Micro-econometric analysis of innovative start-ups: the role of firm-specific factors and industry context in innovation propensity

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Abstract

We explore the innovation-enabling factors in young innovative companies (YICs) considering different elements of firm-specific absorptive capacity along with factors related to the industrial framework. Evidence from Italian YICs, known as innovative start-ups whose creation is prompted by the Start-up Act, shows that absorptive capacity factors matter with differences across product and process innovation. Moreover, the configuration of the industry context remarkably shape innovation, providing implications for policy-makers seeking to improve the national competitiveness by sustaining new ventures of high technological value.

Keywords: innovative start-ups, absorptive capacity, agglomeration economies, technological innovation

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1. Introduction

In recent years, scholars and governments have demonstrated increasing interest towards young innovative companies (YICs). These companies are more likely to adopt new knowledge and new technologies and, therefore, are considered critical for the diffusion of innovation both locally and at the national level, for modernising and reviving more traditional industrial and service sectors and, ultimately, for spurring the economic growth of a country (Schneider and Veugelers, 2010; Czarnitzki and Delanote, 2012; Mas-Tur and Moya, 2015). Several European member states, indeed, have introduced policy measures aimed at supporting the creation and growth of YICs.

A significant body of research on YICs has developed on location determinants, whereas much less research has been done on factors likely to increase the ability to effectively introduce innovations.\(^1\) This paper aims at increasing the understanding of innovation-enabling factors in YICs by considering those that are internal to the company along with those that operate at the level of the industry in the region where the company is located. Studies on firm-level innovation have widely explored the internal determinants, but the mechanisms by which the external environment shapes innovation are still poorly understood (López-Bazo and Motellón, 2018), though external factors can exert a profound influence on firms’ growth and innovation (Howells and Bessant, 2012).

For the purpose of this research, we consider Italian YICs whose creation was prompted by the Italian Startup Act, a policy measure of the government which labels as *innovative startups* the new companies whose business purpose is the development, the production and the

\(^1\) A recent body of research focuses on factors driving the formation of YICs (among the others, Colombelli, 2016; Calcagnini et al. 2016; Fritsch and Aamoucke, 2017; Fritsch and Wyrwich, 2018; Capozza et al. 2018), while, to the best of our knowledge, only Protoperou et al. (2017), Pellegrino et al. (2012), Schneider and Veugelers (2010) explore their innovation performance, whereas Czarnitzki and Delanote (2012) investigate their employment and sales growth.
commercialization of products and services of high technological value. The Startup Survey launched in 2016 by Italian Ministry for Economic Development (MISE) provides micro-level information on different dimensions of innovative start-ups, including innovation activities, that we combine with aggregate data for the industry in the regions under analysis.

More in detail, we explore the innovation propensity of innovative start-ups by placing attention on firm-specific absorptive capacity, namely the ability of a firm to value, assimilate, and exploit new external knowledge (Cohen and Levintal, 1990). To cope with the increasing competition and rapid technological change of today’s world, firms wishing to successfully introduce innovations are required to integrate and recombine their internal knowledge with new knowledge and ideas from beyond their boundaries (Cassiman and Veugelers, 2002; Caloghirou et al. 2004; Escribano et al. 2009). It is worth learning, therefore, which elements determining the absorptive capacity of innovative start-ups are associated to a greater extent with the ability to realize product and process innovation.

At more aggregate level, different configurations of the industrial structure enable different kinds of knowledge externalities that innovative start-ups may accrue from co-location to increase their knowledge stock. We focus on different agglomeration mechanisms to seize whether the specialization or the diversification of the industrial structure in a region, and the underlying kinds of knowledge spillovers, are more conducive to technological innovation in innovative start-ups. We disentangle the effects associated to industry diversification by making a distinction between the related and unrelated industrial variety (Frenken et al., 2007).

Overall, we attempt to offer a view of the actual innovation propensity of YICs by looking at the relevant internal factors without neglecting the features of the industrial framework where these companies are located and operate. The results provide implications for policy-makers seeking to improve the national competitiveness through the design of public policies to support

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2 The “Decree Growth 2.0” approved by the Ministry of Economic Development by the end of 2012. Further information on innovative start-ups are provided in Section 3.
new entrepreneurial ventures of high technological value by shedding light on factors that, at
different levels, might shape innovation and, thus, the effectiveness of such policies.

The rest of the paper is organized as follows. In Section 2 we discuss the theoretical
background of the study, particularly the role of absorptive capacity and agglomeration
mechanisms in firms’ innovation, and we develop the research hypotheses. Section 3 deals with
the empirical design: we first present the research context, then we present the data, the
variables and, finally, the empirical model. Section 4 shows the results, while discussion and
concluding remarks are offered in Section 5.

