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Financial constraints and intangible investments. Do innovative and non-innovative firms differ?

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Abstract

We investigate the extent to which financial constraints hamper the firms' investment in intangibles. Drawing on the extant literature, we maintain that a distinction should be kept between innovators and non-innovators. Moreover, we argue that such a distinction should be investigated along the whole spectrum of intangibles firms invest and by addressing the risks of reverse causality and simultaneity bias in the relationship. Through an original quasi-panel extension of a recent European Innobarometer survey, we estimate two sets of recursive bivariate probit models – for innovative and non-innovative firms' investments – from which interesting results emerge. Financial barriers hamper the investment of both kinds of firms only for R&D, design, and organisation and business processes. With respect to other intangibles, instead, financial barriers act only on innovators (or non-innovators) or are even absent. Furthermore, the hampering role of financial barriers distributes differently across different intangibles between innovators and non-innovators.

Keywords: R&D, intangibles, innovation, financial barriers.

JEL Classification: 030; 032; 033

1. Introduction

Investing in intangibles represents the prominent way firms engage in innovation. By allocating resources to Research and Development (R&D) and to other knowledge-intensive activities – like software and ICT, human capital, design, reputation, branding, and organization/business improvements[1] – firms can increase their capacity of successfully introducing new goods (products or services) and processes (Montresor and Vezzani, 2016).

However, intangible investments are hampered by several barriers, both external (e.g. unfavourable market competition and regulation) and internal (e.g. lack of skills and human capital) to the investing firm (Thum-Thysen et al., 2017). Among the different obstacles, financial constraints to intangible investments are recognised as a severe impediment to innovation outputs, of which intangible investments represent an essential input. As we will see below (Section 2), the literature on the financial barriers to innovation is quite abundant and has provided important results. One of these concerns the different extent to which financial barriers affect innovative *versus* non-innovative firms, and the different perception the two groups of firms have been shown to have with respect to their severity (D'Este et al., 2012). In our opinion, the role of firm's innovative status in moderating the relationship between financial constraints and intangible investments deserves further attention, at least in two respects. First of all, the literature has so far concentrated on the relationship between financial barriers and R&D investments (Hall et al., 2016) or the firm's portfolio of innovative intangibles as a whole. However, the innovation process is complex as firms' innovation strategies rely on heterogeneous resources and capabilities in addition to R&D. Helpful insights would be provided by investigating whether the effect of financial barriers varies not only between innovators and non-innovators, but also across the different intangibles that firms might prioritize to engage in innovation. This is the first research issue we address in the paper.

The second research issue is more methodological and concerns two problems that typically emerge in investigating the relationship at stake: *i)* the risk of reverse causality, which arise when the perception of financial (and non-financial) barriers is assumed to depend on the firm's engagement in innovation (intangible) activities itself; *ii)* the connected risk of simultaneity bias in the measurement of financial barriers and of other structural and contextual factors on which they could depend. In the majority of the research contributions, these issues are posed by the cross-sectional nature of the surveys through which innovation and barriers information is collected and/or by the impossibility of linking their different waves across time given the lack of firm identifiers. We posit that the resort to the quasi-panel literature can provide an interesting and at least partial solution to these problems, as we aim at showing in our analysis.

We investigate these two research issues through an econometric study of nearly 13000 firms based in the EU28 over the period 2012-2014. In particular, we make an original quasi-panel extension of a recent wave of the Innobarometer survey (2015) and estimate two sets of recursive bivariate models, for innovative and non-innovative firms, in which: *i)* perceived financial barriers to innovate are made "exogenous" with respect to some lagged structural characteristics of the focal firms (step 1); *ii)* each and every kind of a set of six intangible investments depends on the estimated firm's perception of financial barriers to innovate (step 2).

[1] The list is possibly non-exhaustive and uncovers a set of typologies that have been also alternatively specified. Still, this is the classification of the dataset we use in the paper.

The results we have obtained are quite interesting. As expected, the lack of financial resources hampers the firms' capacity to excel on their structural peers in investing in intangibles. However, this occurs for both innovators and non-innovators only for intangibles that are inherently innovative and organizational, while with respect to other intangibles financial barriers act on innovators (or non-innovators) only or are even absent. Overall, financial barriers appear to affect non-innovative firms' engagement in innovation to a greater extent than that of innovators. However, their hampering role distributes differently across different typologies of intangibles between innovators and non-innovators, requiring firms to develop different capabilities and strategies to deal with them.

The rest of the article is structured as follows. In Section 2 we position our analysis in the extant literature. In Section 3 we present our dataset and econometric strategy, and in Section 4 we illustrate the results. Section 5 concludes by drawing some research and policy/management implications.

2 Background literature

The role of intangible investments in driving firm's innovation is by now widely recognized. R&D investments have been identified as a basic ingredient of the firm's inventive capacity long since (Mansfield, 1984), and such a role has been subsequently extended also to other "technological" intangibles, like software development and ICT (Hall et al., 2013) and design investments (D'Ippolito, 2014; Montresor and Vezzani, 2019). A less direct, but still pivotal innovation role has been recently attributed also to other softer, "non-technological" intangibles, like training (Ciriaci, 2017), reputation and branding (Wong and Merrilees, 2008), and organization and business process investments (Squicciarini and Le Mouel, 2012). While all of these intangibles represent a form of "engagement" in innovation by firms, the extent to which this translates into actual innovation is variable and recommends us to deal with the innovation impact of intangibles in a disaggregated way (Montresor and Vezzani, 2016).

