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WHERE ARE THE FRAGILITIES? THE RELATIONSHIP BETWEEN FIRMS' FINANCIAL CONSTRAINTS, SIZE, AND AGE

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Abstract

Recessions and financial crisis increase financial constraints and disproportionally affect constrained firms. This paper investigates the differences in firms' financial constraints between sectors using a cash to cash-flow rationale (Almeida et al., 2004) and a firm specific index of constraints (Hovakimien and Hovakimien, 2009). Interpreting higher sensitivities of cash to cash flow as evidence of higher constraints, we find that the relationships between firm size, firm age and constraints are, in general, non-monotonic and not robust to economic sector disaggregation, which contrasts with previous findings.

Keywords: *Financial constraints; Financial crises; Firm size; Firm age; Firm-level studies; Portugal.*

JEL Classification*: D92; G32; L00; L2.*

1. INTRODUCTION

The recent financial and European sovereign debt crisis has put additional pressure on national governments when it comes to addressing the financing problems of firms. As it is pointed in the last OECD Economic Survey of Portugal, the Government should "pay special attention to the financing conditions of small and medium-sized enterprises" (OECD, 2012, p. 9).

Accordingly, it is necessary to understand which firms are more exposed to tightening credit conditions—where are the main fragilities? The goal of this paper is to test if previously devised relationships between financial constraints and firm size and age may work as a simple proxy of financial constraints.

We argue that even though, on average, smaller and younger firms are more prone to financial constraints, there exist a number of economic sector specificities and non-linear relationships—between firm size, firm age and financial constraints—that must not be disregarded.

The paper is organized as follows. Section 2 makes a brief incursion on the relationship between firm size and age and financial constraints, while reviewing the existent literature on firms' financial constraints during crisis periods. In Section 3 we describe the dataset, while Section 4 shows the main results and discusses on the difference across sectors. Finally, Section 6 concludes.

2. SIZE, AGE AND FINANCIAL CONSTRAINTS

Evidence from financial crisis periods

Financial crises have in general a negative impact upon firms ability to raise funds, remarkably due to banking system difficulties and excessive risk aversion in capital markets. Nonetheless, one could argue that, if there is an asymmetric shock in a particular country or region, currency devaluation will lead to increased exports and, arguably, increased available cash-flow (depending on each firm's propensity to export). However, such benefit from an improvement in terms of trade might be not be reaped by national firms, that do not have the ability to raise funds to increase their capacity, whereas foreign-owned firms, with access to international financial markets would be able to do so (see for e.g. Blalock et al., 2008 for the case of Indonesia during the 1998 East Asian crisis).

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 USA, 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 growth policies were severely affected, when compared to unconstrained firms. This confirms Arslan et al., (2008) findings that, during a crisis period in Turkey (2000-2001), firms tended to rely mostly on cash holdings for financing investment. As another example, Ang and Smedema (2011) use an USA 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). Overall, one can expect a considerable deterioration of external financing conditions for domestic firms.

Measuring financial constraints

For the purpose of this paper, we define financial constraints as the inability of a firm to raise the necessary amounts to finance their investment and growth. However, due to this abstract nature of the concept, there is no clear methodology to determine when firms are financially constrained (see Carreira and Silva, 2010, for a discussion).[1] We

[1] Since the seminal work of Fazzari et al. (1988), who introduced the most employed methodology, the investment to cash-flow sensitivity approach, the empirical literature has strived to find consistent methodologies to measure firms' financial constraints. Examples of these measures can be found in Almeida et al. (2004), who suggest the use of cash to cash-flow sensitivities, the Euler equation approach proposed by Whited (1992), different composite indexes such as those advanced by Lamont et al. (2001), Whited and Wu (2006) or Musso and Schiavo (2008) and, recently, firm-level cash-flow sensitivities (Silva and Carreira, 2010) in line with Hovakimien and Hovakimien (2009)—not to mention the use of proxies and, when available, credit ratings.

will make use of two different approaches in order to obtain robust results: first, we estimate the cash-cash flow sensitivity model (hereafter CCFS);[2] then, we employ the approach suggested by Hovakimien and Hovakimien (2009) (hereafter HH index).

