Vol. VIII, Issue 6
December 2018

Management, digital innovation and Industry 4.0. The case of family businesses in Italy

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This paper contributes to the empirical literature on the relationships between external management in family firms and investments in digital innovations. The analysis is based on a survey carried out by the Italian Chamber of Commerce in early 2018 of 2,342 small and medium manufacturing family firms with at least five employees. We empirically tested the relationship between our variables through ordered probit models and marginal effects. Our results showed that the presence of external managers is positively associated with the probability of investing in Industry 4.0. Disaggregating our sample into two sub-samples, external management was also found to be positively associated with the likelihood of investing in Industry 4.0 only for firms without graduates and with comparatively older owners. Finally, our results suggest that the ongoing extensive and structural transformations require skilled managerial leaderships that perceive the need for the more rapid adoption of digital technologies.

Keywords*: Family firms, manufacturing, Industry 4.0.*

Introduction

The new technological paradigm and improved worldwide Internet connections have rapidly changed the way users behave and interact with each other and with technology. These changes have not only influenced the behaviour of consumers but have also triggered extensive organisational

transformations by firms. Consequently, firms have begun to reinterpret their internal business models in various sectors including manufacturing in order to boost their competitiveness within the new global scenario. According to the European Commission [1], by adopting and investing in digital technologies, SMEs can grow two to three times faster. In the manufacturing sectors, Industry 4.0 may generate yearly efficiency gains of between 6% and 8% [2], and the absorption of digital technologies has already explained almost one third of the growth of the overall industrial production in Europe [3].

Industry 4.0 involves substantial innovations in technology for use by firms. For instance, among the new technologies, the Internet of Things and cloud computing are considered to be the most important, capable to generating digitized and interconnected supply chains as well as integrated ecosystems which bring increasing product and process innovations.

The Italian economic system has a prevalence of small and medium enterprises, which are mostly family-owned. Family businesses (FBs) in Italy face diverse challenges due to the increasing global digital processes. To address and overcome these emerging complexities, in the near future firms will likely increasingly recruit external managers as an alternative or complement to family members. However, successful management in family firms is a complex issue as the management has to balance the strategic interests and objectives of the family with technological upgrades and investments in order to survive on the market.

The transition to Industry 4.0 will require significant changes in the architecture of enterprises (both in Italy and elsewhere) together with new business processes management aimed at improving the organisation's overall performance, efficiency and operational flexibility. It is thus very important to understand what role management should play within the business.

This paper widens the scientific debate in two ways. To date, the literature on the relationship between family firms and innovation has mostly investigated how various types of management (family-members managers vs. external managers) have affected the probability of creating product and/or process innovations differently, though the effects are still often unclear. Given the new paradigm of innovation-driven by digitalization, we tested whether the presence of external managers in family firms, as a source of external knowledge, affects the likelihood of in-

vesting in digital innovation technologies (Industry 4.0). Secondly, we examined whether the role of the external manager compensated for the lack of skills within a firm. We first split our sample on the basis of the presence of graduates in the firm, then on the basis of the age of the entrepreneurs, given that younger entrepreneurs may be considered to possess greater skills / vision / digital know-how compared to older entrepreneurs.

The analysis is based on a survey carried out by the Italian Union Chamber of Commerce in early 2018 of 2,342 Italian manufacturing family SMEs in Italy with at least five employees. We empirically tested the relationship between our variables through ordered probit models and related marginal effects.

Our results showed a positive relationship between the presence of external managers and the probability of investing in Industry 4.0. Disaggregating our sample into two subsamples, we also found external managers were also shown to be positively associated with the likelihood of investing in Industry 4.0 only for firms without graduates and within firms with no young owners.

The present paper is organized as follows. In Section 2 we discuss the literature background and the existing studies related to the nexus between innovation and external management in family firms. In Section 3, we present the data set, variables and summary statistics. Section 4 presents the methodology adopted and section 5 presents the results from the econometric model. The final section presents the conclusions.

