Family management and Industry 4.0: Different effects in different geographical areas? An analysis of the less developed regions in Italy

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Abstract

This paper tests the impact of different types of management within family businesses on digital innovation related to Industry 4.0 investments, from a geographical perspective. The data set consists of 3,000 Italian manufacturing small- and medium–sized enterprises. Using probit models, the results show that while in the more advanced area (center-north) external management affects the propensity for innovation significantly, in the less developed area (Southern Italy) external management requires an additional and simultaneous investment in R&D to drive a firm's innovation. This suggests that innovation policy should define incentives that also help enhance new management business models and take into account behavioral features of different firms in relation to the level of the development of the geographical areas in which they operate.

Keywords: *family businesses, Industry 4.0, manufacturing, regions*

INTRODUCTION

Since the first studies on entrepreneurship (Schumpeter, 1934) and the business cycle and economic performance (Freeman, 1987), innovation has been a subject of investigation. Innovation has been examined in relation to the society, through the concept of the National Innovation System (Lundvall, 1992; Nelson & Rosenberg, 1993; Niosi, Saviotti, Bellon, & Crown, 1993; OECD, 1999; Edquist, 2005; Asheim, Isaksen, Nauwelaers, & Tödling, 2003). The subject has also been addressed from a territorial point of view (Acs, 2000;

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Autio, 1998; Bathelt & Depner, 2003; Braczyk, Cooke, & Heidenreich, 1998; Cooke, Boekholt, & Tödling, 2000; de la Mothe & Paquet, 1998; Doloreux, 2002; Fornhal & Brenner, 2003; Howells, 1999; Mytelka, 2000; Moulaert & Sekia, 2003) through the introduction of the Regional Innovation System approach (Autio, 1998; Braczyk et al., 1998; Cooke et al., 2000), which focused on innovation clusters (Audretsch & Feldman, 1996), interdependencies among regions, innovation networks (Boschma & Frenken, 2009) and other themes related to spatial analysis. These new developments in addressing innovation have taken territorial and microeconomic perspectives, highlighting the importance of the absorption capacity of a firm (Tödtling & Trippl, 2005) and the ability to adapt to the structural changes in less-developed, compared to more advanced, regions.

The behavioral characteristics linked to the management and organization of enterprises, also based on innovation capabilities (Aas & Breunig, 2017), particularly for SMEs, were not considered until the 1990s (Lagendijk, 2000): the main innovation factors taken into account were primarily R&D, infrastructure, financial support, and technology transfer. It has become increasingly clear that there is no “best practice” in innovation policy (see also Cooke et al., 2000; Isaksen, 2001; Nauwelaers & Wintjes, 2003), but only policies considering macroeconomic features of the regions and microeconomic features at a firm level. Nauwelaers and Wintjes (2003) divide policy instruments into two: firm-oriented and regional system-oriented.

Stimulating innovation only through the transfer of financial resources may be unsuccessful if the firms lack managerial and organizational competencies (Cobbenhagen, 1999). Many studies view management as one of the main subjects of regional innovation policies (Smallbone, North, Roper & Vickers, 2003; Cooke, 2001; Nauwelaers & Wintjes, 2003; Tödtling & Trippl, 2005). Focusing on the firm level, Family Businesses (FBs) play an important role across all economies (Aronoff & Ward, 1995; La Porta, Lopez-de-Silanes, & Shleifer, 1999; Neubauer & Lank, 1998). According to Mandl (2008), in the EU countries, FBs represent at least two-thirds of the total number of enterprises, while in Italy the share is over 90% (Ferri, Pini, & Scaccabarozzi, 2014).

Within a company the different levels of family involvement in ownership and management may affect the technological innovation process arising from diverse resource management and deployment methods (Sirmon & Hitt, 2003), risk aversion (Gómez-Mejía, Haynes, Núñez-Nickel, Jacobson, & Moyano-Fuentes, 2007; Cucculelli, Mannarino, Pupo, & Ricotta, 2014; Le Breton-Miller & Miller, 2006; Naldi, Nordqvist, Sjöberg, & Wiklund, 2007; Bianco, Bontempi, Golinelli, & Parigi, 2013; Chrisman, Chua, De Massis, Frattini, & Wright, 2015), and long-term vision (Le Breton-Miller & Miller, 2006; Manso, 2011).

In Italy, FBs are characterized by a stronger presence of family members in their management than in other countries (Bank of Italy, 2009; Giacomelli & Trento, 2005; Bianchi, Bianco, Giacomelli, Pacces, & Trento, 2005; Bloom, Sadun, & van Reenen, 2008), and there is a reluctance to outsource management (Bloom et al., 2008). Few empirical studies on the role of management within FBs in terms of technological innovation have been conducted (Craig & Moores, 2006; Kotlar, De Massis, Frattini, Bianchi, & Fang, 2013; Matzler, Veider, Hautz, & Stadler, 2015), particularly from a territorial perspective, which is relevant in a country such as Italy where there are wide socio-economic disparities between the Centre-North and the South.

