Firms' external and internal financial constraints, productivity and size. Evidence from Italy.

Abstract

To what extent financial constraints act as conditioning factors on firm productivity? Is this impact different across firm size classes? We explore these issues for Italy with a merge among three firm level dataset (2002-2009). We use bank indebtedness, as a proxy for external financial constraints and three variables for internal constraints (profit margin, liquidity, coverage). In the first step of our analysis, we use two semiparametric methodologies to estimate productivity (TFP): Levinshon and Petrin (LP) and Olley and Pakes (OP). In the second step, we test the impact of financial constraints on TFP controlling for firm and industry variables. Two different econometric approaches are adopted: a fixed effect model and a GMM system in order to address endogeneity and to correct for potential selection, simultaneity and omitted variable bias. Sensitivity checks for three different size classes are performed. The estimations using the GMM give results that are consistent with the expectations. We find that: (i) differences in productivity between firms strongly depend on internal and external financial constraints: a higher profit margin and coverage increase productivity while a strong negative impact is played by indebtedness with banks; (ii) external financial constraints proxied by indebtedness have an important weakening impact on productivity independently on firm size; (iii) the sensitivity to internal financial constraints is higher in small firms, in line with the evidence in literature that smaller firms get higher returns from internal financial solidity due to their being more financially constrained.

JEL classification: O12, O53, O52, D24, G32.

Keywords: Productivity, Cash Flow, Liquidity, Leverage, Financial constraints, SMEs.

1. Introduction

There are several arguments showing that finance fosters growth and firm-level productivity. Financially constrained firms have to give up on profitable investment opportunities which may reduce their productivity. Furthermore, those firms see their innovation and research & development (R&D) investment highly reduced because R&D projects, due to their intangible nature and high risk, are not easily funded by the banks.

There are examples of recent research in the literature which analyse the links between financial factors and firm growth exploiting micro-level data.[1] These studies find significant effects of financial variables on firms' productivity. We contribute to this body of literature by exploring firm productivity and financial constraints for Italy, with a particular focus on the crucial issue of the impact of financial constraints on small- and medium-sized enterprises (SMEs).

We develop a structural approach where we estimate a production function equation that directly includes our measure of financial constraints as a regressor while allowing productivity to evolve as a first-order autoregressive process.

We explore two main questions. To what extent do financial constraints have an impact on firm productivity as direct conditioning factors? Is there any asymmetry among firms of different size classes in their sensitivity to the indicators of financial constraints?

The present paper contributes to the body of literature in four different directions. Our main contribution lies on investigating the role of firm size as this fundamental aspect is not adequately explored in the literature on finance and productivity. Besides, a documented financial pressure is typical of SMEs in Italy. In our theoretical setup, smaller firms should be more sensitive as large ones should have easier access to credit. We also contribute to the most recent literature on a few other fundamental aspects. First, we adopt two different approaches to estimate TFP: Levinshon and Petrin and Olley and Pakes. Furthermore, we test the hypothesis that an increased availability of financial resources can raise firms' productivity by adopting two different approaches: Fixed effect models and GMM system estimations, which consider the role of endogeneity and of unobservable variables. Taking into account the endogeneity of the financial variables is crucial as any firm-level correlation between firm performance and access to finance is subject to omitted-variable bias or reverse causation, since banks are expected to lend to firms with high performance and prospects. Only a few other studies have already addressed these issues (e.g. Nucci et al. 2005; Coricelli et al. 2012; Chen and Guariglia 2013). Besides, while the majority of previous studies has focused on the links between the degree of external financial constraints faced by firms and their productivity (see for instance Butler and Cornaggia 2010), following Guariglia (2008) we have considered in our productivity regressions also proxies for the availability of internal finance.[2]

We investigate the relationship between firm's financial constraints and productivity using four indicators (a proxy for external funding such as bank indebtedness, and three different proxy for internal financial sources: profit margin as proxy for cash flow, liquidity, coverage).

Hence, differences in our analysis are related to the focus on the firm size (large vs. small), to the estimation approach to measure TFP, to the method to detect endogeneity, and to the adoption of both internal and external credit constraints. The study ultimately aims to provide recommendations with respect to capital access enhancement policies for firms of different sizes.

Our key variables of interest are integrated with other firms' and industry characteristics like size, the age of the firm, whether the firm exports, whether it is a foreign or domestic multinational, the

[1] For a survey see Carreira and Silva (2010).

[2] In particular Guariglia (2008) focuses on the availability of cash flow and considers a firm characterised by a limited amount of it as internally financially constrained.

intensity of foreign and domestic competition within an industry, the technological intensity of the industry, other controls for location in macro areas (North, South and Centre) or regions, and sector and time dummies. Besides, robustness checks for three different size classes are performed: a base class size considers a standard distinction between small (<50) and medium and large firms (above or equal to 50), while other classes are built decreasing respectively the threshold of the separation between small and large firms from 50 workers to 20 workers and increasing it at 100. We take into account the role of the enterprises smaller than 19 employees given the high relevance for Italy of firms with less than 9 employees (micro firms) which correspond to 94,8 per cent of firms and 46 per cent of employees (ISTAT 2011). The threshold of 100 employees is adopted to show whether in addition to micro and small firms also medium size firms have a critical productivity-size sensitivity.

We find that: (i) differences in productivity between firms depend on internal and external financial constraints: in particular, a higher profit margin and coverage increase productivity while a negative impact is played by higher external financial constraints measured by indebtedness with banks; (ii) external financial constraints have an important impact on productivity independently on firm size, i.e. there is no significant difference between the coefficient of the indebtedness of small versus large firms once interacting this variable with our three different size dummies; (iii) the sensitivity to our three internal financial constraints is instead different across size classes quite as expected and in line with the evidence in literature. The results suggest that smaller firms get higher returns from internal financial solidity which might be related to their being more financially constrained.

The paper is organised as follows. Section 2 presents a short review of the literature and some important stylised facts emerging from it. Section 3 presents empirical specification, describing the data and the model adopted. Section 4 presents the results. Section 5 provides some conclusions.

1. Literature background

Under perfect financial market conditions, internal and external sources of financial funds are perfectly substitutable as the Modigliani and Miller (1958) theorem states. In this framework, financial resources are not an obstacle to firm growth. If the hypotheses of the zero information and transaction costs do not hold, the financial markets are likely to be an obstacle to firm growth. Credit rationing which derives from this, when interest rates are below the Walrasian market-clearing level, is described in the Stiglitz and Weiss (1981) model, where banks are unable to cope with information asymmetries. The outcome is that financial resources are allocated in a distorted manner in favour of large organisations. As a result, SMEs are more likely to be financially constrained and are more sensitive to their own cash flows not having the opportunity to rely on debt and equity markets. Besides, financial constraints may have an impact on firm productivity through different channels such as the amount of working capital and the choice of technology (Fazzari et al. 1988). The two important implications are that the access to credit and other external funds are a source of heterogeneity across firms.

On an empirical basis, the literature has largely investigated the issue of the size distribution dynamics and exit and growth of firms, illustrating the presence of financial market failures and the difficulty for firms to access finance whatever the returns to capital (Aghion et al. 2007; Angelini and Generale 2005; Becchetti and Trovato 2002; Beck et al. 2008; Beck and Demirgüç-Kunt 2006; Binks and Ennew 1996; Elston et al. 2016; Giannangeli et al. 2008; Jaffee and Russell, T. 1976; Rajesh Raj and Sen 2013; Vinh Vo et al. 2016). New small-sized firms in developing countries are credit and equity rationed in the vast majority of cases because their financial markets are underdeveloped. Hence, poor formal credit (bank loans) are the major obstacles to performance of SMEs (Quatraro and Vivarelli 2015; Ur Rehman 2016). However, there is restricted firm-level research on the links between finance and productivity.

Two different approaches are used in this scant literature.[3] In a first set of studies, the links between finance and productivity are studied by including financial variables in a Cobb-Douglas production function. In this literature a seminal paper is Pushner (1995) which observes a strong negative relationship between leverage and firm productivity in Japan. On the contrary, Schiantarelli and Sembenelli (1997) find that, both for UK and for Italian firms, leverage, measured by long-term debt, enhances productivity.[4] Also Nickell and Nicolitsas (1999), using UK panel data and borrowing ratio[5], find a positive impact on productivity in addition to employment and wage rises. Their explanation is that if the borrowing ratio rises, then also bankruptcy risks rise and this increases firms' efforts to improve productivity.

More recent studies use an indirect methodology to assess the linkages between financial variables and productivity: a measure of firm-level productivity is generated in a first step, and used in a second step as a dependent variable in a regression that contains financial variables and other controls. Seminal papers which use this indirect methodology are Nucci et al. (2005), Nunes et al. (2007), Gatti and Love (2008), Moreno-Badia and Slootmaekers (2009), Chen and Guariglia (2013). They all use firm-level data on single countries finding positive outcomes on productivity from higher financial support.