2. Theoretical background and hypotheses

2.1 The role of firm’s absorptive capacity

In a context of increasingly competitive environments and rapid technological change,
innovative firms cannot rely on their in-house efforts alone in order to create knowledge, but
need to leverage knowledge generated outside their boundaries to integrate and complement
their internal knowledge and technologies (Cassiman and Veugelers, 2002; Caloghirou et al.
2004). Access to external knowledge, indeed, is widely recognized as a critical element for
successful innovation activities (Escribano et al. 2009). Firms, however, cannot benefit from
external knowledge flows by simply being exposed to them, but they need to build their own
absorptive capacity, conceived by Cohen and Levinthal (1990) as the “ability to recognise the
value of new, external information, assimilate it and apply it to commercial ends”. The
absorptive capacity makes the external knowledge effectively usable within the firms;
consequently, it plays a greater role when the external knowledge to be accumulated is complex
and highly sophisticated (Lund Vinding, 2006), as for the case of high-tech and knowledge-
intensive firms. Innovative start-ups with higher level of absorptive capacity should be in a
better position to assimilate and exploit external knowledge and to pursue innovations. We
discuss the factors determining firms’ absorptive capacity and we formulate hypotheses to shed light on which of these factors is conducive to innovation in innovative start-ups.

According to Cohen and Levinthal (1990), firms can primarily develop their absorptive capacity through in-house R&D. More precisely, in-house R&D plays a dual role. First, it directly stimulates the internal generation of new knowledge and innovation. Second, it increases the knowledge and skills of employees involved in R&D activities, thus enhancing the ability of firms to assimilate and exploit outside knowledge. Hence, intramural R&D expenditure is considered a critical determinant of firm’s absorptive capacity and innovation capability (see, for instance, Griffith et al. 2004; Escribano et al. 2009). Firms have also the possibility to buy their absorptive capacity through the acquisition of extramural R&D performed by external organizations, though its impact on innovation might be limited. Extramural R&D, indeed, might increase the absorptive capacity only if a firm has already built its own absorptive capacity. In other terms, extramural R&D should be considered a complement, not a substitute, of intramural R&D (Veugelers, 1997; Murovec and Prodan, 2009).

To assimilate and exploit external knowledge, firms can also engage in R&D cooperation. Inter-firm R&D alliances, by creating close linkages between partners, enable tacit and firm-specific knowledge transfer, organizational learning and the acquisition of expertise not yet available in-house, leading to synergies and cross-fertilization effects that can expand firms’ innovation capability, especially in technology-based sectors. Moreover, R&D cooperation gains further importance due to the growing complexity, risks and costs innovation (Becker and Dietz, 2004; Belderbos et al., 2004; Caloghirou et al., 2004).

Considering all the above, we formulate the following research hypotheses:

Hypothesis 1 Intramural R&D is positively associated with the ability of innovative start-ups to introduce innovations.
Hypothesis 2 Extramural R&D is positively associated with the ability of innovative start-ups to introduce innovations.

Hypothesis 3 R&D cooperation is positively associated with the ability of innovative start-ups to introduce innovations.

Lund Vinding (2006) proposes a refinement of the concept of firm’s absorptive capacity that extends the view of Cohen and Levinthal (1990), mostly focused on R&D, by introducing the role of human capital, i.e. the knowledge embedded in individuals working in the firms, particularly in those individuals at the interface with the external environment. At the early stages of a new start-up, founders have profound influence on initial strategies and subsequent growth (Cao and Im, 2018); thus, their knowledge may substantially affect innovation capability (Arvanitis and Stucki, 2012). Both the general knowledge in terms of formal education and the specific knowledge in terms of prior work experience (see Becker, 1962) are considered to matter for the determination of absorptive capacity.

Individuals with higher level of formal education increase the stock of knowledge in firms and contribute to know-how trading. They are in a better position to generate new knowledge, to identify and exploit new technological opportunities (Lundvall, 2008; Goedhuys, et al. 2013) and to facilitate the activities of synthesising and commercialising knowledge from internal and external sources (Leiponen, 2005).

Prior work experience can be disentangled in industry-specific experience and entrepreneurial experience. The industry-specific experience includes knowledge of products and technologies specific to the industry, which can be profitably used by founders to understand industry dynamics and technological trends, but also encompasses the established relationship networks with suppliers and customers (Reagans et al., 2005; Colombo and Grilli, 2005; Kor and Sundaramurthy, 2009). On the other side, prior entrepreneurial experience
includes knowledge gradually acquired over time by owning and managing a firm. Founders with entrepreneurial experience are expected to be better at managing the entrepreneurial process and at seeking and exploiting technological opportunities (Cao and Im, 2018).