Cash-Cash Flow Sensitivity model

Within a framework of liquidity demand, Almeida et al. (2004) argue that only constrained firms manage liquidity to maximize their value and, as a consequence, the level of financial constraints can be measured by CCFS. The rationale 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 along the time, in order to maximize their profits and hedge 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.

We will implement the following Almeida et al. (2004) baseline empirical model slightly modified:

$$\begin{aligned}\Delta CS_{it} = {} & \beta_1 CF_{it} + \beta_2 \Delta y_{it} + \beta_3 S_{it} + \beta_4 I_{it} + \beta_5 \Delta NWC_{it} + \beta_6 ISS_{it} + \beta_7 \Delta INT_{it} \\ & + \beta_8 FinI_{it} + \sum \beta_j D_{industry} + \sum \beta_y D_{year} + \varepsilon_{it}\end{aligned}, \qquad (1)$$

where ΔCS_{it} is the variation in cash stocks for firm i in year t, CF_{it} is cash-flow, S_{it} is a control for firm size (log of total assets), I_{it} is investment, $D_{industry}$ and D_{year} are industry and year dummies, respectively, and ε_{it} the error term. One might find firms whose propensity to save cash out of cash flow is low, even if they are financially constrained (Acharya et al, 2007), therefore, we need control for investment opportunities. We use sales growth (Δy_{it}) as a proxy for investment opportunities. Furthermore, as pointed by Almeida et al. (2011), investment in relatively liquid assets other than cash may be used

[2] This methodology was also used, for example, by Khurana et al. (2005), Han and Qiu (2006), Lin (2007), Pál and Ferrando (2010) and Silva and Carreira (2011, 2012).

to transfer resources across time, so we try to control for this effect through variation of investment in non-cash net working capital (ΔNWC_{it}) and financial investments ($FinI_{it}$). According to Lin (2007), we also include the sum of net debt and equity issuances (ISS_{it}) and changes in interest paid (ΔINT_{it}) as a control variable. The former 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). With respect to the latter, firms may decide to reduce their borrowings or pay back debt according to expected interest expenses. (All variables except size are scaled by total assets.)

Hovakimien-Hovakimien index

In order to provide robust findings, we additionally compute the HH index. It is a time averaged, firm-specific measure that, in the spirit of investment to cash-flow sensitivity approach (Fazzari et al., 1988), compares the time average of investment weighted by cash-flow, against the simple average investment. We adapt this index to the CCFS framework by substituting investment by variation of cash stocks (ΔCS). Accordingly, variation of cash stocks receives a higher weight in years when cash-flow is higher, capturing the sensitivity of variation of cash stocks with respect to variations of cash-flow. Therefore, if a firm has larger (smaller) ΔCS in years with higher cash flow, the HH index will yield positive (negative) values. The index is constructed as follows:

$$HH_i = \sum_{t=1}^{n}\left[\frac{(CF/K)_{it}}{\sum_{t=1}^{n}(CF/K)_{it}} * \left(\frac{\Delta CS}{K}\right)_{it}\right] - \frac{1}{n}\sum_{t=1}^{n}\left(\frac{\Delta CS}{K}\right)_{it}, \qquad (2)$$

where K is total assets of firm i in year t and n the number of annual observations for firm i. As in Hovakimien and Hovakimien (2009), in order to avoid extreme negative values, all cash-flow observations with negative values are set to zero. We also remove firms for which ΔCS level is only observed once.

Even though HH index captures firm-level heterogeneity of financial constraints, these are assumed to be constant over time, that is, it does not account for the possibility that the same firm faces different states of constraints over time (see Hubbard, 1998; Cleary, 1999). Additionally, this methodology fails to control for investment opportunities and other variables affecting investment, as well as it does not explore marginal effects (see D'Espallier et al., 2009 for a critique). Finally, it assumes that CCFS correctly identifies firms' financial constraints.

Size and age as proxies of financial constraints

Size and age seem to work as good proxies for financial constraints and, as a consequence, they can be able to provide consistent insights on the degree of firms' financial distress. In fact, there is extensive literature supporting the linear inverse relationships between financial constraints and either size or age (Carreira and Silva, 2010). While on the one hand, smaller firms do not have the "weight" and visibility that larger firms have, on the other, for younger firms there is still not much information available to potential lenders. These entail significant information asymmetries that hinder the ability of investors to screen the real risk and quality of investment projects of these firms. Accordingly, financial constraints are expected to be severer for smaller and younger firms.

