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Financial constraints to investing in intangibles: Do innovative and non-innovative firms differ?

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Abstract
This paper investigates the extent to which financial constraints on investments in intangible activities differ with respect to the kind of intangible and to the firms' innovative status. Through an original pseudo-panel extension of a recent European Innobarometer survey, we are capable to address these research questions by attenuating the risks of reverse causality and simultaneity bias and to obtain interesting new results. Financial barriers significantly hamper the firms' investments in intangibles with respect to R&D, design, software, and organisation or business process improvements. With respect to branding and reputation, and training, instead, financial constraints do not emerge to hinder the relative investments. Furthermore, while innovative firms tend to invest more in intangibles, the hampering role of financial barriers does not seem to differ between innovative and non-innovative firms. Financial barriers reduce firms' investments in intangibles selectively, but the strength of this effect is the same in deterring and in restraining their possible innovative use by non-innovative and innovative firms, respectively.

Keywords R&D · Intangibles · Innovation · Financial barriers

JEL Classification O30 · 032 · O33

1 Introduction

Investing in intangibles represents the prominent way firms engage in innovation and improve their business performance. By allocating financial resources to Research and Development (R&D) and to other knowledge-intensive activities, firms can increase their capacity of successfully introducing new goods (products or services) and processes, and to commercially exploit these innovations by increasing their economic returns (Montresor

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and Vezzani 2016). While desirable, investing in intangibles is however hampered by several barriers, both external (e.g. unfavourable market competition and regulations) and internal (e.g. lack of skills and human capital) to the investing firms (for a review, see Thum-Thysen et al. 2019). Out of these obstacles, the presence of financial barriers has emerged as one of the most complex to deal with. This is due to their heterogeneous nature (e.g. lack of internal resources vs. difficulties in accessing external credit) and to the differential effect they can have on different firms and on their entrepreneurial activities. This is particularly the case of technology transfer and innovative activities, whose analysis has recently come to intersect with that of corporate and entrepreneurial finance (Audretsch et al. 2016).

Important results have been obtained in investigating the financial constraints that innovative firms can undergo with respect to non-innovative ones (for a review, see Kerr and Nanda 2015). In particular, small and medium innovative firms have emerged more financially constrained than their non-innovative counterparts (Freel 2007), while for large companies the divide has appeared less evident across the board (Mina et al. 2013). In spite of its relevant results, this literature is generally silent, or at best partial (i.e. mainly concentrated on R&D), about the kinds of intangible activities firms invest in. Given the inherently heterogeneous nature of intangible activities (Montresor and Vezzani 2016)—one just needs to consider the distinction between technological and non-technological ones—and the different extent to which they can be exposed to financial constraints, this is a first unfortunate gap that the present paper aims to address. In particular, by exploiting the fine-grained information collected by a recent Innobarometer survey for the EU, for the first time we deal with the heterogeneity of intangible activities and expect that financial constraints exert a different hampering effect on the relative investments.

A second research gap that we aim to address concerns the way in which, in a related stream of literature about innovation barriers (for a review, see Pellegrino 2018), differences in the perception of financial constraints between innovative and non-innovative firms are investigated. Given the cross-sectional nature of the surveys through which innovation and barriers information are generally collected, and the frequent impossibility of linking their different waves across time and with external information (given the lack of firm identifiers), the majority of these studies suffer from two problems: a risk of reverse causality, and a simultaneity bias in the measurement of financial barriers and other structural/contextual factors on which they could depend. This is another unfortunate gap, which impedes us to obtain reliable results on the extent to which the innovative status of the firms is actually responsible for a more severe perception of their financial barriers, as it could be expected. To overcome this problem, we propose an original pseudo-panel extension of the Innobarometer survey mentioned above. Through this methodology, we are capable to instrument the same perception of financial barriers and, having made it exogenous, to investigate whether its impact on the decision to invest in intangibles actually varies between innovative and non-innovative firms. In so doing, for the first time, we test on a systematic basis whether a significant difference emerges between innovative and non-innovative firms in the causal relationship between financial barriers and intangible investments on which we focus.

We investigate these two novel aspects of the relationship between financial constraints and investments in intangible activities through an econometric study of nearly 13,000 firms based in the EU28 over the period 2012–2014. In particular, we make an original pseudo-panel extension of a recent wave of the Innobarometer survey (2015) and estimate a recursive bivariate model in two steps. In the first step, the financial barriers that firms perceive at time t are made "exogenous" by instrumenting their presence with respect to

some selected characteristics at $t-1$. In the second step, the firms' investment in a set of intangible activities is estimated against the instrumented value of their perceived financial barriers. In particular, in order to investigate the role of the innovative status of the investing firms in the relationship at stake, the benchmark model is augmented with an interaction term between such a status and the instrumented value of financial barriers.

The results we obtain are quite interesting and contribute to extend and refine our knowledge about the relevance of financial issues for investing in intangibles and innovation. On the one hand, consistently with the extant literature, the lack of financial resources hampers the firms' capacity to excel on their structural peers in investing in intangibles. On the other hand, it is only for some intangibles, which are inherently technological and organizational, that this hampering effect emerges as significant. With respect to other specific intangibles, financial barriers do not seem to hinder the relative investments. This represents a first important result, which suggests that intangibles are indeed heterogeneous and need to be "unpacked". This is necessary in order to identify, not only the intangible activities that contribute more to the firms' innovative performance (Montresor and Vezzani 2016), but also the intangibles on whose investments the policy relief of financial problems could be more effective. A second important result concerns the invariant effect that financial barriers have on the selected intangibles between innovative and non-innovative firms. Contrary to theoretical expectations, the effect of financial barriers reveals the same strength in deterring and in restraining the possible innovative use of intangibles by non-innovative and innovative firms, respectively. On the basis of this result, the policy action to alleviate financial constraints on intangible investments would not need to be tailored with respect to the firms' innovative status and should rather concentrate on the specificities of intangible activities.

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

2 Background literature and research hypotheses

The role of intangible activities in driving firms' innovation is by now widely recognized. Intangibles are a basic ingredient of the firms' inventive capacity and a crucial leverage for turning it into successful innovations (Montresor and Vezzani 2016; Ciriaci 2017).

In contrast to their positive effects, the firms' engagement in intangibles for the sake of innovation can be hampered by the limited availability of financial resources.[1] In particular, financial constraints can emerge both "in-house", because of lacking cash-flows to be re-invested, and externally, given the difficulties in accessing the capital and debt markets (Thum-Thysen et al. 2019; EIB 2017). A consolidated stream of research has argued that these financial constraints are generally more hindering firms' technological innovations than non-financial barriers, like market (e.g., firm competition) or institutional (e.g., intellectual property regulations) ones (e.g. Galia and Legros 2004; Savignac 2008; Strobel and

[1] Innovation barriers can also be non-financial, and rather refer to market conditions or institutional factors. 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).

Kratzer 2016). On the contrary, recent studies have highlighted that some non-financial barriers, in particular related to market demand and knowledge availability, are at least as hampering innovation as financial ones (e.g. Belitz and Lejpras 2015; Pellegrino and Savona 2017). Irrespectively from their relative importance, the peculiarity of financial barriers is that these are the only barriers, whose effect on innovation mainly (if not even exclusively) passes through their effect on intangible investments.[2] 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 actually 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).

Research about the hindering effect that financial constraints have on investing in intangibles for the sake of innovation represents the background literature of this paper. The present paper aims at contributing to such literature by addressing two research hypotheses, which we present in the following two sub-sections.

2.1 "Unpacking" investments in intangibles in front of financial barriers

Building on the early works of the late '80s (see Hall et al. 2016), empirical evidence about the relevance of financial barriers for the firms' investments in innovation 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 intangible investments for the sake of innovation 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 also the firms' capacity to gain economic advantages from their innovations, in particular in terms of productivity and export (Coad et al. 2016; Altomonte et al. 2016).

