***	-0.132***	-0.143***
	(0.022)	(0.023)	(0.022)	(0.023)
$\Delta NWC_{i,t}$	-0.183***	-0.154***	-0.186***	-0.154***
	(0.021)	(0.018)	(0.022)	(0.018)
$\Delta STDEBT_{i,t}$	-0.058***		-0.060***	
	(0.016)		(0.016)	
$ISS_{i,t}$		0.035**		0.035**
		(0.014)		(0.014)
$\Delta INT_{i,t}$		-0.082		-0.090
		(0.279)		(0.280)
$FinI_{i,t}$			-0.108***	-0.097***
			(0.034)	(0.034)
Observations	3,320	3,320	3,320	3,320
Number of firms	1,458	1,458	1,458	1,458
Hansen p-value	0.142	0.697	0.162	0.650
R-squared	0.181	0.164	0.185	0.167

Notes: Regression of different specifications for the estimation of CCFS upon the full sample. Column (1) reports the results using Almeida et al. (2004) specification. In column (2) the variation of short-term debt ($\Delta STDEBT_{i,t}$) is replaced by the sum of net debt and equity issuances ($ISS_{i,t}$) and changes in interest paid ($\Delta INT_{i,t}$). Column (3) adds financial investments to the baseline specification of column (1), while column (4) reports the results from the specification used throughout the Chapter—equation (A1). See Section 3.1 for further explanation. Robust standard errors in parenthesis. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively. Further test statistics and confidence intervals available from the authors on request.

Table VIII.A2. Investment in R&D: CIS waves

VARIABLES	Wave dummies (1)	By wave (2) CIS2	(3) CIS3	(4) CIS4
FC	-0.937***	-2.789**	-0.708***	-0.436
	(0.329)	(1.244)	(0.29)	(0.579)
SIZE	0.981***	1.634***	1.054***	1.072***
	(0.072)	(0.153)	(0.141)	(0.073)
AGE	0.326***	0.683**	0.15	0.312*
	(0.104)	(0.328)	(0.186)	(0.195)
EXP	-0.006	0.095	-0.146	0.197
	(0.132)	(0.431)	(0.246)	(0.188)
Y_IN	1.165***	1.409*	0.697***	2.713***
	(0.266)	(0.903)	(0.273)	(0.497)
ΔY	-0.709***	[a]	-2.499*	0.139
	(0.26)		(1.603)	(0.640)
RD_WORK	4.952***	26.712	2.335*	6.259***
	(1.388)	(22.231)	(1.524)	(1.250)
SUB	0.693***	[a]	0.281	1.52***
	(0.188)		(0.228)	(0.300)
COOP	0.336**	1.173**	0.294	1.424***
	(0.204)	(0.622)	(0.243)	(0.388)
WAVE2	1.128***			
	(0.463)			
WAVE3	0.988**			
	(0.453)			
γ	0.553*	4.957***	-0.205	2.505***
	(0.383)	(1.416)	(0.324)	(0.655)
Observations	1,270	176	307	767
Chi-squared	339.5	0.949 (R2)	0.980 (R2)	0.970 (R2)

Notes: Estimates for Model B. In these estimations we compute the mean of balance sheet variables for each corresponding CIS wave period Bootstrapped standard errors (999 replications) in parenthesis. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively. All regressions include industry dummies. The estimates of the selection variable RD, the dummy variable that represents firms' decision to invest, as well as further test statistics, are available from the authors on request. In all estimations we use the procedure 3.2) of Section 3.2 to take into account FC endogeneity. Statistically significant $\hat{\gamma}$ coefficients indicate the presence of selection.

[a] Dropped for collinearity reasons.

