Firm's Financial Conditions and the R&D-Export trade-off

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Abstract

This paper adds new empirical evidence on the relationships between financial constraints, exports and innovation at the firm level through an instrumental variable approach. The empirical analysis capitalizes on a representative and cross-country comparable sample of manufacturing firms (EFIGE) stemming across seven European countries (Austria, France, Germany, Hungary, Italy, Spain and UK). Results show a positive correlation between the financial health of a firm and its export activities, however not robust to the inclusion of total factor productivity (TFP) once endogeneity is properly controlled for. Financial constraints do not affect innovation activities, which tend to be internally financed by the firm. Although only TFP and R&D seem to drive the probability of exports, we find nevertheless that financial constraints can create a trade-off between the internationalization vs. innovation decisions of firms.

Key words: financial constraints, R&D, export, total factor productivity

JEL classification: F10, G20.

1. Introduction

A vast literature nowadays exists on the fact that firms' financial health matters for exporting activities (see for example Manova 2011 and 2013, Minetti and Zhu 2011 as well as the survey of Wagner, 2014). Along the same lines, starting from the papers by Aw et al. (2007 and 2011) there is evidence of a link between R&D activities of a firm and exporting as resulting from endogenous firms' choices that affect productivity (see Lileeva and Trefler 2010, Bustos 2011). And yet, while in principle the financial conditions of a firm should affect both its export as well as innovation decision, and possibly its productivity levels, these strands of literature have not been systematically explored together.

In our paper we exploit the availability of a very detailed set of information available for representative samples of manufacturing firms across seven European countries (the EFIGE survey) [1] in order to disentangle the potential relations between exports, R&D and financial constraints at the firm level, as mediated by Total Factor Productivity (TFP). In particular, our data offer the possibility to introduce novel instruments for R&D and the financial health of a firm, while controlling at the same time for past TFP levels and the export status. Moreover, we are able to control these effects in a cross-country context, thus purging these relations from unobserved heterogeneity stemming from country-specific institutional contexts.

Our results confirm the positive and significant correlation between the financial health of a firm and its export activities traditionally found in the literature. However, we find that this correlation is not robust to the inclusion of total factor productivity (TFP) once the endogeneity of the financial variable (ex-ante more productive firms tend to enjoy better financial conditions) is properly controlled for. We also find that financial constraints do not affect innovation activities, which tend to be internally financed by the firm. As far as exports are concerned, our IV specification shows that TFP and R&D jointly drive the probability of exporting.

Exploiting the variation across countries of the firms' response to the crisis, we also find that financial constraints can nevertheless create a trade-off between internationalization vs. innovation decisions: in fact, looking at some specific questions in the survey that track the reaction of firms to the 2008 demand shock, we find that on average high productive firms have been able to keep constant both exporting activities and R&D in the aftermath of the crisis (or better, have been able to reduce those to a lower extent than less productive firms), but in the countries where the credit crunch has been more severe (Italy and Spain) equally productive firms have experienced a trade-off between export and R&D activities.

We interpret these findings as evidence that, controlling for TFP, firms tend to raise external credit to finance the fixed costs of exports, while use internally generated cash flow to finance R&D activities. The emergence of (exogenous) credit constraints results in a drain of external finance that imposes a trade-off on the use of these internally generated flows, giving raise to potentially relevant allocative effects.

Section 2 of this paper provides a literature review on the known interrelations between our three variables of interest, namely financial health, TFP and R&D, on exports. Section 3 presents a description of the data sources and variables. The main empirical findings, together with the

[1] The EFIGE dataset is the first harmonized cross-country dataset containing quantitative as well as qualitative information on around 150 items for a representative sample of some 15,000 manufacturing firms in the following countries: Austria, France, Germany, Hungary, Italy, Spain, and the United Kingdom. These items cover international strategies, R&D, innovation, employment, financing and organizational activities of firms.

instrumental variables strategy, are described in section 4 while section 5 discusses some robustness checks. Section 6 concludes.

2. Literature review

The relationship between financial constraints and exports has been analysed in both directions. On the one hand, the literature agrees on the relationship from financing constraints to exporting as the origin of a self-selection mechanism generated by the costs associated to the export activities. Bellone et al. (2010) and Manova (2011) show how high sunk cost hamper financially constrained firms from participating to the international markets, while Manova (2013) studies how high variable trading costs negatively affects the intensive margin of export. Minetti and Zhu (2011) provide evidence that limited access to bank debt decreases firms' export. On the other hand, having access to the international market might imply a significant decrease in the financing constraints level of a firm. Exporters usually have an easier access to international financial markets, widening the possibility of credit supply they can rely on. Campa and Shaver (2002) show how, by exporting, firms operates in markets whose business cycles are perfectly correlated, increasing the probability of having more stable cash flows. This expectation of more stable future cash flows and the information signal from exporting activities can lessen the severity of credit constraints for exporters with respect to non-exporter.
The relationship between firm productivity and export is also traditionally studied in both ways. On the one hand, the effects of TFP on export activities stem from the self-selection of the most productive firms into exports theorized by Melitz (2003) and empirically shown in the pioneering work of Pavcnik (2002). The general finding of this nowadays vast literature is that only few, large and productive firms are productive enough to sustain the costs associated with a deepintegration in the global economy. On the other hand, a more limited number of works study the effects of exporting activities on productivity, or learning by exporting. This stream of literature, since De Loecker (2003), outlines how, under certain circumstances, higher international involvement can be associated to higher productivity levels of firms.
A circular link seems to exist as well between innovation and exporting. The works by Vanbeveren and Vandenbussche (2010), Cassiman and Golovko (2011) and Rubini (forthcoming) show how investments on innovation directly affects the probability of a firm's starting to export. As for the TFP case, evidence supporting the opposite direction of causality (from export to innovation) exists but is more scant (Salomon and Shaver, 2005; Damijan and Kostevc, 2010; Bratti and Felice, 2012). More in general, there is a growing consensus, however, that both innovation and exporting are the result of the endogenous choices of firms (Constantini and Melitz, 2008). Therefore, they are inextricably linked and their drivers are a priori unclear: firms may conduct innovation activity in anticipation of exports, or may start exporting after successfully innovating. In this case, innovation is a type of 'window-dressing', and part of the firm's preparation for embarking on export activity, which gives rise to an observed self-selection effect. Evidence from Canada collected by Lileeva and Trefler (2010) show that the export-innovation link might run both ways. Bustos (2011) finds supporting evidence for this effect in the case of Argentina and Mercosur.
Some authors have also started to combine some of the above mentioned channels in a more comprehensive framework