In nearly all the studies in this stream of literature, the intangible activities in which firms invest to innovate are usually considered as an "aggregate" input that, along with tangible ones, enable firms to "produce new knowledge" and innovate (Griliches 1998). From a conceptual point of view, this compact way of retaining the firms' intangibles is motivated by their high level of knowledge intensity, that is, by the large spectrum of knowledge the relative investments make available to firms. This conceptual premise is also the reason of the frequent "reduction" of firms' intangibles for innovation to Research and Development (R&D): the intangible activity with possibly the highest degree of knowledge intensity. From an empirical point of view, a compact and/or R&D-focused approach to innovative intangibles finds its explanation in the scanty availability of disaggregated data about them. As a consequence, the set of intangibles retained in investigating their innovation impact, and in addressing the role that financial constraints have in the relative investments, do not generally go beyond R&D and some few other non-R&D innovation inputs, like Information and Communication Technologies (Hall et al. 2013).

[2] 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.

Considering intangibles as an aggregate innovative input, disregarding the great heterogeneity that characterizes their nature and role is however unfortunate. As Montresor and Vezzani (2016) have argued, this is first of all inconsistent with a resource-based view of the firm, which few papers about intangibles have begun to undertake only recently (e.g. Molloy et al. 2011; Arrighetti et al. 2013). Following this perspective, different intangibles allow the investing firm to explore the heterogeneous spectrum of activities that the innovation process entails, and this makes recommendable to approach them in an "unpacked" manner. For example, investing in R&D does actually provide firms with more scientific and/or applied knowledge to be used in seeding new (technological) inventions. The same holds true for investing in software/ICT (Quintas 1994) and in training (Bresnahan et al. 2002), from which firms however draw a different kind of inventive knowledge. Design investments can help firms in making their inventions more functional and appealing to consumers (D'Ippolito 2014), while investing in branding and reputation can make their innovations more credible on the market (Wong and Merrilees 2008). Last, but not least, investing in organisation and business process improvements is often crucial for the firm to reorganise internally in such a way to translate new inventions into successful innovations (Squicciarini and Le Mouel 2012).

The specific functional nature of different intangibles makes them heterogeneous also in the extent to which financial constraints can hamper the relative investments. As we said, the heterogeneity of the impact that financial barriers could exert on intangible investments is an aspect that the extant literature has neglected, but which we have reasons to conjecture theoretically and to test empirically. The dimensions along which this hypothesis can be put forward are at least two. First of all, different intangibles have a different placement within the organisational structure of the firm and its governance (Biondi and Rebérioux 2012). For example, R&D, design, software and, though to a lower extent, also human capital, are usually "hosted" (at least in large companies) in specific company departments, while reputation and branding, or organisation and business process improvements, are instead more transversal across different business units. Accordingly, the decisional process underlaying investments in intangibles is likely to be different and, *ceteris paribus*, can be expected to determine a differential impact of financial shortages on the relative investment decisions. For example, the financial implications and constraints of "organisationally hosted" intangibles could be object of internal bargaining and conflicts, but also easier to be identified and addressed than those of transversal intangibles.

A second dimension to consider is the inner technological nature of the firms' intangibles. Different intangibles actually show different "proximity" to the knowledge that characterises technological innovations (i.e. new products/services and production processes). R&D, for example, can be deemed technological by definition (Mairesse and Mohnen 2005), and a technological nature can be recognised also to software (Gago and Rubalcaba 2007) and design (Candi 2006). Other intangibles, instead, like reputation and branding, and organisation or business process improvements, can be deemed more functional to non-technological kind of innovations (e.g. organisational and marketing innovations). Given the higher degree of risk that technological innovations are usually recognised to have with respect to non-technological ones, and the implications that risk has been recognised to have for financing, this is another dimension that could make us expect that different intangibles could differently suffer from financial constraints because of their inner nature.

On the basis of the previous arguments, we propose to test the following research hypothesis:

Hp1: The impact of financial barriers on investing in intangibles is heterogeneous across different kinds of intangible activities.

2.2 Innovative vs. non-innovative firms in front of financial barriers

Despite its generality, the evidence about financial constraints to investing in intangibles has shown a number of interesting nuances. As we said in Sect. 2, 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, and SMEs in particular, could find a more problematic access to finance than non-innovative firms for different reasons (see Lee et al. 2015; Canepa and Stoneman 2007; Czarnitzki 2006; Freel 2007). 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; last but not least, innovative firms produce and rely on innovative collaterals that are largely firm-specific and may hamper fund raising out of their boundaries.

Although some of these mechanisms have been clearly ascertained, what emerges from the relative literature is a 'circular' relationship, which makes the issue at stake difficult to be grasped empirically. Firms do find severe financial problems when engaging in innovation for the first time. However, 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 brief, while the former would impede innovation, the latter would delay, constrain and eventually stop it afterwards (Baldwin and Lin 2002).

The previous distinction is important when devising customized strategic and policy actions to address financial constraints to investing in intangibles. 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). In spite of this intense research effort, what we learnt about the differential impact of financial barriers between innovative and non-innovative firms is unfortunately not conclusive and, being mainly country-specific, hard to generalise. With respect to the UK, D'Este et al. (2012) have found that finance-related cost barriers deter non-innovative firms 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 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 (2018) returns to indicate that internal and external shortages of financial resources are more deterring non-innovating firms than revealed by innovative ones 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) show that financial barriers are an inherently deterring barrier, i.e. for non-innovative firms: but this holds true only in a subset of EU countries far from the technological frontier.

The mixed evidence so far obtained makes the differential impact of financial constraints between innovative and non-innovative firms an hypothesis that, while not new in

conceptual terms, is still open in terms of empirical validation and thus still requires to be posed. To be sure, an element of novelty in its statement emerges when the methodology with which the issue has been addressed by previous studies is disentangled. In the literature about innovation barriers, the twofold nature of financial (and non-financial) barriers is investigated 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.[3] 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, that is, intangible investment, is: either among the explanatory variables (D'Este et al. 2012); or a variable used to split the sample when looking at the role played by other regressors (D'Este et al. 2014). In this methodological setting, an important problematic issue emerges. In accounting for the perception of financial barriers, the innovative engagement of the focal firms is retained simultaneous to it. In so doing, whether financial barriers actually have a differential impact on intangible investments between innovative and innovative firms becomes impossible to be ascertained, as the perception of the seriousness of such an impact is evidently endogenous.

In order to address these methodological issues, we propose to reverse the focal relationship with respect to the extant literature. In particular, we consider the firms' investments in different intangibles as the dependent variable, and the financial barriers that they face as a regressor, which we render exogenous through an instrumental variable approach. By applying this empirical approach to the previous argument about the distinction between "deterring" and "revealed" financial barriers, we expect that:

Hp2: The impact of financial barriers on investing in intangibles is different between innovative and non-innovative firms.

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.

Like most innovation surveys, the Innobarometer is cross-sectional (Mairesse and Mohnen 2010). Furthermore, as for other large-scale surveys on innovation, firms' names or

[3] 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 2008is 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.

identifiers are not available and it is not possible to link different waves of the Innobarometer between them and with other external company data. This makes it difficult to go beyond the estimation of simple correlations among variables. However, as we will detail in the following (Sect. 3.2), an original approach can be adopted to get closer to causal relationships and address the problems we have pointed out in investigating the relationship between financial barriers and intangible investments (Sect. 2.2). In brief, drawing on a pseudo-panel approach, we will use information from a previous wave of the one at stake—the Innobarometer 2014, covering the years 2011–2013—to build up instrumental variables and make the variable about financial barriers exogenous.[4]

The Innobarometer collects information on a wide variety of aspects, including the three focal ones of our analysis.