Finally, most studies on FB management in Italy specifically focus only on product or process innovation (Cucculelli, Le Breton-Miller, & Miller, 2016; Minetti, Murro, & Paiella, 2015). Digitalization (Xu, Xu, & Li, 2018) has become the new technology framework in the current technological age (or Fourth industrial revolution, Schwab, 2016). Many advanced countries and supranational institutions have adopted innovation policies – defined as Industry 4.0 – based on digital technological innovation development, with particular regard to small- and medium-sized enterprises (SMEs) (Crnjac, Veža, & Banduka, 2017; Geissbauer, Vedso, & Schrauf, 2016; European Commission, 2017; Cassetta & Pini, 2018; Dileo & Pini 2018; Pini, Dileo, & Cassetta, 2018). Industry 4.0 is already at the forefront of the strategic agenda of many companies (PWC, 2016) as a push factor to ensure their competitive edge.

Industry 4.0 is, therefore, an important topic from a regional perspective (Ciffolilli & Muscio, 2018) and represents an opportunity to relaunch a firm's competitiveness in less developed areas. It can thus, potentially contribute to reducing territorial gaps. Many scholars suggest that Industry 4.0 requires not only ICT investments but also new business models and business process management, and a high level of expertise (Xu et al., 2018; Liao, Deschamps, Loures, & Ramos, 2017; Lorenz, Ruessmann, Strack, Lueth, & Bolle, 2015; Schneider, 2018; Almada-Lobo, 2016), so the subject of management within FBs becomes even more relevant. Only a few analyses focus on Industry 4.0 (for a review see Liao et al., 2017; Moeuf, Pellerin, Lamouri, Tamayo-Giraldo, & Barbaray, 2018) and particularly within Italy, but only at a country level (Cassetta & Pini, 2018; Dileo & Pini 2018).

Therefore, due to this lack of research, the current study focuses on innovation related to Industry 4.0 and associated with entrepreneurial models within FBs from a territorial perspective. The study investigates whether in less developed regions FBs run by outside managers show a higher propensity to innovate (investing in Industry 4.0) than those where the managers are family members. The study also highlights the differences in more developed areas. We consider Southern Italy as our less-developed region because the competitiveness gap of this area is evident in the GDP per capita, which is 44% lower than that of the Centre-North. The analysis uses a survey conducted in 2018 on a sample of 3,000 Italian manufacturing SMEs with between 5 and 249 employees.

LITERATURE REVIEW

Family businesses are important for the economic production of all countries (Aronoff & Ward, 1995; La Porta et al., 1999; Neubauer & Lank, 1998). According to the literature (Le Breton-Miller, Miller, & Lester, 2011), FBs are divided into the two categories of firms managed by family members (included the owner) and by external managers. This distinction is very important as family involvement in ownership and management can affect innovation propensity in different ways, such as the methods of resource management and deployment (Sirmon & Hitt, 2003); risk aversion degree (Gómez-Mejía et al., 2007; Cucculelli et al., 2014; Miller & Le Breton-Miller, 2006; Naldi et al., 2007; Bianco et al., 2013; Chrisman et al., 2015); debt financing and new ventures investments (Miller and Le Breton-Miller, 2006; Cabrera-Suárez, De Saá-Pérez, & García-Almeida, 2001; Carney, 2005; Naldi et al. 2007; Villalonga & Amit, 2006); entrenchment and personalism level (Gómez-Mejía, Núñez-Nickel, & Gutierrez, 2001; Schulz, Lubatkin & Dino, 2003; Chrisman, Chua, & Litz, 2004; De Massi, Frattini, Pizzurno, & Cassia, 2015); short- and long-term company interests (Davi, Schoorman, Mayer, & Tan 2000; Miller & Le Breton-Miller, 2006; Manso, 2011); and various incentives (Ang, Cole, & Lin, 2000; Demsetz, 1988; Fama & Jensen, 1983a, 1983b).

This view relates to the acknowledged importance of management within regional policies. Smallbone et al. (2003) consider the distinct organizational culture linked to the proximity between ownership and management, which is one of the three SME characteristics for innovation policies. Cooke (2001) identifies among the innovation factors superstructural elements linked to the governance of firms, in addition to the infrastructural elements such as finance, telecom, and transport infrastructures. Nauwelaers and Wintjes (2003) identify the subsidy for hiring innovation managers in SMEs and the innovation management training and advice among the policy innovations at a firm level. Tödtling and Trippl (2005) point out the need for management schools, which can raise the education/skill level of a region (Leon, 2017).

The effect of inside vs. outside managers within the family businesses on performance has been variously analyzed, with mixed results. In Agency theory (Schulze, Lubatkin, Dino, & Buchholtz, 2001), it is assumed that when there is an alignment between owners and managers there is no information asymmetry (Chrisman et al., 2004; Gómez-Mejía et al., 2001; Jensen & Meckling, 1976; Fama & Jensen, 1983a, 1983b) or different incentives (Ang et al., 2000; Demsetz, 1988; Fama & Jensen, 1983a, 1983b): so agency costs can be advantageously low (for a measure of agency cost, see Ang et al., 2000).