Background and previous studies

Over the last ten years, studies on innovation have been increasingly focused on the technological paradigm of the fourth industrial revolution [4], also known as Industry 4.0, which integrates manufacturing with information and communication technologies [5], [6], [7]. As pointed out by Bydet-Mayer [8] many definitions of Industry 4.0 have been reported, each connecting several aspects such as tactical intelligence using the Internet of things, cloud computing and big data [9]; integration of physical objects, human actors, intelligent machines, product lines and processes [10]; decentralisation decisions based on real-time data acquisition which improve processes, products and services [11] and so on. Gotz and Jankowska

[12] defined Industry 4.0 as an in-depth transformation of business models involving digitalization, automation and robotics.

To date, despite the large scale and complexity of Industry 4.0 [13], only a few empirical studies have focused on this topic [14], [15], while most contributions have applied the Narrative Literature Review Method [14].
Among scholars, Radziwon et al. [16] found a positive relationship between the use of Industry 4.0 technologies and a firm's performance. Concerning Italy focusing on a sample of medium-sized enterprises, Cassetta and Pini [17] found positive effects only when the investments in Industry 4.0 were driven by internal efficiency (faster processing and decision-making, organizational and process innovation) instead of external factors (availability of incentives, etc.).

Moeuf et al. [15] carried out a literature review of the existing research, and found that SMEs tend to neglect the adoption of more advanced technologies (e.g. machine-to-machine, big data, etc.) because of the lack of expertise capable of managing complex computer solutions. In fact, Industry 4.0 requires new business processes management [18], [14], [19], [20], [21] to sup-port digital innovation since it reshapes a new level of both intra- and inter- industrial organization [22], [23].

In Italy, management is a topic of great importance as it is closely linked to family businesses (FBs) - which represent over 90% of total firms [24]-and because of the stronger presence of family members in the management functions than other countries [25], [26], [27], [28], [29].

This aspect is significant as technology upgrading may be influenced by the different degree of involvement of the family in the management. The literature has proposed various approaches regarding the impact of inside vs. outside managers on FB performance, such as the agency theory, stewardship theory, and resource and knowledge based views. Agency theory highlights that a complete alignment between owners and managers reduces information asymmetry [30], [31], [32], [33], [34] and this lower agency costs [35]. Also, according to Hoopes and Miller [36] and Jayaraman et al. [37], family managers have a far sighted vision that can improve performance in the long run, while non-family managers may have short-run interests driven by their own personal objectives instead of those of the owners [32], [34], [38] (for a more detailed theoretical explanation, see [39]). However, family managers may generate problems of excessive entrenchment and altruism [30], [40], pursuing different objectives from

profit or firm value maximization [41], with negative effects on innovation process [42] (for a systematic international review of empirical analyses, see [43]).

The stewardship theory relies more specifically on "familiness" [44] and family capital [45]. It follows that innovation propensity is fostered by the emotional link between managers and family. In this respect, family managers are more likely to work for long term interests [38], [46], [47], that involve altruistic aims and yet are also best for the company, its stakeholders and the community [47], [48], [49], [50]. However, innovative activities may be hindered when family managers want to preserve their power also to the detriment of the firm's potential economic benefits [51], [52].

The resource-based and the knowledge-based views highlight the positive effects triggered by the interaction between family unit, business unit and individual family members. This interaction produces a unique system of resources and capabilities [53], [54] related to commitment, trust, reputation, know-how, valuable relationships, innovation skills, and corporate culture and organization [55], [56]. Family managers can also positively support innovation decisions [57].

The presence of non-family managers can benefit the firm in several ways, as they provide additional knowledge and expertise, as well as diverse viewpoints that family members may over-look. They can improve resource allocation decisions by preventing the possible expropriation of a firm's wealth by family members [58], [59], reducing risk aversion, which is much more relevant in family-management, hence positively affecting innovation activities [60], [61].

Despite this, how different types of management influence innovation within family firms is still unclear [42], [43], [60]. Matzler et al. [51] highlight that German family-managers positively affect innovation output (patent counts and the forward citation of patents) but negatively affect innovation input (R&D). Regarding Finnish firms, Hansson et al. [62] found a positive effect of Family CEOs on economic performances (ROA and ROI), particularly when the CEO is the founder. Nieto et al. [63] found that FBs run by family members in Spain are more likely to perform incremental innovation than radical innovation. In Italy, Cucculelli et al. [64] found that family management has a low propensity to introduce new products «that renew technological capabilities», whilst Minetti et al. [65] found a negative effect of the share of external managers on product innovation.