Firstly, it provides information on the shares of turnover that firms have invested in six typologies of activities that the survey itself defines as "intangible".[5] The Innobarometer survey identifies the following six intangibles: (1) training, (2) software development, excluding research and development and web design, (3) research and development (R&D) (4) design of products and services (excluding research and development); (5) company reputation and branding; and (6) organisation or business process improvements. In choosing these six items and in distinguishing among them, the Innobarometer follows previous national surveys on intangibles—in particular, that by the UK Office for National Statistics (ONS) commissioned to NESTA (see Awano et al. 2010—in turn carried out to get more detailed and disaggregated info than that obtainable from national accounting data (see Corrado et al. 2005). In particular, these surveys try to identify intangible activities as inputs (rather than as outputs, like patents) of the innovative process and refer to domains in which firms develop distinguished capabilities to implement their innovative process.

With respect to previous surveys, the Innobarometer has the great advantage to have collected, for the first time ever, harmonised information about intangible activities for all of the European 28 countries (at 2015). Unfortunately, the Innobarometer has reached this pervasive diffusion through a "flash survey", carried out with the CATI methodology,[6] with no chance to provide the respondents with detailed definitions and/or examples about the six intangibles considered. Accordingly, rather than about intangible assets as such, the relative questions are just able to inform about the "intangible activities" (*sic*) of the interviewed firms. As the relative technical documents report, the flash-survey methodology is not free from limitations. However, it has been shown that these limitations—like the presence of systematic response biases and potential groups of outliers—are not prohibitive problems for the analysis (Montresor et al. 2014).

Secondly, the Innobarometer also provides information about the firms' perception of the importance that the lack of financial resources has 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—and makes the Innobarometer suitable to capture a "perceived" kind of financial barriers. While other cross-country surveys exist that collect

[4] The two waves of the survey present very close sample characteristics (available at: https://data.europa.eu/euodp/it/data/dataset/S2054_415_ENG).

[5] 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%.

[6] The computer-assisted telephone interviewing (CAT I) is one of the most popular survey techniques, carried out through a telephone call with the interviewer generally following a script provided by a software program.

information about the "actual" financial barriers that firms experiment—like, for example, the semi-annual Survey on the Access to Finance of Enterprises (SAFE) by the European Commission and the European Central Bank[7]—these surveys lack of information about the firms' investments in intangibles and, above all, they miss of proper identifiers to be linked with the Innobarometer. Once more, the Innobarometer is the first survey to cover harmonised firm information about perceived financial barriers for a large number of countries. Unfortunately, this occurs at the cost of no details about the kind of financial source (e.g. internal vs. external) firms resort to and with respect to which they declare to perceive obstacles. Given that this information is likely to vary across the different intangibles activities (Sect. 2.1), and that innovative and non-innovative firms also differ in the source they privilege for their investments (Sect. 2.2), this is an unfortunate gap that future studies will have to address.

Thirdly, the Innobarometer follows the long tradition of the Community Innovation Survey (CIS) and distinguishes innovative from non-innovative firms by asking to the respondent a dichotomic question about the introduction of product or service innovations in the retained period. This is also the way we deal with innovation in our econometric analysis. As we will say, the variable *Innovation*—taking value 1 if a focal firm has introduced novel products and/or services and 0 otherwise—will be used to control for the different propensity toward investing in intangibles between innovative and non-innovative firms, and to assess whether financial barriers play a differentiated role between the two group of firms.

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 m ($Intangible_{im}$) controlling for a series of other covariates (X_i):

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

In order to address our first research hypothesis (Sect. 2.1), Eq. (1) is estimated separately for each intangible m of the six considered: *R&D*, *Design*, *Software*, *Organization_Business*, *Reputation_Branding*, and *Training*. In each and every case, the dependent variable takes values 1 (0 otherwise) if the firm has invested in the focal intangible activity. As for our second research hypothesis (Sect. 2.2), Eq. (1) will be estimated by augmenting its benchmark specification with an interaction term between our main regressor, $Financial\_barriers_i$, and the variable $Innovation_i$, which takes value 1 if the focal firm has introduced novel products and/or services and 0 otherwise. Should the interaction be significant, a positive (negative) sign would suggest that financial barriers hamper the intangible investments of innovative firms more (less) than non-innovative firms; should the interaction be non-significant, Hp2 would be rejected.

Our main regressor in Eq. (1), $Financial\_barriers_i$, 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.[8] As we have noticed in Sect. 2.2, estimating Eq. (1) *sic et simpliciter*, would expose us to the risks of simultaneity bias and reverse

[7] See https://www.ecb.europa.eu/stats/ecb_surveys/safe/html/index.en.html.

[8] 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.

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
Public support (2014)	0.15	0.11	0.11	0.00	0.42
Public procurement (2014)	0.33	0.16	0.28	0.11	0.73

Calculated on the Innobarometer 2014 (t − 1)

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 Sect. 3.2.1). As we will say (Sect. 3.2.2), for the sake of consistency with this approach, we will also transform our dependent variable $Intangible_{im}$.

3.2.1 Financial barriers: building up the instruments

The way we propose to make exogeneous our focal regressor, $Financial\_barriers_i$, is to instrument it with a set of instrumental variables that firms reveals in a previous period to that of the dependent variable ($Intangible_{im}$). In other words, rather than searching for candidate instruments in the same dataset of the dependent variable—the Innobarometer 2015—we build up our instrumental variables by using a pseudo-panel transformation of the Innobarometer 2014: a 1-year lagged wave of it ($t-1$).

In the absence of firm identifiers to link the two waves directly, this transformation is accomplished in two steps.

(1) First, we create a set of groups by collecting together 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, according to the variable *Innovation*).[9] In so doing, we collect the observations of the Innobarometer 2014 into 32 different groups of structurally similar firms.[10]
(2) Second, we build up group-specific values at $t-1$ of the two instruments of $Financial\_barriers_i$ that we have identified and associate them to structurally similar group-firms at t.

[9] 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 + '.

[10] 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 Sect. 4 for further info).

As far as the instruments are concerned, the first one, $Publicsupport_{t-1}$, is a dummy that tells us whether the sampled firms have received at $t-1$ financial aid from the public sector (e.g. a subsidy) for the introduction of their innovation activities. The underlaying logic of its choice is that, as the literature about the financial motivations of innovation policy has shown (see Hall et al. 2016), public resources are used by the recipient firms to restore the sub-optimal financing of their innovation, with the effect of attenuating the financial barriers they perceive. In brief, we expect $Publicsupport_{t-1}$ to significantly correlate with $Financial\_barriers_i$ with a negative sign. Conversely, we argue that the same public support does not have a direct effect on the firms' decision to invest in intangible activities, as such an effect can only be conveyed by their impact on their financial constraints (see Sect. 2).

The second instrument that we construct is $Publicprocurement_{t-1}$, a dummy that tells us whether the sampled firms have won at least one public procurement contract at *t-1*, for whatever kind of business activity, i.e. not necessarily dedicated to innovation. Also in this case, we argue and expect that the public demand increase induced by the procurement can be eventually reflected in an increase of the firms' turnover, and that such an increase could be internally reinvested by attenuating the perception of their financial constraints. Conversely, we do not expect that a generic increase of the firms' public demand, differently from the dedicated one associated to innovation-procurement, can induce per se a change in their attitude toward investing in specific intangible activities.

As usual, the theoretical arguments that underlay the instruments could be debatable, and an empirical test, which we will present in the following, may reveal therefore decisive in evaluating their validity.

Following the pseudo-panel approach, the two instruments are computed for each group, *g*, of the Innobarometer 2014 (*t-1*), as the share of its firms that declared to have received financial support for their innovation activities ($Financialsupport_{g,t-1}$) and to have won at least a public procurement contract ($Publicprocurement_{g,t-1}$). We then assign these group values 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 receiving public financial support or winning a public procurement contract 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* has been actually backed by public resources.[11]

Following Wooldridge (2012, p. 619), the instrumentation of the financial barriers should be made by regressing them against the two instruments discussed above and the full set of covariates used in Eq. (1), X_i, about which we will say in a while (Sect. 3.2.2):

$$Financial_{barriers_{it}} = \delta_0 + \delta_1 Publicsupport_{ig,t-1} + \delta_2 Publicprocurement_{ig,t-1} + \theta' X_i + \varepsilon_i \quad (2)$$

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

[11] In brief, the higher the share of firms in a certain group at t-1 that appears to be financially supported in their innovation or winner of a public procurement, the higher the probability that a focal firm *i* of the correspondent group at *t* will also be financially supported or winning a public procurement.

group differences among firms. In particular, for each and every firm i of the Innobarometer 2015 we recode the variables $Intangible_{im}$ to 1, 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 0 otherwise.