Non-family managers can have short-run interests and, as agents, pursue their own personal goals rather than those of their principals (Fama & Jensen, 1983b; Jensen & Meckling, 1976): this generates free-ride problems. The owner-manager instead has the incentive and the knowledge to run the business well and has a far-sighted vision that can generate superior performance (Hoopes & Miller, 2006; Jayaraman, Khorana, Nelling, & Covin, 2000).

Nevertheless, non-family managers can avoid problems of excessive entrenchment, altruism, and personalism (Schulze et al., 2003; Chrisman et al., 2004) that can be associated with the family-manager case. In fact, family managers can pursue goals different from profit or firm value maximization (Chrisman, Chua, Pearson, & Barnett, 2012), which can lead to mismanagement or under-management of the business (Schulze et al., 2003; Westhead & Howorth, 2007), and conflicts of interests within the family (Gómez-Mejía et al., 2001; Schulze et al., 2003). Thus, personalism and particularism may negatively affect the innovation process (De Massis et al., 2015). In addition, the close connection between family and firm assets means that the owner-manager may have greater risk aversion, which may hinder innovation activities (Cucculelli et al., 2014; Chrisman et al., 2015).

Second, the stewardship theory is linked to the concepts of "familiness" (Habbershon & Williams, 1999), and family capital (Hoffman, Hoelscher, & Sorenson, 2006), and focuses more on social capital than on financial or economic aspects. This theory states that when managers are family members or emotionally linked to the family, there is more stimulus to pursue long-term interests (Davis, Schoorman, Mayer, & Tan, 2000; Miller & Le Breton-Miller, 2005; Miller & Le Breton-Miller, 2006), which are essential to supporting innovation productivity (Manso, 2011; Bratnicka-Myśliwiec, Wronka-Pośpiech, & Ingram, 2019). The family managers act with altruism to achieve the best for the company, its stakeholders and the organizational collective (Davis, Schoorman, & Donaldson, 1997; Donaldson & Davis, 1991; Fox & Hamilton, 1994: Miller & Le Breton-Miller, 2005), devoting attention to job security, social contribution, belonging and standing within the family (Gómez-Mejía et al., 2007; Miller, Le Breton-Miller, & Scholnick, 2008). However, family managers may tend to preserve their power and authority even at the cost of hindering the firm's potential economic benefits (Kotlar et al., 2013), which can also involve the innovative process (Matzler et al., 2015).

The third theory includes the resource-based view and the knowledge-based view and focuses on the competitive edge of family businesses due to the nature and transfer of knowledge within the family (Barney, 1991; Grant, 1991; Peteraf, 1993). Specifically, the interaction between family unit, business unit, and individual family members generates a unique system of distinctive and inimitable resources and capabilities (Chua, Chrisman, & Sharma, 1999; Zahra, Hayton, & Salvato, 2004), which represents an advantage for the business. These resources and capabilities relate to tacit knowledge: commitment, trust, reputation, know-how, valuable relationships, innovation talents, corporate culture and organization (Cabrera-Suárez et al., 2001; Barney & Hansen, 1994). This harmony also allows for more efficient communication, information sharing (Tagiuri & Davis, 1996) and decision-making (Gersick, Davis, Hampton, & Lansberg, 1997). Thus, management run by family members may have a positive effect on innovation (Matzler et al., 2015). Family managers also have a greater knowledge of their firms and networks, positively supporting innovation decisions (Johannisson & Huse, 2000); but non-family managers can provide new expertise, objectivity and alternative perspectives that may be overlooked by family members, and they can improve resource-allocation decisions by avoiding possible expropriation of a firm's wealth by family members (Anderson & Reeb, 2004; Dalton, Daily, Ellstrand, & Johnson, 1998).

In the literature, the effects of different types of management within FBs on firm performance are still unclear (Cucculelli et al., 2014). More generally, some studies suggest that FBs are more innovative than non-FBs, as highlighted by Craig and Dibrell (2006) with reference to US firms, and Llach and Nordqvist (2010) for Spanish firms.

In terms of management, Matzler et al. (2015) found a positive relationship in Germany between family-managers and innovation output (patent counts and the forward citation of patents) but a negative relationship in terms of innovation input (R&D). Hansson, Liljeblom, and Martikainen (2011) found a positive effect of Family CEO on performances (ROA and ROI) in Finland, particularly when the CEO is the founder. Focusing on FBs where family members are involved in management, Nieto, Santamaria, and Fernandez (2015) found for Spanish firms a greater propensity for incremental innovation instead of radical innovation.

In the case of Italy, the issue has been analyzed from a different point of view. Sciascia and Mazzola (2008) used numerous indicators to measure performance (sales growth, revenue growth, net profit growth, return on net asset growth, reduction of debt/equity ratio, return on equity growth, and dividends growth) and found that family businesses run by family-managers perform worse. Caselli and Di Giuli (2010), using ROA and ROI, confirm this finding. Amore, Minichilli, and Corbetta (2011) found that non-family managers foster investments through an increase in debt. Regarding productivity, Bloom et al. (2008) and Bandiera, Guiso, Prat, and Sadun (2008) identified a negative effect associated with the presence of family managers. Cucculelli et al. (2014) pointed out that when considering only family-owned businesses, there is no difference - in terms of productivity - between FBs run by family managers and those run by outside managers.