The firm's engagement in innovation can be hampered by different typologies of barriers, on which a large body of academic literature has concentrated.[2] Externally, market conditions (e.g. competition, demand for innovation, and availability of innovative partners) and institutional factors (e.g. IPR regulations and (the lack of) public support to innovation) could hamper both the construction and the innovative exploitation of the firm's intangible capital (Lööf and Heshmati, 2002). Internally, firms could lack the knowledge (e.g. skills and human capital) to build up and combine their intangible inputs for the sake of innovation; a lack of absorptive capacity (Cohen and Levinthal, 1989) may also limit the acquisition and integration of external intangible assets. Both across the external and the internal dimensions, investing in intangibles and innovation could be hampered by a limited availability of financial resources. In particular, financial constraints can emerge both "in-house" – e.g. lack of cash-flows to be re-invested – and externally, given the difficulties of financing through the capital market and the resort to debt (Thum-Thysen et al., 2017; EIB, 2017).

[2] For an early taxonomy of innovation barriers, see Piatier (1984). For a recent review of the literature on the barriers to radical innovations, see Sandberg and Aarikka-Stenroos (2014). For the methodological problems in "selecting" rather than "deducing" different barriers and in confusing their "underlying reasons", see Mirow et al. (2008).

Financial barriers have been shown the most hindering technological innovations in a number of studies considering the comparative relevance and complementarity of different barriers (e.g. Galia and Legros, 2004; Savignac, 2008; Strobel and Kratzer, 2016). Some recent studies have instead highlighted that some non-financial barriers (in particular, related to market demand and knowledge) are at least as hampering firm's innovation as financial ones (e.g. Pellegrino and Savona, 2017; Belitz and Lejpras, 2015). Beside their relative importance, the peculiarity of financial barriers is that these are the only ones whose hampering innovation effect mainly (if not even exclusively) passes through an effect on intangible investments.[3] Indeed, what makes innovation difficult to finance is also and above all the "knowledge-intensity" of the intangible inputs on which it relies. The opaqueness and information asymmetries that characterize intangibles make their financing more problematic than their tangible counterparts and add an additional source of market failure to their innovation exploitation (Hall and Lerner, 2010).

Building on the early works of the late '80s (see Hall et al., 2016), empirical evidence about the relevance of financial barriers for the firm's investment in innovation - particularly in R&D - is to date abundant, with respect to different geographical contexts and periods of time (Galia and Legros, 2004; Tourigny and Le, 2004; Canepa and Stoneman, 2007; Savignac, 2008; Mohnen et al., 2008; Segarra-Blasco et al., 2008, Silva and Carreira, 2012; Mancusi and Vezzulli, 2014; Cincera et al., 2016; Hottenrott et al., 2016). Financial constraints to R&D investment have emerged harsher in the aftermath of the last financial crisis (Campello et al., 2010; Mina et al., 2013; Lee et al., 2015) and have been found to inhibit the firms' capacity/propensity also to gain economic advantages – e.g. in terms of productivity and export – from their innovations (Coad et al., 2016; Altomonte et al., 2016).

In spite of its generality, the evidence about financial constraints to intangible investments has shown a number of interesting nuances. An important one has emerged with respect to the "innovative" status of the investing firm. From a theoretical point of view, it has been argued that innovative firms could find a more problematic access to finance than non-innovative firms, for different reasons (see Lee et al., 2015)[4], which have found large empirical support. Innovative firms, especially SMEs, appear actually more affected by financial constraints in (further) engaging in innovation (e.g. Canepa and Stoneman, 2007; Czarnitzki, 2006; Freel, 2007). These difficulties are dependent on several issues.[5] Still, what emerges is a 'circular' relationship. While firms find severe financial problems when engaging in innovation for the first time, once they have reached an innovative status this could worsen their access to finance (Brancati, 2015). As D'Este et al. (2012) argue, and similarly to other innovation barriers, financial ones can have a twofold nature: "deterring" or "prevent[ing] firms from committing to innovation" (p. 482); and "revealed" or "reflect[ing] the degree of difficulty … consequent on the firm engaging in innovation activity" (ib.). In

[3] Just to make an example, the obstacles that market competition can pose to a successful innovation comprehend problems of appropriability, diffusion, and standardization (to mention a few), which do not reduce to the obstacles posed by market competition/concentration to the firm's capacity of investing in intangibles per se.

[4] In brief, their economic returns are subject to uncertainty and frequently punctuated by innovation failures, making their financing riskier; innovative firms have a higher degree of information asymmetry with respect to standard lenders (e.g. banks), especially with respect to the 'serviceability' of their intangible, requiring expert evaluators (e.g. venture capitalists) to be gauged; innovative firms produce and rely on innovative collaterals that are largely firm-specific and hamper fund raising out of their boundaries.

[5] Among the other, the kind of focal innovation (Mina et al., 2013; Czarnitzki and Hottenrott, 2011), the technological intensity of the industry (Canepa and Stoneman, 2007; Revest and Sapio, 2010; Tourigny and Le, 2004), and the conjectural phase of the business cycle (Lee et al., 2014).

brief, while the former would impede innovation, the latter would delay and eventually stop it afterwards (Baldwin and Lin, 2012).

