The impact of technological innovation efficiency on firm growth: the moderating role of family involvement in management

Abstract

Purpose – The purpose of this study is to offer new insights regarding an issue that has attracted the interest of multitude academics and practitioners in business management and family firm literature: technological innovation (TI). Specifically, this study brings new knowledge regarding both the impact of TI efficiency on firm growth and the moderating role of family involvement in management on such relationship.

Design/methodology/approach – The authors use a matched-pairs design and an ordinary least squares regression analysis to examine a sample of 152 Spanish manufacturing firms.

Findings – First, the authors show that firms obtaining higher TI efficiency are also those that achieve superior growth. Second, the authors reveal that as family involvement in management increases, the positive effect that TI efficiency exerts on firm growth is strengthened.

Practical implications – This study suggests that family managers should essentially consider various aspects such as tacit knowledge, social capital and long-standing collaborations with stakeholders to reinforce the relationship between TI efficiency and firm growth.

Originality/value – To the best of our knowledge, this is the first study that analyses the effect of TI efficiency on firm growth, as well as, when and to what extent family involvement in management influences the TI efficiency-growth relationship. Thus, this

paper provides a deeper understanding of the importance that family managers could have on firm growth deriving from TI efficiency.

Keywords: Technological innovation efficiency; Firm growth; Family involvement in management; Resource orchestration; Resource-based view.

Paper type Research paper

1. Introduction

In the current environment where businesses operate, characterized by the continuous introduction of innovations and the shortening of products' life cycles, technological innovation (hereafter, TI) allows companies to grow, evolve and reinvent themselves for the future. TI is defined as the set of activities through which a firm conceives, designs, manufactures, and introduces a new product, service, or technique (Freeman, 1976). Even though most previous innovation research has been inclined to examine innovation inputs (e.g. Verbano & Nosella, 2010), innovation activities (e.g. Serrano-Bedia et al., 2012) and innovation outputs (e.g. Tavassoli, 2018), the potential significance of TI efficiency has been widely unrecognised (Cruz-Cázares et al., 2013). Nevertheless, TI efficiency is gaining increasing momentum in the innovation area (Diéguez-Soto et al., 2018a; Lin et al., 2018; Manzaneque et al., 2018a).

TI efficiency can be settled as the relative capability of a firm to achieve TI outputs given a certain quantity of TI inputs (Cruz-Cázares et al., 2013; Manzaneque et al., 2018b). Whereas prior studies have mostly focused on analysing the antecedents of TI efficiency (e.g. Broekel, 2015; Franco et al., 2016; Kalapouti et al., 2017), so far prior literature is practically silent regarding the consequences of TI efficiency (e.g. Cruz-Cázares et al., 2013), such as for example its effect on firm performance. This is a topic of great interest to delve into, since researchers (e.g. Manzaneque et al., 2018b) agree that the key to improving firms' performance and value is the efficiency with which innovation inputs are transformed into innovation outputs. In others words, the mere fact of having resources (e.g. R&D) does not guarantee the generation of innovation neither the obtaining of superior performance (Chiesa & Frattini, 2009; Song et al., 2007). Thereby, further research is required on how TI efficiency influences firm performance (Cruz-Cázares et al., 2013).

On the other hand, performance is a complex construct with different dimensions that might not be necessarily related (Casillas et al., 2010). It is widely accepted that distinct performance measures, such as profitability or growth, lead to divergent results (Wiklund, 1999; Wiklund & Shepherd, 2005). Therefore, it is necessary to develop both theoretical reasoning and explicit empirical analysis for each performance dimension (Casillas et al., 2010; Short et al., 2009). In this vein, the present study is focused on growth as a specific dimension of firm performance.