Aw, Roberts and Winston (2007) in particular analyze the relationship between TFP, R&D and export. On one hand they confirm the relevant literature in this field showing that export market participation exhibits persistence and is fundamentally related to firm-level variation in productivity due to self-selection. On the other hand, they find evidence to support that exporting firms benefit from technology that is transferred from foreign customers: firm's export market participation positively and significantly affect its future productivity, and this is particularly true if the firm

invests in R&D. On the same line, Aw, Roberts and Xu (2011) estimate a dynamic structural model of a producer's decision to invest in R&D and export, allowing both choices to endogeneously affect the future path of productivity. Both activities are found to have a positive effect on the plant's future productivity. They also find that sunk and fixed costs of investing in R&D are greater than the sunk and fixed costs of exporting, which results in a larger proportion of plants choosing to export than to conduct R&D[2].
Minetti and Zhu (2011) and Manova (2013) present the first attempts to jointly study the relationship between credit rationing, productivity and exporting activities. Both studies do not aim at setting up a comprehensive framework , having as a main focus the relation between financial constraints and exports, but productivity is nevertheless considered through control variables in the main specification or through robustness checks. Minetti and Zhu (2011) find the effect of credit rationing on exporting to loose completely its significance once the authors control for labor productivity. In Manova (2013), when controlling for physical capital per worker, the role of private credit interacted with asset tangibility[3] almost halve its role.

In the remaining of the paper, we set out to explore in detail the relationship of credit constraints, productivity, and innovation vs. the export activities of firms in a single framework.

3. Data and variables

Our main data source is the first survey on European Firms in a Global Economy (EFIGE). EFIGE is a research project, funded by the European Community's Seventh Framework Programme (FP7/2007-2013). The project aims at analysing the competitive performance of European firms in a comparative perspective. This dataset is the first harmonized cross-country dataset containing quantitative as well as qualitative information on around 150 items for a representative sample of some 15,000 manufacturing firms in the following countries: Austria, France, Germany, Hungary, Italy, Spain, and the United Kingdom. These items cover international strategies, R&D, innovation, employment, financing and organizational activities of firms, before and after the financial crisis.

The EFIGE survey covers a broad array of questions that allow us to address several crucial issues linked to the relation between credit rationing and ownership nature. Most questions relate to the year 2008, with some questions requesting information for the reaction of firms to the crisis in 2009/10 while other questions track the persistency of some variables in the years before 2008. The questionnaire has been administered between January and April 2010 via either CATI (Computer Assisted Telephone Interview) or CAWI (Computer Assisted Web Interview) procedures. The complete questionnaire is available on the EFIGE web page, www.efige.org. A discussion of the dataset is available in Barba Navaretti et al (2011), while Békés et al (2011) discusses explicitly the reaction of firms to the crisis as measured in the survey. Related to this paper, Altomonte et al. (2013) have used EFIGE data to monitor the relations between internationalization and innovation activities of firms.

An interesting characteristic of the EFIGE dataset is that, on top of the unique and comparable cross-country firm-level information contained in the survey, data can be matched with balance sheet figures. More precisely, EFIGE data has been integrated with balance-sheet data drawn from the Amadeus database managed by Bureau van Dijck, retrieving nine years of usable balance-sheet

[2] Some literature also focused on the relation between financial constraints and R&D, however without reaching a conclusive evidence. Some works, for example Czarnitzki and Hottenrott (2009), have found that internal sources of funds are more important for R&D than for ordinary investment, while Mulkay et al. (2001) have found that R&D investment is sensitive to financial constraints, but not significantly more than ordinary investment. Mancusi and Vezzulli (2013) found that credit rationing has a significantly negative effect on both the probability to set up R&D activities and on the level of R&D spending, while Bond et al. (2005) find that R&D may not be sensitive to external financial constraints.
[3] Asset tangibility records the share of net property, plant and equipment in total book-value assets, averaged over 1986-1995 for the median firm in each industry.

information for each surveyed firm, from 2001 to 2009. This data in particular enable the calculation of firm-specific measures of productivity and a number of financial health indicators, measured over time.

The EFIGE dataset includes about 3,000 firms operating in Germany, France, Italy and Spain, some 2,200 firms in the United Kingdom, and about 500 firms for Austria and Hungary, as reported in Table 1 below.

Table 1- EFIGE sample size, by country

Country	Number of firms
Austria	443
France	2973
Germany	2935
Hungary	488
Italy	3021
Spain	2832
United Kingdom	2067
Total	14759

The sampling design follows a stratification by industry, region and firm size structure. Firms with less than 10 employees have been excluded from the survey, that instead presents an oversampling of larger firms with more than 250 employees to allow for adequate statistical inference for this size class. Detailed information on the distribution of firms by country/size class and industry can be retrieved on the EFIGE website (http://www.bruegel.org/datasets/efigedataset).

In order to take into account the oversampling and to retrieve the sample representativeness of the firms' population, a weighting scheme (where weights are inversely proportional to the variance of an observation) is set up according to firm's industry and class size. All our regression results are thus computed by taking into account this weighting scheme, except where otherwise specified.