There is evidence that these dimensions of founders’ human capital exert a positive influence on new technology based firms’ growth (Colombo et al. 2004; Colombo and Grilli, 2005; Ganotakis, 2012), young firms’ innovative performance (Protogerou et al. 2017) and new technology ventures’ R&D search intensity (Cao and Im, 2018), although there is some evidence that more experienced individuals at the top of firms could also be more risk averse and less or not willing to undertake novel innovation strategies (Hayton, 2005; Lund Vinding, 2006; Capozza and Divella, 2018).

From the above discussion, we put forth the following research hypotheses:

**Hypothesis 4** Innovative start-ups with higher-educated founders show greater ability to introduce innovations.

**Hypothesis 5** Innovative start-ups whose founders have prior industry-specific experience show greater ability to introduce innovations.

**Hypothesis 6** Innovative start-ups whose founders have prior entrepreneurial experience show greater ability to introduce innovations.

### 2.2 The role of agglomeration economies

Agglomeration economies refer to the benefits that a firm can obtain from co-locating with other firms, because geographical proximity eases the process of knowledge transmission between firms, expanding the knowledge stock available to each single firm (Griliches, 1992; Audretsch, 1998; Audretsch and Feldman, 2004). Therefore, agglomeration economies are considered to play a substantial role in regional innovation capabilities (Audretsch and Feldman, 1996).
In the literature, two types of agglomeration economies are identified: *localization* economies and *diversification* economies. The former refers to the *specialization* of the local production structure in a certain industry that favours intra-industry knowledge spillovers, known as Marshallian externalities. This view is grounded on the idea that knowledge is mostly industry-specific, thus its transmission, occurring primarily between same-industry firms, by increasing the opportunity of direct contacts, learning and exchanging of ideas, can spur innovation.³ The latter, instead, concerns the *diversity* of the local production structure, that promotes inter-industry knowledge spillovers, known as Jacobian externalities (Glaeser et al. 1992). The local concentration of firms operating in *different* industries promotes innovation by triggering the recombination of knowledge and ideas, and leading to the generation of *new* knowledge that can be incorporated in the production of other industries.

The concept of Jacobian externalities has been further developed by Frenken et al. (2007), who explains that the concept encompasses two different economic effects that need to be kept separate: the complementary knowledge spillover effect and the portfolio effect, captured by the *related* and the *unrelated* industrial variety, respectively. It is argued that knowledge effectively spills over only between firms in *related* industries, with complementarities in terms of technologies and competences (Frenken et al., 2007; Boschma and Iammarino, 2009; Asheim et al., 2011). Instead, the *unrelated variety* reflects the diversification of the production structure in very different types of activities. It can be conceived as a portfolio strategy, where a broader range of unrelated industries can preserve the stability of the local economy from industry-specific shocks.

Existing studies on the role of agglomeration economies are mostly conducted at the regional-level of analysis. Evidence on which form of agglomeration effectively improves

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³ Additionally, the local *specialization* attracts a larger pool of specialized labour and leads to a reduction of transportation and distribution costs due to the proximity to specialized suppliers and customers (Ellison et al., 2010).
regional economic performance is rather mixed (see Beaudry and Schiffauerova, 2009). Recently, Caragliu et al. (2016) demonstrate that Marshall and Jacobs are both right, since the impact of the two kinds of agglomeration economies on regional growth is heterogeneous across industries and contexts.

In the last decade, a number of papers has emerged trying to establish whether agglomeration economies can influence single firm’s performance. Some evidence, for instance, is provided on the positive relationship between specialization and labour productivity (Rigby and Brown, 2015; Wixie, 2015). More closely to this work, Barbosa at al. (2013) show that both firms’ idiosyncratic factors and the industry context have the power of shaping innovation choices. Other works claim that regional factors, particularly the regional R&D activity, are relevant for innovation (Naz et al. 2015; López-Bazo and Motellón, 2018). Van der Panne and van Beers (2006) examine the impact of Marshallian and Jacobian externalities on both individual firms’ innovation activities and regional innovativeness. Specialized regions show an increased number of innovating firms and, consistently, incumbent firms’ innovativeness increases with regional specialization. However, innovators in diversified regions prove to be more successful in commercial terms than innovators in specialized regions. Smith et al. (2015) explain firms’ innovation as a function of firm-specific characteristics and agglomeration externalities using measures for specialization and diversification with mixed results. The degree of specialization does not matter for product and process innovations in most sectors, whereas the degree of diversification appears to have stronger impact on firms’ innovation, though positive or negative across different industries. However, they do not make a distinction between related and unrelated diversification.