We thus address the following research questions:
1) Does external management positively affect the probability of investing in digital innovation?
2)Can external management support and compensate for the lack of internal skills in fostering investments in digital innovation?

Methodology

Data set, variables and summary statistics

The analysis is based on data of a survey conducted in early 2018 by the Italian Union Chamber of Commerce on a statistically representative sample of 2,342 Italian manufacturing family SMEs with at least five employees. The sample covers 6% out of a total of 42,115 enterprises.

The overall aim of the survey was to analyse the transformation of the strategy and the organization of the companies linked to their propensity to invest in digital innovation (i.e. Industry 4.0 technologies). The survey was carried out by a professional contractor and both qualitative and quantitative information at the firm level was gathered. The interviews were conducted with entrepreneurs or company directors who had an overall vision of their company's operations. The questionnaire yielded data such as ownership and management, human capital, internationalization, R&D and investments in Industry 4.0. Various structural characteristics of the firm (industrial sector, location, size, etc.) were added using a record that was directly linked to the administrative archive.

All the variables are described in Table 1. The dependent variable are the investments in digital technology. We classified the firms into three categories: 0 = firms that have not invested in Industry 4.0; 1 = firms that are planning investments in Industry 4.0; 2 = firms that have invested in Industry 4.0.

Concerning investments in Industry 4.0, we took into account Italy's Industry 4.0 plan considering firms that have invested/are planning investments in at least one of the nine topics defined by the plan (advanced manufacturing solutions; additive manufacturing; augmented reality; simulation; horizontal/vertical integration; industrial Internet; cloud computing; cyber security; and big data and analytics).

The literature on family firms provides various definitions [66], [67], [68]. Different criteria are used to identify the family's presence in a firm [69], such as capital ownership [70], management decisions [71], and the presence of members of the board who monitor and provision re-sources [72]. In this study we consider family firms as those whose owners are the founder and/or family members (without considering which generation they belong to).

In accordance with the literature [73], we distinguished between FBs run by family members (also including the founder/owner) and FBs run by external managers. Thus, External Management is a dummy variable taking two values (0,1) and indicates whether or not the family firm is run by external managers.

Since many scholars recognized R&D as one of the foremost determinants of innovation [74], [75], [76], [77], [78], we included a dummy variable (R&D) approximating for the propensity of a firm to invest in R&D. Internationalization is another factor that can foster innovation because a presence on foreign markets often requires continuous innovation to be competitive [80], [81], [82], [83], [84]. In this respect, we considered a dummy variable (Export) that takes the value 1 if the firm exports.

According to De Toni and Nassimbeni [85] firms run by older entrepreneurs show a negative relationship in relation to a competitive external environment, thus with innovation propensity and upgrading, as they do not adapt quickly to global changes. The age of entrepreneurs is often used to approximate the effect of accumulated experience and learning [86], [87], a lower perceived risk [88], and many other aspects that can affect a firm's performance (for a review see [60]). Using Spanish data for 2004-2012, Coad et al. [89] found that firms run by younger entrepreneurs showed a better innovative performance than older ones. We used a dummy variable (Young) indicating firms of the owner was under 35 years old.

Technological changes are positively fostered by a higher level of human capital which enables the system to adapt to technological dynamics [90], [91], [92]. Many studies have found a positive relationship between IT adoption, business process reorganization and a high level of human capital [93], [94], [95], [96]; for Italy: [97], [98], [99]. In line with the literature on family business and innovation, we included a variable (Human Capital) that measures the proportion of graduate employees [60], [64].

SUB is a dummy variable indicating whether or not a firm is a subcontractor. In line with Giunta and Trivieri [88] being a subcontractor may affect technology adoption throughout the supply chain, and benefits from a direct relationship with the leader firms [88], [100]. However, as pointed out by Kimura [101], the presence of subcontractors at the lowest level of the supply chain may not affect innovation activities.