However, the role of firm size and age in financial constraints can be non-monotonic. Thus, we test cash-flow interactions with size class and age class dummies, as well as with size and age as continuous variables and its quadratic terms:

$$\begin{aligned}\Delta CS_{it} = {} & \beta_1 CF_{it} + \alpha_1 X + \alpha_2 CF_{it} * X + \beta_2 \Delta y_{it} + \beta_3 S_{it} + \beta_4 I_{it} + \beta_5 \Delta NWC_{it} \\ & + \beta_6 ISS_{it} + \beta_7 \Delta INT_{it} + \beta_8 FinI_{it} + \sum \beta_j D_{industry} + \sum \beta_y D_{year} + \varepsilon_{it},\end{aligned} \tag{3}$$

where X corresponds to the different variables interacted. 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. In the case of size class dummies, we create four firm size classes—the partitions were set at 50, 100 and 250 employees[3]—and in the age case, we create three age classes corresponding to those firms younger than 10, between 10 and 40, and over 40 years old.[4] 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.

Recently, Hadlock and Pierce (2010) proposed a simple new approach to measure firms' financial constraints called Size-Age (or SA) index. In line with this index, we also test if there is a non-linear relationship between size, age and financial constraints through an OLS regression upon:

$$HH_i = \theta_1 \overline{SIZE}_i + \theta_2 \overline{SIZE}_i^2 + \alpha_1 \overline{AGE}_i + \alpha_2 \overline{AGE}_i^2 + \sum \beta_j D_{industry} + \varepsilon_i \, , \qquad (4)$$

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.

[3] These thresholds result from an adjustment of the European Commission firm size classification—that sets upper thresholds at 10, 50 and 250 employees for micro, small and medium enterprises, respectively—to the specificity of our dataset. First, since the information reported by firms with less than 20 employees is not reliable, we consider that, for the purpose of this paper, 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 it covers the universe of firms with more than 100 employees.

[4] 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 (2010) 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.

3. DATA

The dataset used in this work was constructed from the combination of *Inquérito às Empresas Harmonizado* (IEH), an annual business survey, and *Ficheiro de Unidades Estatísticas* (FUE), both collected by the Portuguese National Statistical Office (INE). The former dataset comprises information on firms' balance sheets, while resorting to the latter, that contains information about firm's generic characteristics—including size, age and main sector of activity—, allows to track firms trough time, thus constructing a large unbalanced panel of firms. The dataset comprises the universe of firms operating in Portugal with more than 100 employees and a random, representative, sample of firms with less than 100 employees. The sample is representative of the Portuguese sector disaggregation (at 3-digit level), both in terms of employment size and sales.

For the purpose of this paper the following cleaning procedures were made. First, we eliminated firms with less than 20 employees due to the lack of quality of information reported. Second, we focus only on the manufacturing and the services sectors (excluding the financial sector). Due to a reduced number of observations, we were also forced to exclude the following industries: manufacture of coke, refined petroleum products and nuclear fuel industry; extraction of fossil fuels, uranium and thorium; and electricity, gas and water supply. Observations that were reported either missing or with unreasonable values were dropped—in some cases, whose correct value were possible to obtain from other variables or resulting from change in signal mistyping error, unreasonable values suffered a treatment. As a result we have a large unbalanced panel of 22,651 firms for the period 1996-2004 resulting in 86,455 observations.

Further details on the construction and description of the variables used are available in Silva and Carreira (2010). Table 1 reports the summary statistics of the main variables for the overall sample, as well as for manufacturing and service sectors (correlation matrix available from the authors on request). 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).