In terms of innovation, Cucculelli et al. (2016) found that family management can limit the renewal of technological capabilities in products. Minetti et al. (2015) highlighted a negative relationship between product innovation and shares of external managers, as possible consequence of conflicts between shareholders and managers (for an analysis on family business and innovation from a conceptual point of view, see De Massis et al. (2015); for a systematic international review of empirical analyses, see Duran, Kammerlander, Van Essen, & Zellweger (2016). Overall, studies generally focus on product innovation without territorial considerations. Digitalization increasingly affects innovation (Evangelista, Guerrieri, & Meliciani, 2014), and policies in advanced countries are based on Industry 4.0 platforms, which promote the digital technological innovation of SMEs (Crnjac et al., 2017; Geissbauer et al., 2015; European Commission, 2017). Thus, two insights emerge from the literature: the role of management within family businesses to develop innovation activities in less developed regions, and the innovation framework of Industry 4.0 (Pickering & Byrne, 2014; for a review see Liao et al., 2017; Moeuf et al., 2018).

RESEARCH METHODS

Data

The data source is a survey carried out by Unioncamere (Italian Union of Chambers of Commerce) in early 2018. The data refer to a statistically representative sample of 3,000 small- and medium-sized Italian manufacturing firms with between 5 and 249 employees.

The dataset was enriched with structural characteristics of the firms (age, economic activities, etc.) through a record linkage to an administrative archive. The questionnaire submitted to the firms includes information about the issues of ownership and management, workforce characteristics, innovation and R&D, Industry 4.0, internationalization, and relationships.

Variables description

Dependent variable

The dependent variable concerns the innovation related to the Industry 4.0 program. Industry 4.0 can be defined as an in-depth transformation of business models involving digitalization, automation, and robotics (Gotz & Jankowska, 2017). Italy's Industry 4.0 plan (Ministry of Economic Development, 2017) identifies nine topics: advanced manufacturing solutions; additive manufacturing; augmented reality; simulation; horizontal/ vertical integration; industrial Internet; cloud; cyber security; and big data and analytics. The dependent variable (dummy) used in the regressions takes the value of 1 if the firm invested in at least one topic of Italy's Industry 4.0 plan during the period 2017 to mid-2018. Table 1 displays the variable description.

Table 1. Variables description

Variables	Type	Description
Dependent variable		
Industry 4.0	Dummy	whether the firm has invested in Industry 4.0 during the period 2017 to mid-2018 (yes = 1. *no = 0*)
Independent variables: firm's behavior		
External Management	Dummy	whether the firm run by external manager (yes = 1. *no = 0*)
R&D	Dummy	whether the firm invested in R&D during the period 2015-17 (yes = 1. *no = 0*)
Export	Dummy	whether the firm exports (yes = 1. *no = 0*)
IPP last	Dummy	whether the firm introduced some type of innovation (process/ product) in 2014-2016 (yes = 1. *no = 0*)
Green	Dummy	whether the firm invested in circular economy (energy efficiency, raw materials reuse and renewables, remanufacturing, reverse logistic, recycling and waste reduction) (yes = 1. *no = 0*)
Stakehold	Dummy	whether the firm is no-profit maximization (si = 1. *no = 0*)
Bank R	Dummy	whether the firm strengthened relationships with the banking system (yes = 1. *no = 0*)
University R	Dummy	whether the firm strengthened relationships with the research centers and University (yes = 1. *no = 0*)
Firm R	Dummy	whether the firm strengthened relationships with other firms (yes = 1. *no = 0*)
HC	Dummy	whether the firm has employees with tertiary degrees (yes = 1. *no = 0*)
Independent variables: firm's structural characteristics		
Age	Continuous	Number of years since inception (logarithm)
Size	Continuous	Number of employees (logarithm)
Pavitt sectors	Categorical	Sectoral Pavitt industry classification (Suppliers dominated = 1, Scale intensive = 2, Specialized suppliers = 3, Science based = 4)

Family businesses and management

Family businesses are variously defined in the literature (Astrachan & Shanker, 2003; Chua et al., 1999; Miller, Le Breton-Miller, Lester, & Cannella, 2007). Chua et al. (1999) define family businesses as businesses "governed and/or managed with the intention to shape and pursue the vision of the business held by a dominant coalition controlled by members of the same family or a small number of families in a manner that is potentially sustainable across generations of the family or families". Three criteria have been used to measure a family's influence in a firm (López-Gracia & Sánchez-Andújar, 2007): capital ownership (Donckels & Lambrecht, 1999); management decision (Filbeck & Lee, 2000); and resources monitoring and provision through presence on the board (Anderson & Reeb, 2004). In this study, FBs are regarded as firms where the founder and/or family members (regardless of the generation) are the owners. From the management perspective, FBs are divided into the two categories of FBs managed by the founder and/or family members (*Family management*) and those managed by non-family members (*External management*).