The previous distinction is important when devising customized strategic and policy actions to address financial constraints. Accordingly, the same distinction has attracted a lot of attention in recent research on innovation barriers (D'Este et al., 2012; D'Este et al., 2014; Hölzl and Janger, 2014; Belitz and Lejpras, 2015; Coad et al., 2016; Pellegrino and Savona, 2017; Antonioli et al., 2017; Pellegrino, 2018). From a methodological point of view, the studies at stake investigate the twofold nature of financial (and non-financial) barriers by looking at the different perception that "potential innovators" disclose in survey questions about their importance, considering whether they engage (and to what extent) or not in a portfolio of innovation activities of the relative survey.[6] In econometric terms, the firms' perception of each and every barrier is the dependent variable, while their engagement in the considered portfolio of innovation activities is: either among the explanatory variables (D'Este et al., 2012); or a variable used to split investigated sample when looking at the role played by other regressors (D'Este et al., 2014). In so doing, two problematic assumptions are, at least implicitly, made. First of all, the studies at stake assume that the focal issue should be whether financial barriers differ from other non-financial ones in contrasting innovative and non-innovative firms. Conversely, it is not considered whether specific barriers, like financial ones, deter rather than delay a certain kind of intangible investment instead of another. Given the heterogeneous effect that different intangibles have been found to have on innovation (see Montresor and Vezzani, 2016), this appears to us quite unfortunate. The knowledge about the differential (innovative vs. non-innovative firms) effect of financial barriers we have acquired up to now in generic terms is actually not conclusive, and it is mainly country specific. With respect to the UK, D'Este et al. (2012) have found that finance-related cost barriers deter innovation more than other non-financial ones. By referring to Spain, D'Este et al. (2014) have instead shown that the "lack of external finance" is more frequently perceived by innovative firms (is revealed) than non-innovative ones, and that cost and finance related obstacles are not lowered by the firm's human capital. Still with respect to Spain, Pellegrino (2017) returns to indicate that internal and external shortages of financial resources are more deterring than revealed and that, unlike other barriers, their effect is always stronger for younger than for older firms. In the only cross-country study available up to now, Hölzl and Janger (2014) also show that financial barriers are an inherently deterring, but this holds true only in a subset of EU countries that are far from the technological frontier.

The second problematic assumption is that the investigated barriers, including financial ones, are assumed incapable to affect the firm's engagement in innovation and its innovation status. Especially in the cross-sectional applications, the risk of a reverse causality in investigating the nature of the barriers is often neglected. Related to this assumption is, even in the panel/dynamic applications, that of the determinants of the investigated barriers. In accounting for their perception, the innovative engagement of the focal firms is retained simultaneous to other agency-treats (e.g. their size, age, internationalization degree and the like) and to other contextual determinants (e.g. the

[6] The majority of these studies make use of the Community Innovation Survey (in particular, from the CIS-2010 onwards) and refer to financial barriers either in a narrow meaning, in terms of available (internal/external) resources, or in a broad one, as part of cost barriers (including costs of finance, other innovation costs and risks) (on the correlation among the two, see Mohnen and Rosa, 2001). Using the same source, the firms' engagement in innovation is captured by referring to a basket of "innovation activities", which encompasses R&D, software, training, design, and marketing. With respect to the same activities, a risk of selection-bias (Savignac, 2008) is avoided by referring to "potential innovators" and ruling out those firms that have a nil engagement in them and thus implicitly signal no interest in innovating.

industry/country to which the firms belong), which are arguably "more exogenous" (Coad et al., 2016). In both respects, this is a problematic issue to deal with which we propose an alternative methodology in our empirical application.

All in all, the effect of financial barriers on the firm's engagement in innovation appears contingent on a number of factors, among which the kind of intangible investment is unfortunately missing. This is another shortage to which our empirical application contributes to remedy by also providing an additional cross-country analysis to the few ones available up to now.

3. Empirical application

3.1. Data

Our empirical application uses a sample of 12,995 EU firms from the Eurobarometer survey on innovation trends for 2015: in brief, the Innobarometer 2015. The Innobarometer is an annual survey hinging on a CIS-like questionnaire, submitted to a sample of firms at the beginning of each year and collecting information on their activities for the three previous years: in the present case, 2012-2014. Firms' names or identifiers are not available and therefore it is not possible to link different waves of the Innobarometer. Like most innovation surveys, the Innobarometer is thus cross-sectional (Mairesse and Mohnen 2010) and this makes it difficult to go beyond the estimation of simple correlations among variables. However, as we will illustrate in the following (Section 3.2), an original approach can be adopted to get closer to causal relationships and address the problems we have pointed out in the investigation of the role of financial barriers for intangible investments (Section 2). In brief, drawing on the quasi-panel methodology, we will use information from a previous wave - the Innobarometer 2014, covering the years 2011-2013 – to build up instrumental variables with which to make financial barriers exogenous.[7]

The Innobarometer collects information on a wide variety of aspects, including the three focal ones for our analysis. First, it provides information on the shares of turnover that firms have invested in six typologies of intangibles: *i)* research and development (R&D); *ii)* design of products and services (excluding R&D); *iii)* software development (excluding R&D and web design); *iv)* organization or business process improvements; *v)* company reputation and branding; and *vi)* training.[8] Second, it provides information on the firms' perception of the importance of the lack of financial resources in hampering the commercialization of their goods or services; this is expressed on a three-level Likert scale – not a problem, a minor problem, a major problem. Third, it identifies the firms' introduction of product or service innovations – simply innovation, hereafter – which is expressed as a dichotomic variable.

3.2 Econometric strategy and variables

In our econometric application we model the effect that the financial barriers perceived by firm i ($Financial\_barriers_i$) may have on its decision to invest in the intangible of kind m ($Intangible_{im}$) controlling for a series of other covariates (X_i):

[7] The two waves of the survey present very close sample characteristics (available at: http://ec.europa.eu/growth/industry/innovation/facts-figures/innobarometer/).

[8] The turnover shares of each type of intangible investments are collected in the following four categories: equal to 0%, below 1%, in-between 1 and 5%, and above 5%.

$$Intangible_{im} = \alpha_m + \beta_m Financial\_barriers_i + \gamma'_m X_i + \varepsilon_{im} \quad (1)$$

where the dependent variable takes values 1 (0 otherwise) if the firm has invested in the intangible m of the six considered: $R\&D$, $Design$, $Software$, $Organization\_Business$, $Reputation\_Branding$, and $Training$.