Other studies take a multicountry perspective. A non-linear relationship between leverage and TFP growth is found in Coricelli et al. (2012): in a panel of Central and Eastern European countries the TFP growth rises with low levels of leverage, but declines if leverage increases past a critical threshold. Levine and Warusawitharana (2014) analyse the link between the use of external financing and productivity (TFP) growth within firms for a set of EU countries and find a strong positive relationship. A recent paper by Ferrando and Ruggieri (2015) adds important insights on the negative relation between firms' access to external finance and labour productivity, by using a large dataset of firm-level data for eight Eurozone countries during the period 1995-2011.

To sum up, the research cases in the literature focus in particular on external financial constraints and indicate that there exists an important linkage between financial variables and firms' productivity. However, the measures of financing constraint may affect firms' productivity in various mixed and often unexpected directions.

3. Empirical set up

3.1. Empirical specification

Like a few recent studies, we follow a two-step strategy. In a first step, following Olley and Pakes (1996) and Levinsohn and Petrin (2003), TFP is estimated as the residual of a Cobb–Douglas production function that, taking logarithms, can be specified as follows:

$$\ln y_{it} = \alpha + \beta_1 \ln l_{it} + \beta_k \ln k_{it} + w_{it} + \eta_{it} \quad i = 1,\dots N, t = 1,\dots\dots T \qquad [1]$$

where y_{it}, l_{it} and k_{it} respectively, are value added, labour input, and capital input of firm i at time t; w_{it} is a state variable indicating that part of productivity known by the firm and η_{it} is a white noise component.[6]

[3] Productivity in this literature is measured in various ways, e.g. labour productivity; TFP measured as a production function residual, using either the Olley and Pakes (1996) or the Levinsohn and Petrin (2003) method.

[4] Leverage is measured by total liabilities over total assets. Liabilities include current liabilities + non-current liabilities, where current liabilities is given by bank loans, accounts payable, and other current liabilities.

[5] The borrowing ratio is defined as interest payments divided by the sum of profits before tax, depreciation, and interest payments.

[6] To save space we do not present the results of these TFP regressions.

In a second step, we estimate an equation where TFP is augmented with variables related to financial sources and explained by a set of firm characteristics, including the lagged productivity, variables related to financial sources (also interacted with different dummies for firm size), industry level variables, fixed effects at region, sector and time level.
We estimate for all the two TFP the following baseline equation:

$$tfp_{it} = \alpha_0 + \alpha_1 tfp_{it-1} + \alpha_2 X_{it} + \alpha_3 F_{it} + \alpha_4 Y_{jt} + u_i + u_j + u_t + \varepsilon_{it} \quad [2]$$

where tfp_{it} indicates the logarithm of firm i's TFP at time t. Considering that according to OP and LP firm productivity follows a first-order Markov process, lagged tfp is also included to control for serial correlation. By taking into account the lagged value of productivity we also control for unobservable characteristics, u_i is a firm-specific effect controlled for by estimating our equation in first-differences, u_j is an industry-specific effect controlled for including two-digit industry dummies and u_t is a time –specific effect, controlled for by including time dummies.
Our key variables of interest indicated in F_{it} are proxies of external and internal financial constraints. Drawing on previous studies we use the *ratio of total debt versus banks to total turnover*, as a proxy for leverage and as a measure of external financial pressure.[7] A number of authors have found links between this pressure, proxied by different indicators such as leverage, indebtedness and measures of debt length and productivity (Nucci et al. 2005; Nunes et al. 2007; Coricelli et al. 2012; Chen and Guariglia 2013). We further use indicators of internal financial constraints. First, we use the *coverage ratio* measured by net income over total interest payments. When firms have additional net income they have higher cash flow and may be able to carry out productivity enhancing activities. Internal finance is also measured by the *profit margin* (*ptpm)*, built as the difference between profit before tax (but after extraordinary income and income tax) over turnover. Furthermore, we also use the *liquidity ratio* measured by current assets minus current liabilities over total assets. All these three variables are indicators of the availability of internal sources of finance. If firms face difficulties in raising external finance they can rely on their own funds. Hence, it is quite important to take into account external and internal finance at the same time. The links between the degree of internal financial constraints and firms productivity is a poorly explored issue in the literature. Only Chen and Guariglia (2013) emphasise the relevance of the link between internal finance and productivity, which is quite crucial in their study on Chinese firms. In our case, the focus on the availability of internal finance is also highly motivated by the importance of cash flow in determining small firms' growth in Italy and by the difficulties faced by SMEs in obtaining external finance. Furthermore, cash flow has been found to play an important role in determining firms' growth and spending on R&D in various studies (Brown et al. 2009; Gorodnichenko and Schnitzer 2013; Brown and Petersen 2009; 2011; Carpenter and Petersen 2002). [8]
Control variables at firm level are a vector X_{it} of firm i's characteristics at time t, which includes firms' size measured by three different dummies for size classes (less than 50 employees; less than 100 employees; less than 20 employees), the logarithm of firms' age, export participation, foreign ownership and investment abroad. Firms' size and age have often been found to be related to firms' productivity (Palangkaraya et al. 2009). Firms' export and multinational status (which we proxy with an export dummy variable and a dummy for having foreign affiliates) is linked to productivity in many studies (among these Aw et al. 2008). Exporters and domestic firms investing abroad are, in general, more productive than non-exporters. This may be due to the "learning by exporting"

[7] Other studies use *credit line* (Gatti and Love 2008; Moreno-Badia and Slootmaekers 2009) and *borrowing ratio* (Nickell and Nicolitsas 1999) as a measure of financial pressure.
[8] Elston et al. (2016) reveal that informal capital is still the primary means of firm start-up and growth for Chinese firms which do not make extensive use of financial markets, banks, and credit cards which are primary sources of capital in market-based financial systems like the USA or Germany.

process. Firms access useful technological innovations, international contacts facilitate the technological diffusion and foster a more efficient organisation of firms. Finally, the link between FDI from abroad and TFP appears robust in most studies, confirming the hypothesis of Coe and Helpman (1995), Helpman et al. (2004) that openness can also foster technological spillovers through FDI.

Control variables at industry level Y_{jt} include indicator of market concentration, import and export intensity, minimum efficient scale, at sector level, and technology classes. The first three variables are able to catch the impact of competition on productivity by distinguishing between three dimensions of competition: degree of domestic competition (Herfhndhal index calculated as the sum of the squared market share of firms for an industry), degree of exposure to competition in foreign market (export intensity measured by the share of exports in total sales at sector level) and degree of competition of imports (import intensity at sector level). The higher the Herfindahl index, the less competitive is the market. Besides, we guess that in non-competitive industries, firms adjust their margins rather than their productivity, so, we expect a negative sign for the variable related to market concentration. Foreign competition may also affect the incentives to innovate, increase technology transfers or raise intra-firm productivity through an increase in the variety of intermediate inputs or capital goods, higher quality and/or better technology. We also expect a positive impact of export intensity which proxy foreign competition in explaining the firms' TFP. As for the minimum efficient scale we presume that higher scale economies are generally related to higher productivity. We also consider tech dummies using the OCSE taxonomy and aggregating it in two classes tech1_1 and tech1_2 (respectively for medium-low and medium-high classes).

The strategy for fixed effects that we adopt is the following one:

- a firm-specific effect, which we control for by estimating our equation in first-differences (u_i)
- industry-specific effects (u_j) which we take into account by including two-digit industry dummies, to control for industry-specific characteristics (*j-1* industry dummies where *j=1,..13)*;[9]
- time-specific effects (u_t), which we control for by including time dummies (*t-1* time dummies where *t=1-8)* capturing business cycle effects.

If better finance does exert an influence on firm productivity, we would expect positive and significant coefficients on the key variables of interest. This effect should be stronger for firms more likely to face financing constraints, i.e. for firms who may find it difficult or expensive to raise external finance. SMEs are likely to be more financially constrained for a number of reasons: they often lack sufficient collateral, they tend to show a more volatile pattern of growth and earnings than larger companies, can raise debt with more difficulty than large firms because they are less diversified and more likely to fail. All these factors raise the cost of external finance for SMEs, thereby they should have a higher sensitivity of investment and hence of productivity to internal funds.[10]

[9] This classification is based on the ATECO91 classification aggregated to 13 sectors. ATECO91 classification represents an improvement (with respect to ATECO81) of the Italian Statistical Institute (ISTAT) in the process of harmonisation with the European and American classifications. The 2-digit Italian classification corresponds to ISIC, while the 4-digit classification to NACE.

[10] The more recent literature interprets in a different way the higher investment/cash flow sensitivity of younger and smaller firm: in absence of financial market imperfection it is considered as a reaction to the fact that realisation of their cash flows reveals to firms the direction to go in presence of uncertainty of their growth prospect (Oliveira and Fortunato, 2006).