In terms of validation, it is possible to compute the correlation over time (2001-09) between some firms' characteristics aggregated (with proper weights) at the country level from the EFIGE representative sample vs. official statistics provided by Eurostat (Structural Business Statistics for manufacturing firms >10 employees). The correlations reported on the EFIGE website are significant and range between .6 and .85 per cent on average when considering the number of employees, the cost of labor or the value of labor productivity.[4] Some dispersion exists across countries, due to a different quality of the available balance sheet data retrieved from Amadeus. For this reason, in what follows we will always control for country fixed effects when presenting our econometric results.

We now move to describe the variables used in our analysis.

3.1 Total factor productivity

Thanks to the availability of linked balance sheet data, it is possible to calculate Total Factor Productivity for each firm for the period 2002-2009.

In order to calculate TFP, we run separately for each sector (using the NACE Rev.2 two digit classification) the Levinsohn and Petrin (2003) semi-parametric production function estimation algorithm, controlling for country and year fixed effects. As in Altomonte et al. (2013), variables

[4]The weighting scheme as well as other technical information on the construction of the dataset and its validation with respect to official statistics can be retrieved in the EFIGE User Manual available on the EFIGE website as well as Bruegel Working Paper 753/2012 at http://www.bruegel.org/publications/publication-detail/publication/753-the-eu-efigebruegel-unicredit-dataset/.

included in the estimation of the production function are: value added, deflated using industry-specific (NACE rev 1.1) price indexes retrieved from Eurostat, as a proxy for outcome; number of employees, as a proxy for labour input; value of tangible fixed assets deflated using the GDP deflator, as a proxy for capital; material costs, deflated by average industry-specific Producers Price Indexes weighted by input-output table coefficients.

Given the scope of the paper, with respect to the traditional algorithm by Levinsohn and Petrin (2003), we have also introduced an additional control in our TFP estimation routine, and namely the fact that ex-ante financially constrained firms might endogenously differ in their input choices, thus biasing our measure of productivity.

To control for this potential bias, we have retrieved for each firm an indicator of potential financial constraint traditionally used in the finance literature as suggested by Whited and Wu (Whited and Wu, 2006), defined as follows:

$$\mathrm{WW} = -0{,}091\mathrm{CF} - 0{,}062\ \mathrm{DIV\ POS} + 0{,}021\ \mathrm{TLTD} - 0{,}044\ \mathrm{LNTA} + 0{,}102\ \mathrm{ISG} - 0{,}035\ \mathrm{SG}$$

where CF is Cash Flow / Total Assets), DIV POS =1 if paid cash dividends), TLTD is long term Debt / Total Assets), LNTA is the log of Total Assets ISG is the industry sales' g0rowth while SG is a firm's sales growth). We have then assigned each firm to a given quartile of the WW distribution (calculated for the entire period 2001-2009), so as to create an additional fixed effect to be included (together with *country* and *year*) in the TFP estimation procedure. Unlike Kaplan and Zingales (1997), the Tobin's q is not included in our index. This choice stems from the evidence in Erickson and Whited (2000) that Tobin's q contains a great deal of measurement error in its role as a proxy for investment opportunities. Instead, we include sales growth and industry sales growth to capture the intuition that only firms with good investment opportunities are likely to want to invest enough to be constrained. The idea is to identify these firms as belonging to high-growth industries but as having low individual sales growth. A detailed description of the WW index estimation as well as descriptive statistics are available in the appendix.

As a result of this additional control, the power of our regressors increases and thus, in principle, the error term (namely, our TFP) should decrease. However, at the same time the control for ex-ante more financially constrained firms allows us to estimate with less distortions the production function. Specifically, if a firm is financially constrained but has obtained the observationally equivalent level of predicted output of a non-financially constrained firm, the latter implies that the same firm should end up in having a larger TFP. And in fact, as expected, the retrieved new TFP measure (from now on, *Ntfp*) is shifted to the right with respect to the old TFP distribution. A T-test confirms that the two distributions are significantly different in their first moment (p-value=0.000), but with an almost identical shape.

In Table 2 we provide descriptives for the Ntfp distribution by country and size class in 2008.

Table 2- Ntfp mean distributions by country and size class, 2008

	Size Class			
Country	1	2	3	4
Austria	0.646	-0.531	0.094	0.622
France	-0.205	-0.124	-0.030	0.083
Germany	-0.206	-0.110	0.010	0.229
Hungary	-0.290	-0.212	0.043	0.178
Italy	-0.313	-0.176	0.045	0.317
Spain	-0.250	-0.133	0.064	0.332
United Kingdom	-0.388	-0.162	-0.075	0.004

3.2 Financial variables

The way financial constraints are measured is strongly debated in the literature. Theory offers only limited guidance in this area, and hence there is no clear-cut consensus on the best variable to use empirically to this extent , as also emerging from the empirical survey of Wagner (2014).
The latter is also due to the noise with which some of the variables related to credit constraints are measured. In the EFIGE sample firms are directly asked whether they have applied for credit over the last year and whether the request was successful. However answers are available for this question only for 1989 firms, i.e. less than 15 per cent of the sample. Moreover, the i variable is weakly related to other standard measures of financial stress as retrieved from balance sheet information (such as Leverage and Liquidity Ratios and Index of Financial Pressure).

For this reason, and for the above considerations concerning the complexity in measuring the credit constraints level of a firm, we focus our analysis on an indirect index that allows us to exploit to a larger extent our sample of firms and better exploit the richness of the data at hand. In particular we measure the financial soundness of a firm through a combination different elements: the indebtness ratio of the firm (the ratio between non-current liabilities and total assets), its interest repayment ability (the ratio between cash flow and interest paid) and the previously discussed Whited and Wu index (2006). Considering that these variables measure different aspects of potential financial constraints, but are highly correlated (due to overlapping information content), we have used a principal component approach to calculate the load factors of each underlying variable, retrieving a synthetic index of *financial health (FH)* for each firm. The index has a straightforward interpretation: the higher the FH factor, the financially healthier the firm.