Furthermore, due to the importance and ubiquity of family firms worldwide (Family Firm Institute, 2018; La Porta et al., 1999; Zellweger, 2017), it seems especially relevant to analyse the relationship between TI efficiency and growth in a family firm context. In this vein, there are theoretical reasons to believe that the effects of TI efficiency on growth are different in family and non-family firms (e.g. Cabrera-Suárez et al., 2001). Namely, family firms have the ability to effectively manage their resources (Habbershon & Williams, 1999; Sirmon et al., 2007), specifically their innovative resources (Classen et al., 2014; Duran et al., 2016). Consequently, the role of managers, and more precisely family managers, is essential to enhance the effect of TI efficiency on firm growth.

Based on Diéguez-Soto et al. (2018a) and on Kotlar et al. (2014), we conceptualized family management as the active involvement of the controlling family in firm management for all those firms that are family owned. Family-managed firms possess a unique combination of resources (e.g. human or organisational) and capacities that allows the development of idiosyncratic innovative capabilities (Habbershon & Williams, 1999). The proper combination of these resources and capacities by family managers lead to certain resource orchestration advantages (Sirmon et al., 2011), which contribute to obtain higher performance, namely firm growth (Chirico et al., 2011), and

thus, ensuring the firm survival. Family-managed firms also possess other features such as tacit knowledge, social capital and long-standing relationships with different stakeholders (Arregle et al., 2007; Matzler et al., 2015; Von Krogh et al., 2000), which also generate particular advantages that boost TI activities and processes (Cassia et al., 2011; Duran et al., 2016). The abovementioned characteristics make family managers to allocate innovative resources in a peculiar manner (Manzaneque et al., 2018a), contributing to the development of capabilities that are valuable for enhancing firm growth (Dyer, 2006). Thus, based on the resource-based view (RBV) and resource orchestration, we state that family management might act as an essential driver in the ability of translating TI efficiency into growth.

Despite the relevance of the topic and recent attempts to investigate TI efficiency in a private firm context (Cruz-Cázares et al., 2013; Manzaneque et al., 2018b), no empirical study thus far has focused on determining both whether TI efficiency influences firm growth and whether family-managed firms have greater ability to translate TI efficiency into firm growth than their nonfamily-managed counterparts.

To shed light on this topic, our study contributes to prior literature by addressing the following research questions: (1) Does TI efficiency exert a positive influence on firm growth?, and (2) Does family involvement in management moderate the expected positive relationship between TI efficiency and firm growth? To answer these questions, we use a matched-pairs design and applied ordinary least squares (OLS) regression analysis to a sample of 152 Spanish manufacturing firms. Spain is an ideal context for examining the moderating effect of family management on the TI efficiency-firm growth relationship, inasmuch as the family presence in Spanish firms' management is around 70%, while in 51.6% of Spanish family firms, all managers belong to the family (IEF & Red de Cátedras de Empresa Familiar, 2015, 2018). Therefore, by drawing on

RBV and resource orchestration, we analyse when and to what extend family involvement in management affects the TI efficiency-growth relationship. In this respect, we argue that the RBV is especially appropriate to analyse how family goals, relationships, and innovative resources affect firm growth (Dyer, 2006; Eddleston et al., 2008). Accordingly, we strongly believe that resource orchestration provides a holistic view regarding the integration of inherently different resources in strategic activities such as the translation of TI efficiency into growth.

This study provides significant contributions to the literature on TI and family businesses. Whereas previous family firm studies have mainly analysed TI inputs, outputs and activities (e.g. De Massis et al., 2013), we examine the implications of TI efficiency on growth. That is, we investigate how firms' relative capability of achieving TI outputs given a certain quantity of TI inputs -*TI efficiency*- affects performance outcomes, specifically growth. This is of utmost interest inasmuch as the impact of TI efficiency on growth has been under-explored in the innovation research field. Furthermore, we go a step further by investigating the moderating role of family management on the TI efficiency-growth relationship. To the best of our knowledge, this is the first study that empirically analyses to what extend family management influences the relationship between TI efficiency and firm growth. Thereby, we answer to both, recent calls for more research regarding the effect of TI efficiency on firm performance outcomes (e.g. Cruz-Cázares et al., 2013) and also to the requirement of further research on the moderating role of family management on innovative strategies (Diéguez-Soto et al., 2018a; Martínez-Alonso et al., 2018).