Control variables: Determinants of innovation and firm's characteristics

We consider different variables related to innovation determinants. We include R&D investments (Cuccullelli et al., 2016; Guerrieri, Luciani, & Meliciani, 2011) (a dummy variable that takes the value 1 if the firm invested in R&D and 0 otherwise) as R&D is recognized as a reasonable indicator of innovation input (Adams, Bessant, & Phelps, 2006; Barker & Mueller, 2002; Block, 2009; Chen & Hsu, 2009; O'Brien, 2003; Spithoven, Frantzen, & Clarysse, 2010). The firm accumulates essential technological and market capabilities enabling them to develop innovations through R&D.

Regional innovation policies identify the importance of internationalization. Nauwelaers and Wintjes (2003) and Tödling and Trippl (2005) highlight the need to support firms in linking to international input and output markets, achieving synergies and global visibility. Studies on FBs and innovation also consider internationalization as an important push factor for innovation (Nieto et al., 2015) because it requires continued innovation to remain competitive (Galende & De La Fuente, 2003; Veugelers & Cassiman, 1999). We, therefore, considered a dummy variable that takes the value 1 if the firm exports.

Within regional innovation systems, economic growth also depends on the integration of research into industry (Muscio, 2006) and on relationships between actors, in addition to investments in R&D (Camagni & Capello, 2013). Another aspect highlighted by the regional innovation framework (Nauwelaers & Wintjes, 2003; Tödling & Trippl, 2005; González-López, Dileo, & Losurdo, 2014; Dileo & Divella, 2016) considers the relationships of the firm with technological resources (R&D centers). Thus, we include a variable that considers whether the firm has relationships with universities and research centers. Moreover, we used another variable to capture whether the firm has relationships with other firms.

The regional innovation policy framework addresses two other themes: financial, highlighting the importance of the firm's relationships with external resources; and human capital, highlighting the relevance of attracting and retaining highly skilled workers (Nauwelaers & Wintjes, 2003). Thus, we add into the analyses two variables: the first identifies whether the firm strengthened the relationships with the banking system, and the second indicates if the firm has employees with tertiary degrees.

A connection between Industry 4.0 and sustainable manufacturing has been identified (Stock & Seliger, 2016), so we consider whether the firm made green investments. We also control for a firm's innovation propensity, identifying the businesses that innovated in the years before the introduction of the Industry 4.0 program. Social aspects may also affect innovation. Studies have found a positive relationship between social capital (trust, relational equity, etc.) and innovation at a firm level (Landry, Amara, & Lamari, 2000; Cook & Clifton, 2004; Cook, Clifton, & Oleaga, 2005; Cook, 2007). To capture this, we use a variable that identifies firms pursuing social sustainability (e.g., stakeholder interests) (Freeman, 1984) instead of only profit maximization.

We also controlled for different firm characteristics. In the empirical studies on innovation, age is used to take into account the firm's level of experience and learning (Kumar & Saqib 1996). The variable used refers to years since establishment (Cucculelli et al., 2014, 2016; Matzler et al., 2015; Nieto et al., 2015). The size may be an important determinant of innovation activities (Becheikh, Landry, & Amara, 2006), although this issue is still controversial (Tsai & Wang, 2005). We thus include the number of employees as a variable (Cucculelli et al., 2014, 2016; Nieto et al., 2015; Minetti et al., 2015).

Finally, we also control for sectoral characteristics related to the technological regime (Nieto et al., 2015): we distinguish the firms by Pavitt sectoral classification (Cucculelli et al., 2016; Minetti et al., 2015) using the 2-digit activities Nace rev.2 Classification (Bogliacino & Pianta, 2016).

Descriptive statistics

The descriptive statistics are reported in Table 2. Family businesses make up 80% of the total sample. Around 15% of the FBs (referred to as "firms" here) are located in Southern Italy. In this area, almost 10% of businesses invested in Industry 4.0. Regarding family management, over 10% of FBs are managed by non-family members. Investments in R&D involved about one third (35.5%) of the firms, as did the exporters' share (34.1%). Innovation activities in the past (before the introduction of Industry 4.0) were carried out by just over half of the firms (54.9%). Green investment propensity is less intensive and was relevant to 11.6% of the firms. Relationships with banks and with universities are more widespread (respectively 28.0% and 20.2%) than those between firms (9.5%). About one third (32.7%) of the firms employ graduate personnel. In almost all these cases in Southern Italy, the percentages are lower than those in the Centre-North, confirming the competitiveness gap between the two areas. The firm's size is in general lower in Southern Italy, where the average number of employees is 22, versus 31 in the Centre-North. From the Pavitt sectors perspective, there are no significant territorial differences. The correlation matrix between independent variables (with the exception of age, sectoral, and size control variables) is reported in Tables 3 and 4. We also calculated the Variance Inflation Factor to test for multicollinearity. Values greater than 10 indicate a multicollinearity problem (Yoo et al., 2014). As all values are lower than this threshold, this is not a concern.