3.2. Data

The empirical analysis has been conducted for Italy using a firm level database for the period 2002-2009 resulting from the intersection of three different sources: IXth Survey on Manufacturing Firms, by Capitalia[11], AIDA (Analisi Informatizzata delle Aziende) and Mint-Italy, these two latter by Bureau Van Dyck.[12] In order to have a longer time horizon we build up a panel where the Capitalia dataset units of analysis are located in the present by subsequent observations drawn from AIDA. By matching all firms in the 2001-2003 Capitalia dataset with AIDA information we have obtained a sample of 4066 firms (that is 94,8 per cent of the Capitalia sample) followed over 2002-2009. Variables about internationalization activity of firms are drawn from AIDA and Mint-Italy.[13] Each variable included in the database was deflated through the NACE two digit price indexes provided by ISTAT (Italian Institute of Statistics). For each firm, we know the region it is located in and the sector of the Ateco 2 digit classification. In tab. 1 we list the variables used in the analysis.

Table 1. Definition of variables, data sources and expected relationships with TFP

Category	Variables	Description	Source	Exp. Sign
FIRM LEVEL COVARIATES				
FIRM CHARACTERISTICS	SIZE	Firm size measured by dfferent size classes dummies (0-49; >50; 0-100;>100; 0-19; >19)	AIDA	-
	AGE	Firm age measured by the number of years since establishment.	AIDA	-
	EXPORT	Dummy variable equal to 1 if the firm exports over the period 2002-2009.	MINT-ITALY	+/-
	OWN2	Foreign ownership dummy that takes on the value 1 if the firm is foreign-owned, 0 otherwise.	AIDA	+/-
	OWN3	Domestic multinational ownership dummy that takes on the value 1 if the firm is an Italian owned-MNE, 0 otherwise.	AIDA	+/-
	TECH CLASS	Technology macrosector dummies (TECH CLASS LOW for firms belonging to low and medium-low technology sectors and TECH CLASS HIGH for firms belonging to medium-high and high technology sectors; OECD taxonomy)	OECD	+/-
FINANCIAL INDICATORS	PROFIT MARGIN (PTPM)	Firm profits before tax over turnover (%)	AIDA	-
	LIQUIDITY RATIO	current assets-current liabilities/total assets	AIDA	+/-
	COVERAGE RATIO	coverage index measured by net income/total interest payments	AIDA	+/-
	DEBTS WITH BANKS OVER TURNOVER	Firm short and long term debts with banks over turnover (%).	AIDA	+/-
INDUSTRY VARIABLES	HERF	Herfindahl index of turnover by 2 digit Ateco, proxy for the level of concentration within the sector.	AIDA	+/-
	MES	Minimum efficient scale of the industry measured as the ratio of firms' sales above the average sales for the industry on total industry sales (Comanor and Wilson 1967)	AIDA	+/-

[11] The Capitalia database was a survey in 3-years waves which provided micro evidence about manufacturing companies on a sample of more than 4,000 firms drawn from Italian manufacturing. The samples were stratified and randomly selected (it reflected sector's geographical and dimensional distribution of Italian firms) for firms with 11 to 50 employees and by census for firms with more than 50 employees. We use the IXth Capitalia survey, i.e. the wave 2001-2003 of the survey run in 2004 through questionnaires distributed to a sample of 4289 firms with more than 10 employees.

[12] The firm level dataset AIDA is supplied at the University of Salerno by the commercial data provider Bureau Van Dyck, while access to the Bureau Van Dyck Mint-Italy dataset was given confidentially and exceptionally to the authors. Aida collects annual accounts of Italian corporate enterprises and contains information on a wide set of economic and financial variables. The dataset Mint-Italy is a firm level database of Italian companies, banks and insurance companies with variables on export and import activities.

[13] In particular, using the ownership status variable in AIDA, we define domestic multinationals (DMNEs) as non foreign-owned firms with a share of direct ownership greater/equal to 10 percent in firms located in countries other than Italy; foreign multinationals (FMNEs) are defined as Italian firms whose ultimate beneficial owner is foreign. AIDA database offers a flexible definition of ultimate ownership (over 25% or over 50%), in our analysis we considered a share of 25%.

	IMPSHARE	Ratio of 3 digit Ateco industry j's total imports over total output at year t.	ISTAT	+
	EXPSHARE	Ratio of 3 digit Ateco 2007 industry j's total exports over total output at year t.	ISTAT	+
REGION FIXED EFFECTS	REGION DUMMIES	*R-1* macrosector dummies *(R=1,..3)* for firms belonging to North, Centre, South	ISTAT	
SECTOR FIXED EFFECTS	ATECO SECTORS DUMMIES	Sector dummies 2 digit Ateco 2002 classification	ISTAT	
TECH CLASSES	TECH CLASSES DUMMIES	High tech &Medium-high tech; low and medium low tech manufacturing sectors	EUROSTAT/ OECD Classification (ATECO91)	
TIME FIXED EFFECTS	YEAR DUMMIES	2002-2009		

3.3. Descriptive statistics

Table 2 summarizes the main characteristics of our sample, considering all firms and splitting the sample in different subsamples. The first subsample concerns firms with a total number of workers below or equal to 49 while the second one focuses on firms having more than 49 workers (columns 1, 2 and 3). In the following columns we cut the sample at 100 employees and 20 employees respectively. Productivity measures such as TFP vary considerably across size groups. In particular, medium and large firms display a higher TFP measured by LP (69281) while, small firms display a much lower one (48852). The differences in real total assets are also very large (2.7 thousand millions for small firms with respect to more than 34.8 thousand millions for medium large firms) and statistically significant applying an adjusted Wald test of mean differences.
There are not large age differences among the firms according to size (27 and 29) but they are statistically different. The exporters are less numerous in the small firm category (0.48) than in the medium and large one (0.58) and this difference is also statistically significant.
Turning to the financial variables, the table shows statistically significant differences in the financial indicators according to firm size. Medium and large firms have a higher proxy of cash flow (ptpm is 4 in medium large firms versus 3 for the small firms) and also a higher coverage which reflect their better profitability. However, they show a lower liquidity and higher indebtedness.

Tab. 2. Descriptive statistics of the variables used in the estimates (values are expressed in euros)