Other works offer more clear evidence that specialization does matter for innovation, since firms appear to more likely introduce product innovations regions with greater specialization in firm’s same sector (Knoben, 2009; Hervas-Oliver et al., 2018).
There is also evidence that the related and unrelated industrial variety do influence firms’ performance. Aarstad et al. (2016) show that related industrial variety has a positive effect on firms’ propensity to be innovative, whereas it does not affect the productivity. The unrelated industrial variety, instead, appears to be not related with firms’ innovation, but it has a negative effect on productivity. Recently, Cainelli and Ganau (2019) show a positive impact of related variety and a negative impact of unrelated variety on employment growth.

Keeping in mind the high technological content of the start-ups under analysis, we conjecture that their innovation propensity can benefit from intra-industry knowledge spillovers, but some degree of diversification, giving rise to knowledge spillovers from complementary industries, might also foster innovation. Therefore, we formulate the research hypotheses as follows:

**Hypothesis 7** Industrial specialization is positively associated with innovative start-ups’ ability to introduce innovations.

**Hypothesis 8** Related industrial variety is positively associated with innovative start-ups’ ability to introduce innovations.

**Hypothesis 9** Unrelated industrial variety is not associated with innovative start-ups’ ability to introduce innovations.

### 3. Empirical design

#### 3.1 Research context

Since 2012, the Italian Government has developed a comprehensive and coherent legislation aimed at favouring the creation and growth of YICs. The Italian Ministry of Economic Development approved the “Decree Growth 2.0”\(^4\), also known as the Italian Start-up Act, which

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\(^4\) The Decree Law 179/2012 provides “Further urgent measures for Italy’s economic growth”, converted by the Parliament into Law No 221/2012.
introduced into the Italian legal system the definition of new innovative company with high technological value, namely the innovative start-up. The Italian Start-up Act grants to innovative start-ups some benefits for five year after their setting-up.\(^5\) These benefits do not apply to any newly established firms but only to those that meet the requirements set by this specific legislation. Besides this, there is no limitation for the industrial sector in which the start-ups operate.

More specifically, innovative start-ups are non-listed companies that meet the following requirements. They are new firms or, at most, active from less than 5 years; they have their headquarters in Italy or in another EU country, provided that there is a production site or a branch in Italy; they have a yearly turnover of less than 5 million Euros; they do no distribute profits; they are not the result of a merger, split-up or selling-off of a company or branch; their business purpose is the production, the development and the commercialization of innovative goods or services of high technological value.

The innovative nature is identified by the fulfilment of, at least, one the following three criteria: (1) at least 15% of the firm’s expenses are ascribed to R&D activities; (2) at least 1/3 of the workforce (including founders) are PhD students, PhDs or researchers or, alternatively, 2/3 of the workforce hold a master’s degree; (3) the firm is the holder, the depository or licensee of a registered patent (industrial property) or the owner and author of a registered software.\(^6\)

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\(^5\) To innovative start-ups are granted a wide range of benefits: tax incentives for investments, tax credit for highly-qualified staff, flexible remuneration system, access to equity crowdfunding, fail-fast procedures, cuts to red tape and fees, online free of charge setting-up, etc. For the complete overview of benefits see http://www.sviluppoeconomico.gov.it/images/stories/documenti/Executive-Summary-of-Italy-s-Startup-Act-new-format-23_02_2017.pdf

\(^6\) In summary, by the Decree innovative start-ups are young, as they are less than five years; are small, as their yearly turnover is lower than five million euros; and are innovative, given their business purpose; thus, they meet the definition of YICS, namely young and small firms intensively engaged in innovation activities (Schneider and Veugelers 2010; Czarnitzki and Delanote, 2012).
3.2 Data collection and variables’ construction

This study combines firm-level data with industry data for the regions under analysis, collected from different data sources. Firm-level data stem from the Startups Survey, launched by the Italian Ministry of Economic Development (MISE), developed within the “Technical committee for the monitoring and evaluation of policies in favour of the ecosystem of innovative start-ups” provided for by the Italian law. The questionnaire was administered by the Italian National Institute of Statistics (ISTAT) in April and May 2016. As of December 31, 2015, there were 5,150 companies listed in the Innovative Start-ups register, the dedicated section of the business register of the Italian Chambers of Commerce. Overall, 2,250 start-ups voluntarily participated in the survey, which amount to 43.7% of the target population. The Startups Survey provides micro-level information on different dimensions of innovative start-ups, including innovation activities, together with the industry and the province where each start-up is located.