Therefore, the present study advances a more fine-grained understanding of the TI efficiency-growth relationship in a family firm context. First, we show a positive impact of TI efficiency on firm growth, that is, firms generating more efficiency in the

conversion of their innovation resources are those that achieve superior growth. Second, we reveal that a higher family involvement in management reinforces the positive relationship between TI efficiency and firm growth.

The remainder of this article is organized as follows. The next section provides the theoretical framework and presents the research hypotheses. Then, section 3 introduces the research method, presenting the sample and the variables used. In section 4, the empirical findings are presented and discussed. Finally, we highlight the contributions, the practical implications and some future research avenues.

2. Theoretical framework

2.1. Technological innovation efficiency and firm growth

The vast majority of firms around the world, such as SMEs, start-ups and other types of businesses operate with critical resource constraints (Duran et al., 2016). Given that these firms may be unable to increase their investment in innovation to reach their competitors, they are largely forced to work efficiently and constantly increase their effectiveness in such competitive circumstances (De Massis et al., 2018). In fact, the continuous renovation of products and processes is related to the improvement of sustainable competitive advantages and firm growth (Geroski, 1989).

Innovation is increasingly recognized as an essential firm-specific determinant in the enhancement of firms' growth (Audretsch & Coad, 2014; Stremersch & Tellis, 2004). Overall, the findings from both theoretical and empirical studies (e.g. Crossan & Apaydin, 2010; Geroski & Toker, 1996) that have focused on the abovementioned relationship show that innovation has a positive effect on growth. For instance, by conducting a panel data analysis of Spanish manufacturing and service firms, Coad et al. (2016) showed that R&D is positively related to growth. However, Coad and

colleagues demonstrated that this effect is contingent upon the firm age, in such a way that the effect of R&D investment on growth seems to be significantly riskier in young firms than in more mature firms. Moreover, Demirel and Mazzucato (2012) analysed a sample of publicly quoted US pharmaceutical firms and found that the positive effect of R&D on firm growth is contingent upon a set of firm characteristics such as firm size, patenting and persistence in patenting. Casillas and Moreno (2010) revealed that the positive effect of innovativeness on firm growth is strengthened as family involvement in the firm increases using a sample of 449 Spanish SMEs. Even more recently, Bianchini et al. (2018) states that the combination of three basic innovation activities i.e. internal R&D, product innovation and process innovation, can be the most effective strategy in the achievement of sustained firm growth. Finally, there are also studies that have identified both external (dynamic and hostile environments, external sourcing…) and internal (employee involvement in renewal activities, generational involvement…) factors, which positively contribute to the translation of innovation activities into growth (e.g. Coad et al., 2016; Eiriz et al., 2013; Uhlaner et al., 2013).

Nevertheless, to date, little emphasis has been placed on analysing the relationship between TI efficiency and growth, which remains unexplored, as well as on the specific factors that influence this relationship (e.g. Cruz-Cázares et al., 2013). Instead, prior research (e.g. Broekel, 2015; Franco et al., 2016; Kalapouti et al., 2017) has primarily focused on examining the antecedents of TI efficiency. For example, Franco et al. (2016) studied the role of upstream product market regulation in innovation efficiency and found that service regulation reduces R&D efficiency in the manufacturing sector. Broekel (2015) showed that subsidies for R&D cooperation are an appropriate policy measure for encouraging the innovation efficiency of different regions. For its part, Kalapouti et al. (2017) evidenced that regions engaged in high-innovation activities

through patent production achieve higher innovation efficiency. Moreover, most of the papers dealing with TI efficiency have been developed in a Chinese context and considering public firms (e.g. Manzaneque et al., 2018b). Therefore, there are few studies that have analysed TI efficiency in Western countries and in private businesses, leaving research open to enhance prior knowledge regarding the relationship between TI efficiency and firm performance.