	Total firms		Firm with less than 50 employees		Firm with 50 and more employees		Firm with less than 100 employees		Firm with 100 and more employees		Firm with less than 20 employees		Firm with 20 and more employees	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Variable	N. 16093		N. 6680		N. 9413		N. 10944		N. 5149		N. 2105		N. 13988	
TFP by Levinshon Petrin	60801	219000	48853	327000	69281	74794	51022	258000	81586	86891	52080	579000	62114	67133
TFP by Olley and Pakes	45652.97	96820.84	31027.61	49539.81	56987.29	120000.00	34914.08	58721.73	70238.60	149000.00	25728.67	38447.95	49001.81	103000.00
real value added	12,400,000	43,200,000	1,860,000	8,470,000	19,800,000	54,800,000	2,750,000	6,880,000	32,800,000	71,500,000	1,290,000	14,900,000	14,000,000	45,700,000
real total assets	21,500,000	106,000,000	2,720,000	15,100,000	34,800,000	136,000,000	3,680,000	12,600,000	59,400,000	180,000,000	2,130,000	26,200,000	24,400,000	112,000,000
raw materials	31,700,000	170,000,000	6,600,000	18,900,000	49,600,000	220,000,000	8,090,000	17,700,000	82,000,000	293,000,000	4,780,000	28,400,000	35,800,000	182,000,000
age	28.45	15.71	27.11	13.46	29.4	17.06	27.78	14.33	29.87	18.22	26.63	12.07	28.72	16.17
employees	169.24	490.64	27.22	12.29	270.02	622.1	44.3	25.05	434.78	804.65	13.16	3.51	192.73	522.25
size <50	0.42	0.49	1	0	0	0	0.61	0.49	0	0	1	0	0.33	0.47
size >=50	0.58	0.49	0	0	1	0	0.39	0.49	1	0	0	0	0.67	0.47
size <100	0.68	0.47	1	0	0.45	0.5	1	0	0	0	1	0	0.63	0.48
size >=100	0.32	0.47	0	0	0.55	0.5	0	0	1	0	0	0	0.37	0.48
class<20	0.13	0.34	0.32	0.46	0	0	0.19	0.39	0	0	1	0	0	0
class>=20	0.87	0.34	0.68	0.46	1	0	0.81	0.39	1	0	0	0	1	0
Techclass1 low tech	0.70	0.46	0.75	0.44	0.67	0.47	0.73	0.44	0.64	0.48	0.8	0.4	0.69	0.46
Techclass1 high tech	0.29	0.46	0.25	0.43	0.32	0.47	0.26	0.44	0.36	0.48	0.2	0.4	0.31	0.46
Foreign multinational	0.88	0.33	0.97	0.17	0.81	0.39	0.95	0.21	0.72	0.45	0.99	0.11	0.86	0.35
Domestic multinational	0.04	0.19	0.01	0.11	0.05	0.22	0.02	0.13	0.08	0.27	0.01	0.09	0.04	0.2
Italian Domestic	0.09	0.28	0.02	0.14	0.14	0.34	0.03	0.17	0.21	0.4	0.01	0.07	0.1	0.3
Exporting	0.54	0.50	0.48	0.5	0.58	0.49	0.52	0.5	0.58	0.49	0.43	0.49	0.56	0.5
Liquidity	0.93	0.68	0.97	0.76	0.9	0.61	0.95	0.71	0.89	0.61	1	0.89	0.92	0.64
PTPM	3.69	7.16	3.25	7.54	4.01	6.87	3.38	6.94	4.35	7.57	3.33	6.92	3.75	7.2
Coverage	18.35	42.03	17.91	41.75	18.67	42.22	18.09	42.47	18.89	41.07	18.8	45.76	18.28	41.44
Debt bank/Turnover	23.34	21.27	23.71	21.47	23.07	21.13	24.09	21.41	21.73	20.89	24.04	21.8	23.23	21.19
MES	766.08	41.41	762.47	42	768.65	40.8	762.98	40.75	772.68	42.03	761.65	41.8	766.75	41.32
IMP	7.60	5.01	7.68	5.02	7.54	5.01	7.69	5.03	7.39	4.96	7.76	5.54	7.57	4.93
EXP	13.77	10.43	13.43	10.43	14.01	10.42	13.86	10.44	13.58	10.39	13.34	10.99	13.83	10.34
HERFHINDAL	4.99	6.11	4.71	6.08	5.18	6.12	4.64	5.69	5.72	6.85	4.88	6.94	5	5.97
South	0.15	0.36	0.18	0.38	0.13	0.34	0.17	0.37	0.11	0.31	0.16	0.36	0.15	0.36
Center	0.17	0.38	0.2	0.4	0.15	0.36	0.18	0.38	0.15	0.36	0.21	0.4	0.16	0.37
North	0.68	0.47	0.63	0.48	0.72	0.45	0.65	0.48	0.74	0.44	0.64	0.48	0.69	0.46
_lanno_2003	0.15	0.36	0.14	0.35	0.15	0.36	0.15	0.36	0.15	0.36	0.12	0.32	0.15	0.36
_lanno_2004	0.14	0.35	0.13	0.33	0.15	0.36	0.14	0.34	0.15	0.36	0.1	0.29	0.15	0.36
_lanno_2005	0.15	0.36	0.14	0.35	0.15	0.36	0.15	0.36	0.15	0.36	0.13	0.34	0.15	0.36
_lanno_2006	0.15	0.36	0.15	0.36	0.15	0.36	0.15	0.36	0.15	0.36	0.14	0.35	0.15	0.36
_lanno_2007	0.17	0.37	0.18	0.38	0.16	0.36	0.17	0.38	0.16	0.37	0.19	0.39	0.16	0.37
_lanno_2008	0.14	0.35	0.14	0.35	0.14	0.34	0.14	0.34	0.14	0.35	0.18	0.38	0.13	0.34
_lanno_2009	0.10	0.30	0.11	0.31	0.1	0.3	0.11	0.31	0.1	0.3	0.14	0.35	0.1	0.3
Food products (Ateco 15)	0.13	0.34	0.18	0.38	0.09	0.29	0.15	0.36	0.08	0.27	0.21	0.4	0.12	0.32
Textiles (Ateco 17)	0.07	0.26	0.08	0.27	0.07	0.25	0.08	0.26	0.06	0.25	0.09	0.29	0.07	0.25
Clothing (Ateco 18)	0.03	0.17	0.03	0.17	0.03	0.17	0.03	0.17	0.03	0.17	0.03	0.17	0.03	0.17
Leather (Ateco 19)	0.03	0.18	0.04	0.19	0.03	0.17	0.04	0.19	0.03	0.17	0.04	0.2	0.03	0.18
Wood and wood products (Ateco 20)	0.03	0.17	0.04	0.19	0.02	0.15	0.03	0.17	0.02	0.15	0.03	0.17	0.03	0.17
Pulp and paper (Ateco 21 & 22)	0.05	0.22	0.04	0.21	0.05	0.22	0.05	0.22	0.04	0.2	0.05	0.22	0.05	0.21
Chemical (Ateco 23,24,25)	0.13	0.33	0.13	0.34	0.13	0.33	0.13	0.33	0.13	0.34	0.1	0.31	0.13	0.34
Non metallic products (Ateco 26)	0.06	0.23	0.06	0.24	0.05	0.23	0.06	0.23	0.06	0.23	0.06	0.23	0.06	0.23
Basic Minerals (Ateco 27)	0.04	0.20	0.03	0.18	0.05	0.22	0.04	0.19	0.06	0.23	0.04	0.19	0.04	0.21
Metal products (Ateco 28)	0.13	0.33	0.13	0.33	0.13	0.33	0.13	0.34	0.12	0.32	0.14	0.34	0.12	0.33
Machinary and vehicles (Ateco 29, 34,35)	0.17	0.37	0.13	0.33	0.2	0.4	0.15	0.36	0.21	0.41	0.09	0.28	0.18	0.39
Electrical products (Ateco 30,31,32,33)	0.08	0.27	0.06	0.24	0.09	0.28	0.06	0.24	0.11	0.31	0.07	0.25	0.08	0.27
Furniture (Ateco 36)	0.06	0.24	0.06	0.23	0.06	0.24	0.06	0.24	0.06	0.23	0.06	0.24	0.06	0.23
regione_num1	0.04	0.18	0.03	0.18	0.04	0.19	0.04	0.18	0.04	0.18	0.03	0.17	0.04	0.19
regione_num2	0.00	0.06	0	0.06	0	0.06	0	0.06	0	0.06	0	0.04	0	0.06
regione_num3	0.00	0.06	0	0.05	0	0.07	0	0.06	0	0.06	0	0.02	0	0.06
regione_num4	0.04	0.20	0.06	0.23	0.03	0.17	0.05	0.21	0.03	0.17	0.04	0.19	0.04	0.2
regione_num5	0.13	0.33	0.12	0.33	0.13	0.34	0.12	0.33	0.13	0.34	0.12	0.33	0.13	0.34
regione_num6	0.04	0.19	0.03	0.17	0.04	0.2	0.03	0.18	0.04	0.2	0.03	0.16	0.04	0.19
regione_num7	0.03	0.17	0.03	0.16	0.03	0.17	0.03	0.16	0.04	0.19	0.03	0.18	0.03	0.17
regione_num8	0.01	0.09	0.01	0.09	0.01	0.09	0.01	0.09	0.01	0.09	0.01	0.11	0.01	0.09
regione_num9	0.26	0.44	0.25	0.43	0.27	0.45	0.25	0.43	0.29	0.45	0.27	0.44	0.26	0.44
regione_num10	0.04	0.20	0.03	0.18	0.05	0.22	0.04	0.2	0.05	0.21	0.02	0.14	0.05	0.21
regione_num11	0.00	0.06	0	0.06	0	0.07	0.01	0.07	0	0.04	0.01	0.07	0	0.06
regione_num12	0.09	0.28	0.08	0.26	0.09	0.29	0.08	0.27	0.1	0.3	0.08	0.28	0.09	0.28
regione_num13	0.03	0.17	0.04	0.19	0.02	0.15	0.03	0.18	0.02	0.14	0.04	0.19	0.03	0.16
regione_num14	0.01	0.11	0.01	0.12	0.01	0.09	0.01	0.12	0.01	0.08	0.02	0.13	0.01	0.1
regione_num15	0.02	0.14	0.03	0.16	0.01	0.12	0.02	0.15	0.01	0.1	0.02	0.15	0.02	0.14
regione_num16	0.08	0.28	0.12	0.32	0.06	0.23	0.1	0.3	0.05	0.22	0.14	0.35	0.07	0.26
regione_num17	0.02	0.13	0.01	0.11	0.02	0.14	0.01	0.12	0.02	0.15	0.01	0.11	0.02	0.13
regione_num18	0.02	0.12	0.02	0.13	0.01	0.12	0.02	0.13	0.01	0.11	0.01	0.11	0.02	0.12
regione_num19	0.00	0.03	0	0.01	0	0.04	0	0.02	0	0.05	0	0	0	0.04
regione_num20	0.14	0.35	0.13	0.34	0.15	0.36	0.14	0.35	0.14	0.35	0.12	0.32	0.15	0.35

3.4. Estimation methodology

We estimate TFP in the first step by using two different methods: Levinshon and Petrin, and Olley and Pakes. Then, the determinants of TFP are estimated with a fixed effect model (FEM), and also with a system GMM dynamic panel data technique developed by Arellano and Bond (1991) and Blundell and Bond (1998), which enables us to control for the possible simultaneity and endogeneity problems in our models.[14]

[14] The Arellano-Bond (1991) and Arellano-Bover (1995)/Blundell-Bond (1998) dynamic panel estimators are general estimators designed for situations with 1) small T, large N panels, meaning few time periods and many individuals; 2) a linear functional relationship; 3) a single left-hand-side variable that is dynamic, depending on its own past realizations; 4) independent variables that are not strictly exogenous, meaning correlated with past and possibly current realizations of the error; 5) fixed individual effects; and 6) heteroskedasticity and autocorrelation within individuals but not across them. Arellano-Bond estimation starts by transforming all regressors, usually by differencing, and uses the Generalized Method of Moments (Hansen 1982), and so is called Difference GMM. The Arellano-Bover/Blundell-Bond estimator augments Arellano-Bond by making an additional assumption, that first differences of instrument variables are uncorrelated with the fixed effects. It builds a system of two equations - the original equation as well as the transformed one - and is known as System GMM. This allows the introduction of more instruments, and can dramatically improve efficiency (Blundel et al. 2000; Roodman 2006).