Based on the information gathered by the Startups Survey, we can make a distinction between innovation aimed at cost reduction (process innovation) from innovation aimed at increasing the range of goods and services offered (product innovation). We define two dependent variables: Product innovation, equal to 1 if the start-up reports having realized a product innovation, 0 otherwise; and Process innovation, equal to 1 if the start-up reports having realized a process innovation, 0 otherwise. This distinction allows us to assess whether the impact of firm-specific and industry variables differs according to the type of innovation.

To test Hypothesis 1, we define the variable Intramural R&D, equal to 1 if the start-up reports having spent a positive amount for conducting intra mural R&D, 0 otherwise, while to

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7 ISTAT (2018) has performed a comparative analysis of the responding start-ups’ main structural characteristics with respect to the target population, considering different dimensions: the industrial sector, the region of localization, the year of establishment and joint analysis of industry and regional distribution. The results confirm the fully representativeness of responding start-ups.
test **Hypothesis 2**, we define the variable *Extramural* R&D, equal to 1 if the start-up reports having spent a positive amount for conducting extra mural R&D, 0 otherwise. **Hypothesis 3** is tested by variable *R&D cooperation*, equal to 1 if the start-up has engaged in technological cooperation with external partners, 0 otherwise.

Three variables concerning founders’ human capital are introduced to test the **Hypotheses 4, 5 and 6**, respectively. First, the variable *Formal education* is the average educational attainment of founders. Specifically, the educational attainment is constructed as equal to 1 if the founder has junior high school, equal to 2 if the founder has high school, equal to 3 if the founder has undergraduate studies, equal to 4 if the founder has postgraduate studies and equal to 5 if the founder holds a PhD. The variable *Industry-specific experience* is defined as the number of founders with prior working experience in the same start-up’s industry, and the variable *Entrepreneurial experience* is defined as the number of founders with prior entrepreneurial experience.

Moreover, some firm-level controls are considered. Since international competition might spur innovation (Archibugi and Iammarino, 1999; Narula and Zanfei, 2003), we define the variable *Foreign market* equal to 1 if the firm sells its products/services abroad, 0 otherwise. We include also the variable *Size* as the number of employees.

To construct variables for agglomeration economies, we collect data from the 2011 Industry and Services Census provided by ISTAT. Data on the number of active firms and the number of employees in active firms are retrieved by industry, corresponding to the four-digit level of Statistical classification of economic activities in the European Community (NACE Rev. 2), for all the Italian provinces, corresponding to the third level of Nomenclature of Territorial Units for Statistics (NUTS 3 level).\(^8\)

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\(^8\) The NUTS classification is a hierarchical system for dividing the economic territory of the European Union. In the specific, NUTS 1 level corresponds to macro-regions, NUTS 2 level corresponds to regions and NUTS 3 level corresponds to provinces. Further information can be found at: http://ec.europa.eu/eurostat/web/nuts/.
To test Hypothesis 7 on industry specialization, we employ the location quotient, the share of same-industry firms $k$ (four-digit sector) within each province $p$, relative to the national industry share:

$$Specialization_{k,p} = \frac{N_{k,p}/\sum_k N_{k,p}}{N_{k,IT}/\sum_k N_{k,IT}}$$

(1)

where $IT$ indexes Italy and $N$ denotes the number of active firms. A location quotient higher than unity indicates that industry $k$ is relatively overrepresented in province $p$ that, consequently, can be regarded as specialized in that industry. The degree of industrial specialization can represent the potential for Marshallian externalities because it captures the intensity and the density of interaction among firms (Glaeser et al., 1992).

To test the Hypothesis 8 and Hypothesis 9 on the industry diversification, we consider the following measures for Related variety and Unrelated variety:

$$Related\ variety_{s,p} = 1/\left[\sum_{k=1}^{K} \left( \frac{E_{k,p}}{\sum_{k=1}^{K} E_{k,p}} \right)^2 \right]$$

(2)

where $E_{s,p}$ denotes the number of employees in active firms at four-digit sector $k$, located in province $p$, such that each four-digit sector $k$ belongs exclusively to a two-digit sector $s$.

$$Unrelated\ variety_{s,p} = 1/\left[\sum_{j=1}^{J} \left( \frac{E_{j,p}}{\sum_{j=1}^{J} E_{j,p}} \right)^2 \right]$$

(3)

where $E_{s,p}$ denotes the number of employees in active firms operating in a two-digit sector $j$, with $j \neq s$ and located in province $p$.