To limit the potential for omitted-variable bias, we added a set of controls to the main variables of interests, which are based on the large literature focusing on the determinants of innovation at the firm level. First, we controlled for the technological level of the firms; secondly, we controlled for a set of characteristics such as size and geographical location. According to Becheikh et al. [102], size can affect innovation. To date, the results from the literature are not consistent [103]. In fact, despite Schumpeter [104] arguing that innovation activity is positively related to large firms since they are in a better position to invest more financial resources and absorb the returns of the investments on innovation. Cohen and Levinthal [105], Romer [106], Van Dijk et al. [107] underlined that small firms may have a higher propensity to innovate than large ones, given the greater benefit that they can obtain from local markets and any state-funded R&D incentives. To capture this effect, we included a dummy variable (Medium): 1 if the firm was a medium sized firm (50-249 employees) and = 0 if the firm had a number of employees lower than 50 (5-49 employees).

According to Mohnen et al. [108], sectorial affiliation reflects the technological opportunity of the industry. Thus, we controlled for sectorial characteristics by aggregating a two-digit manufacturing industry classification NACE rev.2 [109] and provided a dummy variable taking the value = 1 if the firm belonged to high/medium-high technology intensive sectors (Technology) and = 0 if the firm belonged to low/medium-low technology sectors (according to the EUROSTAT classification of manufacturing industries by technological intensity).

Finally, we included the geographical location to control for the fact that innovation may benefit from knowledge concentration and related externalities [106], [110], [111], [112], [113]; and know-how flows are often geographically bounded [110], [114]. Among the macro geographical locations, firms in the north of Italy are larger and most industrialized than those in the center and south. Hence, we used a dummy variable for North (1) and the centre-south (0).

Table 1. Description of variables

Variables	Type	Description
Dependent variable		
IND4.0	Ordinal	0 = if the firm has not invested in Industry 4.0; 1= if the firm is planning to invest in Industry 4.0; 2 = if the firm has invested in Industry 4.0
Independent variables		
External management	Dummy	1 = if the firm is run by external manager; 0 = otherwise
R&D	Dummy	1 = if the firm has carried out R&D investments; 0 = otherwise
Export	Dummy	1 = if the firm exports; 0 = otherwise
Young	Dummy	1 = if the owner is under 35 years old; 0 = otherwise
Human capital	Continuous	Share of employees with a university degree (0-100)
SUB	Dummy	1 = the firm is a subcontractor; 0 = otherwise
Medium	Dummy	1 = if the firm has 50-249 employees; 0 = if the firm has 5-49 employees
Technology	Dummy	1 = if the firm belongs to the high/medium-high technology intensive sectors; 0 = if the firm belongs to the low/medium-low technology intensive sectors
North	Dummy	1 = if the firm is located in the north; 0 = otherwise

Table 2 presents the summary statistics. Of the 2,342 family firms, 11.8% firms had already invested in Industry 4.0. As highlighted by many scholars [25], [26], [27], [28], [29], FBs run by external managers represent a small proportion of the total (11.2%). Investments in R&D involved about 40% of businesses which was similar for exporting firms (43.1%).

Young firms, namely those in which the entrepreneurs were under 35 years old, represented slightly more than 26.0%. The share of employees with a university degree (Human capital) was quite low (6.1%), probably due

to the fact that a higher share of graduate workers is usually employed in larger sized firms [115] which represented only 15.2% of our sample.

Most of the firms were characterized by a lower technology intensity (approximately 85%) while 17.6% of the total sample belonged to high/medium-high technology sectors. The firms were mainly located in northern Italy (65.6%). Finally, around 26.0% of the total firms sampled were subcontractors.

Table 2. Summary statistics

Variable	Mean	95% CI		S.D.
IND4.0 = 0	0.782 (0.009)	0.766	0.799	0.413
IND4.0 = 1	0.100 (0.006)	0.088	0.112	0.300
IND4.0 = 2	0.118 (0.118)	0.105	0.131	0.322
External management	0.112 (0.007)	0.099	0.125	0.315
R&D	0.393 (0.010)	0.373	0.413	0.488
Export	0.431 (0.010)	0.411	0.451	0.495
Young	0.268 (0.009)	0.249	0.284	0.442
Human capital	6.095 (0.257)	5.590	6.600	12.453
SUB	0.260 (0.009)	0.242	0.277	0.439
Medium	0.152 (0.007)	0.136	0.165	0.357
Technology	0.176 (0.008)	0.161	0.192	0.382
North	0.656 (0.010)	0.636	0.675	0.475

Standard errors in parentheses.