Our main regressor, $Financial\_barriers_i$, takes value 1 (0 otherwise) if the firm has perceived the lack of financial resources to the commercialization of its (innovative) goods or services as a major problem.[9] As we have noticed in Section 1, estimating Eq.(1) would expose us to the risks of simultaneity bias and reverse causality. In order to mitigate these risks and correctly identify the role of financial barriers, we thus propose to instrument the variable $Financial\_barriers_i$ by borrowing an approach from the pseudo-panel literature (Deaton, 1985; Meng et al., 2014; see Section 3.2.1). As we will say (Section 3.2.2), for the sake of consistency with this approach, we will also transform our dependent variables $Intangible_{im}$.

3.2.1 Financial barriers: building up the instruments

In trying to make it exogenous, we obtain a measurement of $Financial\_barriers_i$, which is accounted by the value of its explicative variables revealed by the sample firms in a previous period to that of the dependent variable ($Intangible_{im}$). Rather than searching for candidates in the same dataset of the dependent variable - the Innobarometer 2015 - we thus build instrumental variables by using a pseudo-panel transformation of the Innobarometer 2014; a one-year lagged wave of it (*t-1*). This transformation is accomplished by bringing together into groups, firms that are similar in terms of their structural characteristics: macro-sector (manufacturing, retail, services, industry), size (classes of employees) and innovation status (yes or no).[10] In so doing, we collect the observations of the Innobarometer 2014 into 32 different groups of structurally similar firms.[11]

These groups are then used to build up, and associate to the firms of the wave t, the value that the firms of wave *t-1* reveal with respect to the two instruments that we have identified for the $Financial\_barriers_{it}$ perceived at t. The first one is $Internationalised_{t-1}$, whether a sampled firm has a positive turnover on international markets. Being active on foreign and/or multiple markets may actually help firms hedging against the risk of a negative shock hitting the national market and be perceived as a sign of firm competitiveness by financing institutions, therefore relaxing financial barriers. This suggestion appears consistent with the different barrier perception that firms belonging to a group (especially multinational) have been found to show with respect to single domestic firms (Iammarino et al., 2009). The second instrument is $Few\ competitors_{t-1}$, whether a sampled firm has ticked the category "few" among the alternative answers to the question about the number of competitors in the main market. The degree of rivalry and the market structure can actually be expected to have a twofold effect on the perception of financial barriers. On the one

[9] Although the adjective "innovative" has been dropped from the survey question posed to non-innovators, descriptive statistics (available from the authors upon request) reveal that innovators and non-innovators did not statistically differ in reporting to the question, suggesting that the two have meant to be asked about the same kind of financial shortage.

[10] The macro-sectors are defined according to the NACE nomenclature: manufacturing = category C, retail = category G, services = categories H/I/J/K/L/M/N, industry = categories D/E/F. As for the employees, these are available in the Innobarometer in the following four classes: '<10', '10-49', '50-249', and '250+'.

[11] In deciding the number of subgroups, a crucial trade-off emerges. A higher number increases the between group heterogeneity, but also decreases the average number of observations per group, thus leading to less precise estimates of the group statistics. As recommended by the pseudo-panel literature, groups should have at least 30 observations each. Consistently with this criterion, our smaller group contains 36 firms and only 4 groups have less than 100 observations (see Table 1 in Section 4 for further info).

hand, firms' innovation could be favoured or disfavoured by oligopolistic rather than (imperfectly) competitive markets, depending on the relevant Schumpeterian regime (Aghion et al., 2005), thus entailing either higher or lower innovative costs and financial needs, respectively (Malerba and Orsenigo, 1995). On the other hand, the degree of competition in the relevant market influences the extent to which firms can (or not) appropriate and re-invest their rents (e.g. by persisting in innovation) and thus attenuate the relative financial needs and constraints (Thum-Thysen et al., 2017; Belitz and Lejpras, 2016).[12]

For each group, *g*, of the Innobarometer 2014 (*t-1*), the two instruments are computed as the share of firms that declared to have operated in international markets ($Internationalised_{g,t-1}$) and to operate in markets with few competitors ($Few\ competitors_{g,t-1}$). We then assign these group values, computed on the Innobarometer 2014 (*t-1*), to each and every firm i of the Innobarometer 2015 (*t*) presenting the same structural characteristics of the group. In so doing, as the anonymous nature of the two surveys prevents us from merging observations, we rely on the assumption that the frequency of firms internationalized and perceiving few competitors in a certain group *g* at *t-1*, can be used to proxy the probability that a given firm *i* of the correspondent group at *t* is internationalized ($Internationalised_{ig,t-1}$) or perceives few competitors ($Few\ competitors_{ig,t-1}$) too.[13] Following Wooldridge (2012, p.619), the instrumentation of the financial barriers should be made by regressing them against the full set of covariates used in Eq. (1), X_i, and the two instruments discussed:

$$Financial_{barriers_{it}} = \delta_0 + \delta_1 Internationalised_{ig,t-1} + \delta_2 Few\_competitors_{ig,t-1} + + \theta' X_i + \varepsilon_i \qquad (2)$$

3.2.2 Intangible investments: transformations and controls

Consistently with the pseudo-panel approach used to build up the instrumental variables, we also transform our dependent variables, $Intangible_m$, in Eq. (1) to represent within group differences among firms. In particular, for each and every firm i of the Innobarometer 2015 we recode the variables $Intangible_{im}$ to be equal to one, if it presents investment values (as percentage of its turnover) higher than the average of the group of firms presenting the same structural characteristics, and zero otherwise.