A further element that may influence firms’ innovation is the regional degree of urbanization. More urbanised areas generally offer a better accessibility to transport infrastructures, a crucial aspect for firms since a substantial part of their activities involves

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9 See Cainelli and Ganau (2019) for a similar construction.
moving inputs and outputs. They can also stimulate firms’ achieving economies of scale through a relatively larger market demand and are likely to host universities and research centres that, by fostering the production and absorption of knowledge, can encourage the innovation at firm-level. On the other side, urbanised areas may also have negative congestion diseconomies, such as traffic, pollution, or higher land rents, hampering any business activity (Harrison et al., 1996; Renski, 2011). To control for the effect of urbanization on firm-level innovation, we include the variable *Population density*, the number of inhabitants per km$^2$, a widely adopted proxy of urbanization as the infrastructure of services and inputs is supposed to be more developed in more densely populated areas (see Audretsch and Fritsch, 1994; Reynolds et al., 1994). Moreover, it also captures the demand size and variety (Armington and Acs, 2002).

Finally, we introduce macroregional dummies to control for the different technological opportunities available to *innovative start-ups* depending on their geographical location, and industry dummies following the well-known Pavitt taxonomy to capture heterogeneous innovation patterns across industries.$^{10}$

We end up with a final sample of 1,804 *innovative start-ups* with complete observations. In Table 1 we provide the descriptive statistics and in Table 2 the correlation matrix.

![Table 1 near here]
![Table 2 near here]

### 3.3 Econometry strategy

To analyse the role of firm-specific and industry factors on innovation propensity in *innovative start-ups*, we adopt the multivariate probit modelling.$^{11}$ We specify the following equation

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$^{10}$ Industry dummies are constructed following Pavitt (1984), Miozzo and Soete (2001) and Bogliacino and Pianta (2010).

relating explanatory variables to the probability that a firm engages in the two types of innovation:

\[ y_{ikph} = x'_{ikph} \beta_h + z'_{kph} \gamma_h + \varepsilon_{ikph} \] \hspace{1cm} (4)

\( y_{ih} \) is the binary variable of whether innovative start-up \( i \) located in industry \( k \) and province \( p \) has introduced one of the two types of innovation, where \( h \) indicates the type: product innovation and process innovation. Moreover, \( x_{ikp} \) is the matrix of firm-specific variables, while \( z_{kph} \) is the matrix of industry-related variables for province \( p \). Finally, \( \beta_h \) and \( \gamma_h \) are the respective vectors of coefficients and \( \varepsilon_{ikp} \) are the error terms.

The multivariate modelling approach allows us to predict several correlated binary outcomes jointly and to compare the role of shared variables across equations. Moreover, this approach permits to control for potential correlation of the error terms. The error term can be divided into two parts, one specific for each equation describing the outcome of interest and one common to the others:

\[ \varepsilon_{ikph} = \eta + u_{ikph}. \] \hspace{1cm} (5)

To ascertain the appropriateness of the multivariate approach, we perform the likelihood ratio test. The rejection of the null would indicate that the multivariate probit modelling is preferred to the univariate probit modelling. Finally, coefficients are obtained through maximum likelihood estimator.

4. Results

The empirical results from the multivariate probit model are presented in Table 3, reporting estimated coefficients. The likelihood ratio test on the null hypothesis that the correlation coefficient of error terms is equal to zero is strongly rejected, thus supporting the choice of multivariate probit modelling. We present the result starting with factors determining the absorptive capacity, then we move to illustrate the industry factors.
The variable *Intramural R&D* is positively associated, with high significance, both with product innovation and process innovation. Therefore, **Hypothesis 1** is confirmed. The coefficient for product innovation appears to be more than twice the coefficient for process innovation, suggesting that *Intramural R&D* is more strongly associated to product innovation. Instead, the *Extramural R&D* turns out to be not associated with both type of innovation. Therefore, **Hypothesis 2** is not supported. The absorptive capacity derived from other organization is not relevant for innovation propensity of innovative start-ups.

The variable *R&D cooperation* is positively and significantly associated both with product innovation and process innovation. Therefore, **Hypothesis 3** is confirmed. The coefficient and the significance level appears to be higher for process innovation compared to product innovation, entailing that *R&D cooperation* is more relevant for innovative start-ups aiming at achieving process innovation.

Since *Intramural R&D* and *R&D cooperation* are both binary variables, coefficients can be compared. For product innovation, *Intramural R&D* seems to be more important than *R&D cooperation*, whereas for process innovation the opposite occurs.