By analyzing the correlation matrix, we found that multicollinearity was not an issue as the correlation coefficients are not high (Table 3). Moderate positive correlations were found only in three cases (values between 0.3 and 0.4).

Table 3. Correlation matrix

Variable	1	2	3	4	5	6	7	8	9
1.External management	1.000								
2.R&D	0.039	1.000							
3.Export	0.033	0.238	1.000						
4.Young	-0.076	-0.001	0.027	1.000					
5.Human	0.055	0.214	0.311	0.103	1.000				

capital									
6.Medium	0.067	0.249	0.409	-0.051	0.358	1.000			
7.Technology	0.038	0.074	0.139	0.065	0.163	0.184	1.000		
8.SUB	0.003	-0.001	0.158	-0.104	0.015	0.108	0.029	1.000	
9.North	-0.039	0.040	0.116	0.039	0.031	0.114	0.122	0.048	1.000

Model specification

In order to study the factors influencing the likelihood of SMEs in Italy investing in industry 4.0 technologies, we used ordered probit models. Ordered-response models analyze the indexed nature of diverse response variables on the probability of investing in Industry 4.0. The variables in our study are mostly binary with one continuous variable (share of graduates employed). In our specification, y is an indicator of the firm's probability of investing in industry 4.0 technologies and has three response categories (0: no investment, 1: planned investment, 2: already investing). Using multinomial probit or logit would misspecify the data-generating process in assuming that there is no order in the different categories that the dependent variable can take into account.

According to Greene [116], using multinomial logit or probit would fail to take into account the ordinal character of the dependent variable. Also, OLS estimation would also be unsuitable, since it would assess the difference in the dependent variable between 0 and 1 as similar to the difference between a 1 and a 2.

Our model specification is as follows:

$$Y = \Phi(\beta_0 + \beta_1 x_1 + \beta_1 x_1 + \ldots + \beta_n x_n) \quad (1)$$

Although Logit and Probit coefficients do not provide an intrinsic interpretation, we compute marginal effects to effectively interpret the results. As a derivative, the marginal effect shows the slope of a tangent to the probability curve at a specific point, thus the instantaneous rate of change of the probability at that point. Consequently, the marginal effects show how the probabilities of each outcome change with regard to changes in regressors. Among the possibilities, we may consider two types of

marginal effects: the average of the marginal effects (AME) which measures the overall effect of the predictor, and the marginal effect evaluated at the mean of all of the predictors (MEM). Since the marginal effects depend on the levels of all variables, we computed them at the mean of all variables. For dummy variables, the marginal effects indicate the changes in the predicted probabilities in the independent variable while, for continuous variables, the marginal effects can be interpreted as elasticities.

$$\frac{\partial Y}{\partial x_1} = \beta_i \Phi(\beta_0 + \beta_1 x_1 + \beta_1 x_1 + \ldots + \beta_n x_n) \quad (2)$$

Results

The first step in our empirical analysis consisted in estimating the ordered probit model described in equation (1). Table 4 presents the econometric estimates regarding the entire sample of family firms, including marginal effects. The specification with the three indicators of a firm's investments in Industry 4.0 allowed us to test the impact of each independent variable on the probability of investing in digital innovation related to Industry 4.0 technologies (0 = if the firm does not invest; 1 = if the firm is planning to invest; 2 = if the firm has invested). In this first part, we focused on the effect of external management on the probability of investing in Industry 4.0.

After controlling for various characteristics, we found that external management exerts a positive effect on the likelihood of investing in Industry 4.0 (Table 4, column A). The predicted probability of planning investments (IND4.0 = 1) for a family firm run by an external manager was 2.1% higher than for a family firm run by family members and up to 3.0% for firms that had already invested (IND4.0 = 2) (Table 4, columns C and D). This result is in line with Cucculelli et al. [64], who found that the presence of a family manager reduces the propensity to introduce new products «that renew technological capabilities». Since digital technologies represent extensive transformations, our findings are also in line with Nieto et al. [63] who observed that the presence of family management does not support radical innovation. Our results seem to highlight the main role of the external manager in providing knowledge and additional competences [38],

as this expertise may reduce risk aversion, stimulate new investments and increase the propensity to upgrade the level of technology [60], [61].