Given that groups are defined also on the basis of the firm size (Sect. 3.2.1), the transformation already cleans out its effect and, accordingly, we do not include size in the control vector, X, in the estimates of Eq. (2). In order to control for unobserved heterogeneity, we instead plug in both Eqs. (1) and (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 proxing it with two dummies, capturing whether the observed firms experienced a substantial increase or decrease in their turnover. Secondly, we consider whether the focal 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 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.

A description of the variables and the relative survey questions is reported in Table 6, while descriptive statistics and the correlation table are reported in Tables 7 and 8, respectively (see the Appendix). It is worth noticing that while innovative and non-innovative firms display quite different mean values for most variables, highlighting structural differences across the two groups, the same does not hold true for financial barriers.[12] Innovative firms tend to invest more in intangible activities than non-innovative ones, but they seem to have the same probability to face financial barriers: a crucial aspect on which we will return among the results.

3.2.3 Econometric strategy

Considering the nature of our dependent variable and of our focal regressor, Eqs. (1) and (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 for the estimate of the binary dependent variable in Eq. (1).

As we have anticipated, in order to distinguish the role that financial barriers have in driving the firms' investments in our set of intangible activities between innovative and non-innovative firms, for each of the six intangibles we estimate three sets of recursive bivariate probit models: the first one pools all firms together, without distinguishing their innovative status; the second specification accounts for the innovative status of the sample firms by plugging the dummy *Innovation* in Eq. (1); the third model introduces in Eq. (1) the interaction term between $Financial\_barriers_i$ and the variable $Innovation_i$, to test for the possible different role played by financial barriers across the two groups of firms.

While capable to control for the possible endogeneity of financial barriers in a binary setting, the adopted recursive bivariate probit models unfortunately does not provide us the usual battery of tests to assess the validity of the adopted instrumental variables. Given the importance of these tests, just for the sake of their calculation, we have a run preliminary

[12] A t-test suggests that there is no significant difference between the means of the two groups (p-val 0.212).

estimates of Eqs. (1) and (2) using a linear probability model (LPM) in a "standard" instrumental variable regression setting. For the sake of illustration, Table 9 in the Appendix reports the relative results with respect to the firms' investments in R&D.[13] All the tests, reported at the bottom of the table, support the choice of our instruments and reassure us about the validity of our theoretical arguments. The results of Table 9 does also provide some introductory evidence about our research questions, showing that the instrumented financial barriers variable is negatively correlated with R&D investments and that the relationship is robust to the inclusion of the innovation variable, which is also expectedly correlate with R&D investments in a positive way. However, in spite of the provided tests for the instruments, the LPM does not appear suitable to carry on with our investigation. In addition to the usual concern about the non-delimited domain of its estimated dependent variable, the use of the LPM renders problematic the estimate of the interaction term between $Financial\_barriers_i$ and $Innovation_i$, which is instead pivotal for testing our second research hypothesis. In the same setting, the construction, interpretation and comparison of the marginal effects, important for testing our first research hypothesis, is particularly cumbersome.[14]

Because of these problems, we refer to the LPM estimates only in supporting the choice of our instruments for the variable $Financial\_barriers_i$ and keep on using the recursive bivariate setting in presenting our main results in the following section.

4 Results

4.1 The Innobarometer pseudo-panel: descriptive statistics

Before commenting our results, it should be noted that the 32 sub-groups used to merge the two waves of the Innobarometer by using our selected firms' characteristics (size, industry, and innovation status) have an appreciable size, which favours a reliable estimation of their 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 distribution of firms across the sub-groups is only slightly right skewed. The smallest of the 32 identified sub-groups contains 36 firms and only 4 groups have less than 100 observations.

As for the instrumental variables, *Public procurement* lies on a larger support (*Min–Max*) and has a higher standard deviation than *Public support*. In other words, the sub-groups are more heterogeneous with respect to the former variable than to the latter. This appears visible also from Fig. 1, where we plot the estimated kernel distribution for the two variables. *Public procurement* is less concentrated, but both are almost normally distributed, with a slightly fatter tail on the right side (higher values) of the distribution.

[13] Similar results about the tests, available from the authors upon request, are obtained for the other intangibles, with respect to which the role of financial barriers appears consistent with that we will comment in the next Sect. 4.

[14] We have also estimated our focal relationship with a multivariate probit model, which accounts for the possible correlation between investments in different intangibles, but do not provide a suitable framework for an instrumental variable approach and also makes the construction and interpretation of the marginal effects particularly cumbersome. Results, available from the authors upon request, are generally consistent with the ones reported in the next Section.

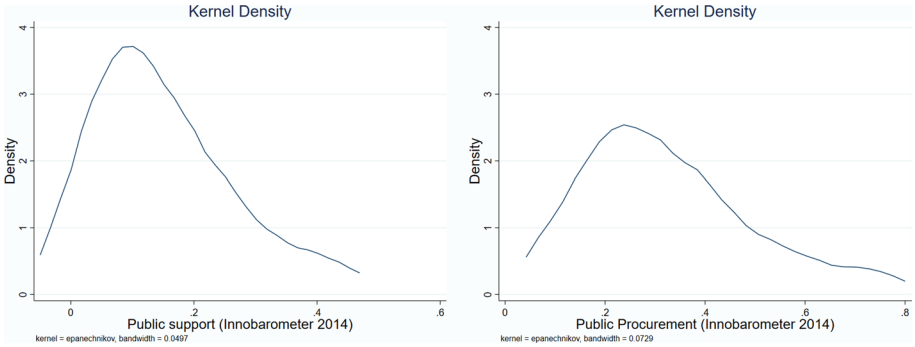

Fig. 1 Kernel density estimates of the instrumental variables

Before commenting our estimates, it should also be noticed that the Wald test for the exogeneity of financial barriers (reported at the bottom of Table 2) reject the null hypothesis of no endogeneity for five out of the six intangibles 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.

4.2 On the determinants of perceived financial barriers

The results of the first step of our econometric strategy for the basic specification of Eq. (2) confirm that our two focal instruments significantly account for the firms' perception of financial barriers. In general, and as expected, the two instruments reduce the chance of perceiving financial barriers as severe, showing negative coefficients when they are statistically significant.

Indeed, Table 2 reveals that this occurs with differences across the types of intangibles that we consider. Receiving financial support for innovation and winning a public procurement jointly reduce the probability of perceiving financial constraints only in the bivariate estimations for design and organisation & business processes improvements. With respect to R&D and training investments, it is only a direct public support that attenuates the probability of perceiving severe financial barriers; with respect to investments in software and in reputation & branding (though only limitedly significant), instead, it is only public procurement that plays the same role. Leaving aside the conjectures that could be formulated in interpreting this heterogeneity in the first-step results, the important thing that emerges from their reading is that the joint consideration of the two types of instruments helps us in capturing possible specificities in the relationship between public support, financial barriers and the firms' decision to invest in different kinds of intangible activities.

The results about the other regressors of $Financial\_barriers_{it}$ in Eq. (2), which we have inserted to be consistent with the second step of our model, are also generally

[15] The hypothesis of exogeneity of financial barriers is supported by the data only for reputation and branding (and for training in the full specification reported in Tables 4 and A5). Therefore, we have also tried to estimate the same equations for these intangibles without instrumenting the financial barriers. The coefficients attached to financial barriers, innovation and their interaction are not different from those reported in the tables. Results are available upon request.