Given that groups are defined also on firm size (Section 3.2.1), the transformation cleans out its effects and we do not include it among the regressors. In order to control for unobserved heterogeneity, we instead plug in both Eq. (1) and Eq. (2), in addition to sector and country fixed effects, other possible determinants of the firms' decision to invest in intangibles that the Innobarometer makes available. First of all, we account for the availability of internal financial resources (e.g. cash-flows) to be invested by using two dummies, capturing whether observed firm experienced a substantial increase or decrease in their turnover. Secondly, we consider whether a firm has adopted advanced manufacturing technologies, which in turn could require further investments in knowledge assets to be properly used. We finally control for the age of the firm with a

[12] As usual, in order to work as suitable instruments for them, the previous two explicative variables of financial barriers should be deemed incapable to account for the firms' decision to invest in intangibles. While this can't be ruled out a priori, among those available in our dataset these variables are among the few ones that (at least) do not enter (directly) in a standard investment function.

[13] In brief, the higher the share of firms in a certain group at t-1 that appears internationalised or facing few competitors, the higher the probability that a focal firm *i* of the correspondent group at *t* will also be internationalised or facing few competitors.

dummy, *Young*, denoting whether it has been recently founded (no more than 5 years before the administration of the questionnaire); and for the firm belonging to a group, still with a dummy.

Eq. (1) and Eq.(2) are estimated with a recursive bivariate probit model. This model allows the two equations to have correlated errors terms, and to treat the binary dependent variable of Eq. (2) as an endogenous regressor in Eq. (1). More precisely, in order to distinguish the role that financial barriers have for the six intangibles between innovative and non-innovative firms, we estimate two sets of recursive bivariate probit models: the first with respect to the firms that have introduced a new product or process, the second with respect to the firms that have not. As a robustness check, we also consider that investment decisions for different intangibles can correlated among them. Therefore, Eq.(1) is also estimated with a multivariate probit model (MPM) that jointly models different investment decisions, by allowing the error terms to be correlated across equations as in the seemingly unrelated regression (SUR) models.

4. Results

4.1. On the perception of financial barriers

Before commenting our results, it should be noted that the sub-groups we have identified using firms' structural characteristics (size, industry, and innovation status) have an appreciable size, which favours a reliable estimation of their relative statistics. Table 1 shows that the median sub-group is made of 346 firms, while the average one is only slightly larger (377), suggesting that the sub-group distribution is only slightly right-skewed.[14]

As for the instrumental variables that we have identified, *Internationalised* lies on a larger support (*Min-Max*) and has a higher standard deviation with respect to the mean than *Few competitors*. In other words, the sub-groups are more heterogeneous with respect to the former variable than to the latter. This appears visible also from Figure 1, where we plot the estimated kernel distribution for the two variables. *Internationalised* is much less concentrated and bimodal, with an increase in density for very high values.

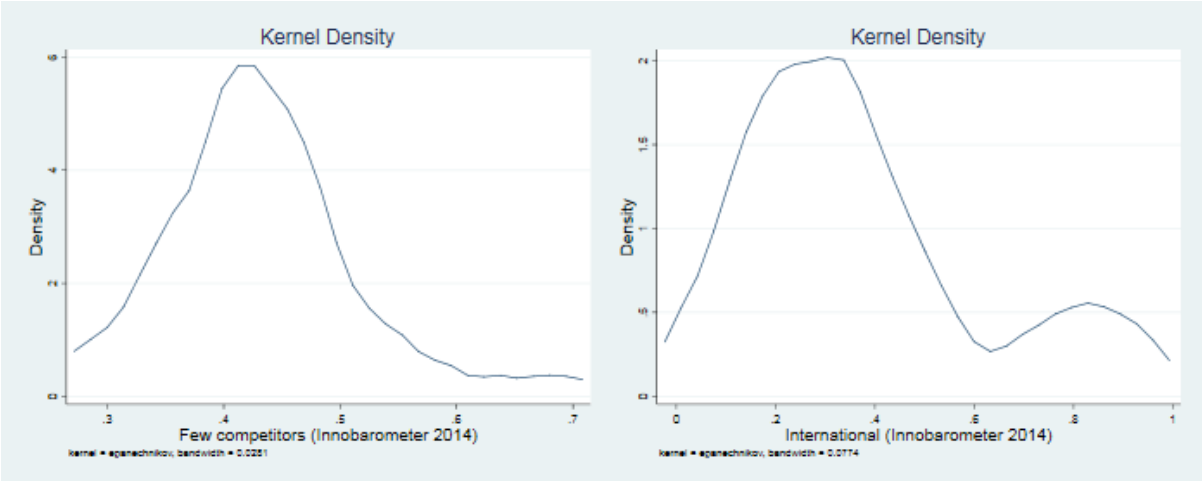
Table 1: Descriptive statistics for the subgroups and the instrumental variables

	Mean	Std. Dev.	Median	Min.	Max.
# of firms per group	377.88	265.67	346	36	1048
Internationalised (2014)	0.37	0.24	0.31	0.05	0.92
Few competitors (2014)	0.43	0.08	0.43	0.30	0.68

Note: *calculated on the Innobarometer 2014 (t-1).*

[14] The smallest of the 32 identified sub-groups contains 36 firms and only 4 groups them have less than 100 observations.

Figure 1: Kernel density estimates for the instrumental variables



Note: *calculated on the Innobarometer 2014 (t-1). NB: The scales of the y-axes are not equal in the two panels.*

Before commenting our estimates, it should also be noticed that the results of the Wald tests for the exogeneity of financial barriers (reported at the bottom of Table 2.a and 2.b) reject the null hypothesis of no endogeneity for four of the six intangible investment considered.[15] This confirms our concern about the risk of simultaneity bias and reverse causality in the estimation of the effect of financial barriers on the firms' decision to invest in intangibles.

Coming to the first step of our econometric strategy, Table A2.a and A2.b (in the Appendix) confirm that our two focal instruments significantly account for the firms' perception of financial barriers, but with differences between innovative (Table A2.a) and non-innovative (Table A2.b) firms.