This approach is only adopted in few recent papers (Nucci et al. 2005; Coricelli et al. 2012; Chen and Guariglia 2013), while most of the studies in the literature on the finance-productivity nexus, use OLS and simple fixed effects estimators accounting for plant fixed effect which do not take endogeneity into account.

Our estimator combines in a system the equation in first-differences with an equation in levels. We treat all the regressors in our equations (except age, exporting and MES) as endogenous and instrument them. Total factor productivity, multinational property, ptpm, liquidity index, coverage ratio and debts with banks over turnover are used to form GMM type instrument for level and differenced equation. The others variables (except age, exporting and MES) were used as standard instruments only in levels equation. We follow two specifications for GMM: in one we include the variables of interest that are time variant and the year dummies, in another we add time invariant variables as two-digit industry dummies, the dummies for territorial area (North, Centre and Southern) and other time invariant regressors (as technology and exporters).

This estimation method allows us to assume that the firms' characteristics are endogenous variables. A major problem with the use of GMM methods concerns the choice of the instruments. The instruments should be highly correlated with the variables to be instrumented to be strong in Murray (2006) terminology. They should also be uncorrelated with the disturbances of the equation of interest.[15] The validity of the instruments can be tested using the Hansen/Sargan statistics (or J statistics). This test of over identifying restrictions implies that the estimator is valid if its P-value is above the chosen critical level (i.e. 1, 5 or 10 percent).[16]

Another test to be carried out is made to assess the presence of nth-order serial correlation in the differenced residuals using the m (n) test, which is asymptotically distributed as a standard normal under the null of no nth-order serial correlation of the differenced residuals. This test needs to be performed as the dynamic model specifications can only be appropriate if they are exempt from serial correlation in the first-differenced residuals. In the presence of serial correlation of order n in the differenced residuals, the instrument set for the equation in first-differences needs to be restricted to lags n + 1 and deeper. We use indeed three and four lags. However, we report the m1, m2 and m3 tests for third order serial correlation of the differenced residuals in our tables.

4. Results

4.1. Base econometric results

Tab. 3 introduces the estimations of firm TFP using Levinshon and Petrin and confronting Fixed Effects with GMM system estimates.

The table presents in column 1-9 the results for three different estimation models (FEM and GMM without and with time invariant variables), taking into account different firm size classes as control: the first 3 columns include a dummy size equal to 1 for firms above or equal to 50 and 0 otherwise; column 4-6 include a dummy size equal to 1 for firms above or equal to 100 and 0 otherwise; the last three columns include a dummy size equal to 1 for firms above or equal to 20 and 0 otherwise.

[15] Econometric tests are used to judge whether the chosen instruments are strong and valid. Following Staiger and Stock (1997), the instruments can be considered as good if the first-stage F-statistic of the regression of the variable to be instrumented on the instrument is above 10 (Sekkat 2011).

[16] The Sargan test regresses the residuals from the IV estimation of the equation of interest on the instruments and uses the R^2 to test the significance of this regression. The test statistic is the number of observations times the R^2 and has a chi square distribution. Its degree of freedom is equal to the number of instrument minus the number of variables to be instrumented (Sekkat 2011). However, the Monte Carlo evidence of Blundell et al. (2000) shows that when using system GMM on a large panel data to estimate a production function, the Sargan test tends to over-reject the null hypothesis of instrument validity.

It is worthwhile to first focus on our financial indicators starting from internal funding measures. We find that the most robust result is shown by firms' cash flow (*ptpm*) which affects productivity positively and is highly significant in all the regressions independently on the size dummy used as control. This suggests that firms in the presence of a negative cash flow shock will face a reduction in their productivity. Coverage is also positive and highly significant in all the estimations. Quite surprisingly, liquidity affects productivity negatively in all our FEM regressions, however, when controlling for the endogeneity the coefficient loses significance. Our proxy for external funding, debt with banks over turnover, gets a negative and significant sign in all the GMM regressions and also in the FEM.[17] The regressions where the coefficient has a weak significance are in column 2 and 5 where we do not control for time invariant covariates and where the control for size are the first two dummy size classes. Taking into account that our favourite estimation is the GMM with time invariant controls we conclude with a certain confidence that firms with higher bank exposure get a negative premium on TFP from indebtedness even if they should be more efficient and trusted by the banks. This is quite consistent with the hypothesis that if on the one hand higher debt means that the firm had access to external finance in the past, which may be an indication that the firm does not face liquidity constraints, on the other hand, increased leverage reduces the current funds available for investment and highly leveraged firms may face higher obstacles in accessing external sources of capital.

Regarding the other variables, whatever the size class considered as control, we observe that larger firms are more productive then smaller ones. The coefficient of age is on the contrary quite unstable and the sign changes: while in the FEM it is positive and significant, as expected, in the GMM gets negative. The lagged productivity has a positive and significant coefficient which is also consistent with our expectations. In the GMM estimates exporters and foreign owned firms are more productive even when controlling for different size classes, while the coefficients are never significant for domestic multinationals. Minimum efficient scale affects productivity positively while market concentration affects productivity negatively as expected. Being located in the South has always a negative impact on productivity while being in the Centre is not clearly showing a negative or positive impact.

Tab. 3 Average effect of financial variables on TFP (Levinshon and Petrin). FEM and GMM SYS estimates 2002-2009

Dependent variable in the GMM: ln (TFPit))

[17] We also adopted short and long run indebtedness, following Schiantarelli and Sembenelli (1997), which use the length of debt maturity. We got the same results with long run indebtedness.

	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)	
Variable	**FE**		**GMM**		**GMM**		**FE**		**GMM**		**GMM**		**FE**		**GMM**		**GMM**	
TFP by Levison Petrin (lag)	0.129	***	0.324	***	0.361	***	0.125	***	0.328	***	0.348	***	0.128	***	0.350	***	0.403	***
Lnage	0.158	***	-0.063		-0.506	***	0.159	***	0.032		-0.315	***	0.150	***	-0.171	***	-0.573	***
size class >=50	-0.142	***	0.183	***	0.190	***												
size class >=100							-0.105	***	0.194	***	0.242	***						
size class >=20													-0.245	***	0.189	***	0.168	***
Foreign multinational	0.008		0.064		0.107	**	0.005		0.063		0.106	**	0.010		0.071		0.125	**
Domestic multinational	0.011		-0.017		0.028		0.011		-0.016		0.010		0.013		-0.016		0.041	
Exporting					0.383	***					0.372	***					0.470	***
PTPM	0.012	***	0.014	***	0.015	***	0.012	***	0.014	***	0.015	***	0.012	***	0.014	***	0.012	***
Liquidity	-0.047	***	-0.034		-0.023		-0.046	***	-0.044		-0.034		-0.046	***	-0.042		-0.044	
Coverage	0.001	***	0.002	***	0.002	***	0.001	***	0.002	***	0.002	***	0.001	***	0.002	***	0.002	***
Debt bank/Turnover	-0.003	***	-0.006	***	-0.006	***	-0.003	***	-0.006	***	-0.006	***	-0.003	***	-0.006	***	-0.005	***
MES	0.000	**	0.005	***	0.006	***	0.000	*	0.005	***	0.006	***	0.000	**	0.006	***	0.006	***
IMP	-0.007	**	-0.035	***	-0.042	***	-0.007	***	-0.036	***	-0.045	***	-0.007	***	-0.034	***	-0.039	***
EXP	0.002		0.021	***	0.019	***	0.002		0.022	***	0.023	***	0.002		0.021	***	0.017	***
HERFHINDAL	-0.001		-0.017	***	-0.008	***	-0.001		-0.017	***	-0.008	***	-0.002		-0.020	***	-0.007	***
South					-0.149	***					-0.109	***					-0.158	***
Center					0.020						0.024						0.014	
Techclass1 low tech					0.038						0.064						0.056	
YEAR FIXED EFFECTS	YES		YES		YES		YES		YES		YES		YES		YES		YES	
SECTOR FIXED EFFECTS					YES						YES						YES	
Constant	8.688		3.447	***	3.931	***	8.707	***	3.075	***	3.107	**	8.868	***	2.869	**	3.590	***
N.	16093		16093		16093		16093		16093		16093		16093		16093		16093	
F, Wald	165.04	***	1656.570	***	19113.960	***	158.17	***	1613.300	***	21795.010	***	177.94	***	1691.430		16229.250	
Rho	0.941						0.940						0.943					
m1 (pvalue)			0.000	***	0.000	***			0.000	***	0.000	***			0.000	***	0.000	***
m2 (pvalue)			0.075	*	0.047	**			0.077	*	0.058	*			0.069	*	0.046	**
m3 (pvalue)			0.682		0.334				0.622		0.399				0.598		0.302	
Sargan test (pvalue)			0.288		0.137				0.300		0.219				0.244		0.126	