Actually, as far as we know, there are only two papers that have linked TI efficiency with firm performance indicators. On the one hand, Cruz-Cázares et al. (2013) empirically showed that TI efficiency exerts a positive effect on firm performance, measured by ROA. Moreover, Cruz-Cázares and colleagues revealed that both technological intensity level and firm size are two essential factors in the TI efficiency-firm performance relationship. On the other hand, Manzaneque et al. (2018b) recently revealed how performance below aspiration levels, computed by the decline in ROA at t−1 relative to ROA at t−2, reinforces the relationship between R&D and the probability of obtaining TI -*TI efficiency*-. Furthermore, these authors confirm that financial slack and family management are two relevant contingencies that impact on the abovementioned relationship between performance below aspiration levels and TI efficiency.

Therefore, as different forms of innovation (e.g. R&D investments, product or process innovations) have been proved to exert a positive impact on firm growth (e.g. Casillas & Moreno, 2010; Demirel & Mazzucato, 2012), and as TI efficiency also exerts a positive effect on firm profitability (Cruz-Cázares et al., 2013), a positive influence of TI efficiency on growth can be established. Accordingly, it can be argued that the key to improve firm growth is the efficiency with which TI activities are developed, inspired by the idea that innovation inputs engender innovation outputs (Cruz-Cázares et al.,

2013). Thus, firm growth is derived from an appropriate endowment and management of innovation resources and the efficiency with which these resources are transformed into TI (Barney, 1991; Manzaneque et al., 2018a).

Based on the abovementioned arguments, we claim that those firms obtaining greater efficiency in their TI activities will achieve higher growth. Stated formally:

H1: Technological innovation efficiency will have a positive effect on firm growth

2.2. The moderating effect of family involvement in management

Family firms own unique set of ownership, management and governance (Huybrechts et al., 2012) that allow them to produce sustainable competitive advantages (Barney, 1991), and ultimately, superior growth (Dyer, 2006).

The unique set of family characteristics is intensified when the family presence in firm management increases (Revilla et al., 2016) due to the overlap between the family and the firm (Sciascia et al., 2015). That is, as the number of family managers increases, so does the integration between the family and the firm (Le Breton-Miller et al., 2011).

Firm managers are one of the most imperative decision making units in organizations (Vandekerkhof et al., 2015), who determine the goals to be achieved and the means of getting them (Kor, 2006; Ruiz-Jiménez & Fuentes-Fuentes, 2016). Specifically, family managers are the most important decision-makers in family firms, since they provide the interface between firm, family and environment (Vandekerkhof et al., 2015). This particular connection leads to a powerful context (Hambrick et al., 2005) that is quite appropriate for strengthening the development of family-based competitive advantages (Mazzi, 2011). Consequently, family managers decide how resources are managed and deployed (Sirmon & Hitt, 2003).

Based on the RBV, Habbershon and Williams (1999) revealed that family firms possess unique resources and capabilities (e.g. social capital) for managing innovation. These resources and capabilities must be properly used and combined by family managers to spur firm performance (Manzaneque et al., 2018a), and specifically, firm growth. In this vein, we state that family involvement in management affects resource orchestration (Sirmon et al., 2007), given the differential ability of family managers to efficiently manage innovation resources to face changing conditions (Chirico et al., 2011). Namely, family managers influence a resource-based competitive advantage (Diéguez-Soto et al., 2018a; Sirmon et al., 2011), specifically the translation of TI efficiency into firm growth.

Notwithstanding the relevance of the TI efficiency-firm growth relationship (Martínez-Alonso et al., 2018), no research has been conducted regarding when and to what extent family management affects the abovementioned relationship. In this respect, we argue that the effect of TI efficiency on firm growth will be moderated by family involvement in management. That is, the effect of TI efficiency on firm growth will be more important for firms with a higher number of active family members in management.