Table 3 - Financial Health factor component descriptive by country, 2008

	WWr	Indebtness	Interest repayment ability
Austria	0.848	0.678	90.479
France	0.676	0.602	29.157
Germany	0.764	0.685	29.783
Hungary	0.652	0.592	31.866
Italy	0.691	0.715	22.570
Spain	0.675	0.629	19.688
United Kingdom	-	0.615	51.051

3.3 Innovation and export variables

Information on firm's R&D activities and export are directly provided by the EFIGE questionnaire.
In line with the previously quoted studies that use this variable from EFIGE, we define a dummy variable *R&D* assuming value one for those firms that declare having had a positive number of employees involved in R&D activities in 2008.
We set a dummy variable *EXP* which is equal to one if, in 2008, the firm sold abroad directly from the home country some or all of its own products/services.
The following tables provide some descriptive statistics for these variables. As we can observe in Table 4, both the percentage of exporters and R&D investing firms grow with TFP. Note that both the percentage of exporters and R&D investing firms grow also with size for all countries (see Appendix A.3).[5]

[5] Similar trends are identified for export by OECD national statistics.

Table 4 – Percentage of firms exporting and investing in R&D by TFP quartiles, 2008

	% firms EXP	% firms R&D
1° TFP quartile	53	51
2° TFP quartile	55	59
3° TFP quartile	60	62
4° TFP quartile	68	68

3.4 Control variables

The effects of firms' size on TFP, export, R&D and financial constraints have been widely discussed in the literature (see for example Hadlock and Pierce, 2010). We introduce this control in the form of a categorical variable *SizeClass*, varying from 1 to 4. Firms with a number of employees between 10 and 19 are assign value 1 for the variable *SizeClass*, value 2 is assigned to firms with 20-50 employees, to firm with 50-249 employees we assign value 3 and to firms with more than 250 employees we assign value 4. The choice of a categorical variable is driven by the willingness of reducing the possible endogeneity with TFP, export activity and R&D. All our results are confirmed if we substitute the natural log of the number of employee, in the analysis section *log(employees)*, to the variable *SizeClass.*

Manova (2012) has also pointed out the importance of two additional variables that may impact firms' access to finance and other variables of interest in our framework. First, *asset tangibility*, which captures the extent to which a firm operates with fixed tangible assets, computed as tangible fixed assets over total assets. We compute this first variable from Amadeus for each firm, and then we create a categorical variable (varying from 1 to 4) showing the quartile where the firms stands with respect to the *asset tangibility* distribution. The second variable, *financial vulnerability*, captures the extent to which a firm relies on outside capital for its investment, it is computed as the share of capital expenditure of firms not financed with cash flows from operations. This second variable, defined at sector-level and averaged over time to avoid endogeneity issues, is retrieved from Manova (2012)..
In addition, all our analysis are computed using *country dummy variables*.

4. Empirical findings

In this section we describe our empirical analysis. We first show the different channels relating our variables of interest, namely FH, TFP, R&D and EXP, without controlling for any kind of endogeneity between them. We then propose an instrumental variable approach to solve the endogeneity issues which appear in the first section. The remaining of the paragraph presents the main IV results of our estimations.

4.1 Relations between FH-TFP-R&D-EXP

The first step of our analysis consist in studying the unconditional correlations between our three variables of interest (always controlling for our country / sector vulnerability / asset tangibility dummies as well as the size class of the firm). Table 5 in particular shows three main stylized facts:

- *R&D* and *Financial Health* are strongly correlated to the productivity level of a firm (column 1);
- *Financial Health* turns out to be not significantly correlated with *R&D*, while *Ntfp* is strongly correlated to the innovation activities of the firm (column 2);
- In turn, financial conditions are correlated with TFP, but not with innovation activities (column 3).

These preliminary results are consistent with the idea that ex-ante more productive firms tend to enjoy better financial conditions, but their R&D activities tend to be internally financed. However, it is clear from the detected cross-correlations that there could exist some endogeneity between our variables of interest. The way to solve it is through an instrumental variable approach, which is described in the next section.

Table 5 - Relations between FH-TFP-R&D

	(1)	(2)	(3)
	ols	probit	probit
Dependent variable	Ntfp	R&D	FH
R&D	0.0267***		-0.00250
	(0.00997)		(0.0314)
Financial Health	0.0933***	0.00276	
	(0.00502)	(0.00936)	
Size Class	0.123***	0.0986***	0.0136
	(0.00692)	(0.0123)	(0.0218)
Ntfp		0.0698**	1.044***
		(0.0313)	(0.0497)
Constant	0.428		
	(0.463)		
Observations	3,599	3,793	3,885
Country dummy	YES	YES	YES
Sector vulnerability dummy	YES	YES	YES
Asset tangibility dummy	YES	YES	YES

4.2 Instrumental variables

From the previously reviewed literature we know that some of the previous coefficient estimates of TFP, R&D and exports are potentially biased due to reverse causality affecting regression estimates, hindering the proper interpretation of the regression coefficients[6]. Moreover, a firm's financial health seems to be positively correlated with both the TFP measure and the probability of export, but only to the extent that TFP is not controlled for in the latter regression, also signalling a potential endogeneity problem. In fact, financially healthier firms have the opportunity to heavily invest both in physical capital (machinery, equipment etc.) and organizational capital that can increase a firm's productivity. At the same time, a firm's productivity levels are potentially determining its economic health causing in this way the reverse causality problem.

In order to solve these endogeneity issues , we have exploited the richness of our data and have built instruments for the three regressors of interest, namely *FH, TFP* and *R&D.*

[6] The reverse causality issue can be potentially found between R&D and TFP, TFP and exports and R&D and exports. See literature review for details.

Financial health is instrumented through a synthetic factor based on two variables that should impact productivity only through their correlation with the financial status of the firm.