Table 2 Financial barriers perceived as a major problem by firms investing in specific intangibles: first-step probit estimates (Eq. 2)

Financial constrain for eq. →	R&D	Design	Software	Organis. business	Reput. branding	Training
Public support	−1.628***	−1.090***	−0.274	−0.682***	−0.305	−1.019***
	(0.248)	*(0.215)*	*(0.250)*	*(0.264)*	*(0.341)*	*(0.350)*
Public procurement	−0.284	−0.482**	−0.823***	−0.571**	−0.495*	−0.209
	(0.201)	*(0.189)*	*(0.203)*	*(0.235)*	*(0.289)*	*(0.291)*
Turnover increased	−0.091**	−0.111***	−0.112***	−0.109***	−0.121***	−0.116***
	(0.036)	*(0.037)*	*(0.039)*	*(0.039)*	*(0.032)*	*(0.037)*
Turnover decreased	0.468***	0.470***	0.476***	0.483***	0.491***	0.482***
	(0.026)	*(0.027)*	*(0.028)*	*(0.028)*	*(0.026)*	*(0.029)*
Adv_technologies	0.095	0.025	−0.023	0.013	−0.032	0.030
	(0.072)	*(0.063)*	*(0.057)*	*(0.069)*	*(0.069)*	*(0.067)*
Young	0.213***	0.227***	0.235***	0.239***	0.251***	0.251***
	(0.036)	*(0.037)*	*(0.036)*	*(0.035)*	*(0.031)*	*(0.033)*
Group	−0.074*	−0.096**	−0.136***	−0.123***	−0.163***	−0.139***
	(0.039)	*(0.044)*	*(0.049)*	*(0.045)*	*(0.040)*	*(0.038)*
Industry fixed effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Country fixed effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Constant	0.237*	0.237**	0.224*	0.180	0.079	0.126
	(0.124)	*(0.107)*	*(0.123)*	*(0.129)*	*(0.133)*	*(0.145)*
Observations	12,198	12,065	12,194	12,089	12,222	12,260
Rho	0.911	0.794	0.785	0.724	0.449	0.598
Wald test rho = 0	76.76	24.35	14.05	36.43	3.179	23.43

Standard errors clustered at the sub-group level. ***$p<0.01$, **$p<0.05$, *$p<0.1$

Table 3 Investing in intangibles and (instrumented) financial barriers: second-step probit estimates of the benchmark model (Eq. 1)

Intangible investments →	R&D	Design	Software	Organis. business	Reput. branding	Training
Financial barriers	−1.412***	−1.206***	−1.306***	−1.177***	−0.679*	−1.040***
	(0.037)	*(0.112)*	*(0.146)*	*(0.101)*	*(0.360)*	*(0.156)*
Turnover increased	0.089***	0.077**	0.060**	0.145***	0.153***	0.076**
	(0.032)	*(0.031)*	*(0.029)*	*(0.038)*	*(0.037)*	*(0.037)*
Turnover decreased	0.220***	0.183***	0.183***	0.147***	0.048	0.092***
	(0.024)	*(0.042)*	*(0.040)*	*(0.039)*	*(0.072)*	*(0.034)*
Adv_technologies	0.308***	0.269***	0.149**	0.337***	0.101*	0.227***
	(0.059)	*(0.048)*	*(0.059)*	*(0.037)*	*(0.055)*	*(0.055)*
Young	0.105**	0.103**	−0.024	0.112***	0.080	0.011
	(0.047)	*(0.049)*	*(0.041)*	*(0.042)*	*(0.060)*	*(0.035)*
Group	0.089**	0.021	0.025	0.032	−0.020	0.068*
	(0.039)	*(0.041)*	*(0.036)*	*(0.041)*	*(0.043)*	*(0.038)*
Constant	0.506***	0.457***	0.752***	0.570***	0.718***	0.601***
	(0.099)	*(0.085)*	*(0.090)*	*(0.087)*	*(0.195)*	*(0.139)*
Observations	12,198	12,065	12,194	12,089	12,222	12,260
Rho	0.911	0.794	0.785	0.724	0.449	0.598
Wald test rho = 0	76.76	24.35	14.05	36.43	3.179	23.43

Standard errors clustered at the sub-group level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. The Wald tests reject the null hypothesis of no correlation among the errors of the two equations: only for the Reput. Branding equation the p-value is in a "grey zone" (0.075). The estimations include country and industry fixed effects

expected. Younger firms reveal a higher propensity of perceiving themselves as strongly constrained in financial terms, while the contrary holds true for firms that belong to business groups, in which they can find alternative sources of finance. Quite interestingly, firms experiencing a decrease in their turnover have a higher probability to perceive financial barriers as strong with respect to firms with a stable turnover; conversely, firms with an increased turnover have a lower probability of the same perception. Assuming that, as we argued, an increased (decreased) turnover could feed (impoverish) the financial resources internally available to the firms, and thus (imperfectly) proxy their cash-flow, this appears consistent with the implications of the "pecking order" theory of finance (Myers and Majluf 1984), predicting that internal resources are the priority source of funding for investing in intangibles.

4.3 The impact of financial barriers on investing in intangibles

Moving to the second step of our recursive bivariate probit models, Table 3 shows that by estimating Eq. (2) in its benchmark specification, without controlling for the innovative status of the sample firms, *Financial barriers* significantly reduce the probability

that firms invest in intangible activities across the board. This is consistent with the literature that we have reviewed in Sect. 2, pointing to the relevance of financial obstacles for investing in intangible activities. However, as we will see in the next section, when we account for the innovative status of the investing firms, the picture becomes more heterogeneous, as our Hp1 would predict, and interesting results also emerge by looking at the moderating effect of the same innovative status (Hp2).

Before moving to these results, some comments are necessary with respect to the controls considered in the estimate of Eq. (1). As expected, having adopted advanced manufacturing technologies is positively correlated with the investment decision in each and every of the six intangibles. This confirms that the adoption of advanced technologies entails the need of a wide set of knowledge-intensive, intangible assets (Gómez and Vargas 2012). With respect to those intangibles in which it emerges significant—that is, R&D, design and organization or business process improvements—*Young* reveals a positive sign, suggesting that, consistently with the extant literature (Pellegrino et al. 2012), younger firms could result more eager to invest in intangibles and to increase their innovativeness through these types of investments. Quite interestingly, being part of a business group is positively associated with a higher probability to invest only in R&D, suggesting that more articulated business structures offer an investment advantage only in intangible expenditures that are closely related to the inventive stage.

Finally, special attention should be paid to the effect that a change in the firms' turnover, as we said a (possibly imperfect) proxy of their availability of internal resources, can have on their decision to invest in intangible activities. Those firms that declared to have experienced a turnover increase show, as expected, a higher probability to invest (more intensively than their structural peers) in intangible activities. This is consistent with the demand-pull hypothesis, which links demand, profitability and innovation (Schmookler 1966; Mowery and Rosenberg 1979). More interestingly, with the exception of reputation and branding, we also find a positive coefficient for firms that experienced a decrease in their turnover. At first sight, this could appear counter-intuitive. However, at a closer scrutiny, and combined with that about turnover increase, this result is in line with recent research on the "out-of-equilibrium" conditions at the basis of the innovative efforts of firms (Antonelli and Scellato 2011). In brief, intangible investments and innovative efforts would be spurred, not only by high (increasing) profits and resources—leaving more scope to undertake risky activities—but also by low (decreasing) levels of them—setting a situation in which firms' exit is a threat and their innovation represents a crucial leverage to survive. Revealing an interesting U-shape relationship, firms with "normal" performances, that is "in-equilibrium", may be less ready to change their technologies and their organization (Antonelli and Scellato 2011).

In spite of some marginal variations, the previous results about the controls remain unchanged when we consider the augmented specifications of Eq. (1) (see Tables 10 and 11 in the Appendix). As we anticipated, this is not the case of the test of our research hypotheses, to which we move in the next sub-sections.