Table 1. Summary statistics

VARIABLES	Overall	Manufacturing	Services
ΔCS_{it}	0.0021 (0.062)	0.0002 (0.057)	0.0043 (0.068)
CF_{it}	0.0842 (0.089)	0.0856 (0.089)	0.0825 (0.090)
Δy_{it}	0.0365 (0.288)	0.0185 (0.245)	0.0572 (0.329)
S_{it}	15.5066 (1.402)	15.5314 (1.325)	15.4779 (1.486)
I_{it}	0.0622 (0.081)	0.0645 (0.079)	0.0596 (0.084)
ΔNWC_{it}	-0.0472 (0.167)	-0.0536 (0.161)	-0.0397 (0.173)
ISS_{it}	0.0306 (0.157)	0.0295 (0.150)	0.0320 (0.164)
ΔINT_{it}	-0.0006 (0.007)	-0.0007 (0.007)	-0.0005 (0.007)
$FinI_{it}$	0.0392 (0.090)	0.0366 (0.082)	0.0423 (0.097)
$SIZE_{it}$	170.1442 (490.211)	157.0521 (265.542)	185.2585 (660.256)
AGE_{it}	26.8550 (17.739)	28.0386 (17.880)	25.4886 (17.476)
Observations	15,441	8,274	7,167
No. of firms	4,255	2,247	2,006

Notes: Mean values and standard deviations in parentheses of the variables used in regression analyses.

4. EMPIRICAL RESULTS

Firms' financial constraints

In order to assess the financial constraints faced by Portuguese firms we estimate equation (1) using instrumental variables (GMM) along with fixed effects to take account of unobserved firm-level heterogeneity and panel-robust standard errors, since the financial and investment covariates are endogenous. 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 are easy to obtain and do not entail significant measurement problems.

As expected, the regression of equation (1) reports positive and significant sensitivities of cash to cash-flow—all cash flow coefficients reported are significantly different from zero at the 1% level for the overall sample (Table 2). For the overall sample (column 1), the estimated CCFS is 0.160, meaning that Portuguese firms save, on average, 16 cents out of each euro of cash flow, which is symptomatic of the presence of severe financial constraints.

The comparison between 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, 10.8 cents out of each euro of extra cash flow, service firms save 22.8 cents out of each euro of extra cash flow (both significant at the 1% level and statistically different at the 1% level). 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. (The results are robust to the use of different proxies for investment opportunities—available from the authors on request.)

Table 2. Cash-Cash Flow Sensitivity estimation

VARIABLES	Overall (1)	Manufacturing (2)	Services (3)
CF_{it}	0.160*** (0.018)	0.108*** (0.020)	0.228*** (0.032)
	[0.124;0.195]	[0.068;0.148]	[0.166;0.291]
Δy_{it}	0.015*** (0.003)	0.018*** (0.004)	0.011** (0.005)
	[0.008;0.021]	[0.009;0.026]	[0.002;0.020]
S_{it}	0.016*** (0.004)	0.019*** (0.005)	0.016** (0.007)
	[0.008;0.025]	[0.009;0.030]	[0.003;0.029]
I_{it}	-0.202*** (0.012)	-0.142*** (0.014)	-0.270*** (0.020)
	[-0.225;-0.178]	[-0.170;-0.115]	[-0.309;-0.230]
ΔNWC_{it}	-0.124*** (0.006)	-0.109*** (0.008)	-0.139*** (0.009)
	[-0.135;-0.112]	[-0.124;-0.094]	[-0.157;-0.121]
ISS_{it}	0.078*** (0.006)	0.063*** (0.008)	0.095*** (0.010)
	[0.066;0.091]	[0.048;0.078]	[0.075;0.114]
ΔINT_{it}	-0.126 (0.104)	-0.057 (0.130)	-0.215 (0.166)
	[-0.329;0.077]	[-0.311;0.197]	[-0.540;0.110]
$FinI_{it}$	-0.126*** (0.018)	-0.091*** (0.024)	-0.161*** (0.027)
	[-0.162;-0.090]	[-0.139;-0.044]	[-0.215;-0.107]
Year dummies	included	included	included
Industry dummies	included	included	included
Observations	13,874	7,590	6,256
No. of firms	4,322	2,277	2,043
Hansen p-val.	0.560	0.455	0.830
R-squared	0.159	0.132	0.195

Notes: Regression of equation (1). Robust standard errors are in parentheses; 95% confidence intervals are 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 (available from the authors on request). Industry dummies were partialed-out in estimation because of variance-covariance matrix rank. Further test statistics available from the authors on request.

