Proof-of-concept model for technology transfer: an empirical evidence from Italy

The innovation ecosystem is characterized by a research context that each year produces a substantial portfolio of scientific results and patents (Netval, 2017). However, these results often remain far from industrial application. Companies, for their part, may find difficult to evaluate the applicability of research results and to understand their potentiality, also because the stage of their development could be too embryonic. Stemming from these difficulties, among practitioners, new technology transfer models are emerging (Munari *et al,* 2017; Passarelli, 2017); these are *co-development models*, in which the research and industrial sectors work together to validate (proof) scientific results (concept) from the very early stages of the innovation process. While several studies analyse the demand-pull and technology-push models for technology transfer, the literature on proof-of-concept models is still in the development stage and very few empirical analysis are available (Hayter and Link, 2015; Munari et al.,2017; Passarelli et al., 2018). This is a significant gap in the literature. Coherently with a previous work (Passarelli et al, 2018), we try to test some key factors that can encourage the proof of concept co-development process. Some relevant works in the literature show that through the patent development, researchers may develop frontier researches looking at the specific industrial applications, especially when the co-applicant is an industrial partner (Baldini et al, 2007). A lot of influential studies in the literature, in fact, show that companies' interest in the process of technology transfer from academia depends on their having the opportunity to take part upstream and in a cogent way in setting the targets of scientific research (Arora and Gambardella, 2010).by appealing the interest of firms in the matching activity. Thus, **a first key factor** can be related to the **propensity of researchers to perform applied research**. The literature proposes as a proxy, the number of patents (filed and granted) of which the researcher is the inventor and the applicant is an industrial partner. So it is reasonable to assume the following: *HP1. The propensity for applied research increases the probability that the researcher will create a match with industry to co-develop an innovation project.* Another factor is related to **the awareness declared by the scientific team** about the industrial applicability of the technology (number of potential application). This indicates the degree of the market potentiality perceived by the research team. The proxy is *incremental diversification*, which refers to the number of segments within the same sector where the technology could be applied (Corsino and Passarelli, 2009). In fact, if a technology is applicable in multiple segments within a sector, it can meet the needs of a greater number of industries by exploiting economies of scope. So the related hypothesis is : H2: *The awareness of the business team about the business potentiality of the technology increases the probability that the researcher will create a match with industry to co-develop an innovation project.* The literature (Dutta *et al*., 1999) shows also that a strong market orientation of technology is a winning strategy, because, market needs must be at the heart of the innovation process from the very beginning of idea generation. Other influent works in the literature (Song et al.,2016; Geum et al.,2013) show a positive correlation between the value of patents and the likelihood of be popular outside and beginning projects with external partners. Coherently, **the third key factor** can be the **technology potentiality** *(*in terms of *market value and intellectual property value (IPV)). M*arket value can be measured by using the size of the market, the level of competitive advantage, the time to market; the IPV can be measure by using the level of protection of the invention, the level of novelty and the level of feasibility of the technology subject to co-development. So it is reasonable to assume the following: *Hp3a. A high level of market and sector feasibility for the technology proposed by the researcher increases the probability of a match with industry to co-develop an innovation project. H3b. A high level of intellectual property efficiency for the technology proposed by the researcher increases the probability of a match with industry to co-develop an innovation project.* By looking at the role of Knowledge sharing, the literature (Lundvall, 1992; Aharonson and Schilling, 2016) highlights that in the innovation processes, the less the distance between universities and firms, the more interactions between them. Geographical proximity, in fact, can help to improve overall technology performance as a generator of territorial innovation because it is an intermediation factor between context-related learning processes based mainly on tacit knowledge. Tacit knowledge in fact, is linked to geographical context and to personal interactions between partners. So, another **key factor** is **the geographical proximity** among the different actors. As a proxy of physical proximity, the distance between partners measured in kilometres can be used. So it is reasonable to assume the following: *HP4. Geographical proximity increases the probability of a match between an SME and the research system.* The present work attempts to contribute the literature through a quantitative empirical analysis on a proof-of-concept network (PoCN), the first experience of a co-development technology transfer process in Italy.