4.3.1 "Unpacking" investments in intangibles in front of financial barriers (Hp1)

At the outset, let us notice that, as expected, the innovative status of the sample firms is generally associated with a higher probability to invest in intangibles (Table 4). Although to a different extent, all of the six intangibles have been shown to be innovative inputs (Montresor and Vezzani 2016), and this gets reflected in our results, but with the notable

Table 4 Investing in intangibles and (instrumented) financial barriers: second-step probit estimates with innovation dummy (top) and innovation interaction (down)

	R&D	Design	Software	Organis. business	Reput. branding	Training
Model with innovation dummy						
Financial barriers	−1.176***	−0.759***	−1.230***	−1.007***	−0.513	−0.529
	(0.150)	*(0.230)*	*(0.200)*	*(0.151)*	*(0.510)*	*(0.341)*
Innovation	0.412***	0.416***	0.158***	0.202***	0.086	0.216***
	(0.065)	*(0.059)*	*(0.060)*	*(0.072)*	*(0.071)*	*(0.056)*
Model with innovation dummy & interaction between innovation and financial barriers						
Financial barriers	−1.153***	−0.757***	−1.231***	−1.011***	−0.488	−0.527
	(0.126)	*(0.229)*	*(0.215)*	*(0.143)*	*(0.522)*	*(0.343)*
Innovation	0.427***	0.414***	0.147**	0.215***	0.072	0.214***
	(0.063)	*(0.065)*	*(0.071)*	*(0.078)*	*(0.082)*	*(0.059)*
Financial barriers * innovation	−0.081	0.008	0.048	−0.058	0.060	0.008
	(0.052)	*(0.053)*	*(0.069)*	*(0.057)*	*(0.064)*	*(0.057)*

The full tables of reporting the results of the bivariate probit estimations are reported in the appendix (Tables 10 and 11). Standard errors clustered at the structural group level

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

exception of reputation and branding. In spite of the evidence about its relevance in increasing the market value of innovations (Argenti and Druckenmiller 2004), innovative firms do not seem to dedicate greater resources to its development than non-innovative ones. This might suggest that, in the sample of EU firms at stake, building up a reputation and a corporate branding is seen as strategic to compete across the board, invariantly between innovative and non-innovative firms and irrespectively from the marketing needs imposed to the latter by newly developed products and processes.

Coming to our focal regressor (*Financial barriers*), our Hp1 finds confirmation in two respects. In a first respect, financial barriers appear to constrain the firms' investments in some selected intangibles only, namely in four out of the six intangibles that we have considered (Table 4).

As expected, the first of these intangibles is R&D: a result consistent with the standard literature on innovation and finance, as we said, exclusively focused on the problems posed by the idiosyncratic knowledge (i.e. opaque, incompletely appropriable) characterizing R&D (Hall and Lerner 2010; Lee et al. 2015). These market-failures apparently make the presence of financial problems constraining the realisation of R&D investments.

Investments in software appear significantly reduced (still, in the comparison with structurally similar firms) by financial constraints too, pointing to the burden of monetary resources that an apparently "soft" kind of technological intangibles does also require in order to be developed (Quintas 1994). In this last respect, we should consider that, in the lack of detailed definitions with a CATI survey, the Innobarometer question about software does not only capture the simple (and possibly "cheap") acquisition of software, but extends to all the expenditures that firms face in developing, customizing and using software to compete in the digital economy (Oliveira et al. 2018).

As for the remaining intangibles, considering the complex role that design plays for firms' innovation performances (Montresor and Vezzani 2020), both technological (i.e. functional) and non-technological (i.e. aesthetic), the results we got about its financial

Table 5 Marginal effects of financial barriers on intangible investments

Intangible	MEM *(p-val)*	AME *(p-val)*
R&D	−0.131*** *(0.000)*	−0.127*** *(0.000)*
Software	−0.120*** *(0.000)*	−0.126*** *(0.000)*
Organization_business	−0.094*** *(0.000)*	−0.101*** *(0.000)*
Design	−0.075*** *(0.001)*	−0.076*** *(0.002)*
Branding	−0.042 *(0.379)*	−0.045 *(0.385)*
Training	−0.048 *(0.124)*	−0.051 *(0.122)*

In the table we report the marginal effects computed at the mean of the remaining variables (MEM) and the average marginal effect (AME)—computed averaging the marginal effects for each observation—of being financially constrained. Marginal effects are computed for the regressions including the innovation dummy and its interaction with the financial constraints, and allowing for heteroskedasticity or other violations of distributional assumptions as well as for the correlation among observations

implications can also be deemed consistent. Design is central to new product development and absorbs an important part of its costs, forcing firms that cannot afford to cover these costs to reduce their relative involvement (Roper et al. 2016). Not surprising is also the role that financial barriers have with respect to the investment in organisation and business process improvements. The organisational dimension of firms seems to be as financially problematic as its knowledge dimension. Firms may find difficult, and costly, to comprehend and adopt new business methods to sustain the organizational change needed to enhance their dynamic capabilities; probably one of the factors that matter more over the long-run in determining their success (Nelson 1991).

At the opposite extreme of the spectrum, *Financial Barriers* do not have a significant effect on investments in reputation and branding and in training. As far as the former is concerned, in spite of the stock-market evaluation that advertising and trademarks have been found to guarantee to the investing firm (Hall 1993; Dosso and Vezzani 2020), and that financers could positively retain in lending, this result is 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). This result could tentatively 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.

Possibly more unexpected is the result about training investments, which do not appear significantly affected by the firms' financial constraints either. Skills and competencies are notably hard to be developed at the corporate level, both in-house (corporate training) and through outsourced human-resource-management practices: the occurrence of financial constraints would thus appear relevant in constraining the relative investments. In contrast to this argument, we could recall (see Sect. 2.1) the organisational placement that these intangible investments usually find in dedicated company divisions, where the relative costs could be better managed and controlled. An additional explanation could be provided by the fact that, still in the absence of detailed intangible definitions in the CATI survey,

the most expensive kind of training could have been referred by the respondents in addressing the other intangible investments: for example, this might be the case of training qualified research personnel, which could be captured by R&D investments.

The second respect in which our Hp1 is confirmed concerns the marginal effects that being financially constrained has on the significant intangible investments of the six (Table 5). At the outset, let us notice that such effect is not negligible at all. Even by considering the lowest value, the probability that a focal firm invests in design more than its (subgroup of) structural peers is about 7.5 percentage points lower when it is financially constrained.

More importantly, even with respect to these four financially constrained intangibles, the average marginal effects appear heterogeneous. In particular, the effects of financial barriers result the highest with respect to the most technological of the four intangibles, that is R&D (-0.13) and software (-0.12), while the most non-technological ones, that is design (-0.075) and organisation or business improvements (-0.094), stay somehow behind. Thinking of the different implications and costs of these two kinds of intangibles (for which, see Montresor and Vezzani 2016), this result appears consistent and, as we said, provides further support to our Hp1.

4.3.2 Innovative vs. non-innovative firms in front of financial barriers (Hp2)

When we further augment the specification of the second step, and plug among the regressors of Eq. (2) the interaction between *Financial_barriers* and *Innovation*, the results are not supportive of our Hp2.

For each and every of the considered intangible activities, the interaction at stake is always statistically non significant (Table 5, lower panel). Contrary to our expectations, in spite of the higher propensity that innovative firms show to invest in (the significant) intangibles, the strength with which financial barriers hamper their investments does not significantly differ with respect to non-innovative firms. In conceptual terms, this result might suggest that having an innovative status could both exacerbate and attenuate the extent to which facing financial problems translate into (relatively) lower intangible investments. On the one hand, being (or having been) innovator presumably provides the focal firm with experience and competences about how to deal with intangible activities, which are in fact crucial innovative inputs; and this could also make innovators more capable to recognise and manage the problems that a (relative) increase of their financial barriers could pose to investing in intangibles. On the other hand, an innovative status could also make firms disadvantaged in facing the consequences of major financial problems on intangible investments, given the more pervasive trade-offs (e.g. between exploration and exploitation) that innovators have to face in choosing the extent to which to reduce their intangible efforts. As these and possibly other exacerbating vs. attenuating effects could emerge and contrast each other, the "net" outcome of an innovative status could be precisely that of letting the strength of the hampering effect played by financial barriers unaltered with respect to a non-innovative status.