Table VIII.A3. Innovation: CIS waves

	CIS2		CIS3		CIS4	
VARIABLES	Probit	Ordered Probit	Probit	Ordered Probit	Probit	Ordered Probit
	(1)	(2)	(3)	(4)	(5)	(6)
$FC^c \setminus$ FC	-2.858***	-1.205***	-1.217***	-0.722***	-0.898***	-0.566***
	(0.326)	(0.225)	(0.301)	(0.098)	(0.307)	(0.191)
RD_I	0.267***	0.272***	0.239***	0.172***	0.176***	0.208***
	(0.027)	(0.028)	(0.032)	(0.039)	(0.017)	(0.038)
SIZE	0.174**	0.229**	-0.140*	-0.058	0.024	0.047
	(0.075)	(0.105)	(0.078)	(0.093)	(0.035)	(0.050)
AGE	-0.011	-0.078	-0.098	0.046	0.050	0.105
	(0.114)	(0.146)	(0.105)	(0.132)	(0.068)	(0.081)
SUB	4.883***	7.064***	0.609**	0.505*	0.085	0.107
	(0.301)	(0.227)	(0.294)	(0.287)	(0.236)	(0.387)
COOP	-0.420	0.066	0.710	-0.411	0.797***	1.108***
	(0.257)	(0.344)	(0.451)	(0.272)	(0.228)	(0.357)
B_TRAB	0.160	0.109	-0.408*	-0.248*	0.185	-0.240
	(0.203)	(0.285)	(0.230)	(0.150)	(0.157)	(0.201)
B_TECH	0.271	0.591*	0.401**	0.030	-0.035	0.162
	(0.413)	(0.337)	(0.194)	(0.149)	(0.152)	(0.190)
B_MARK	-0.830**	-0.202	-0.161	-0.051	-0.270**	0.016
	(0.403)	(0.494)	(0.150)	(0.136)	(0.123)	(0.151)
ΔY	-6.242	-3.545	5.436	14.255*	0.880	2.528
	(4.685)	(5.696)	(4.853)	(7.667)	(2.317)	(2.394)
RD_WORK	-335.582	-336.592	1.281	0.459	0.527	0.794**
	(509.347)	(503.060)	(0.846)	(1.175)	(0.344)	(0.379)
MKTS	0.320	0.253	0.485*	-0.344	0.161	0.068
	(0.252)	(0.277)	(0.268)	(0.229)	(0.175)	(0.181)
ρ	0.545**	0.348*	0.545**	0.348*	0.545**	0.348*
	(0.261)	(0.209)	(0.261)	(0.209)	(0.261)	(0.209)
Observations	897	897	585	585	1,848	1,848
Chi-squared	2126	4870	3225	323.6	619.1	657.5

Notes: Estimates for equation (C2). In these estimations we compute the mean of balance sheet variables for each corresponding CIS wave period. Robust standard errors in parenthesis. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively. All regressions include industry dummies. Further test statistics are available from the authors on request.

Table VIII.A4. Innovation: Product vs Process

	Product		Process	
VARIABLES	Probit	Ordered Probit	Probit	Ordered Probit
	(1)	(2)	(3)	(4)
FC^c \ FC	-0.974***	-0.517***	-0.919***	-0.395**
	(0.163)	(0.141)	(0.203)	(0.178)
RD_I	0.103***	0.123***	0.135***	0.146***
	(0.007)	(0.020)	(0.009)	(0.016)
SIZE	-0.037	-0.064	0.037	0.121*
	(0.026)	(0.053)	(0.029)	(0.071)
AGE	-0.011	0.168**	-0.040	0.143*
	(0.043)	(0.074)	(0.049)	(0.080)
SUB	0.354***	0.100	0.107	-0.002
	(0.097)	(0.191)	(0.122)	(0.211)
COOP	0.345***	0.424***	0.481***	0.708***
	(0.089)	(0.146)	(0.102)	(0.182)
B_TRAB	-0.060	-0.201	0.070	0.255
	(0.102)	(0.197)	(0.112)	(0.232)
B_TECH	-0.040	-0.044	0.284**	0.298
	(0.102)	(0.209)	(0.115)	(0.240)
B_MARK	0.093	0.162	0.005	0.060
	(0.079)	(0.157)	(0.090)	(0.210)
ΔY	1.892*	0.312	-2.677**	-3.379*
	(1.092)	(1.117)	(1.109)	(1.875)
RD_WORK	-0.113	0.037	-0.308**	-0.183
	(0.115)	(0.280)	(0.126)	(0.335)
MKTS	-0.080	-0.352	-0.097	-0.114
	(0.122)	(0.217)	(0.119)	(0.236)
ρ	0.723***	0.897**	0.645***	0.522*
	(0.160)	(0.409)	(0.185)	(0.311)
Observations	3,206	3,206	3,206	3,206
Chi-squared	1227	360.2	1221	356.3