Table 2. Descriptive statistics

	Southern		**Centre-North**	
	Mean	**S.D.**	**Mean**	**S.D.**
Industry 4.0	0.092 (0.016)	0.290	0.127 (0.007)	0.333
External Management	0.127 (0.018)	0.334	0.109 (0.007)	0.312
R&D	0.355 (0.026)	0.479	0.437 (0.011)	0.496
Export	0.341 (0.026)	0.475	0.490 (0.011)	0.500
IPP last	0.549 (0.027)	0.498	0.569 (0.011)	0.495
Green	0.116 (0.017)	0.320	0.132 (0.008)	0.339
Stakehold	0.630 (0.026)	0.483	0.718 (0.010)	0.450
Bank R	0.280 (0.024)	0.450	0.312 (0.010)	0.463
University R	0.202 (0.022)	0.402	0.214 (0.009)	0.410
Firm R	0.095 (0.016)	0.294	0.124 (0.007)	0.330
HC	0.327 (0.025)	0.470	0.412 (0.011)	0.492
Age	32.312 (0.613)	11.402	36.075 (0.283)	12.672

	Southern		Centre-North	
	Mean	S.D.	Mean	S.D.
Size	22.291 (1.802)	33.516	31.010 (0.946)	42.406
Supplier dominated	0.627 (0.026)	0.484	0.572 (0.011)	0.495
Scale intensive	0.251 (0.023)	0.434	0.215 (0.009)	0.411
Specialized suppliers	0.090 (0.015)	0.286	0.168 (0.008)	0.374
Science based	0.032 (0.094)	0.176	0.045 (0.004)	0.208

Note: standard error in parenthesis.

Table 3. Correlation matrix: Southern

	1	2	3	4	5	6	7	8	9	10	VIF
1.External Management	1.000										1.03
2.R&D	0.097	1.000									1.29
3.Export	0.110	0.319	1.000								1.33
4.IPP last	-0.020	0.248	0.113	1.000							1.14
5.Green	0.052	0.298	0.198	0.201	1.000						1.28
6.Stakehold	0.041	0.119	0.059	0.076	0.109	1.000					1.06
7.Bank R	0.013	0.088	0.108	0.178	0.076	-0.122	1.000				1.07
8.University R	0.013	0.287	0.245	0.153	0.290	0.043	0.070	1.000			1.21
9.Firm R	0.024	0.149	0.140	-0.022	0.313	0.004	0.082	0.204	1.000		1.15
10. HC	0.012	0.268	0.422	0.123	0.192	0.151	0.018	0.217	0.131	1.000	1.29
										Mean VIF	1.19

Table 4. Correlation matrix: Centre-North

	1	2	3	4	5	6	7	8	9	10	VIF
1.External Management	1.000										1.02
2.R&D	0.034	1.000									1.25
3.Export	0.024	0.203	1.000								1.24
4.IPP last	-0.005	0.324	0.136	1.000							1.19
5.Green	0.071	0.183	0.081	0.153	1.000						1.14
6.Stakehold	0.099	-0.012	0.075	-0.059	0.069	1.000					1.04
7.Bank R	0.012	0.128	0.074	0.205	0.089	-0.105	1.000				1.09
8.University R	0.055	0.233	0.192	0.109	0.265	0.017	0.204	1.000			1.23
9.Firm R	0.096	0.181	0.172	0.129	0.227	0.085	0.063	0.286	1.000		1.16
10. HC	0.035	0.303	0.413	0.229	0.132	0.044	0.078	0.209	0.158	1.000	1.32
										Mean VIF	1.17

Empirical model

The aim of this study is to assess the impact of different types of management within family firms on the investments in Industry 4.0 in a less-developed Italian area (Southern Italy); and if there are differences with the Centre-North. As the dependent variable is binary, taking only values 1 and 0, we use probit models. Binary response models allow one to overcome the two most important disadvantages of the linear probability models: the fitted probabilities can be less than zero or greater than one; the partial effect of any independent variable is constant (Wooldridge, 2016). Our probit model is as follows:

$$\mathrm{P}(Y_i = 1 | EM_i\, ,\, S_i) = \mathrm{P}(\beta_0 + \beta_1 EM_i + \beta_2 S_i + \varepsilon_i > 0) = \Phi(\beta_0 + \beta_1 EM_i + \beta_2 S_i + \varepsilon_i) \quad (1)$$

where Y_i represents the probability that the firm *i* invests in Industry 4.0 (Industry 4.0).

The independent variables are EM_i that indicates if the family firm is run by external managers, and S_i is a vector including the other independent variables relating to firm's behaviour and characteristics. All variables are binary except for age and size. Φ is a standard normal cumulative distribution function, taking only values strictly between zero and one for all values of the parameters and the independent variables. Thus, this ensures that the estimated response probabilities are between zero and one 0 < Φ(z) <. Finally, ε_i is the normally distributed random error with zero mean and constant variance $N(0,\sigma^2)$, that captures other any unknown factors.