Note: Instruments in columns 2 - 3, 5 - 6 and 8 - 9 include all regressors (except age, exporting and MES) lagged three or four times. The time invariant variables when included are used as standard instrument in level.

Table A.1 in the Appendix shows the same regressions performed with the OP methodology. We observe that broadly our results are confirmed but they appear less stable and some variables loses significance. In particular, *coverage* is not significant in the GMM estimations and debt with banks is only slightly significant.

4.2. Heterogeneity in size

We next take into account the heterogeneity in size characterizing firms in our dataset to explore the extent to which the link between financial constraints and productivity varies for firms belonging to different size classes. The following table hence uses the same specification but add interactive terms between each of our financial variables and our three size classes dummies. The estimation of the twelve equations containing interaction terms allow us not to reduce the sample size and degrees of freedom and to formally test whether the effects of financial indicators on firm productivity are statistically different between different groups of firms. This is to be preferred to estimate separate regressions for firms with small and larger size (Chen and Guariglia 2013).

In table 4, we have three different estimation models which use the three different size classes: adopted before with threshold of 50 (columns 1-4), 100 (columns 5-8), and of 20 employees respectively (columns 9-12).

We first need to better clarify the meaning of the interaction terms.[18] Taking as an example column 1, the coefficient on the financial indicator ptpm not interacted needs to be interpreted as the effect of cash flow for smaller firms while the interaction term coefficient gives us the difference of the coefficient of the cash flow on TFP on the upper size class (above 50) with respect to the coefficient on smaller firms (<50).

Tab. 4 Average effect of financial variables on TFP wih interaction with size dummies
GMM SYS estimates 2002-2009. Levinshon and Petrin TFP estimates

[18] The interpretation of the negative coefficient of a variable not interacted tells us that the obstacle to finance get a negative impact on small firms, the coefficient of the term interacted with size tell us the difference between the big and the smaller firms.

	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)		(10)		(11)		(12)	
Variable																								
TFP by Levison Petrin (lag)	0.432	***	0.337	***	0.366	***	0.343	***	0.509	***	0.336	***	0.365	***	0.339	***	0.531	***	0.538	***	0.533	***	0.527	***
Lnage	-0.146		-0.167		-0.111		-0.011		0.116		-0.158	*	-0.109		0.018		-0.407	***	-0.396	***	-0.427	***	-0.436	***
size class >=50	0.097	***	0.319	***	0.221	***	0.152	*																
size class >=100									0.207	***	0.410	***	0.280	***	0.231	***								
size class >=20																	0.152	***	0.238	***	0.165	***	0.176	*
Foreign multinational	0.092	***	0.117	***	0.011		-0.007		0.114	**	0.118	***	0.016		0.026		0.135	***	0.130	***	0.131	***	0.125	**
Domestic multinational	0.009		0.003		0.063	*	0.057		-0.002		0.021		0.043		0.033		0.070	**	0.065	**	0.067	**	0.065	**
Exporting	0.296	**	0.239		0.230		0.172		0.020		0.202	*	0.190		0.182		0.318	***	0.307	***	0.318	***	0.306	**
PTPM	0.001		0.015	***	0.011	***	0.013	***	0.018	***	0.014	***	0.011	***	0.012	***	0.014	**	0.004	*	0.004	*	0.005	**
PTPM X SIZE	0.016	***							-0.008								-0.011							
Liquidity	-0.040		0.074	*	-0.007		-0.015		0.000		0.055	*	0.009		-0.023		-0.037		0.056		-0.027		-0.031	
Liquidity X SIZE			-0.154	**							-0.175	***							-0.127	*				
Coverage	0.001	*	0.000		0.003	***	0.001	**	0.001		0.001	***	0.002	***	0.001	**	0.001	**	0.001	*	0.003	**	0.001	**
Coverage X SIZE					-0.003	**							-0.002	***							-0.003	*		
Debt bank/Turnover	-0.002	**	-0.002	**	-0.002	***	-0.004	*	-0.002	**	-0.001		-0.001	*	-0.003	*	-0.001	*	-0.001	*	-0.001		0.001	
Debt bank/Turnover X SIZE							0.001								0.001								-0.002	
MES	0.002		0.005	***	0.006	***	0.004	***	0.004	***	0.004	***	0.007	***	0.006	***	0.005	***	0.004	***	0.004	***	0.004	***
IMP	-0.061	***	-0.057	***	-0.036	**	-0.031	**	-0.049	***	-0.062	***	-0.053	***	-0.057	***	-0.048	***	-0.049	***	-0.047	***	-0.049	***
EXP	0.025	*	0.024	*	0.022	*	0.018		0.025	**	0.039	***	0.035	***	0.038	***	0.035	***	0.035	***	0.033	***	0.036	***
HERFHINDAL	0.009		0.009		0.003		0.009		-0.001		0.006		-0.002		0.000		0.008		0.010		0.008		0.009	
South	-0.107	***	-0.158	***	-0.132	***	-0.124	***	-0.072	***	-0.132	***	-0.124	***	-0.105	***	-0.148	***	-0.149	***	-0.152	***	-0.155	***
Center	0.011		0.000		0.014		0.006		0.001		0.003		0.008		0.008		0.002		0.002		0.001		-0.001	
Techclass1 low tech	-0.153		0.623		0.401		0.534	*	-0.017		-0.136	*	-0.001		-0.030		-0.110		-0.127		-0.106		-0.125	
YEAR FIXED EFFECTS	YES		YES		YES		YES		YES		YES		YES		YES		YES		YES		YES		YES	
SECTOR FIXED EFFECTS	YES		YES		YES		YES		YES		YES		YES		YES		YES		YES		YES		YES	
Constant	4.954	***	3.114	***	1.847		2.801	**	1.322		3.723	***	1.639		1.899		2.351	*	2.409	*	2.538	**	2.516	*
N.	16093		16093		16093		16093		16093		16093		16093		16093		16093		16093		16093		16093	
Wald	31057.96	***	16403.73	***	20017.81	***	22706.54	***	42424.59	***	27433.23	***	23129.37	***	24242.60	***	23479.60	***	23364.56	***	23327.81	***	22486.44	***
m1 (pvalue)	0.000	***	0.000	***	0.000	***	0.000	***	0.000	***	0.000	***	0.000	***	0.000	***	0.000	***	0.000	***	0.000	***	0.000	***
m2 (pvalue)	0.066	*	0.066	*	0.063	*	0.069	*	0.079	*	0.068	*	0.057	*	0.053	*	0.048	*	0.053	*	0.053	*	0.058	*
m3 (pvalue)	0.423		0.524		0.839		0.848		0.231		0.590		0.540		0.610		0.793		0.746		0.775		0.694	
Sargan test (pvalue)	0.173		0.127		0.560		0.278		0.170		0.156		0.653		0.310		0.153		0.179		0.189		0.144	

Note: In the first 4 columns we have the interactions of our financial variables with the size dummy equal to 1 for firms above or equal 50 employees, in column 5 to 8 we have the interactions with the size dummy equal to 1 for firms above or equal 100 employees, in column 9 to 12 we have the interactions with the size dummy equal to one for firms above or equal to 20 employees.

The positive sign we get on the coefficient of the ptpm variable gives us the coefficient for smaller firms which turns out positive but not significant. Besides, the interaction of cash flow with the size dummy suggests the effect of cash flow on productivity to be higher for larger firms. As small size could impose extra difficulties on firms in raising external funds since it increases firms' risk of bankruptcy, we would have expected the effect of cash flow on productivity to be positive and significant for small firms and the coefficient of the interacted terms to be negative and statistically significant. However, in the following regressions, where ptpm is interacted with the two other size dummies, we get as expected that the cash flow coefficient for smaller firms is positive and significant. These results suggest a u-shaped pattern of TFP-cash flow sensitivity with respect to size.