Notes: Estimates for equation (C2) using either product (columns 1-2) or process (columns 3-4) innovation as dependent variable. Robust standard errors in parenthesis. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively. All regressions include industry dummies. Further test statistics are available from the authors on request.

Table VIII.A5. Frequencies of FC and SUB: Lagged values

	FC_w	SUB_{w-1} 0	1	Total	FC_{w-1}	SUB_w 0	1	Total
Frequency	0	214	53	267	0	213	65	278
SUB %		80.15	19.85	100.00		76.62	23.38	100.00
FC %		48.09	39.26	46.03		63.96	62.50	63.62
Total%		36.90	9.14	46.03		48.74	14.87	63.62
Frequency	1	56	24	80	1	35	9	44
SUB %		70.00	30.00	100.00		79.55	20.45	100.00
FC %		12.58	17.78	13.79		10.51	8.65	10.07
Total%		9.66	4.14	13.79		8.01	2.06	10.07
Frequency	2	73	31	104	2	41	10	51
SUB %		70.19	29.81	100.00		80.39	19.61	100.00
FC %		16.40	22.96	17.93		12.31	9.62	11.67
Total%		12.59	5.34	17.93		9.38	2.29	11.67
Frequency	3	102	27	129	3	44	20	64
SUB %		79.07	20.93	100.00		68.75	31.25	100.00
FC %		22.92	20.00	22.24		13.21	19.23	14.65
Total%		17.59	4.66	22.24		10.07	4.58	14.65
Frequency	YES	231	82	313	YES	120	39	159
SUB %		73.80	26.20	100.00		75.47	24.53	100.00
FC %		51.91	60.74	53.97		36.04	37.50	36.38
Total%		39.83	14.14	53.97		27.46	8.92	36.38
Frequency	Total	455	135	580	Total	333	104	437
SUB %		76.72	23.28	100.00		76.20	23.80	100.00
FC %		100.00	100.00	100.00		100.00	100.00	100.00
Total%		76.72	23.28	100.00		76.20	23.80	100.00

Notes: Frequencies of financial constraints (rows) and subsidies (columns). SUB % (FC %) are relative frequencies within rows (columns) of each cell. For the ordinal FC variable, higher values correspond to higher reported constraints (zero for absence of constraints). We compare current (w) values of FC and SUB with the corresponding CIS wave lagged values (w-1).