As probit is a non-linear model, the coefficients do not correspond to marginal effects (they indicate the change of z-values, whose effects on the probability are not linear), as in linear regressions. Thus, after estimating the probit model, we calculate marginal effects (reported in Table 5): they indicate «the effect on conditional mean of Y of a change in one regressor, say, x_j » (Cameron & Trivedi 2010, p. 343). Specifically, for binary independent variables, marginal effects show how P(Y=1) changes as the independent variable changes from 0 to 1, after controlling for the other variables in the model. For categorical variables with more than two possible values, marginal effects show how P(Y=1) changes for cases in one category relative to the reference category. For continuous independent variables, marginal effects show how P(Y=1) changes as the independent variable changes by a 1-unit (Cameron & Trivedi, 2010; Williams, 2012). We used average marginal effects (AME).

Any conclusion regarding causality is limited when working on a cross-section analysis. Stata version 13 was used for all the estimates.

RESULTS

Table 5 reports the results. All regressions are based on the sample related to only family businesses by differentiating between FBs run by outside managers (*External management*) and those run by owner/family-members. To study the innovation factors in less-developed regions, all models focus separately on Southern Italy and on the Centre-North. We would point out that the results for the South might be less reliable than those for the Centre-North due to the much fewer observations for the former group.

After controlling for various firm characteristics and behavior, we find that external management affects the probability to invest in Industry 4.0 less significantly in Southern Italy ($p<0.10$) than in the Centre-North ($p<0.01$) (Models 1 and 2). This finding suggests that in less-developed regions family businesses require additional factors to invest in digital innovation. We, therefore, control for R&D as this is acknowledged as the main innovation input. This variable is not significant in Southern Italy, while it is significant in the Centre-North.

When we combine these two variables (Model 3), we find that in Southern Italy, the FBs run by outside managers that invest in R&D are more likely to innovate in Industry 4.0. The marginal effect of the variable *External management*R&D* is more significant ($p<0.05$; Model 3) than that related to only *External management* in Model 1. In Model 3, the variable *External management* also loses significance. This suggests that in less-developed regions family businesses require a strong injection of know-how that only an external manager can bring, as in the more developed areas. A possible lower level of management skill in Southern Italy could explain this. Furthermore, human capital has a positive and significant impact ($p<0.05$) on the propensity to invest in Industry 4.0 regardless of the development level of the territory.

For a robustness check, we replicate the model with the interaction (*External management*R&D*) for the Centre-North (Model 4) and do not find the same evidence as in the Southern case. Indeed, in the Centre-North the variable *External management*R&D* does not influence the likelihood to invest in Industry 4.0, while *External management* and *R&D* when considered separately confirm significant and positive marginal effects ($p<0.05$ in both cases).

Regarding other variables, we find that the firms that innovated in the past are significantly more likely to invest in Industry 4.0 in both areas. This may contribute to a possible increase in the innovation divide between the innovative firms that have continued to invest in innovation (in this case, digital innovation) and the non-innovative firms.

Table 5. Results

	Southern (1)	Centre-North (2)	Southern (3)	Centre-North (4)
External Management	0.066*	0.070***	-0.039	0.064**
	(0.034)	(0.019)	(0.065)	(0.030)
External Management*R&D			0.172**	0.011
			(0.081)	(0.039)
R&D	0.027	0.039***	-0.007	0.038**
	(0.032)	(0.015)	(0.035)	(0.016)
Export	0.029	0.049***	0.023	0.049***
	(0.033)	(0.016)	(0.033)	(0.016)
IPP last	0.077**	0.040**	0.083**	0.040**
	(0.033)	(0.016)	(0.033)	(0.016)
Green	0.073**	0.064***	0.078**	0.064***
	(0.036)	(0.018)	(0.036)	(0.018)
Stakehold	0.126***	0.029*	0.132***	0.030*
	(0.044)	(0.017)	(0.044)	(0.017)
Bank R	0.006	-0.005	0.005	-0.005
	(0.033)	(0.015)	(0.033)	(0.015)
University R	-0.045	0.047***	-0.049	0.047***
	(0.037)	(0.016)	(0.037)	(0.016)
Firm R	0.031	0.038**	0.034	0.037**
	(0.044)	(0.019)	(0.044)	(0.019)
HC	0.063**	0.041**	0.075**	0.041**
	(0.031)	(0.017)	(0.031)	(0.017)
Age	-0.096	0.023	-0.090	0.022
	(0.077)	(0.036)	(0.074)	(0.036)
Size	0.013	0.031*	0.001	0.031*
	(0.038)	(0.017)	(0.037)	(0.017)
Pavitt sectors	Y	Y	Y	Y
Observations	346	2,009	346	2,009
Pseudo R^2	0.292	0.156	0.316	0.156

Note: (a) Dependent variable: Industry 4.0. (b) The regressions are estimated by probit. (c) The table reports regressions marginal effects. (d) Standard errors are in parentheses. (e) *** p<0.01; ** p<0.05; * p<0.10.

DISCUSSION AND CONCLUSION

In this study, we analyze the effects of different types of management within family businesses on digital innovation - related to investments in Industry 4.0 - in less-developed Italian regions (Southern) in comparison to more developed regions (the Centre-North). Following the literature (Le Breton-

Miller et al., 2011), we differentiated FBs run by family-members and those run by external managers.