As expected, operating on international markets reduces the probability of perceiving financial barriers as important, for both innovative and non-innovative firms and along all the considered intangibles. While increasing financial needs, the firms' internationalization possibly allows them to better diversify risk, by reducing the probability of being financially constrained; furthermore, it could also guarantee a better credit rating in debt financing (Reeb et al., 2001). Operating in markets with few competitors reduces instead the perception of financial constraints as problematic for nearly all the considered intangibles, but only for innovative firms. Within concentrated markets, in which the returns of innovation can be more easily appropriated by innovators, financial constraints appear less binding. Furthermore, getting external financing (by banks and/or non-standard financial intermediaries), could be also easier for innovators that do not appear to the lenders' eyes threaten by turbulent, competitive market environments (Hall and Lerner, 2010). For non-innovative firms, with respect to which the previous issues do not emerge, the perception of financial barriers does not seem to be affected by market structure issues.

The results about the other regressors of $Financial\_barriers_{it}$, which we have inserted to be consistent with the second step of our model, are also generally consistent. In particular, for both

[15] In the two cases where the hypothesis of exogeneity of financial barriers is supported by the data – that is, branding and software - the coefficients attached to the instrumented financial barrier are not statistically significant. Therefore, we have also tried to estimate the same equation for branding and software without instrumenting financial barriers. For the former intangible, the coefficient attached to financial barriers is still not significant, while for the latter is negative and significant, but at least 10 times smaller than those attached to the other intangibles (-0.078). Results are available upon request.

kinds of firms, a decreased turnover correlates with a higher probability to perceive financial problems as problematic. Conversely, though for innovative firms only, an increased turnover correlates with a lower probability of the same perception. Assuming that the gained turnover could feed the financial resources internally available to the firms, this actually appears consistent with the implications of the "pecking order" theory of finance (Myers and Majluf, 1984), predicting that internal resources should actually be their priority source of funding.

4.2. The impact of financial barriers on intangible investments: innovators vs. non-innovators

Coming to the estimate of Eq. (1), while *Financial barriers* generally emerge to significantly reduce the probability of engaging in innovation by investing in intangibles, Tables 2.a and 2.b show some interesting nuances of this result between innovative and non-innovative firms.

First of all, for only three of the six intangibles at stake, financial constraints appear to reduce the firm's investment capacity both in the case of innovators and non-innovators.

Table 2.a: Investing in intangibles, bivariate probit: innovators

	R&D	Design	Software	Organis. business	Reput. Branding	Training
Financial barriers	-1.192***	-0.467**	0.281	-0.974***	-0.129	-0.992***
	(0.106)	*(0.209)*	*(0.285)*	*(0.149)*	*(0.270)*	*(0.137)*
Turnover increased	0.048	0.054	0.043	0.068**	0.114***	0.034
	(0.033)	*(0.034)*	*(0.035)*	*(0.033)*	*(0.035)*	*(0.033)*
Turnover decreased	0.125***	0.043	-0.125**	0.057	-0.086	0.064
	(0.045)	*(0.053)*	*(0.061)*	*(0.048)*	*(0.060)*	*(0.047)*
Adv_technologies	0.242***	0.244***	0.217***	0.325***	0.127**	0.186***
	(0.058)	*(0.060)*	*(0.059)*	*(0.060)*	*(0.060)*	*(0.059)*
Young	0.135***	0.072	-0.190***	0.095*	0.043	0.001
	(0.048)	*(0.053)*	*(0.055)*	*(0.050)*	*(0.056)*	*(0.050)*
Group	0.081**	0.040	0.133***	0.026	0.021	0.099***
	(0.035)	*(0.037)*	*(0.038)*	*(0.035)*	*(0.038)*	*(0.035)*
Industry fixed effects	*Included*	*Included*	*Included*	*Included*	*Included*	*Included*
Country fixed effects	*Included*	*Included*	*Included*	*Included*	*Included*	*Included*
Constant	0.481***	0.200	0.137	0.691***	0.568***	0.663***
	(0.130)	*(0.155)*	*(0.181)*	*(0.135)*	*(0.174)*	*(0.133)*
Observations	7,976	7,976	7,976	7,976	7,976	7,976
Chi2	2571	1493	1247	1489	1310	1711
Rho	0.693	0.297	-0.212	0.545	0.0998	0.549
Wald test rho = 0	42.33	5.175	1.515	22.80	0.391	27.37

Note: *Standard errors in parentheses,* *** p<0.01, ** p<0.05, * p<0.1.

As expected, the first of these intangibles is R&D: a result consistent with the standard literature on innovation and finance, exclusively focused on the problems posed by the idiosyncratic knowledge (i.e. opaque, incompletely appropriable) characterizing R&D (Hall and Lerner, 2010), and with that on innovative firms' financing usually investigated by referring to R&D (Lee et al., 2015) too. Considering the crucial technological and non-technological (i.e. aesthetic) role that design plays for firms' innovation performances (Montresor and Vezzani, 2019), the results about its financial implications can also be deemed consistent. Somehow less expected is the twofold role that financial barriers have with respect to investing in organisation or business process improvements. Not only is this investment hampered by financial barriers when it is implemented by innovators, possibly

because they try to implement a resource-demanding complementarity between technological and non-technological changes (Cozzarin and Percival, 2006). Financial barriers appear even deterring the shift that non-innovators could try to make. This is an interesting result, showing that the organisational dimension of the innovation engagement is financially as problematic as its knowledge dimension. Firms may find difficult to comprehend and adopt business methods that make other firms' strength (Nelson, 1991), thus making the path towards the improvement of dynamic capabilities perilous.