The positive and significant effect of graduate employees (Human capital) corroborates the idea that also internal competences may increase the probability of innovating and investing in new digital technologies. This thus confirms the view that Industry 4.0 requires new business management as well as a high level of expertise [14], [18], [19], [20], [21].

Thus, external management positively affects the probability of investing in digital innovation.

Then, we included sets of separate models. Firstly, by dividing the sample into two subsamples depending on whether or not employees had a university degree, we investigated whether external management may exert a sort of compensatory effect, supporting and compensating for a lack of internal skills, thus fostering investments in digital technologies. The results of the ordered probit (Table 5, columns A and B) show that external management is positively correlated with the probability of investing in Industry 4.0 only for those firms with no graduates amongst their employees. Marginal effects indicate that, for those firms with no graduates, external managers show respectively a 2.7% higher probability of planning investments in digital innovation (IND4.0 = 1) and a 2.4% higher probability of having already invested (IND4.0 = 2), compared to family firms run by family members (Table 5, columns F and H). We computed further robustness tests, dividing firms with high and low levels of graduates and classified them in the upper tertile as high-skilled firms and in the lower tertile as low-skilled firms. However, we found no significant differences. Moreover, we also controlled for the effect of the share of graduate employees in the model A in Table 5; however, econometric estimates did not produce significant results.

In addition, competences related to digital innovation may depend on the age of the entrepreneur as young people have faster access and use of the new and upgraded technologies and skillsets. Hence, we divided the whole sample into another sub-sample according to whether or not there were young entrepreneurs, i.e. if the entrepreneur is under or over 35 years old.

Interestingly, the results showed the positive effects of external managers only with regard to firms that were not run by young entrepreneurs (Table 6, columns A and B). External management shows a

2.4% higher probability of planning investments in Industry 4.0 (IND4.0 = 1), and 3.6% of having already invested in digital innovation (IND4.0= 2) (Table 6 columns F and H).

Thus, external management may support and compensate for the lack of internal skills in fostering investments in digital innovation.

As expected, R&D exerted the strongest effect, as it represents one of the most important innovation inputs [74], [75], [76], [77], [78], [79]. This variable was positive and highly significant for each specification and sub-sample (Tables 4, 5 and 6). Marginal effects showed that the firms that invest in R&D had a 5.8% higher probability compared to firms that did not invest in R&D investments in Industry 4.0 (IND4.0 = 1), and 8.2% in the case of having already invested (IND4.0 = 2) (Table 4, columns C and D). We also found a positive and significant effect of exports on technology adoption which is in line with results found by Giunta and Trivieri [88] for Italy and by others [80], [81], [84].

On the other hand, the marginal effects of subcontracting activities (SUB) showed positive signs also with reference to the sub-samples "no Young" (firms with no young entrepreneurs) and "no GE" (firms with no graduate employees). This result suggests that FBs working throughout the supply chain may benefit from doing businesses with other leader firms [100] only in particular cases.

After controlling for firm size, we found that medium sized firms positively affected the probability of investing in Industry 4.0 (Table 4) which is consistent with Cucculelli et al. [60], [64] who highlighted the direct relationship between size and innovation/productivity performance. The technological regime (Technology) was also not significant. The effect of geographical location remains unclear. In fact, only the sub sample "no GE" showed a positive relationship between firms located in northern Italy and the probability of planning investments or having invested in digital technologies compared with the centre-south.

Table 4. Results of order probit and marginal effects at mean on total sample

Variable	Ordered probit (A)	Marginal effects at mean IND4.0 = 0 (B)	IND4.0 = 1 (C)	IND4.0 = 2 (D)