The first item considered is the stability of a firm's relationship with its main bank. Specifically, firms were asked the length in years of the relationship with their main bank:[7] we have then created a dummy variable that takes the value of 1 if the relationship with the main bank is stable, i.e. the relationship has a length above the average of the variable distribution in our sample. The idea is that a long lasting relationship with the main bank is a signal of both ex-ante better financial shape of a firm (the bank keeps the firm as a client) as well as of the ability of a firm to access financial resources at better conditions (the bank has less informational asymmetries in providing credit), giving the same firm the possibility to invest more in physical and intangible assets, and thus improve productivity. In this sense, a stable financial relationship with the firm's main bank should affect the same firm's TFP only through the impact that this stable relation has on a firm's financial health, and thus is a good candidate for an instrument.

The second item taken into account refers to some of the activities undertaken by the firms in order to invest on its human capital. In particular, we focus on the percentage of employees who have participated to formal training programs in 2008.[8] Of course firms invest in formal training programs in order to improve the skills of their employees with the aim to ultimately increase their productivity. However, and crucially for our exogeneity condition, there is evidence that only firms that have strong financial fundamentals are able to implement formal and extensive training programs, due to the nature of their costs. For these reasons, we have created a dummy variable taking the value of 1 for firms whose percentage of employees who have participated to formal training programs in 2008 is above the average of our sample distribution, thus identifying firms that are heavily involved in organizing formal training programs. In this case it is plausible to assume that the impact of extensive training programs on TFP only goes through the firm's financial health variable, once country and industry fixed characteristics are controlled for

We then generate our synthetic instrument based on the values taken by the two dummies previously defined. The variable takes the value of 0 if both dummies are equal to zero. It is 1 if only one of the two dummies takes the value of one, while if both dummies are equal to one the variable takes the value of 2.

In the first stage of our IV panel specification, we also add as an additional instrument the fourth lag of a firm's financial health, in order to avoid contemporaneous autocorrelation with the TFP measure, which enters in our main specification with a three year lag (to avoid in turn contemporaneous correlation with the export status).

The second instrument we build is used to tackle the potential endogeneity issues linked to the use of a firm's R&D activity as a firm-level regressor in an export equation. As the entire literature on "learning by exporting" shows, R&D activities not only affect the probability of export of a firm, but also the other way round. In order to tackle this endogeneity issue which could bias our estimations, we instrument the *R&D* variable with two instruments.[9]

The first instrument is an in-sample variable indicating the share of *other* firms doing R&D activities in the same region of the considered firm (defined at the NUTS-2 level of territorial aggregation as defined by Eurostat). We expect a positive correlation between this instrument and the R&D variable via the presence of geographically concentrated knowledge that spills over across

[7] The EFIGE variable taken into account is F11: *"For how many years has this bank been the firm main bank?"*
[8] The EFIGE variable taken into account is B22: "*In 2008 what percentage of employees have participated to formal training programs?*"
[9] It is well known that *R&D* positively and significantly affects *TFP* levels, and the same is true in the opposite direction. As our focus is their joint impact on the export activities of firms, we are not interested in claiming any direction of causality among these two variables.

firms. In theory, it is also possible that an external context favourable to innovation directly affects the probability of exporting of a firm, on top of the impact this has on R&D. However, this is likely to be driven by country and, most importantly, industry specific effects that are in any case controlled for in the analysis (see infra).

The second instrument we use is an out of sample proxy for R&D intensity computed from OECD data, as the share of investment in R&D over the value added of a given (NACE 2 digits) industry and country for the years 2002-2006. The idea is to capture the general (past) R&D intensity of a specific country/industry cell to which a given firm belongs. Altomonte et al. (2013) use this instrument on EFIGE data and show how this variable is positively correlated to contemporaneous R&D activities, as it proxies the likelihood of an average firm belonging to a given country/industry pair to engage in research activities, but weakly correlated with contemporaneous internationalization choices of firms.

We also experiment in some specifications with an alternative instrument coming directly from the EFIGE survey, namely whether the firm has claimed a copyright in the past three years.[10] The idea is again that, as for the R&D intensity, the claim of a copyright in the past signals the likelihood of an average firm to engage in research activities, with the same variable being however weakly correlated with contemporaneous internationalization choices.

Finally, we turn our attention towards instrumenting TFP by simply using the three-year lagged firm-level variable, with the aim to avoid autocorrelation with the R&D measure and the FH factor given the panel structure of our data.[11]

The first stage regressions reported in Annex for the three variables of interest confirm that the chosen instruments are significant at any statistical conventional level and with the expected coefficient. The F-test statistic is always much above the conventional critical level of 10, signalling the strength of the instruments and the efficiency of our estimations.

4.3 Main specification

The results of the cross-sectional exporters regression are reported in Table 6. We first report standard panel probit export regressions where our variables of interest are progressively added as independent variables, while in the last column we include the second stage of our panel IV regression on exports, with TFP, R&D and FH jointly considered.

In line with the literature, exporting is driven by firm-level productivity (column 1), a result robust to the inclusion of firm size (column 2). Results show that the probability to export rises when firm are bigger and with higher productivity.

In columns (3) and (4) we add the financial variable and then TFP to the export equation. We can notice the lack of significance of the financial variable on export once TFP is controlled for. Moreover R&D, as expected, has a positive and significant effect on EXP (column 5), without affecting the other results.

Importantly, these results are confirmed in the IV specification. Column (6) is our main baseline specification, where we instrument *Ntfp, FH factor* and *R&D*. The first stage F-statistics suggest that instruments are relevant (see Table 11 in Annex A.4 for the results of the first stage) while the

[10] The EFIGE variable taken into account is the C17_m_c4: "In the last three years (2007-2009) the firm claimed copyright", possible answer Yes/No
[11] Experimenting with the second or the fourth lag of TFP yielded similar results in terms of power of the instrument.

Hansen J-statistic has a p-value well above the significance level, thus confirming also the exogeneity of our instruments.