Differences across firms' size and age

Table 3. CCFS with size classes interactions

VARIABLES	Overall (1)	Manufacturing (2)	Services (3)
$CF_{it} * \overline{SIZE}_i$			
[20;50[	0.230*** (0.030)	0.164*** (0.038)	0.297*** (0.045)
[50;100[	0.163*** (0.028)	0.147*** (0.032)	0.185*** (0.046)
[100;250[	0.114*** (0.023)	0.084*** (0.026)	0.149*** (0.050)
[250;+∞[	0.132*** (0.030)	0.047 (0.037)	0.241*** (0.050)
Δy_{it}	0.015*** (0.003)	0.020*** (0.004)	0.011** (0.004)
I_{it}	-0.201*** (0.012)	-0.141*** (0.014)	-0.271*** (0.020)
ΔNWC_{it}	-0.123*** (0.006)	-0.106*** (0.008)	-0.141*** (0.009)
ISS_{it}	0.086*** (0.006)	0.071*** (0.008)	0.103*** (0.010)
ΔINT_{it}	-0.091 (0.103)	-0.011 (0.130)	-0.180 (0.165)
$FinI_{it}$	-0.118*** (0.018)	-0.083*** (0.024)	-0.148*** (0.027)
Year dummies	included	included	included
Industry dummies	included	included	included
Observations	13,874	7,590	6,256
No. of firms	4,322	2,277	2,043
Hansen chi2 p-val.	0.473	0.533	0.277
R-squared	0.158	0.129	0.196

Notes: Regression of equation (2), where *X* corresponds to size classes dummies. Robust standard errors are in parentheses. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively. Industry dummies were partialed-out. Further test statistics available from the authors on request.

Tables 3 and 4 reports the estimation results for equation (3), where *X* corresponds to size and age classes dummies, respectively. 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 4), this is not the case for of size-cash flow interactions (Table 3). 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

(Table 3, column 3). This suggests that, for the case of services, a non-monotonic (U-shaped) relationship between firm size and financial constraints might be present.

Table 4. CCFS with age classes interactions

VARIABLES	Overall (1)	Manufacturing (2)	Services (3)
$CF_{it} * \overline{AGE}_i$			
[0;10[	0.179*** (0.038)	0.132*** (0.045)	0.247*** (0.061)
[10;40[	0.169*** (0.019)	0.114*** (0.022)	0.238*** (0.034)
[40;+∞[	0.125*** (0.034)	0.089** (0.037)	0.168** (0.068)
Δy_{it}	0.015*** (0.003)	0.020*** (0.004)	0.011** (0.004)
I_{it}	-0.201*** (0.012)	-0.140*** (0.014)	-0.271*** (0.020)
ΔNWC_{it}	-0.122*** (0.006)	-0.106*** (0.008)	-0.140*** (0.009)
ISS_{it}	0.086*** (0.006)	0.071*** (0.007)	0.102*** (0.010)
ΔINT_{it}	-0.097 (0.104)	-0.015 (0.130)	-0.195 (0.166)
$FinI_{it}$	-0.116***(0.018)	-0.079*** (0.024)	-0.148*** (0.027)
Year dummies	included	included	included
Industry dummies	included	included	included
Observations	13,874	7,590	6,256
No. of firms	4,322	2,277	2,043
Hansen chi2 p-val.	0.364	0.499	0.308
R-squared	0.156	0.127	0.193

Notes: Regression of equation (2), where *X* corresponds to age classes dummies. Robust standard errors are in parentheses. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively. Industry dummies were partialed-out. Further test statistics available from the authors on request.

Also using equation (3), we further investigate these relationships by testing the inclusion of size and age interactions as continuous variables and its quadratic terms (Table 5). We find that, for the case of size and both the overall sample and manufacturing firms (columns 1 and 2, lines 3 and 4), 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 5. CCFS with size and age interactions