External management	0.188**	-0.050**	0.021**	0.030**
	(0.090)	(0.024)	(0.010)	(0.014)
R&D	0.524***	-0.140***	0.058***	0.082***
	(0.062)	(0.016)	(0.008)	(0.010)
Human capital	0.009***	-0.002***	0.001***	0.001***
	(0.002)	(0.001)	(0.000)	(0.000)
Young	-0.045	0.012	-0.005	-0.007
	(0.070)	(0.019)	(0.008)	(0.011)
Export	0.478***	-0.128***	0.053***	0.075***
	(0.068)	(0.018)	(0.008)	(0.011)
SUB	0.174***	-0.047***	0.019***	0.027***
	(0.070)	(0.018)	(0.008)	(0.011)
Medium	0.395***	-0.106***	0.044***	0.062***
	(0.083)	(0.022)	(0.010)	(0.013)
Technology	0.010	-0.003	0.001	0.002
	(0.077)	(0.021)	(0.009)	(0.012)
North	0.126*	-0.034*	0.014*	0.020*
	(0.066)	(0.018)	(0.007)	(0.010)
Observations	2,342			
LR chi2	362.64			
Log likelihood	-1,397.807			
Prob > chi^2	0.000			
Pseudo R^2	0.115			

Standard errors in parentheses. *** p<0.01; ** p<0.05; *p<0.10

Table 5. Results of ordered probit and marginal effects at mean (Subsample: Firms with and without graduate employees)

Variable	**Ordered probit**		**Marginal effects at mean**					
			IND4.0 = 0		**IND4.0 = 1**		**IND4.0 = 2**	
	GE (A)	**no GE (B)**	**GE (C)**	**no GE (D)**	**GE (E)**	**no GE (F)**	**GE (G)**	**no GE (H)**
External management	0.102	0.313**	-0.039	-0.050**	0.009	0.027**	0.029	0.024**
	(0.121)	(0.135)	(0.046)	(0.022)	(0.011)	(0.012)	(0.035)	(0.010)
R&D	0.424***	0.574***	-0.161***	-0.092***	0.039***	0.049***	0.122***	0.044***
	(0.085)	(0.096)	(0.032)	(0.015)	(0.009)	(0.009)	(0.024)	(0.008)
Young	-0.133	-0.032	0.051	0.005	-0.012	-0.003	-0.028	-0.002
	(0.090)	(0.114)	(0.034)	(0.018)	(0.008)	(0.010)	(0.026)	(0.009)

Export	0.301*** (0.099)	0.438*** (0.099)	-0.114*** (0.037)	-0.070*** (0.016)	0.028*** (0.010)	0.037*** (0.009)	0.087*** (0.029)	0.033** * (0.008)
SUB	0.011 (0.089)	0.369*** (0.105)	-0.004 (0.034)	-0.059*** (0.017)	0.001 (0.008)	0.031*** (0.009)	0.003 (0.026)	0.028** * (0.008)
Medium	0.237*** (0.092)	0.563** (0.284)	- 0.090*** (0.035)	-0.091** (0.046)	0.022*** (0.009)	0.048** (0.025)	0.068*** (0.026)	0.043** (0.022)
Technology	0.075 (0.097)	-0.094 (0.134)	-0.028 (0.036)	0.015 (0.022)	0.007 (0.009)	-0.008 (0.011)	0.022 (0.028)	-0.007 (0.010)
North	0.096 (0.091)	0.176* (0.101)	-0.036 (0.034)	-0.028* (0.016)	0.009 (0.008)	0.015* (0.009)	0.028 (0.026)	0.013* (0.008)
Observations	933	1,409	933	1,409	933	1,409	933	1,409
LR chi2	74.26	96.88						
Log likelihood	-827.205	-537.809						
Prob > chi^2	0.000	0.000						
Pseudo R^2	0.043	0.083						

GE: firms with graduate employees; no GE: firms without graduate employees.
Standard errors in parentheses. *** p<0.01; ** p<0.05; *p<0.10

Table 6. Results of ordered probit and marginal effects at mean (Subsample: Young and No young firms)

Variables	**Ordered probit**		**Marginal effects at mean**					
			IND4.0 = 0		**IND4.0 = 1**		**IND4.0 = 2**	
	Young (A)	**no Young (B)**	**Young (C)**	**no Young (D)**	**Young (E)**	**no Young (F)**	**Young (G)**	**No Young (H)**
External management	0.080 (0.212)	0.222** (0.099)	-0.021 (0.056)	- 0.060** (0.027)	0.009 (0.025)	0.024** (0.011)	0.011 (0.030)	0.036** (0.016)
R&D	0.606** * (0.219)	0.493** * (0.073)	- 0.159*** (0.031)	- 0.133** * (0.019)	0.072** * (0.016)	0.053** * (0.009)	0.087** * (0.018)	0.080*** (0.012)
Human capital	0.012*** (0.004)	0.008** * (0.003)	- 0.003** * 0.001	- 0.002** * (0.001)	0.001** * (0.001)	0.001** * (0.000)	0.002** * (0.001)	0.001*** (0.000)
Export	0.411*** (0.131)	0.498** * (0.080)	- 0.108** * (0.034)	- 0.134** * (0.021)	0.049** * (0.016)	0.054** * (0.009)	0.059** * (0.019)	0.080*** (0.013)