These results confirm our intuition that the positive and significant correlation between the financial health of a firm and its export activities traditionally found in the literature might not be robust to the inclusion of total factor productivity (TFP), once the potential endogeneity of the financial variable (ex-ante more productive firms tend to enjoy better financial conditions) is properly controlled for: 12 more productive firms are both able to export more and to enjoy better financial conditions.

As far as exports are concerned, our IV specification shows instead that TFP and R&D jointly drive the probability of exporting.

Table 6 - How to get to the Main Specification

	(1)	(2)	(3)	(4)	(5)	(6)
	probit	probit	probit	probit	probit	ivreg
Dependent variable	EXP	EXP	EXP	EXP	EXP	EXP
Ntfp	0.160***	0.0863***		0.143***	0.134***	0.110**
	(0.0144)	(0.0152)		(0.0337)	(0.0338)	(0.0493)
Size Class		0.117***	0.114***	0.1000***	0.0847***	0.0577***
		(0.00733)	(0.0125)	(0.0152)	(0.0147)	(0.0143)
Financial Health			0.0324***	0.00588	0.00555	0.0217
			(0.00837)	(0.00920)	(0.00934)	(0.0145)
R&D					0.197***	0.331***
					(0.0234)	(0.0715)
Observations	8,307	8,307	4,517	3,793	3,793	3,015
R-squared						0.056
Country dummy	YES	YES	YES	YES	YES	YES
Sector vulnerability dummy	YES	YES	YES	YES	YES	YES
Asset tangibility dummy	YES	YES	YES	YES	YES	YES
HansenJ test of Identification						0.231
First stage F-test for instruments						
Ntfp						187
Financial Health						191
R&D						45

In (6) we instrument:

* *Ntfp*, with its t-3 value;

Financial Health, with a categorical variable assuming value 2 if the firm has a long-lasting relation (>50th percentile of bank-duration-relation distribution) with its main bank and it offered training programs for a significant (>50th percentile of %employees-trained distribution) share of employees, value 1 if either the first or the second condition holds, value 0 if neither of the two conditions is present. We also add the t-4 value of the variable, to avoid simultaneous correlation with the Ntfp's lag;

* R&D, with a dummy indicating if the firm in the last three years claimed a copyright and the share of other firms doing R&D activities in a given firm's region.

4.4 Credit constraints and the R&D-export financing trade-off

The first implication of this new set of results on the relationships between TFP, R&D and financial variables with respect to the export activities can be studied by looking at the reaction of firms in countries where the credit crunch has been particularly severe.

[12] Minetti and Zhu (2011) also find this lack of significance of the financial variable when they control for labour productivity in their specification.

Based on our results, our conjecture is that firms use the financial resources obtained thanks to their productivity level (Table 5, col. 1 and 3) to finance their costs of exporting (comparing column 4 with column 6 in Table 6), while they use only internally generated funds to cover the costs of their innovation activities (Table 5, col. 2 and 3).

If this is true, then in countries hit by an exogenous financial shock leading to a credit crunch, and thus less external financial resources available to firms, we should find that equally productive firms start facing a trade-off in financing their innovation vs. their export activities.

To test for the latter implication, we have looked at a direct question raised in the EFIGE survey, asking whether, during 2009 the firm has decided to postpone investments in innovation activities ". At the same time, we have created a variable, namely *Increased or constant Export*, indicating if during 2009 the firm kept constant or increased its value of export with respect to 2008.[13] We have then defined as credit crunched countries Italy and Spain, creating the dummy variable *Stress Countries*.

In Table 7 we have then regressed the probability of having reduced innovation in 2009 on the TFP and the financial condition of the firm, and on whether the firm, in the same period, has avoided decreasing exports. Not surprisingly, more productive and financially healthy firms are less likely to reduce innovation during the crisis. The negative and significant coefficient of the *Increased or constant Export* variable also underlines the fact that, on average across countries, firms able to keep exporting during the crisis are also less likely to reduce their investments in innovation.

However, when we interact our dummy for the countries experiencing a credit crunch with the *Increased or constant Export*, we find a positive and significant sign, i.e. the fact that firms maintain their export operations is positively associated, in these countries, with an *increase* in the probability of reducing innovation In other words, in countries where credit has been particularly crunched, firms have been less able to keep exporting and investing in innovation at the same time during the crisis. The emergence of (exogenous) credit constraints thus results in a drain of external finance that imposes a trade-off on the use of these internally generated flows, giving raise to potentially relevant allocative effects.

Table 7 - Stress Countries analysis

Dependent variable	probit Reduced Innovation
Ntfp	-0.100***
	(0.0286)
Financial Health	-0.0196**
	(0.00911)
Stress Countries	0.0517
	(0.0335)
Increased or constant Export	-0.168***
	(0.0367)
Stress Countries * Increased or constant Export	0.0992**
	(0.0403)
Observations	3,786
Sector vulnerability dummy	YES
Asset tangibility dummy	YES

[13] This is another EFIGE question: "During 2009, did you experience a reduction or an increase in terms of value of your export activities in comparison with 2008?" with possible answer: "Yes, an increase of …" or "Yes, a decrease of …" or "No, we did not experience any change".

5. Robustness checks

In this section we provide a robustness check for each of the key variables used in the work.

In specification (1) of Table 8 we substitute the second instrument used for *R&D* in our baseline equation (copyright) with the R&D intensity at the country-industry level derived from the OECD. All our results are confirmed, showing that they are not instruments-specific.

Other checks are devoted to control the robustness of our results using a specific subsample of our EFIGE dataset. The availability of firm's balance sheet data from Amadeus database varies significantly among countries and the latter could induce a non-random sample selection which could influence our results. In particular, three countries (France, Italy and Spain) display a significant percentage of surveyed firms with non-missing balance sheet information, and an overall correlation with aggregate Eurostat variables above 90 per cent.. Thus, in specification (2) we restrict our analysis to these countries. Our results are confirmed with this specification, and are also robust to the adding of age as an additional firm-level control, as outlined in specification (3).