It is a project proposed by the prestigious 'innovation brokerage organization', AREA Science Park and financed by the Italian Government and is in line with the key objectives of Europe 2020. We focus on an **exploratory** analysis, to obtain a better understanding of the object of study: the co-development technology transfer process, that is a phenomenon recently observed and still poorly understood. We analysed 94 technologies developed and proposed from some Italian Universities and research centers to a panel of 67 national and international companies (79% were small or medium-sized enterprises). At the end the process, according to the criteria of appropriateness and eligibility, only 23 proof of concept were drawn up with the financial support of AREA. The primary data were collected by consulting the documents made available by AREA (including, for example, technology description worksheets, assessment scorecards filled out by experts, publications and patents) and via a semi-structured survey. data from Orbis Burovandic and secondary data from all the project documents. The secondary data on firms (size, core business, localization) were extracted from the ORBIS database provided by Bureau van Dijk; all information about researchers and patents was gathered by consulting specialized websites (Scopus, Thomson Reuters, GoogleScholar, MIUR, Espacenet). **We applied a cross-sectional study to our research design using a *Generalized Linear Model* estimation (GLM)**. In order to test how independent variables affect firms' matching procedures, we developed a regression model including 5 key factors (Table 1). Our empirical analysis was carried out through a **logit regression model,** given the binary outcome of the dependent variable "matching", whose parameters are reported in Table 2.

Table 1. Variables description and measurement

ID	**Description**	**Measures**
Dep. Variable		
Matching	Industry-University interaction	0,1
Ind. Variables		
Appl_prop (H1)	Number of patents whose inventors have an external/industrial applicant	No.
Incr_Div (H2)	Perceived Incremental diversification (by research team)	Likert Scale
IND_exp ($H3_a$)	Rating issued by industrial experts about the market potentiality of the technology	1-100 Scale
IP_exp ($H3_b$)	Rating issued by Intellectual Property experts about the IP level of the technology	1-100 Scale
Dis (H4)	Geographical Distance between firm and Research Department	Km (ln)

Table 2. Logit Regression results for the relationship between Academics and Practioners

Ind. Variables	**Dependent variable: Matching**
App_prop (H1)	0.4548**
Incr_Div (H2)	1.004**
IND_exp ($H3_a$)	5.203***
IP_exp ($H3_b$)	3.087***
Dis (H4)	1.8855***
R2_Adj *Chi²*	0.7087 49.18***
Refer to Table 1 for the description of the variables. * P < 0.05; ** P <0.01; *** P < 0.001	

What clearly results from our study is that a university research team which has the attitude to patent with an industrial partner is more aligned with entrepreneurs' purposes, since they share a scientific result exploitable in industrial terms. On this ground, inventors with an industrial partner as patent applicant consolidate their matching (p<0.05), improving as a consequence a sustainable firms network and taking benefit from financial support or market promotion for future research projects (HP1). Concerning with the market application of scientific results, our empirical findings seem to recognize the importance of scientists' awareness about the capability of technology to satisfy specific market needs (HP2). Moreover, we employ specific scores issued by industrial and intellectual property experts about research outcomes, showing their positive and significant (p<0.01) association to a high matching probability. This in turn explains how a good level of business and intellectual rating can encourage inventors to find an industrial partner and viceversa in order to cover knowledge-intensive investments and to share experimental risk in *proof of concept* phase (HP3a,b). Moreover, university matching willingness towards industrial environment or viceversa is significantly and positively (p<0.01) affected by geographical distance, implying on one hand that the higher is the distance the greater is the matching probability, and on the other hand that university research teams (firms) aren't able to involve a scientific (industrial) partner in the same territory (HP4). This is not coherent with the previous literature. So, the creation of long-line networks are encouraged, instead of short and local networks. Through our quantitative analysis, we contribute to attempt the recent literature on technology transfer, by testing the role of some key drivers in the co-development process. The results can suggest some implications for all the innovation system (researcher's, firms and policy makers) asked to invest on some crucial assets: knowledge and skills of the R&D team, complementary assets of research team, knowledge sharing processes. Since the R&D teams are asked to be heterogeneous, by including research and market competences, researchers are asked to create stable relations with the industrial system, by involving firms in the innovation process since the embryonic life of technology. Consequently, a multidirectional knowledge exchange can be shaped, with the opportunity to produce new knowledge, to identify additional market needs, to stimulate latent customer needs, and to create new needs for the market, by using frontiers technology. A synergic collaboration in the proof of concept process can offer advantages to all the actors involved: the research team, in fact, can have the advantage to persist in its "*core mission*" by keeping its "*research soul*" with high level performance; at the same time, it can become more and more conscious of market and industrial needs; on the other side, firms can develop new products and processes through cooperation with experts with strong scientific reputations, offering specialized skills that are not available internally (this applies especially to SMEs).

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