The interactive terms with the other indicators of internal funding give results quite in line with our expectations. When getting higher liquidity smaller firms get a TFP premium which is significant in two out of three cases (it is not significant when the interaction is with the smaller size class dummy 0-19), besides, the impact on TFP for larger firms is negative and the differential impact with respect to smaller counterparts is significant in all the cases; results in the same directions are shown by the variable coverage which has an important positive impact on small firms in all the regressions, conversely, for larger firms sensitivity of TFP to coverage is much smaller than for smaller firms and the differential impact is significant.

These results suggest that smaller firms get higher returns from internal financial solidity which might be related to their being more financially constrained.

Turning to the indicator of external finance, unlike for the indicators of internal finance, we find evidence that this plays an important negative impact on productivity independently on firm size, i.e. there is no significant difference between the coefficient of the indebtedness of small and large firms when interacting this variable with our three different size dummies.

Table A.2 in Appendix shows the results obtained by using OP. The cash flow and liquidity variables, as expected, suggest higher sensitivity of smaller firms to internal financial constraints, as the coefficient for smaller firms is positive and significant. Besides, there is no evidence of a positive significant impact on larger firms with respect to smaller counterparts.

Less robust is the positive effect of the variable coverage on small firms which is not significant in all the regressions; besides, for larger firms sensitivity of TFP to coverage is much smaller than for smaller firms but the differential impact is significant only for firms with size above or equal to 100 employees.

As before, the evidence on external financial constraints is negative and significant independently on firm size, i.e. there is no significant difference between the coefficient of the indebtedness of larger versus small firms when interacting this variable with our three different size dummies.

5. Conclusions

This article investigates the extent to which the presence of financial constraints to firms prevent them increasing their productivity. The focus is on the difference in the impact according to firm size. We verify the robustness of our results with alternative proxies of internal funding (three proxies of financial constraints namely cash flow, coverage, liquidity). The analytical framework assumes an enlarged model which include financial variables on TFP estimated with both Levinshon and Petrin and Olley and Pakes. It also allows output to consider unobserved-time-invariant firm characteristics and correct for potential endogeneity bias using system GMM in addition to fixed effects models.

The estimations using the GMM give results consistent with the expectations: differences in productivity between firms strongly depend on internal and external financial constraints: a higher profit margin and coverage, i.e. a higher internal financial solidity, increase productivity while a strong negative impact is played by higher external finance measured by indebtedness with banks.

In addition, testing firm sensitivity to financial constraint for firms with different size, our results show that smaller firms experience the most serious obstacle as the coefficient of interactions with size dummies has a negative and significant impact on smaller firms while the coefficients, with the exception of coverage are often not significant for larger firms or show a lower sensitivity for this category with respect to their smaller counterpart. Hence, the impact of our variables of interest is significant and different according to firm size. The findings are robust to the introduction of various control variables. The high sensitivities of firm-level productivity to internal finance suggest that access to external finance is constrained in Italy.

We may conclude that investing in financial sector reforms is a potential important tool for SMEs in Italy. Given the importance of such firms in the country, the results support government efforts to foster bank and in general financial system development, in particular of the stock and bond markets, would ensure that more finance is channelled towards those firms whose productivity is highly dependent on the availability of finance.

Further checks and robustness exercises and enlargement of the analysis will be carried out to improve our results and to get more detailed and robust information. In the specific case of Italy, an important insight can be gained by taking into account efficiency measures dispersion at territorial level like in previous analyses (Destefanis 2000). We would also like to take into account the unobserved heterogeneity of the technology following quite recent development within the techniques of stochastic frontier models (Chaffai and Plane 2014).

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Appendix 1. Estimation methodologies based on the Levinshon and Petrin and on Olley and Pakes procedures.

In the first step, we estimated the TFP and when it's estimated at firm-level production functions simultaneity bias and selection bias may emerge (Van Beveren 2012; Syverson 2011).

The "simultaneity bias" problem is due to endogeneity in the inputs, arising from the potential correlation between input choices and the unobserved productivity shock as firms may alter their mix of inputs in response to a productivity shock.This implies that the error and the the inputs in the production might be correlated and that coefficient estimates obtained with OLS might be biased

The firm-specific error term consists of two parts: firm productivity, ε_{it}, which are unpredictable zero-mean shocks to productivity after inputs are chosen, ω_{it}, which is observed by the firm but not by the econometrician. This asymmetric information about ω_{it} causes two biases in the OLS estimates: a simultaneity bias and a selection bias.

Hence, the firm can choose the amount of inputs according to its prior knowledge about its productivity levels, which are not observable. This implies correlation between unobserved productivity and a plant's input decisions. If more productive plants tend to hire more workers due to higher current and anticipated future profitability, OLS will tend to provide upwardly biased estimates on the input coefficients (Van Beveren 2012).

The selection bias arises because firms with larger capital stocks can expect larger future returns for any given level of current productivity, and will therefore continue to operate for lower productivity levels, thereby leading to a negative bias in the OLS capital coefficient: firms with a higher capital supply will be able to survive with lower ω_{it}, relative to firms with a lower capital stock. The

selection bias or 'endogeneity of attrition' problem will generate a negative correlation between ε_{tt} and K_{it}, causing the capital coefficient to be biased downwards.

Over the last years, several methodologies have been developed in the literature to solve these problems. Firm-level fixed effects including time-invariant individual effects and instrumental variable strategies for input choices have been proposed in a first attempt. More recent methodologies instead include Olley and Pakes (1996), GMM by Blundell and Bond (1998) and Levinsohn and Petrin (2003).

Olley and Pakes (1996) developed a semiparametric approach in which the simultaneity problems are addressed by using investment to proxy for an unobserved time-varying productivity shock, This is based on the assumption that future productivity is strictly increasing with respect to productivity shock so firms that observe a positive productivity shock in period will invest more in that period (Van Beveren 2012).[19] Olley and Pakes (1996) were also the first to take the selection bias explicitly into account by using survival probabilities.

However, because of indivisibility, investment is often zero, which prevents inverting the function. Levinsohn and Petrin (2003) suggested a modification of the Olley-Pakes approach by using intermediate inputs (raw materials, electricity, or fuels) instead of investment to proxy for unobservable productivity. Levinsohn and Petrin (2003) argue that using information on intermediate input choices, such as demand for raw materials or services, allows controlling for productivity shocks to obtain consistent and unbiased estimates of K and L. In their model, labour and materials are freely variable inputs, but capital is treated as a state variable that is affected by the distribution of the productivity shock.

The data coverage of the proxy for unobservable productivity is an important factor in deciding which approach to use, since plants with zero or missing observations on investment would be dropped from the estimation. As with our data we may follow both LP and OP approach, for the second stage we consider important to use both methodologies. On the one hand, plants with zero or missing observations on investment would be dropped from the OP estimation[20] on the other hand, LP do not incorporate the survival probability which the OP method takes into account.[21]

In OP, investment decisions at the firm level can be shown to depend on capital and productivity or $i_{it} = i_t (k_{it},\omega_{it})$, where lower-case notation refers to logarithmic transformation of variables. Provided investment is strictly increasing in productivity, conditional on capital, this investment decision can be inverted, allowing us to express unobserved productivity as a function of observables and under the conditions of monotonicity and investment strictly increasing in productivity, the production function can be specified as follows:

$$\ln y_{it} = \gamma + \alpha \ln l_{it} + \beta \ln k_{it} + \delta \ln m_{it} + h_i(k_{it} i_{it}) + \eta_{it} \qquad [A.1]$$

The LP methodology is a two-step approach that allows the simultaneity problem between productivity shock and input choices to be solved by controlling for unobservable, using intermediate inputs as the proxy variable. Hence, intermediate inputs are expressed as a function of capital and productivity: $m_{it} = m_i(k_{it}\varpi_{it})$ and under the conditions of monotonicity and

[19] A number of assumptions are made. First, the model assumes there is only one unobserved state variable at the firm level, i.e. its productivity, and it evolves as a first-order Markov process. Second, the model imposes monotonicity on the investment variable, to ensure invertibility of the investment demand function. This implies that investment has to be increasing in productivity, conditional on the values of all state variables. As a consequence, only non-negative values of investment can be used in the analysis. Finally, industry-wide price indices are used to deflate inputs and output in value terms to proxy for their respective quantities, which entails assuming that all firms in the industry face common input and output prices (Ackerberg et al. 2007; Cainelli et al. 2015; Van Beveren 2012).

[20] In our case for OP as a proxy for investment we have built the ratio between the real operational result and the return on investment (which in turn depends on real operational results on total assets i.e. on the investment.