Table 7- Robustness checks on R&D variable and Main Specification

		Robustness checks			
		(1)	(2)	(3)	(4)
Dependent: Prob(Exp=1) in year 2008	Baseline Specification	out of sample instrument for R&D	only ITA, SPA, FRA	only ITA, SPA, FRA and control for Age	Excluding only-EU28 exporters (verifying Aghion evidence)
Ntfp	0.110**	0.112**	0.107**	0.115**	0.118**
	(0.0493)	(0.0489)	(0.0507)	(0.0508)	(0.0589)
Size-Class	0.0577***	0.0619***	0.0557***	0.0536***	0.0786***
	(0.0143)	(0.0147)	(0.0145)	(0.0143)	(0.0165)
Financial Health	0.0217	0.0217	0.0206	0.00999	0.0267
	(0.0145)	(0.0145)	(0.0147)	(0.0148)	(0.0170)
R&D	0.331***	0.313***	0.342***	0.302***	0.390***
	(0.0715)	(0.0757)	(0.0721)	(0.0728)	(0.0812)
lnAge				0.0761***	
				(0.0153)	
Observations	3,015	2,951	2,942	2,937	2,075
R-squared	0.056	0.062	0.050	0.070	0.092
Country dummy	YES	YES	YES	YES	YES
Sector vulnerability dummy	YES	YES	YES	YES	YES
Asset tangibility dummy	YES	YES	YES	YES	YES
HansenJ test of Identification	0.231	0.103	0.265	0.123	0.0923
First stage F-test for instruments					
Ntfp	187	187	179	178	175
Financial Health	191	191	186	176	146
R&D	45	38	44	43	32

In Main Specification we instrument:

* *Ntfp*, with its t-3 value;
* Financial Health, with a categorical variable assuming value 2 if the firm has a long-lasting relation (>50th percentile of bank-duration-relation distribution) with its main bank and it offered traingings program for a significant (>50th percentile of %employees-trained distribution) share of employees, value 1 if either the first or the second condition, value 0 if neither of the two, together with its t-4 value, to avoid dimultaneous correlation with the Ntfp's lag;
* R&D, with a dummy indicating if the firm in the last three years claimed a copyright and the share of firms doing R&D activities in firm's region.

In (1) we substitute the copyright instrument for R&D with a OECD variable measuring the percentage of R&D investment over GDP, on a country-year-sector basis.

In (2) we restrict our sample to only Italy, Spain, France.

In (3) we add a year control on restricted sample specification (2).

In (4) we check the Aghion evidence (innovation is less important in more competitive markets) by excluding from our sample only-EU28 exporters. T-test between R&D coefficients in Main Specification and specification (4): t=-27.36 (p-value=0.000).

In specification (4) we restrict our analysis to firms which export also outside the EU-28, i.e. we compare large global exporters to domestic firms, thus excluding firms that only export in the EU. All our main results are confirmed also on this sample, in which we observe a stronger role of innovation on export (a coefficient of .39 vs. .33 in the baseline, significantly different: T-test with t=-27.36 and p-value=0.000). This might be consistent with evidence presented by Aghion et al. (2005) showing how, in markets less dominated by strong Schumpeterian competition and more by neck and neck competing incumbents (as the export markets outside the EU are likely to be), innovation is relatively more important.

Furthermore, we have also experimented with different proxies of our variables of financial health and TFP. For financial health, we have used the main loading factor of this variable, namely indebtedness, as well as different lag structures in its instrument. Results do not change. For TFP, we have used the standard Levinsohn and Petrin (2003) measure (i.e. not corrected for the sample selection induced by credit constraints), as well as labor productivity (added value per employee). Again the main findings are confirmed. [14]

6. Conclusions

In this paper we exploit the availability of a very detailed set of information available for representative samples of manufacturing firms across seven European countries (the EFIGE survey) in order to disentangle the potential relations between exports, R&D and financial constraints at the firm level, as mediated by Total Factor Productivity (TFP).

In particular, our data offer the possibility to introduce novel instruments for R&D and the financial health of a firm, while controlling at the same time for past TFP levels and the export status. Moreover, we are able to control these effects in a cross-country context, thus purging these relations from unobserved heterogeneity stemming from country-specific institutional contexts.

Our results confirm the positive and significant correlation between the financial health of a firm and its export activities traditionally found in the literature. However, we also find that this correlation is not robust to the inclusion of total factor productivity once the endogeneity of the financial variable (ex-ante more productive firms tend to enjoy better financial conditions) is properly controlled for.

Access to finance by firms is however a potentially very important variable in terms of its allocative effects. In fact, in countries where credit has been particularly crunched, we find that firms have been less able to keep exporting and investing in innovation at the same time during the crisis. The emergence of (exogenous) credit constraints thus results in a drain of external finance that imposes a trade-off on the use of these internally generated flows, giving raise to potentially long-term negative effects for the growth of these firms.

In this sense, proper access to credit might represent, although indirectly, an important driver of the ability of a firm to innovate, and thus to grow.

[14] All these results are available upon request.

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Appendix

A.1 Withed and Wu index estimation

The estimation of the index is obtained with a GMM estimation, using firm-level data from the quarterly, 2002 Standard and Poor's COMPUSTAT industrial files. The authors selected the sample by first deleting any firm-year observations with missing data or for which total assets, the gross capital stock, or sales are either zero or negative. To eliminate coding errors, the authors deleted any firm for which reported short-term debt is greater than reported total debt or for which reported changes in the capital stock cannot be accounted for by reported acquisition and sales of capital goods and by reported depreciation. Another deletion concerned any firm that experienced a merger accounting for more than 15% of the book value of its assets. Firms whose primary SIC classification is between 4900 and 4999 or between 6000 and 6999 were omitted, since the investment model proposed in their paper is inappropriate for regulated or financial firms. Authors only included a firm if it has at least eight consecutive quarters of complete data and if it never has more than two quarters of negative sales growth. This last criterion is important considering we are interested in identifying firms that face external finance constraints rather than firms that are in financial distress.
These screens finally propose an unbalanced panel between 131 and 1390 firms per quarter. The sample period runs from January, 1975 to April, 2001. According to the main literature on this field, the Whited and Wu paper outlines that firms deemed constrained by they index are small, underinvest, have low analyst coverage, and do not have bond ratings. In contrast, firms deemed constrained by the KZ index are large, overinvest, have high analyst coverage, and have a markedly higher incidence of bond ratings than the population of firms as a whole.