Table 2.b: Investing in intangibles, bivariate probit: non-innovators

	R&D	Design	Software	Organis. business	Reput. Branding	Training
Financial barriers	-1.260***	-0.879**	-1.411***	-0.856***	-0.426	0.329
	(0.124)	*(0.363)*	*(0.086)*	*(0.238)*	*(0.439)*	*(0.431)*
Turnover increased	0.002	0.019	0.088**	0.171***	0.137***	0.035
	(0.046)	*(0.047)*	*(0.043)*	*(0.045)*	*(0.047)*	*(0.045)*
Turnover decreased	0.102	0.021	0.157***	0.052	-0.032	-0.217**
	(0.065)	*(0.103)*	*(0.053)*	*(0.071)*	*(0.098)*	*(0.088)*
Adv technologies	0.325***	0.314***	0.131	0.319***	0.178**	0.163*
	(0.089)	*(0.089)*	*(0.084)*	*(0.088)*	*(0.089)*	*(0.090)*
Young	-0.090	-0.033	-0.088	0.053	0.027	-0.060
	(0.067)	*(0.067)*	*(0.058)*	*(0.059)*	*(0.063)*	*(0.063)*
Group	0.247***	0.165**	0.152***	0.181***	0.138**	0.148***
	(0.058)	*(0.064)*	*(0.050)*	*(0.054)*	*(0.058)*	*(0.054)*
Industry fixed effects	*Included*	*Included*	*Included*	*Included*	*Included*	*Included*
Country fixed effects	*Included*	*Included*	*Included*	*Included*	*Included*	*Included*
Constant	0.536**	0.370	0.896***	0.257	0.682**	0.012
	(0.212)	*(0.272)*	*(0.197)*	*(0.234)*	*(0.282)*	*(0.288)*
Observations	4,833	4,833	4,833	4,833	4,833	4,833
Chi2	1853	1258	2051	1155	1039	913.5
Rho	0.806	0.575	0.834	0.562	0.301	-0.208
Wald test rho = 0	22.81	3.892	33.91	9.408	1.226	0.643

Note: *Standard errors in parentheses,* *** p<0.01, ** p<0.05, * p<0.1.

At the opposite extreme of our spectrum, *Financial Barriers* have no significant effect on investments in reputation and branding, neither for innovators nor for non-innovators. In spite of the stock-market evaluation that advertising has been found to guarantee to the investing firm (Hall, 1993) and that financers could retain in lending, this result is still somehow unexpected. Indeed, building up an effective corporate branding, especially in terms of external communication strategies, is often very costly and financially demanding (Argenti and Druckenmiller, 2004). On the other hand, this result could suggest that investing in this very special kind of "soft" and "symbolic" intangible, does not generally entail expenditures of such a big scale to translate into a hampering or prohibitive barrier. Furthermore, it could be argued that even when it occurs, the same kind of intangible investment is usually so integrated with the verifiable reputation and experience of the investing firm to make its financing more easily contractible and less problematic than other intangibles.

The lack of financial resources deters investing in software development by non-innovators, while it does not so for innovators. Conversely, financial constraints to training investments appear at work for innovators, but not for non-innovators. This asymmetry of results could be explained by the different kind and stage of innovation engagement that the two investments represent. On the one hand, investing in software development could be financially hampered only when non-innovators approach it without the capacity (e.g. human capital and management experience) that innovators presumably already have and that they could use to control and bear the relative costs (Hempell, 2003). In the presence of such a capacity, investing in ICT does not seem to be hampered by financial constraints. On the other hand, it might be the case that investing in training turns out hard to get financed only by innovators because of the requirements of their innovative status. Indeed, this status might require them to invest in a more innovation-empowering and higher skilled human capital, which could reveal prohibitively costly.

Summarizing, the lack of financial resources appears to hamper the firms' capacity to excel on their (subgroup of) structural peers in building-up innovative capabilities through intangible investments. However, this occurs for both innovators and non-innovators only for intangibles that are inherently innovative (R&D and design) and organizational (organization and business processes). As for the other intangibles, two interesting nuances emerge. On the one hand, the softest kind of intangible investments, of an inherently symbolic nature (reputation and branding), appears unaffected by financial barriers - both for innovative and non-innovative firms. On the other hand, some other intangible investments emerge hampered by financial barriers only when they are made either by innovative (training) or by non-innovative (software) firms, depending on requirements they could pose for translating into further (innovators) or new (non-innovators) innovation.

Overall, the need of dealing with the role of financial barriers in a disaggregated way, not only by distinguishing innovative from non-innovative firms but also by singling out the kind of intangible activity through which engaging in innovation substantiate, appears supported by our results. Additional insights emerge by looking at Table 3, which reports the marginal effects that financial barriers exert.

Table 3: Marginal effects of financial barriers on intangible investments

	Innovators	Non-Innovators
R&D	-0.465** *(0.036)*	-0.631** *(0.091)*
Organis/business	-0.328** *(0.039)*	-0.344** *(0.092)*
Design	-0.178* *(0.076)*	-0.388* *(0.186)*
Training	-0.323** *(0.033)*	-
Software	-	-0.609** *(0.036)*
Branding	-	-

Note: *Marginal effects from regressions reported in Table 3 (innovative firms) and Table 4 (non-innovative firms). Only marginal effects with at least 5% significance are reported. Standard errors in parentheses, ** p<0.01, * p<0.05*

With respect to the three intangibles affecting both innovators and non-innovators (R&D, design and organisation/business), financial barriers show a larger marginal effect for the latter than for the former.[16] The lack of financial resources generally emerges more likely to be a deterring kind of barrier than a barrier faced by innovators, supporting some of the previous evidence with respect to the firms' innovation engagement in aggregated terms (see Section 2). This is particularly the case for R&D and design, key inputs to enter into the innovative realm, while with respect to the organisational intangibles the difference is negligible.