From an empirical point of view, the result that we have obtained about Hp2 could be read as consistent with the contrasting picture that emerges from the tests carried out about the deterring rather than revealed nature of financial (and non-financial) barriers (see Sect. 2). As we said, in a typical single-country setting, these tests turned out inconclusive, suggesting that financial barriers could be deterring rather than revealed also depending on the specific context. In a large multi-country setting like ours, opposite outcomes could

compose and lead to an invariant nature of financial barriers: in brief, the strength of their effect in hampering intangible investments is the same in deterring and in restraining their possible innovative use by non-innovative and innovative firms, respectively.

As we will say in the next Section, once combined with the support to Hp1, the rejection of Hp2 poses new policy implications about the types of public action through which investments in intangible activities could be stimulated at the firm level.

5 Conclusions

The lack of financial resources has emerged as an important obstacle to the firms' engagement in innovation since long. While the literature on the topic is already abundant, two important gaps remain to be filled. First, the way in which firms engage in innovation, by allocating resources across different kinds of intangible activities has been scantly considered so far, implying that financial barriers hamper intangible investments uniformly. Second, whether financial barriers affect innovative and non-innovative firms to a different extent has been investigated under the weight of some methodological problems that prevent from grasping its actual relevance. Both gaps are indeed relevant, as their filling would make policy interventions and managerial actions to attenuate financial barriers more accurate and effective in promoting investments in innovative activities.

The present paper aims at filling these two gaps. On the one hand, rather than focusing on R&D investments only, as much of the extant literature has done, we have also considered a set of non-R&D intangibles (software, design, reputation and branding, organization and business processes improvements) relevant in the innovation process. On the other hand, we have improved previous analyses of the differences between innovators and non-innovators in investing in intangibles, by better dealing with the possible endogeneity that affects the perception of financial barriers emerging from survey data. In particular, by referring to a large multi-country sample of firms in the EU28, we have proposed an original pseudo-panel extension to instrument financial barriers. Through these two novel aspects, we have obtained new interesting results about the impact that financial barriers have on the firms' investments in intangible activities.

Before turning to their implications, it should be retained that our results are obviously not free from limitations, mostly related to the dataset we used. While an extremely precious and in some respects unique source of information, the Innobarometer forced us to focus only on a perceived kind of financial barriers. Our results would need to be integrated with those of other analyses, about the actual financial obstacles that firms experiment in investing in intangibles. However, this would need data with available firm identifiers to allow the link between different datasets. Another limitation is represented by the concise way in which the flash Innobarometer survey has collected data about intangible activities. More detailed and accurate information (e.g. on their specific definition, amortization, life expectancy, and the like) are required to extend our results to the realm of "intangible assets" as such. Again, this would need a link with company balance-sheet data or a much detailed (and heavy) questionnaire, to whose implementation future research should also dedicate.

Coming to the results that we have obtained, they support our research hypotheses only partially, suggesting important research and policy implications. To start with, as we did expect, the impact of financial barriers on investing in intangibles is heterogeneous across different kinds of activities. Out of the six intangibles that we consider, only four appear

systematically hindered by financial barriers. Furthermore, the marginal effect that financial barriers have on investing in intangibles is also heterogeneous. The extent to which financial barriers hamper the firms' engagement in innovation depends also and above all on their portfolio of intangible activities and on the strategies that they pursue in order to fill it.

This first result has implications for the academic debate on the topic, as future research should avoid aggregated analyses of the impact of financial barriers on intangibles and concentrate on the inner motivations of their heterogeneity. Furthermore, the same result has also relevant policy implications. In particular, an effective public support to the investments at stake requires a careful screening of the intangible domains in which firms are requested to invest for their innovation projects. Different projects could rely on different intangibles and the relative financial needs and constraints could thus require a different extent and kind of policy action. In brief, the firms' portfolio and their profile of intangible activities should enter in the toolbox of information that policy-makers use to support innovation.

Contrary to our expectations financial barriers do not differently affect intangible investments by innovative and non-innovative firms. In other words, the weight of financial constraints is apparently the same in deterring and in restraining their possible innovative use by non-innovative and innovative firms, respectively. This result does also have important implications. The financial heterogeneity of intangible investments does not depend on the innovativeness of the investing firms and is apparently intrinsic to their own nature. Future research might ascertain whether the invariance of the hampering effect of financial constraints also applies to the specific kind of innovative profile of the investing firms; for example, by focusing on non-technological (marketing and/or organisational) rather than technological (product and/or process) innovators. The result has also interesting policy implications. When deciding about the public interventions to alleviate the firms' financial constraints on intangible investments, the innovative status of the recipient firms appears less decisive than their portfolio of intangible activities, letting policy makers with more degrees of freedom in addressing the relative market failures.

Appendix

See Tables 6, 7, 8, 9, 10, and 11.

Table 6 Description of variables and of the relative survey questions

Variable name	Question	Building the indicator
From Innobarometer 2015		
Innovation	Has your company introduced any of the following types of innovation since January 2012?	=1 if new or significantly improved goods or new or significantly improved services
R&D	Since January 2012, what percentage of its total turnover did your company invest in the following activities?	Research and development (R&D)
Design		Design of products and services (excluding research and development (R&D))
Software		Software development, excluding research and development (R&D) and web design
Organis. business		Organisation or business process improvements
Reput. branding		Company reputation and branding
Training		Training
Financial barriers	Thinking about the commercialisation of your company's *innovative* goods or services since January 2012, has any of the following been a major problem, a minor problem or not a problem at all? [*The word innovative is included only if a firm has introduced new or significantly improved goods or new or significantly improved service]*	=1 if yes to lack of financial resources Lack of human resources, Finding or using new technologies, Cost or complexity of meeting regulations or standards, Difficulties in maintaining intellectual property rights, Administrative or legal issues, Lack of marketing expertise, Market dominated by established competitors, Low demand for your innovative goods or services, Weak distribution channels
Turnover increased	Since January 2012 has your company's turnover … ? *[residual category: Remained approximately the same]*	=1 if risen between 5 and 25% or more than 25%
Turnover decreased		=1 if fallen between 5 and 25% or more than 25%
Advanced technologies	Have you used any of the following technologies?	Sustainable manufacturing technologies (i.e. technologies which use energy and materials more efficiently and drastically reduce emissions ICT-enabled intelligent manufacturing (i.e. technologies which digitalise the production processes) High performance manufacturing which combines flexibility, precision and zero-defect (e.g. high precision machine tools, advanced sensors or 3D printers)

Table 6 (continued)

Variable name	Question	Building the indicator
Young	When was your company established?	=1 if After 1 January 2009 =0 if Before 1 January 2009
Group	Is your company part of a group?	=1 if Yes, =0 if No
From innobarometer 2014		
Public support	Has your company received any public financial support for research and development or other innovation activities from any of the following?	=1 yes to Local or regional governments or administrations, National government or administration, European Union or Other, =0 otherwise
Public procurement	Has your company won at least one public procurement contract?	=1 if yes, =0 if No

Table 7 Descriptive statistics of the sample firms and by their innovative status

	Non-innovative (37.7%)		Innovative (62.3%)		Total (100%)	
	Mean	Std.dev	Mean	Std.dev	Mean	Std.dev
R&D	0.214	0.410	0.433	0.495	0.349	0.477
Design	0.363	0.481	0.462	0.499	0.424	0.494
Software	0.294	0.455	0.502	0.500	0.422	0.494
Organis. business	0.421	0.494	0.550	0.498	0.501	0.500
Reput. branding	0.455	0.498	0.524	0.499	0.498	0.500
Training	0.469	0.499	0.572	0.495	0.532	0.499
Financial barriers	0.250	0.433	0.260	0.439	0.256	0.437
Turnover increased	0.283	0.450	0.415	0.493	0.365	0.481
Turnover decreased	0.269	0.444	0.206	0.404	0.230	0.421
Adv_technologies	0.069	0.253	0.146	0.353	0.117	0.321
Young	0.122	0.327	0.111	0.314	0.115	0.319
Group	0.179	0.383	0.290	0.454	0.248	0.432
Public support	0.062	0.043	0.176	0.097	0.133	0.098
Public procurement	0.230	0.145	0.287	0.123	0.266	0.135