SUB	0.161	0.181**	-0.042	-0.049**	0.019	0.020**	0.023	0.029**
	(0.148)	(0.076)	(0.039)	(0.021)	(0.018)	(0.008)	(0.021)	(0.012)
Medium	0.288	0.424***	-0.076	-0.114***	0.034	0.046***	0.041	0.068***
	(0.179)	(0.094)	(0.047)	(0.026)	(0.022)	(0.011)	(0.026)	(0.016)
Technology	-0.036	0.032	0.010	-0.009	-0.004	0.003	-0.005	0.005
	(0.144)	(0.092)	(0.038)	(0.025)	(0.017)	(0.010)	(0.021)	(0.015)
North	0.136	0.121	-0.036	-0.032	0.016	0.013	0.020	0.019
	(0.133)	(0.076)	(0.035)	(0.021)	(0.016)	(0.008)	(0.019)	(0.012)
Observations	624	1,718	624	1,718	624	1,718	624	1,718
LR chi2	89.70	274.70						
Log likelihood	-368.620	-1,027.599						
Prob > chi^2	0.000	0.000						
Pseudo R^2	0.109	0.118						

Young: firms in which the owner is under 35 years old; no Young: firms in which the owner is 35 years old or over. Standard errors in parentheses. *** p<0.01; ** p<0.05; *p<0.10

Conclusions

This paper contributes to the empirical literature on the relationships between external management in family firms and investments in innovation related to Industry 4.0. Our results suggest that the ongoing transformations within the fourth industrial revolution required skilled managerial leaderships that perceive the need for faster digital technologies. This last point corroborates the idea that increasing innovations entails leveraging external sources of knowledge, especially for family firms which are mostly small sized and thus cannot rely on a high amount of financial resources and investments in skilled human capital.

This is even truer for family firms in Italy where expertise that is lacking may be provided by external support not only in terms of reducing the cultural gap but also because family owners (and members) tend to have a lower propensity to risk taking.

Hence external managers may stimulate the propensity to invest, or invest more, and to adopt digital technologies developing, at the same time, the innovation mentality within the firm that is essential to fully leverage the benefits of innovations. It is also likely that the advantage of the potential compensatory effect that the external management may exert is

not enough compared with the potential effect of having external managers working alongside better skilled employees.

Also, we observed that external management is a strong push factor for investing in digital in-novation in family firms, which tend to be run by older entrepreneurs. In this case external management may provide new business and organizational models which are more innovative and strategic in terms of a firm's competitiveness, thus fostering a propensity for digital innovation. This may in turn increase and pass on additional knowledge and open mindedness to the next generations of family entrepreneurs, who might already be working within the company.

Digital transformation requires a mix of digital skills and management expertise. Institutions and public bodies need to promote professionals training, thus increasing the awareness of the importance of digital innovations throughout the community and diffusing a strong innovation-driven mentality. Discovering and improving the features and competences provided by innovation which vary across different areas, means that not all the expertise is embodied just in the owner/CEO.

Future research could involve analyzing in more depth how external management affects the propensity to invest in digital innovation in terms of where a firm is located. Another possibility may be to investigate the different impacts of the adoption of more advanced and mature digital technologies. Finally, it would be worth analyzing how a combination of Global Value Chains and cooperation networks can foster Industry 4.0 investments.

Acknowledgment

We wish to thank Giacomo Giusti and Alessandro Rinaldi who provided us the possibility to realize this article and Valentina Meliciani for valuable suggestions for the analysis and for helpful conversations.

Disclosure

The views expressed in this article are those of the authors and do not necessarily reflect those of the Unioncamere-Si.Camera and the Department of Political Science.

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