Table VIII.A6. Subsidies: The impact of financial constraints

			FC treated as endogenous			
	FC^c		FC^c	FC	FC^c	FC
CIS wave lag	(1) NO	(2) YES	(3) NO	(4) NO	(5) YES	(6) YES
FC	0.107	0.095	-0.302	0.021	0.548	0.209
	(0.083)	(0.148)	(0.569)	(0.251)	(1.251)	(0.429)
SIZE	0.069**	0.183**	0.053	0.062*	0.203**	0.189**
	(0.033)	(0.078)	(0.040)	(0.037)	(0.081)	(0.085)
AGE	0.078	0.023	0.064	0.056	0.041	0.035
	(0.049)	(0.111)	(0.054)	(0.055)	(0.110)	(0.111)
FOR_K	-0.013	-0.157*	-0.042	-0.008	-0.164	-0.169*
	(0.053)	(0.090)	(0.077)	(0.055)	(0.112)	(0.099)
RD_WORK	0.177***	0.171**	0.157***	0.167***	0.196**	0.152*
	(0.048)	(0.079)	(0.050)	(0.049)	(0.094)	(0.089)
COOP	0.969***	0.495***	0.995***	0.987***	0.444*	0.497***
	(0.088)	(0.171)	(0.091)	(0.091)	(0.232)	(0.169)
EXP	0.171**	0.062	0.179**	0.178**	0.097	0.117
	(0.073)	(0.122)	(0.076)	(0.077)	(0.137)	(0.154)
SUB%I	6.941***	1.457***	6.773***	6.795***	1.334*	1.413**
	(0.558)	(0.485)	(0.603)	(0.559)	(0.755)	(0.571)
SUB%R	-0.007***	0.009***	-0.009***	-0.007***	0.008**	0.008**
	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)
MKTS	-0.906***	-0.147	-0.937***	-0.926***	-0.119	-0.126
	(0.290)	(0.498)	(0.296)	(0.299)	(0.512)	(0.510)
PATENT	0.084	0.269	0.086	0.075	0.293	0.264
	(0.055)	(0.185)	(0.062)	(0.058)	(0.192)	(0.188)
INTANG	0.177	-0.370	0.152	0.133	-0.340	-0.284
	(0.391)	(0.829)	(0.424)	(0.414)	(0.862)	(0.807)
ϱ			0.195	0.016	-0.231	-0.231
			(0.274)	(0.353)	(0.680)	(0.680)
Observations	3,208	556	3,180	3,180	549	549
Log-likelihood	-1701	-377.3	-1346	-2108	-339.8	-510.3

Notes: Columns (1-2) report estimates from an probit regression, columns (3) and (5) those from an instrumental variables probit and columns (4) and (6) report the results for a simultaneous equations specification in line with equation (D1). Columns (1-3) and (5) use the financial constraints collapsed variable FC^c. Robust standard errors in parenthesis. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively. All regressions include industry dummies.

Table VIII.A7. Spearman's rank correlation matrix: Models A and B

VARIABLES MODEL A	$\Delta CS_{i,t}$	$CF_{i,t}$	$\Delta y_{i,t}$	$S_{i,t}$	$I_{i,t}$	$\Delta NWC_{i,t}$	$ISS_{i,t}$	$\Delta INT_{i,t}$	$FinI_{i,t}$	FC	SUB	$INNOV$	RD
$\Delta CS_{i,t}$	1.0000												
$CF_{i,t}$	0.0620	1.0000											
$\Delta y_{i,t}$	0.1435*	0.1900*	1.0000										
$S_{i,t}$	0.0300	-0.0312	0.0473	1.0000									
$I_{i,t}$	-0.0001	0.1987*	0.2170*	0.0449	1.0000								
$\Delta NWC_{i,t}$	-0.2171*	0.0080	-0.0108	-0.0110	-0.3578*	1.0000							
$ISS_{i,t}$	0.1021*	-0.1067*	0.2313*	0.0027	0.2261*	-0.1203*	1.0000						
$\Delta INT_{i,t}$	-0.0035	-0.0689*	0.0791*	-0.0267	-0.0470	0.0101	0.2056*	1.0000					
$FinI_{i,t}$	0.0023	-0.0828*	-0.0481	0.4019*	-0.0157	-0.0125	-0.0155	-0.0377	1.0000				
FC	-0.0037	-0.0890*	0.0353	-0.0413	0.2043*	-0.0862*	0.0614	-0.0557	0.0151	1.0000			
SUB	-0.0074	0.0571	0.0540	0.1222*	0.1096*	-0.0256	0.0412	-0.0198	0.0457	0.0703*	1.0000		
INNOV	-0.0063	0.0811*	0.0812*	0.2069*	0.1321*	-0.0321	0.0417	-0.0129	0.0939*	0.0359	0.3024*	1.0000	
RD	-0.0025	0.1017*	0.0598	0.2558*	0.1230*	-0.0472	0.0344	-0.0441	0.1345*	0.0758*	0.2675*	0.6426*	1.0000