The variable *Formal education* is positively but weakly significantly associated with product innovation, while it is not associated with process innovation. It follows that **Hypothesis 4** is only partially confirmed. Similarly, the variable *Industry-specific experience* is positively and significantly associated with product innovation, while it is not associated with process innovation. **Hypothesis 5** is, therefore, only partially confirmed. Finally, the variable *Entrepreneurial experience* turns out to be not associated with any type of innovation. Therefore, **Hypothesis 6** is not supported. Overall, the human capital determinants of absorptive capacity are found to matter only for innovative start-ups pursuing product innovations. Particularly, the *specific* human capital attained by founders through same-
industry working experience appears to more relevant for product innovation than the general human capital achieved through formal education.

About firm-level control, the variable *Foreign market* is positively and significantly associated with product innovation, but it is not associated with process innovation. The variable *Size*, instead, is not associated with any type of innovation.

Regarding the industry structure, the variable *Specialization* is positively and highly significantly associated both with product innovation and process innovation. However, the relationship with product innovation appears to be U-inverted: the coefficient of *Specialization* is positive and significant, but the coefficient of the *Specialization*² is negative and significant. It turns out that co-location in a relatively highly specialised own-industry province has a positive influence on the likelihood that *innovative start-ups* introduce product innovation, but too high degree of specialization starts hindering product innovation. The negative effect of *Specialization*, however, does not occur for process innovation. Overall, we can consider that *Hypothesis 7* is confirmed, although a negative effect of industry specialization on product innovation can take place for *innovative start-ups* located in too much specialized province.

The variable *Related variety* is significantly associated both kinds of innovation. However, the coefficient for product innovation is positive, while the coefficient for process innovation is negative. It follows that *Hypothesis 8* is partially confirmed with respect to product innovation. Moreover, the variable *Unrelated variety* turns out to be not associated with any type of innovation outcome. Therefore, *Hypothesis 9* is confirmed.¹²

The variable *Population density* is negatively and significantly associated with product innovation, while it is not associated with process innovation. The *innovative start-ups* located in more densely populated provinces are less likely to introduce product innovations, whereas

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¹² The non-linearity has been tested also for the variables *Related variety* and *Unrelated variety*, but the results show that the relationship with innovation probability is linear.
process innovation are not influenced by this aspect. For product innovations, it seems that the positive effects of regional urbanization are overwhelmed by the negative ones (see Aarstad et al., 2016 for a similar finding). This might also occur because more densely populated provinces in Italy do not always have better infrastructure and services.

In Figure 1 we provide an overview at a glance of the hypotheses tested and results.

[Figure 1 near here]

5. Discussion and conclusions

The paper provides evidence on the main drivers of innovation in YICs, considering firm-specific characteristics but placing attention also to industry context, which seems to be less regarded in firm-level innovation studies, though potentially affecting innovation propensity. To this end, we combine micro-level information from the Startup Survey on Italian innovative start-ups with industry-level variables describing the industry structure. In so doing, we differentiate between product innovation and process innovation to see whether they are equally affected by firm-specific and industry factors or, instead, some differences emerge across types of innovation.

As far as firm-specific factors are concerned, we turn the attention to different elements determining the absorptive capacity of innovative start-ups. First, results highlight the positive influence of in-house R&D and R&D cooperation on technological innovations, whereas the simple acquisition of R&D performed by others is not relevant. These results are totally in line with Pellegrino et al. (2012) discussing the source of product innovation in Italian manufacturing YICs. It turns out that innovative start-ups wishing to successfully innovate need to build their absorptive capacity internally through own R&D activities, also in cooperation with external partners, rather than referring R&D to other organizations without any involvement or interaction in the R&D process. It should be noted that, for process innovation
R&D cooperation is more relevant than internal R&D. This suggests that cooperation, possibly occurring between complementary supply chain actors, by facilitating technical know-how and experience sharing and by enabling learning processes within the start-up, can increase the firm-specific technical knowledge and competences required for process innovation, which would need more time and effort to be attained by a single, non-cooperating, innovative start-up.

Some dimensions of founders’ human capital seem to matter for product innovation propensity in innovative start-ups. Particularly, the general knowledge of founders acquired through formal education seems to support product innovation, but to a lesser extent than the industry-specific knowledge does, whereas prior accumulated knowledge of entrepreneurial processes appears to be not relevant. Our results are partially consistent with Protogerou et al. (2017) that explore the determinants of young firms’ innovative performance across European countries, showing that product innovations appear to be influence by founders’ educational attainment but not influenced by prior industry-specific experience.