[21] Due to these differences the results between the OP and LP method may significantly differ.

intermediate inputs strictly increasing in productivity, the production function can be specified as follows:

$$\ln y_{it} = \gamma + \alpha \ln l_{it} + \beta \ln k_{it} + \delta \ln m_{it} + \varpi_{it}(k_{it} l_{it}) + \eta_{it} \qquad [A.2]$$

where m_{it} denotes intermediate inputs of firm i at time t, the term $\varpi_{it} = s_t(k_{it} m_{it})$ expresses the unobserved productivity as a function of the observables and $s_t(k_{it} m_{it}) = m_t^{-1}(k_{it} m_{it})$ denotes the inversion of the intermediate inputs function.
Deflated balance sheet data on value added, total labour costs, intermediate inputs, and fixed capital are used to estimate industry specific production functions.

Appendix 2. Tables

Tab. A.1 Average effect of financial variables on TFP
GMM SYS estimates 2002-2009. Olley and Pakes estimates

	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)	
Variable	**FE**		**GMM**		**GMM**		**FE**		**GMM**		**GMM**		**FE**		**GMM**		**GMM**	
TFP by Olley and Pakes (lag)	0.145	***	0.999	***	0.844	***	0.141	***	0.999	***	0.845	***	0.144	***	0.999	***	0.842	***
Lnage	0.173	***	-0.136		-0.091		0.172	***	-0.111		-0.083		0.162	***	-0.060		-0.120	
size class >=50	-0.153	***	-0.028		0.033													
size class >=100							-0.099	***	-0.030	**	0.043							
size class >=20													-0.231	***	-0.061	***	0.007	
Foreign multinational	-0.026		-0.008		-0.010		-0.031		0.005		-0.015		-0.026		0.014		-0.009	
Domestic multinational	0.003		0.035		-0.028		0.002		0.031		-0.028		0.005		0.035		-0.027	
Exporting					0.031						0.004						0.030	
PTPM	0.013	***	0.006	**	0.010	***	0.013	***	0.006	**	0.010	***	0.013	***	0.007	***	0.010	***
Liquidity	-0.031	***	-0.069		-0.010		-0.030	***	-0.060		-0.011		-0.031	***	-0.069		-0.011	
Coverage	0.001	***	-0.001		0.000		0.001	***	-0.001		-0.001		0.001	***	-0.001		0.000	
Debt bank/Turnover	-0.002	***	-0.002		-0.005	*	-0.002	***	-0.001		-0.005	**	-0.002	***	-0.001		-0.004	*
MES	-0.001	***	-0.001		0.000		-0.001	***	-0.001		0.000		-0.001	***	-0.001		0.000	
IMP	-0.008	**	0.011		0.024		-0.008	**	0.000		0.028		-0.008	***	0.000		0.023	
EXP	0.001		-0.007		0.006		0.001		-0.002		0.004		0.001		-0.002		0.006	
HERFHINDAL	0.002		0.006		0.012		0.003		0.008		0.014		0.002		0.008		0.011	
South					0.003						0.001						-0.004	
Center					-0.110	***					-0.112	***					-0.117	***
Techclass1 low tech					-0.223						-0.216						-0.226	
YEAR FIXED EFFECTS	YES		YES		YES		YES		YES		YES		YES		YES		YES	
SECTOR FIXED EFFECTS					YES						YES						YES	
Constant	60.604	***	1.543		8.695	***	60.874	***	1.449		8.595	***	60.876		1.259		8.980	***
N.	13378		13378		13378		13378		13378		13378		13378		13378		13378	
F, Wald	1.81E+02	***	7.48E+05	***	4.72E+07	***	1.73E+02	***	6.98E+06	***	4.76E+07	***	1.90E+02	***	8.60E+06	***	4.68E+07	***
Rho	1.000						1.000						1.000					
m1 (pvalue)			0.000	***	0.000	***			0.000	***	0.000	***			0.000	***	0.000	***
m2 (pvalue)			0.039	**	0.035	**			0.040	**	0.035	**			0.039	**	0.036	**
m3 (pvalue)			0.577		0.469				0.579		0.452				0.586		0.473	
Sargan test (pvalue)			0.270		0.341				0.215		0.343				0.221		0.340	

Tab. A.2 Average effect of financial variables on TFP with interactives with size dummies GMM SYS estimates 2002-2009. Olley and Pakes estimates

	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)		(10)		(11)		(12)	
Variable																								
TFP by Olley and Pakes (lag)	0.817	***	0.844	***	0.494	***	0.814	***	0.819	***	0.829	***	0.814	***	0.811	***	0.808	***	0.825	***	0.496	***	0.794	***
Lnage	0.092		0.055		0.512	**	0.070		0.051		0.029		0.051		0.062		0.003		0.119		0.164	***	-0.001	
size class >=50	0.050		0.027		0.174	***	0.083																	
size class >=100									0.049		0.175	*	0.128	***	0.068									
size class >=20																	0.020		0.010		0.046		0.078	
Foreign multinational	0.133	*	0.117		0.031		0.083		0.116	*	0.081		0.081		0.080		0.107		0.051		0.017		0.076	
Domestic multinational	0.061		0.055		-0.039		0.039		0.057		0.044		0.066		0.038		0.058		0.052		-0.038		0.041	
Exporting	0.309		0.281		0.488		0.267		0.266		0.134		0.194		0.224		0.276		0.166		0.255		0.244	
PTPM	0.015	*	0.007	*	0.006	*	0.007	**	0.011		0.008	**	0.008	**	0.007	**	0.017	*	0.005	*	0.007	**	0.007	**
PTPM X SIZE	-0.011								-0.007								-0.013							
Liquidity	0.074		0.117	*	0.109	*	0.071		0.079		0.100	*	0.053		0.062		0.069		0.073		0.082		0.071	
Liquidity X SIZE			-0.022								-0.165								-0.032					
Coverage	0.000		-0.001		0.002		0.000		0.000		-0.001		0.001		0.000		0.000		0.000		0.002		0.000	
Coverage X SIZE					-0.003								-0.006	***							-0.003			
Debt bank/Turnover	0.003		0.002		0.001		0.001		0.003		0.000		0.000		0.000		0.002		-0.001		0.000		0.003	
Debt bank/Turnover X SIZE							-0.003								-0.002								-0.004	
MES	-0.001		-0.001		0.002		0.000		-0.001		0.000		0.000		0.000		-0.001		0.000		0.001		0.000	
IMP	-0.086	**	-0.080	*	0.025		-0.036		-0.078	*	-0.040		-0.004		-0.031		-0.085	**	-0.024		0.024		-0.033	
EXP	0.088	***	0.087	***	0.029		0.058	*	0.081	**	0.059	*	0.023		0.055	*	0.085	***	0.033		0.021			*
HERFHINDAL	0.001		-0.008		-0.002		0.005		0.003		-0.002		0.001		0.006		0.004		0.017		0.009		0.007	
South	0.051		0.048		0.136		0.046		0.038		0.028		0.045		0.040		0.030		0.037		0.029		0.031	
Center	-0.095	*	-0.081		-0.319	***	-0.102	*	-0.101	*	-0.105	**	-0.107	**	-0.108	**	-0.112	**	-0.109	**	-0.375	***	-0.126	**
Techclass1 low tech	-2.346	***	-2.000	***	-1.944	*	-1.708	**	-2.134	**	-1.539	*	-1.262		-1.660	**	-2.201	**	-0.876	*	-1.046		-1.751	**
YEAR FIXED EFFECTS	YES		YES		YES		YES		YES		YES		YES		YES		YES		YES		YES		YES	
SECTOR FIXED EFFECTS	YES		YES		YES		YES		YES		YES		YES		YES		YES		YES		YES		YES	
Constant	10.948	***	9.629	***	24.146	***	10.245	***	10.966	***	9.382	***	10.180	***	10.269	***	11.694	***	9.172	***	25.577	***	11.698	***
N.	13378		13378		13378		13378		13378		13378		13378		13378		13378		13378		13378		13378	
Wald	1.85E+07	***	2.17E+07	***	1.15E+07	***	2.88E+07	***	2.49E+07	***	4.12E+07	***	4.08E+07	***	3.58E+07	***	2.48E+07	***	9.27E+07	***	1.63E+07	***	3.18E+07	***
m1 (pvalue)	0.000	***	0.000	***	0.000	***	0.000	***	0.000	***	0.000	***	0.000	***	0.000	***	0.000	***	0.000	***	0.000	***	0.000	***
m2 (pvalue)	0.039	**	0.031	**	0.015	**	0.030	**	0.033	**	0.030	**	0.039	**	0.028	**	0.027	**	0.035	**	0.021	**	0.031	**
m3 (pvalue)	0.865		0.896		0.229		0.843		0.997		0.752		0.541		0.727		0.920		0.593		0.402		0.838	
Sargan test (pvalue)	0.472		0.477		0.576		0.463		0.440		0.484		0.818		0.468		0.490		0.278		0.514		0.539	