MODEL B	RD_I	FC	SIZE	AGE	*EXP*	Y_IN	ΔY	RD_WK	SUB	COOP
RD_I	1.0000									
FC	-0.0764	1.0000								
SIZE	0.4384*	-0.1282*	1.0000							
AGE	0.0260	0.0230	0.1493*	1.0000						
EXP	0.1465*	-0.0254	0.2506*	0.0872	1.0000					
Y_IN	0.1492*	0.0550	0.0716	0.0213	0.1774*	1.0000				
ΔY	-0.0240	-0.0590	0.0528	0.1248*	0.0580	-0.0512	1.0000			
RD_WORK	0.1377*	-0.0211	0.1360*	0.0840	0.2034*	0.1733*	0.0133	1.0000		
SUB	0.2116*	0.0399	0.1371*	0.0446	0.1082	0.1261*	-0.0049	0.1640*	1.0000	
COOP	0.1800*	0.0119	0.1906*	0.0204	0.0290	0.1191*	0.0054	0.1582*	0.2491*	1.0000

Notes: Rank correlation coefficients were calculated using Sidak's adjustment. * denotes statistical significance at the .01 level.

Table VIII.A8. Spearman's rank correlation matrix: Models C.and D

VARIABLES MODEL C	INNOV	FC	RD_I	SIZE	AGE	SUB	COOP	B_TRB	B_TEC	B_MK	ΔY	RD_WK	MKTS
INNOV	1.0000												
FC	0.0739	1.0000											
RD_I	0.7713*	0.0711	1.0000										
SIZE	0.1717*	-0.0446	0.2451*	1.0000									
AGE	0.0174	0.0363	0.0225	0.1343*	1.0000								
SUB	0.3551*	0.0723	0.4299*	0.1542*	0.0374	1.0000							
COOP	0.4233*	0.0606	0.4561*	0.1881*	0.0171	0.3746*	1.0000						
B_TRAB	0.1117*	0.5557*	0.0874*	-0.0488	0.0261	0.0677	0.0850*	1.0000					
B_TECH	0.1272*	0.5489*	0.0965*	-0.0364	0.0215	0.0654	0.0776*	0.8064*	1.0000				
B_MARK	0.0572	0.4963*	0.0125	-0.0502	0.0130	0.0280	0.0376	0.6756*	0.6842*	1.0000			
ΔY	0.1994*	0.0131	0.2397*	0.1612*	0.0735	0.2105*	0.2216*	0.0168	0.0410	0.0056	1.0000		
RD_WORK	-0.1054*	-0.0352	-0.0789*	-0.0298	0.0945*	-0.0416	-0.0455	-0.0602	-0.0549	-0.0184	-0.0338	1.0000	
MKTS	0.0449	-0.0214	0.0490	-0.0694	0.0503	0.0474	0.0363	-0.0177	-0.0293	-0.0467	0.0735	-0.0031	1.00