All things considered, knowledge of industry dynamics, technological trends, market demand and consumer preferences accumulated by founders through prior work experience in the same industry, is the most important source of founders’ knowledge for product innovation. Instead, process innovation seems to be not related to founders’ embedded human capital.

From these results, we can outline some characteristics of innovation patterns in innovative start-ups. Successful implementation of product innovation requires different aspects of absorptive capacity to be developed within the start-ups. In other terms, product innovation appears to rely on different knowledge sources, such as knowledge developed and absorbed through R&D and knowledge embedded in founders resulting, in particular, from prior accumulated expertise matured in the same industry. Process innovation seems to be centred on the R&D side of innovative start-ups’ absorptive capacity, probably because firm-specific
technical knowledge is mostly held by employees involved in the R&D process, rather than by founders that, instead, have a market-oriented knowledge, more useful for product innovation.

The industry structure and the agglomeration mechanisms also are found to affect innovation propensity in a different way depending on the type of innovation. *Innovative start-ups* are more likely to succeed in product innovation in an industrial context specialised in their same sector. However, this positive effect shrinks as the degree of specialization increases, until it becomes negative. In other terms, too high degree of industry specialization within a province hampers product innovation. Overall, the relationship between product innovation and specialization appear to be inverted-U shaped. This finding appears to be opposite to Hervas-Oliver et al. (2018) on a sample of Spanish firms. They find a positive effect of specialization in specialized regions (i.e. location quotient greater than one) and a negative effect in non-specialized regions (i.e. location quotient lower than or equal to one).

*Innovative start-ups* are also more likely to introduce product innovation in provinces with greater *diversity* in technologically related sectors (i.e. related variety), while greater *diversity* in very different industrial sectors (i.e. unrelated variety) does not support product innovation.

The inverted-U effect of industry *specialization* along with the positive effect of related industrial variety would indicate that product innovation in *innovative start-ups* is enhanced by contacts and knowledge exchange with firms in the same industry (industry-specific knowledge spillovers) and with firms in different but technologically complementary industries (complementary knowledge spillovers). Too much industry specialization reduces the chances of *innovative start-ups* to get in touch and share knowledge and experiences with technologically complementary firms, thus limiting the potential for synergy and cross-fertilization effects.

On the other side, *innovative start-ups* are more likely to accomplish process innovation in provinces with a specialized industry structure in their same sector. Differently from product
innovation, there is no negative effect of industry specialization, which is consistent with the negative impact of related industrial variety. This would indicate that process innovation in innovative start-ups is boosted by highly industry-specific knowledge and competences, which are deeper in more specialised contexts.

Our results on related and unrelated industrial variety are quite consistent with Aarstad et al. (2016) considering a sample of Norwegian firms. For product innovation, results are in line as they find a positive relationship with related variety and a non-significant relationship with unrelated variety. For process innovation, instead, neither the related nor the unrelated variety are found to matter.

Overall, the results of this work show that researchers should consider jointly firm-specific factor and industry-related factors to understand innovation in YICs in depth. This is of particular importance especially for cases, such as the present, in which YICs creation and subsequent growth is favoured by public industrial policy measures. As shown by our results, the innovation propensity of innovative start-ups can be shaped by the characteristics of the local production structure and, thus, also the effectiveness of the targeted policy intervention. Learning about these aspects might support policy makers in assessing the results of the policy, which could be misleading if the reference context is not considered, and in designing complementary interventions if the local production structure is not suitable or sufficiently settled to sustain the innovation capability and, thus, the future development of YICs.

Clearly, this work has avenues for improvements and future research. First, data on innovative start-ups are currently cross-sectional. This limit the possibility of exploring the innovative behaviour of these companies, but the availability of longitudinal data will allow to deal with factors that ensure the persistence of innovation. Moreover, the emergence of YICs is a relatively new phenomenon. It would be interesting to explore the stability of the
relationships between firm-specific and industry-related factors with innovation over a longer period when the phenomenon becomes more mature.
References


Table 1. Descriptive statistics.

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<th>Max</th>
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Table 2. Correlation matrix.

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Table 3. Results of multivariate probit estimations.

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<td>Product innovation</td>
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<td>1,804</td>
<td>1,804</td>
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Notes: the grouping criteria of industries follows the Pavitt classification: 1 = science-based; 2 = Specialised suppliers; 3 = Specialised suppliers; 4 = Supplier dominated. Macro-regional dummies are: 1 = North-west; 2 = North-east; 3= Centre; 4= South; 5 = Isles. Cluster-robust standard errors at province-industry level are reported in parentheses.  
*** p<0.01, ** p<0.05, * p<0.10
Figure 1. Hypotheses tested and results.