As said before, Whited and Wu index is defined as:

$$\mathrm{WW} = -0{,}091\mathrm{CF} - 0{,}062\ \mathrm{DIV\ POS} + 0{,}021\ \mathrm{TLTD} - 0{,}044\ \mathrm{LNTA} + 0{,}102\ \mathrm{ISG} - 0{,}035\ \mathrm{SG}$$

where CF is Cash Flow / Total Assets), DIV POS =1 if paid cash dividends), TLTD is long term Debt / Total Assets), LNTA is the log of Total Assets ISG is the industry sales' g0rowth while SG is a firm's sales growth).

In our analysis we need to instrument the DIV POS variable, because only 5% of our firms are listed firms. Data on dividends are so obtained with two different approaches (Mancusi and Vezzulli, 2010). In the first approach, we instrument the dividend dummy with capital, creating a variable which is 1 if the value of the firm's capital at time *t* is lower than the value of capital at time *t-1* plus their profit at time *t*. The second approach consists in carrying out the same procedure, but substituting capital with net asset (defined as total assets minus liabilities). Concerning the ISG variable, we evaluate it dividing for country, year and sector (using *nace revision 1*, two digit). Now we have two different indexes, one using capital as instrument for the DIV POS variable, and another one using net asset. However, the correlations between these two indexes result to be very high (0.9911), therefore from now on we will refer only to the *WW* index. To ease the legibility of the index (that in the original specification was higher for those firms displaying a higher level of financial constraints) we shift the values in the range 0-1 and invert the order, obtaining the *WWr* index. The way to read this index is: the higher the index, the financially healthier the firm. Note that 0 is just a theoretical minimum, since the lowest observed value is approximately 0.40.

Considering the large number of missing values (around 9000), we test the predictive power of our index in different ways, to ensure it against possible selection bias effects. We can observe that the index is statistically different in size, percentage of exporters and percentage of R&D investing

firms. We can explain it considering the fact that out of the seven countries we are collecting our data from (France, Austri, Hunghery, Germany, Italy, Spain, United Kingdom), a high percentage of financial variables are missing for Austria, Germany, Italy and Hunghery. These countries are all characterized by bigger firms, higher percentage R&D intensive firms with respect to France, Italy, Spain. Than we control for country specific bias, finding that there is no statistical difference in our subsample between those firms for which we can evaluate the indexes and those for which we have a missing value.

A.2 Additional descriptive statistics

Table 8 - Export and R&D descriptives by Country and Size Class,2008

	Size Class 1		Size Class 2		Size Class 3		Size Class 4	
Country	%EXP	%R&D	%EXP	%R&D	%EXP	%R&D	%EXP	%R&D
Austria	53	39	52	58	84	77	87	80
France	40	47	52	56	69	72	84	86
Germany	35	57	46	68	62	79	67	91
Hungary	47	17	57	28	71	34	93	44
Italy	60	41	69	55	84	68	94	83
Spain	43	52	57	63	73	71	84	82
United Kingdom	53	56	58	60	73	68	77	69

A.3 Instrumental variables

TFP is instrumented with its *t-3* value, to avoid persistency issues;
FH is instrumented through:

- a categorical variable assuming
  - value 2 if the firm has a long-lasting relation (>50th percentile of bank-duration-relation distribution) with its main bank and it offered trainings program for a significant (>50th percentile of %employees-trained distribution) share of employees,
  - value 1 if either the first or the second condition,
  - value 0 if neither of the two,
- its *t-4* value (in order to avoid contemporaneous effects with the *t-3* lag of the *TFP* variable)[15];

R&D is instrumented with:

- dummy indicating if the firm in the last three years claimed a copyright (direct question in EFIGE survey)
- the share of firms doing R&D activities in your region[16], computed as

$$\frac{(number\ of\ firms\ doing\ R\&D\ in\ the\ firm\ region - 1)}{total\ number\ of\ firms\ in\ the\ firm\ region}$$

[15] If this setting seems to be ad-hoc, note that our results are robust also bringing both the lag of *TFP* and *FH* to their *t-4* values.
[16] Our results are robust also substituting the variable on copyright with a OECD variable measuring the percentage of R&D investment over GDP (country-year-sector)

A.4 Fist stage regressions

We present here the first stages of our IV estimation (column 6 in Table 6).

Table 9- First-stage regressions

	(1)	(2)	(3)
Dependent variable	Ntfp	Financial Health	R&D
Size Class	0.050***	-0.061***	0.085***
	(0.0061)	(0.3053)	(0.123)
Ntfp $_{t-3}$	0.613***	0.305***	-0.000
	(0.0305)	(0.0493)	(0.0295)
Share of firms doing R&D activities in firm's region	0.069***	-0.052	0.588***
	(0.01993)	(0.0538)	(0.0443)
The firm in the last three years claimed a copyright	-0.009	0.053	0.245***
	(0.0257)	(0.1510)	(0.0531)
Categorical variable for lenght of relation with main bank	0.009	0.045**	0.054***
	(0.0055)	(0.0152)	(0.0139)
Financial Health $_{t-4}$	0.031***	0.806***	0.004
	(0.0061)	(0.0285)	(0.0110)
Observations	3015	3015	3015
R-squared	0.561	0.594	0.084
First stage F-test for instruments	186	191	45