MODEL D	FC	SUB	SIZE	AGE	PUB_K	FOR_K	ΔY	CS	CF	LEV	ISS	ΔNWC	R_FinI	EXP	MKTS
FC	1.0000														
SUB	0.0729	1.0000													
SIZE	-0.0403	0.1534*	1.0000												
AGE	0.0363	0.0386	0.1325*	1.0000											
PUB_K	-0.0285	0.0760	0.1719*	-0.1143*	1.0000										
FOR_K	-0.0898*	0.0104	0.1839*	0.0177	0.0195	1.0000									
ΔY	-0.0336	-0.0412	-0.0290	0.0965*	-0.0032	-0.0316	1.0000								
CS	-0.0622	-0.0545	-0.1410*	-0.0053	-0.0881*	0.0221	0.0069	1.0000							
CF	-0.0785*	0.0931*	0.0073	-0.0673	-0.0756	0.0721	-0.0532	0.2049*	1.0000						
LEV	0.0947*	-0.0969*	-0.0907*	-0.2132*	-0.0273	-0.0770	-0.0505	-0.1682*	-0.4140*	1.0000					
ISS	-0.0924*	-0.0479	0.0232	0.0497	0.0155	0.0556	0.2448*	-0.0334	-0.0156	0.0148	1.0000				
ΔNWC	0.1025*	0.0747	0.0337	0.0265	-0.0099	-0.0063	0.0710	-0.0636	0.0336	0.0212	0.1684*	1.0000			
R_FIN	-0.0532	0.0445	0.2101*	0.2374*	0.0662	-0.0183	0.0118	-0.0632	-0.0373	-0.1040*	0.0419	0.0186	1.0000		
EXP	-0.0140	0.1131*	0.2612*	0.0709	-0.0807*	0.2051*	0.0368	-0.0241	0.0855*	-0.1392*	0.0307	0.0366	-0.0349	1.0000	
MKTS	-0.0227	0.0477	-0.0733	0.0480	0.0199	0.0633	-0.0034	0.0286	0.0940*	-0.1318*	-0.0181	-0.0131	-0.0288	0.1384*	1.0000

Notes: Rank correlation coefficients were calculated using Sidak's adjustment. * denotes statistical significance at the 0.01 level.

CONCLUSION

The research work that lead to the elaboration of the present thesis, has provided a number of new insights regarding the ability of firms to finance their investment and growth. The implications of the findings described in the previous Chapters can be grouped into three main areas—empirical findings, policy implications and research implications. While our investigation contributes to a better knowledge of the financial problems affecting firms, we provide further guidance for policymaking actions. Additionally, this work depicts a series of complications related with the study of firms' financial constraints and unveils a number of research questions that require further investigation in the near future.

From the discussion throughout the thesis we can extract a number of relevant findings, which we now highlight. First, from the discussion in Chapter II, it is very difficult to identify if, and to what extent, are firms financially constrained. The findings described in Chapter V support this view. As an example, the direct use of the SA index of Hadlock and Pierce (2010) is shown to provide a flawed measure of financial constraints.

Second, both indirect (Chapters V-VII) and subjective self-assessed (Chapter VIII) measures of constraints provide compelling evidence that Portuguese firms are, in general, financially constrained.

Third, while in Chapter V we point that smaller firms are in general more financially constrained, Chapter VI unveils that the relationships between constraints and both size and age is non-monotonic and not robust to economic sector disaggregation.

Fourth, also from the findings of Chapter VI, we can conclude that service firms are more financially constrained than manufacturing ones, even though differences are larger within than between sectors—due to a considerable heterogeneity between industries.

Fifth, the results in Chapter VII indicate that the European financial and monetary integration process that came along with the introduction of the common currency, eased firms' financial constraints. This effect was most noticed in highly open firms. Accordingly, such findings had to the argument that integration, by means of access to foreign financial markets and lower domestic loan prices (for the Portuguese case), effectively alleviates financial constraints.

Sixth, also from Chapter VII, we argue that exporting firms face lower financial constraints, while we cast some doubts on the argument that only unconstrained firms self-select into exporting. The latter conclusion is driven by the finding that firms also exhibit a significant level of constraints before they start to export, which is then reduced after they engage in exporting activity.

Seventh, the use of both indirect and direct measures of constraints in Chapter VIII shows that financial constraints have a perverse effect upon the innovation process. Specifically, we point that firms that invest in R&D and those that innovate are not as affected by constraints. Additionally, we provide compelling evidence that financial constraints significantly reduce the amounts invested in R&D, as well as they severely reduce the probability that a firm innovates.

Eighthly, even though innovation subsidies are generally regarded as having an additionality effect upon R&D investment and a positive impact upon innovation, in Chapter VIII we raise some doubts on their role in alleviating firms' financial constraints. In particular, we question the extent to which these subsidies are allocated to those firms in need (constrained) and whether they effectively mitigate financial constraints.