The results show that in Southern Italy FBs are significantly more likely to invest in Industry 4.0 when the firm is run by an external manager and simultaneously invests in R&D. External management and R&D, when considered separately, do not affect digital innovation, as in the Centre-North. Thus, this study contributes to the literature by providing empirical evidence that the effects of external management on innovation (for the Italian case, e.g., Cucculelli et al., 2016; Minetti et al., 2015) may change according to the areas' development levels.

Several policy implications can be drawn from our findings. Since there are different results between less and more advanced regions, innovation policies should be based on specific "innovation patterns" defined within individual regions. In line with the recent literature, policies should not just be "embedded" in the local reality, assets and skill base but also in "connectedness," thereby guaranteeing the connection to the external environment (Camagni & Capello, 2013; Capello, 2017; McCann & Ortega-Argilés, 2015). Detailed analyses of local areas are thus very important in increasing the success of innovation policies (Hughes, 2012), because there is no single "best practice" innovation policy approach (see also Cooke et al., 2000; Isaksen, 2001; Nauwelaers & Wintjes, 2003).

Our findings also show that policies should be developed in at least two different directions: not only in terms of R&D incentives but also encouraging management openness, hence stimulating management innovation (Kraśnicka, Głód, & Wronka-Pośpiech, 2016), within family businesses. Such openness can lead to an important change in mentality in terms of firm's innovation aimed at leveraging their full potential.

In the Industry 4.0 revolution, firms increasingly need professionals who combine organizational capabilities and digital skills in order to gain a competitive edge. Indeed, our results show that in less developed regions, R&D requires new competencies and capabilities, which may be provided by the external management, in increasing digital innovation. As highlighted in the literature, this confirms the innovation effect produced by the relationship between R&D and skills endowment (Magro, Aranguren, & Navarro, 2010; Marino & Parrotta, 2010), in self-reinforcing feedback between innovation and knowledge (Camagni & Capello, 2013). Only financial transfers, e.g., incentives for R&D, may be unsuccessful (Cobbenhagen, 1999).

All these implications confirm the importance of the "policy mix" approach (Nauwelaers, Boekholt, Mostert, Cunningham, Guy, Hofer, & Rammer, 2009; Flanagan, Uyarra, & Laranaja, 2011; OECD, 2010), hence overcoming the "linear approach" that is entirely based on R&D and technology issues.

Innovation has evolved from considering science and technology as the unique drivers of innovation to also considering the organizational and social aspects, as the determinants of innovation (Magro & Wilson, 2013).

The limitations of the study have been addressed in other papers (Cucculelli et al., 2014, 2016; Matzler et al., 2015; Nieto et al., 2015; Minetti et al., 2015). The study does not distinguish management run by founders from that run by other family members, nor does it differentiate the first generation from the second or later. It does not take into account the degree of involvement of family in the management or the ownership concentration, or the foreign equity share, or if the firm is listed on the stock market. Data were not available for these factors. Balance sheet indicators were not considered as control variables (leverage, capital intensity). However, as a large proportion of the sample consists of micro and small firms, we can state that many of the abovementioned points may be less relevant. In terms of budgetary indicators, data for micro and small businesses was not available.

Integrative research could be conducted in this domain from a territorial perspective. For example, the intensity of investments in Industry 4.0, which overcomes the limitation related to the binary variable, can be investigated. Investigating whether intergenerational transfer problems may hinder innovation activities could also be of benefit.

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Disclaimer

The views expressed in the article are those of the author and not of the institution he is affiliated with.

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Abstrakt

W niniejszym artykule zbadano wpływ różnych rodzajów zarządzania w firmach rodzinnych na innowacje cyfrowe związane z inwestycjami w Przemysł 4.0 z perspektywy geograficznej. Zestaw danych obejmuje 3000 włoskich małych i średnich przedsiębiorstw produkcyjnych. Wykorzystując modele probitowe, wyniki pokazują, że podczas gdy w bardziej zaawansowanym obszarze (centrum-północ) zarządzanie

zewnętrzne wpływa znacząco na skłonność do innowacji, w mniej rozwiniętym obszarze (południowe Włochy), zarządzanie zewnętrzne wymaga dodatkowych inwestycji w badania i rozwój w celu wprowadzenia innowacji. Sugeruje to, że polityka innowacyjna powinna określać zachęty, które również pomagają ulepszać nowe modele biznesowe zarządzania i uwzględniać cechy behawioralne różnych firm w odniesieniu do poziomu rozwoju obszarów geograficznych, w których działają.
Słowa kluczowe*: firmy rodzinne, przemysł 4.0, produkcja, regiony*

Biographical note

Marco Pini is an economist at Unioncamere-Si.Camera, Italian Union of Chambers of Commerce. Previously, he served at the Institute for Studies and Economic Analyses (ISAE, Rome, Italy) and at G. Tagliacarne Institute (Foundation of Unioncamere, Rome, Italy). He is also a member of Italian Society of Economics Demography and Statistics (SIEDS) and of Italian Society of Industrial Economics and Policy (SIEPI). His research interests include entrepreneurship, family business, industrial economics, the labor market, innovation, digitalization, the green economy, and social economy.