VARIABLES	Overall (1)	Manufacturing (2)	Services (3)
CF_{it}	0.157*** (0.047)	0.104* (0.057)	0.217*** (0.076)
$SIZE_{it}$	-0.000** (0.000)	-0.000 (0.000)	-0.000* (0.000)
$CF_{it}*SIZE_{it}$	-0.000* (0.000)	-0.000** (0.000)	-0.000 (0.000)
$CF_{it}*SIZE_{it}^2$	0.000*** (0.000)	0.000** (0.000)	0.000 (0.000)
AGE_{it}	0.000 (0.002)	0.001 (0.002)	-0.001 (0.002)
$CF_{it}*AGE_{it}$	0.003 (0.002)	0.004 (0.003)	0.002 (0.004)
$CF_{it}*AGE_{it}^2$	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
Δy_{it}	0.015*** (0.003)	0.020*** (0.004)	0.011** (0.005)
I_{it}	-0.196*** (0.012)	-0.139*** (0.014)	-0.262*** (0.020)
ΔNWC_{it}	-0.122*** (0.006)	-0.106*** (0.008)	-0.138*** (0.009)
ISS_{it}	0.084*** (0.006)	0.070*** (0.007)	0.100*** (0.010)
ΔINT_{it}	-0.061 (0.105)	0.029 (0.132)	-0.173 (0.169)
$FinI_{it}$	-0.116*** (0.018)	-0.081*** (0.024)	-0.150*** (0.028)
Year dummies	included	included	included
Industry dummies	included	included	included
Observations	13,724	7,527	6,169
No. of firms	4,255	2,247	2,006
Hansen chi2 p-val.	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. Robust standard errors are in parentheses. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively. Industry dummies were partialed-out. Further test statistics are available from the authors on request.

Alternatively, we look at the relationship between the HH index and either size or age. The results from a simple OLS regression of equation (4) report an U-shaped relationship between size and constraints for the overall and manufacturing samples

(Table 6, columns 1 and 2, respectively).[5] Oddly, neither of the coefficients is statistically significant for service firms and one can not exclude a direct relationship between age and constraints for manufacturing firms.

Table 6. Relationship of size and age with the HH index

VARIABLES	All firms			Firms' financially constrained		
	Overall (1)	Manuf. (2)	Services (3)	Overall (4)	Manuf. (5)	Services (6)
$\overline{SIZE}_i$	-0.473**	-0.592**	-0.415	-1.777***	-2.368***	-1.424***
	(0.196)	(0.286)	(0.276)	(0.299)	(0.437)	(0.409)
$\overline{SIZE}_i^2$	0.040**	0.052*	0.034	0.141***	0.202***	0.105***
	(0.018)	(0.028)	(0.025)	(0.028)	(0.043)	(0.038)
$\overline{AGE}_i$	-0.217	-0.052	-0.293	-1.091***	-0.563	-1.346**
	(0.270)	(0.272)	(0.449)	(0.371)	(0.358)	(0.606)
$\overline{AGE}_i^2$	0.050	0.035	0.052	0.176***	0.112*	0.198**
	(0.044)	(0.047)	(0.073)	(0.061)	(0.062)	(0.099)
Industry dum.	included	included	included	included	included	Included
Observations	8,841	4,298	4,543	4,745	2,264	2,481
R-squared	0.0093	0.0061	0.0111	0.0568	0.0527	0.0551

Notes: Regression of equation (4). Rescaled HH index to the interval [0;100]. A firm is constrained if the non-scaled hh index>0 (i.e. the value 49.79 in the rescaled index). Robust standard errors are in parentheses. ***, **, and * denote statistical significance at the .01, .05, and .10 levels, respectively. Further test statistics available from the authors on request.

However, if we restrict our sample to positive HH values (only those firms that are financially constrained), we find an U-shaped relationship between constraints and firm size for all subsamples (columns 4-6) and an U-shaped relationship between age and constraints both for the overall and services subsamples.

[5] 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, in the regression exercise, the HH index is rescaled to the interval [0; 100]—HH_rescaled=100/[max(HH)-min(HH)]*[HH-min(HH)]. A firm is constrained if the non-scaled hh index>0, which is equivalent to the value 49.79 in the rescaled index.

Overall, size and age interplay with financial constraints in a rather non-trivial way.

5. CONCLUSION

In this paper, we investigate if the relationship between firms' financial constraints and firm size and age may work as a proxy of financial constraints, by estimating cash-cash flow sensitivities upon a large unbalanced panel of Portuguese firms. As robustness tests, we additionally make use of the HH index.

On the whole, our results clearly show that financial constraints is a serious problem affecting the dynamics of Portuguese firms. Moreover, the distinct results obtained between manufacturing and services with respect to firm size and age 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 paper shows that such findings are not robust to sector disaggregation. Still, 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 clearer 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. Our findings put into perspective widely accepted results on financial constraints and firm size and age. Depending on the sector being analysed, size or age may work as better proxies of financial constraints.

Finally, the design of policy actions should definitely take into consideration the sector specificities and nonlinearities uncovered here.

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