These conclusions are particularly true with respect to the Portuguese economy, even though most of them may be extended to, at least, other European Economies (see Cabral, 2007).

The findings of this work have serious policy implications that are worthwhile mentioning. First, the existence of financial constraints indicates that suitable policies should be designed in order to tackle this problem. Additionally, even though it is generally agreed that smaller and\or younger firms face higher constraints, policymaking should accommodate the fact that the relationship between size, age and financial constraints is non-monotonic and not robust to sector disaggregation. Notwithstanding, such policies should be particularly aimed at those firms that: a) operate in industries where the level of constraints is higher and have a preponderate role in the economy (e.g. the education industry); b) have a key task in the processes of Economic Growth and Economic Evolution, such as firms that desire to export and\or those willing to innovate. Furthermore, the use of subsidies as a remedy for financial constraints is questionable. Therefore, policymakers should make an effort to either improve the allocation of subsidies to financially constrained firms and\or design alternative instruments that can effectively alleviate constraints.

In addition to the policy implications aforementioned, this work also unveils a number of research questions that certainly deserve our attention in the near future. We summarize them as follows.

With respect to theoretical modelling and given the discussion in Chapter I, there is still room to improve the functional form of the borrowing constraints function, specifically incorporating the findings of an increasingly large empirical literature—Chapter III. As an example, the analysis of firm dynamics within a Schumpeterian framework that stresses the role of financial constraints is certainly justified.

To what concerns empirical research, as it was shown in Chapter II, a “perfect” measure of constraints is yet to be found. Accordingly, it is of outmost importance that future research focuses on developing a consistent—or at least more reliable—measure of financial constraints.

The recent financial crisis has stimulated research on the effects of financial crisis and firm constraints—Chapter III. Even though we have analysed the role of the monetary expansion brought by the introduction of the common currency (Chapter VII), with respect to the Portuguese Economy there is a lack of research aimed at explaining the effects of crisis upon firms’ financial constraints. It is therefore desirable that one analyses the extent to which financial crisis lead to: a) a “flight to quality”, prevailing the better firms; b) or if instead they disproportionally affect firms with better future prospects via financial constraints. Once available, data on the recent financial crisis will certainly help in clarifying this point.

Even though associated with innovation (Chapter VIII), the entrepreneur is a key driver of Economic Evolution (Schumpeter, 1939). Albeit the existence of a large body of literature on the subject (Chapter III), it often disregards (because of selection bias) potential entrepreneurs that face a financial barrier to entry. Therefore, it is possible that the importance of this barrier is underestimated. Accordingly, efforts to unveil the magnitude of such barrier are certainly warranted.

On the other side of the coin, the factors driving firm survival have also been extensively analysed. However, even though one expects that financial constraints increase the risk of exiting the market (see Chapter III), the extent to which they have a distinct effect upon different types of exit (e.g. mergers, company buyouts or bankruptcy) is still an open question.

Furthermore, our data reveals that, contrary to the empirical literature (Chapter III), the relationship between age and financial constraints is not as clear—specifically it is found to be non-monotonic (Chapter VI). Therefore, a closer look at this relationship is desirable.

Finally, the role of public financial support to alleviate financial constraints (namely subsidies) still requires further investigation. Specifically, the extent to which subsidies are allocated correctly on one hand, and whether they effectively reduce such constraints on the other, is still very unclear. In addition to a welfare analysis of the impact of these public incentives, alternative remedies to financial constraints should also be explored and put forward.

On the whole, although there is still much to be said with respect to financial constraints, this thesis shows that they are an important factor that shapes firms' behaviour. Therefore, the existence of financial constraints may be grounds for policy intervention. Nevertheless, the corresponding action should take into account that the severity of such constraints depends on a number of distinct firm characteristics, as well as it should be undertaken using adequate policy instruments.

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