Moving along the columns of Table 3, let us notice that, with respect to innovators, the marginal effects of financial barriers are the highest on R&D, followed by organization and business processes, training, and finally design. With respect to non-innovators, instead, R&D is the most financially hampered along with software, followed by design and, to the least extent, organization and business processes. In brief, being innovator rather than non-innovator entails that financial problems distribute their hampering role differently across different typologies of intangibles, requiring the two firms to develop different capabilities and strategies to deal with them.

In concluding our analysis, some comments are necessary with respect to the controls considered (Tables 2.a and 2.b). Both for innovators and non-innovators, having adopted advanced manufacturing technologies is positively related to the probability that firms invest in all of the intangibles more than their average group. This confirms that the adoption of these technologies actually entails the need of a wide set of knowledge-intensive, intangible assets (Gómez and Vargas, 2012). Being part of a business group also correlates with a higher probability to invest in all the considered intangibles, but mainly for non-innovators (for innovators only in software, R&D and training). While consistent with previous evidence about the interplay between business group relationships and intangibles in driving multinational investments (Belderbos and Sleuwaegen, 1996), this result adds that the innovative status of the firm could make the same interplay not beneficial (though not detrimental either). Conversely, with respect to innovators, being young correlates with higher intangible investments only with respect to R&D and software (and with an opposite sign). Once controlling for other factors, we do not find a clear relationship between firm age (young) and engagement in intangible investments.

Finally, attention is required by the results about the increased and decreased turnover of the firm, as our (possibly not close) proxy of the firm's availability of resources to invest in intangibles. Not only are the relative coefficients non-statistically significant in some cases; but they are even positive with respect to a *decreased* turnover in some others – suggesting its correlation with a higher, rather than lower, probability to invest in intangibles. While this result might appear odd at a first look, its interpretation becomes less fuzzy when we consider the results of estimations not including the financial barriers among the regressors. To clarify this point, we present in Table A.4 (see the Appendix) the results of a bivariate probit estimation for innovators where we do not include the financial barriers in the intangible equation. Both the signs and the statistical significance of the coefficients attached to turnover variations return to be as expected: innovative firms tend to

[16] Also the standard deviation of the coefficients for the group of non-innovators is larger, hinting a less precise point estimation of the parameters.

invest more (less) then their group average when their turnover increases (decreases). This finding, coupled with that discussed with respect to Table 2.a, suggests an additional interesting result of our study. With respect to innovative firms, which previous evidence has shown to react to times of crisis (like that of our dataset) by increasing innovative (intangible) investments (Archibugi et al., 2013), the effect of the firms' economic performance mainly passes through the relaxation (or tightening) of the financial constrains faced.

Before concluding, it is important to notice that the results we have discussed above, including that about the apparently ambiguous effect of the turnover trend, appear generally confirmed also when Eq.(1) is estimated following a multivariate probit model, which accounts for the possible correlation between investments in different intangibles (see Table A.3a and A.3b in the Appendix). The only difference concerns design, which now appears affected by financial barriers only in the case of innovators. Although the log-likelihood test supports the choice of the MPM over a set of separated probit models, these does not provide a suitable framework for an instrumental variable approach, making the construction and interpretation of the marginal effects particularly cumbersome.

5. Conclusions

The lack of internal and/or external resources has emerged to be an important obstacle to the firms' engagement in innovation in different periods and geographical contexts. This has appeared the case for both non-innovative and innovative firms, although to a different extent between them. However, the way in which firms engage in innovation, by deciding how to allocate their resources across different intangible investments, has been hardly disentangled so far.

The present paper tries to fill this gap, by "unpacking" the firms' engagement in innovative activities that financial barriers may hamper in two respects. On the one hand, rather than focusing on R&D investments only, we also retain a set of non-R&D intangibles (software, design, reputation and branding, organization and business processes) that have been shown to significantly affect firms' innovation (Montresor and Vezzani, 2016). On the other hand, we disaggregate previous analysis of the possible differences between innovators and non-innovators in the extent to which financial barriers hamper their engagement in innovative activities. In order to do that, we investigate whether these are more deterring (for non-innovators) than revealed (for innovators) with respect to different types of intangible investments. While these are already two important contributions to the extant literature, we also add to it by better addressing the econometric problems such a literature has encountered (reverse causality and simultaneity bias) in dealing with the relationship between perceived financial barriers and innovation. In particular, by referring to a sample of nearly 13000 firms in the EU28 from the Innobarometer survey 2015 (2013-2015), we have proposed an original pseudo-panel extension of it in order to instrument financial barriers.

The results we have obtained only partially confirm previous literature and provide some novel insights from which a series of implications can be drawn. As expected, the lack of financial resources generally hampers the firms' capacity to excel on their structural peers in investing in intangibles. However, the channels through which financial constraints could obstacle the firms' engagement in innovation are multiple and work heterogeneously, thus requiring a differentiated policy action to be contrasted. For example, a public support appears pervasively needed, for both innovators and non-

innovators, not only for investing in R&D, but also in design and those organisational and business processes that are often needed to complement it. On the other hand, innovative firms appeare in need of back-up for their investment in training, while non-innovative ones for their software investments.

Overall, confirming previous evidence on their impact on innovation, financial constraints appear a barrier to invest in intangibles, with a larger impact on non-innovators than on innovators. This result suggests that the tough problems that non-innovative firms have been found to have in financing their R&D extends also to other non-R&D intangibles. Furthermore, the hampering role of financial barriers distribute differently across different typologies of intangibles between innovators and non-innovators, requiring firms to develop different capabilities and strategies to deal with them. For example, innovators should be more concerned with the financial obstacles to organization and business processes, while non-innovators should pay more attention to those affecting design investments.

All in all, the relationship between financial constraints and innovation engagement appears non-monolithic and thus urges further studies to disentangle the specific channels and effects across firms and industries.

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