Table 8 Correlations across variables

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. R&D	1.000												
2. Design	0.247	1.000											
3. Software	0.368	0.233	1.000										
4. Organis. business	0.257	0.245	0.316	1.000									
5. Reput. branding	0.220	0.227	0.321	0.294	1.000								
6. Training	0.195	0.175	0.203	0.305	0.233	1.000							
7. Financial barriers	−0.013	−0.021	0.020	0.000	0.003	−0.030	1.000						
8. Turnover increased	0.097	0.060	0.080	0.099	0.081	0.058	−0.128	1.000					
9. Turnover decreased	−0.054	−0.034	−0.045	−0.053	−0.052	−0.050	0.222	−0.414	1.000				
10. Adv_technologies	0.141	0.032	0.122	0.079	−0.001	0.010	−0.010	0.065	−0.035	1.000			
11. Young	−0.027	−0.050	−0.004	0.003	0.016	−0.021	0.041	0.094	−0.070	−0.046	1.000		
12. Group	0.115	0.059	0.074	0.061	0.024	0.055	−0.100	0.082	−0.062	0.114	−0.064	1.000	
13. Public support	0.238	0.089	0.196	0.136	0.027	0.095	−0.083	0.157	−0.131	0.438	−0.123	0.348	1.000
14. Public procurement	0.089	0.089	0.043	0.085	0.008	0.073	−0.070	0.085	−0.089	−0.101	−0.103	0.225	0.397

Table 9 Investing in R&D and financial barriers: IV reg linear probability model

	(1)	(2)
Financial barriers	− 3.874***	− 1.000***
	(0.872)	*(0.182)*
Innovation		0.201***
		(0.013)
Turnover increased	− 0.074	0.011
	(0.048)	*(0.015)*
Turnover decreased	0.629***	0.147***
	(0.153)	*(0.034)*
Adv_technologies	0.115*	0.112***
	(0.066)	*(0.024)*
Young	0.305***	0.070***
	(0.088)	*(0.024)*
Group	− 0.142**	0.006
	(0.063)	*(0.018)*
Industry fixed effects	*Yes*	*Yes*
Country fixed effects	*Yes*	*Yes*
Constant	2.170***	0.719***
	(0.418)	*(0.095)*
Observations	12,198	12,198
F-stat (model)	9.04	22.31
Sargan test (*p*-val)	0.09	0.15
Cragg-Donald (F-stat)	14.46	32.59
Anderson (LM stat)	28.95	65.08

Standard errors in parentheses. ***$p<0.01$, **$p<0.05$, *$p<0.1$. The Sargan test suggest that instruments are valid (uncorrelated with the error term) and correctly excluded from the estimated equation. The Cragg-Donald statistics suggests that instruments are not weak. The Anderson statistics confirm that the equation is identified (excluded instruments are "relevant").

Table 10 Investing in intangibles and (instrumented) financial barriers: second-step probit estimates with the innovation dummy (Eq. 1)

Intangible investment →	R&D	Design	Software	Organis. business	Reput. branding	Training
Financial barriers	−1.176***	−0.759***	−1.230***	−1.007***	−0.513	−0.529
	(0.150)	*(0.230)*	*(0.200)*	*(0.151)*	*(0.510)*	*(0.341)*
Innovation	0.412***	0.416***	0.158***	0.202***	0.086	0.216***
	(0.065)	*(0.059)*	*(0.060)*	*(0.072)*	*(0.071)*	*(0.056)*
Turnover increased	0.086**	0.072**	0.050*	0.141***	0.153***	0.080**
	(0.034)	*(0.035)*	*(0.028)*	*(0.037)*	*(0.038)*	*(0.039)*
Turnover decreased	0.155***	0.093	0.168***	0.115***	0.019	−0.002
	(0.042)	*(0.058)*	*(0.054)*	*(0.043)*	*(0.099)*	*(0.070)*
Adv_technologies	0.290***	0.242***	0.128**	0.322***	0.091	0.215***
	(0.042)	*(0.054)*	*(0.064)*	*(0.041)*	*(0.058)*	*(0.066)*
Young	0.070	0.063	−0.036	0.099**	0.068	−0.037
	(0.056)	*(0.056)*	*(0.043)*	*(0.042)*	*(0.064)*	*(0.043)*
Group	0.102***	0.024	0.018	0.026	−0.019	0.085**
	(0.038)	*(0.039)*	*(0.034)*	*(0.038)*	*(0.046)*	*(0.042)*
Constant	0.046	−0.092	0.598***	0.338***	0.590**	0.223
	(0.168)	*(0.159)*	*(0.109)*	*(0.123)*	*(0.264)*	*(0.193)*
Observations	12,198	12,065	12,194	12,089	12,222	12,260
Rho	0.720	0.501	0.725	0.610	0.350	0.284
Wald test rho = 0	21.53	8.473	9.862	22.03	1.132	1.815

Standard errors clustered at the structural group level. ***$p<0.01$, **$p<0.05$, *$p<0.1$. The Wald tests does not reject the null hypothesis of no correlation among the errors for the Reput. Branding and the Training equations; for these two equations, a probit model provides similar results. The model includes country and industry fixed effects.

Table 11 Investing in intangibles and (instrumented) financial barriers: second-step probit estimates with innovation dummy and innovation interaction (Eq. 1)

Intangible investment →	R&D	Design	Software	Organis. business	Reput. branding	Training
Financial barriers	−1.153***	−0.757***	−1.231***	−1.011***	−0.488	−0.527
	(0.126)	*(0.229)*	*(0.215)*	*(0.143)*	*(0.522)*	*(0.343)*
Innovation	0.427***	0.414***	0.147**	0.215***	0.072	0.214***
	(0.063)	*(0.065)*	*(0.071)*	*(0.078)*	*(0.082)*	*(0.059)*
Financial barriers * Innovation	−0.081	0.008	0.048	−0.058	0.060	0.008
	(0.052)	*(0.053)*	*(0.069)*	*(0.057)*	*(0.064)*	*(0.057)*
Turnover increased	0.081**	0.073**	0.053*	0.137***	0.157***	0.080**
	(0.034)	*(0.035)*	*(0.028)*	*(0.035)*	*(0.038)*	*(0.039)*
Turnover decreased	0.161***	0.092	0.162***	0.122***	0.008	−0.003
	(0.039)	*(0.058)*	*(0.059)*	*(0.043)*	*(0.102)*	*(0.071)*
Adv_technologies	0.286***	0.243***	0.131**	0.318***	0.092	0.215***
	(0.042)	*(0.054)*	*(0.066)*	*(0.043)*	*(0.057)*	*(0.066)*
Young	0.075	0.062	−0.042	0.103**	0.063	−0.037
	(0.054)	*(0.055)*	*(0.046)*	*(0.042)*	*(0.066)*	*(0.044)*
Group	0.097***	0.025	0.022	0.022	−0.014	0.085**
	(0.037)	*(0.039)*	*(0.034)*	*(0.037)*	*(0.047)*	*(0.042)*
Constant	0.055	−0.094	0.593***	0.347***	0.575**	0.221
	(0.158)	*(0.156)*	*(0.117)*	*(0.115)*	*(0.270)*	*(0.197)*
Observations	12,198	12,065	12,194	12,089	12,222	12,260
Rho	0.741	0.497	0.705	0.635	0.313	0.280
Wald test rho = 0	23.19	8.590	7.638	23.53	0.888	1.695

Standard errors clustered at the structural group level. ***$p<0.01$, **$p<0.05$, *$p<0.1$. The Wald tests does not reject the null hypothesis of no correlation among the errors for the Reput. Branding and the Training equations; for these two equations, a probit model provides similar results. The model includes country and industry fixed effects.

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