Prior research (e.g. Matzler et al., 2015) indicates that family-managed firms present specific advantages in human and relational capital that might be valuable in strengthening the positive effect that TI efficiency exerts on firm growth. Broadly speaking, family managers are endowed with superior tacit knowledge (Von Krogh et al., 2000), due to the unique developed capabilities concerning the different routines, know-how and resources of their firm. In this respect, family managers possess deeper levels of firm-specific knowledge (Sirmon & Hitt, 2003) and also promote the exchange of such knowledge throughout the firm (Zahra, 2007). In view of the foregoing, family-managed firms are expected to improve their innovation ability and favour a better

management of innovation resources (Ashwin et al., 2015; Duran et al., 2016). Further, bearing in mind that family managers make decisions in uncertainty environments, the dissemination of tacit knowledge may benefit the creation of a unique resource orchestration (Firfiray et al., 2018), which is advantageous for firm growth. Moreover, the propensity for personalism, parsimony and particularism enable family managers to develop unique knowledge structures (Patel & Fiet, 2011), which encourages the transition of TI efficiency into firm growth. Family firm social capital is also an important factor (Llach & Nordqvist, 2010), as it helps to identify, develop and disseminate internal and external knowledge to improve family firm's competitive advantages (Arregle et al., 2007). Social capital enables family managers to establish greater quality long-standing relationships between the own family and external stakeholders (Miller & Le-Breton-Miller, 2005). These stakeholders are likely to develop close links with family firms, since the latter are usually managed on a stable basis (Ward, 2004). The formation of close ties with selected stakeholders allow family managers to exchange new ideas that may foster the generation of higher efficiency from TI activities (Classen et al., 2014). In fact, the sharing of these ideas between firms and stakeholders is a key factor in boosting TI processes (Antolín-López et al., 2015). Finally, family managers seek to conduct open innovations throughout the cooperation with external partners (Cassia et al., 2011), which might also enhance the translation of the TI efficiency generated by family-managed firms into growth.

Hence, we expect that the abovementioned features (e.g. tacit knowledge, social capital and the establishment of quality long-standing relationships with external stakeholders) may favour the resource orchestration advantages of family managers and thus, significantly improve its innovative abilities. Thereby, family management can be

beneficial for the translation of TI efficiency into firm growth. Accordingly, we propose the following hypothesis:

H2: As family involvement in management increases, the positive effect of technological innovation efficiency on firm growth is strengthened.

The theoretical model and the proposed hypotheses are presented in Figure 1.

(Insert Figure 1 here)

3. Methods

3.1. Data and sample

In order to check our hypotheses, we employed a cross-sectional sample for 2012 of Spanish firms from the Survey on Business Strategies (ESEE). This database is administered by the State Partnership of Manufacturing Equity foundation on behalf of the Spanish Ministry of Industry. The sampling procedure of ESEE was designed with the purpose of gathering data that guarantee the representativeness of Spanish manufacturing firms. In particular, the data include the whole population of Spanish manufacturing businesses with 200 or more employees, and a stratified random sample of 5% of the population of firms with at least 10, but fewer than 200 employees. In accordance with the arguments of Dorling and Simpson (1999), the fact that the data are collected by a public agency ensures the quality of the information, which means a high response rate, a high level of participation and the representativeness of the population. After removing businesses with incomplete data and atypical values for the analysed variables, the sample comprised 598 firms. Of the remaining sampled firms, we focused on those that have developed R&D investments and consequently, a group of 357 businesses was eliminated. Thus, from those 241 firms, we recognized which firms had performed any type of TI (product innovation and/or process innovation) for the

proposed year. We then used a matched-pair research design (e.g. Allouche et al., 2008) through which each firm that had performed TI was matched with other business without TI. This approach maintains the sample-matched characteristics, has several desirable statistical properties (Mangena & Chamisa, 2008) and enables us to control for size and industry as a firms' specific features (Peasnell et al., 2001). Thus, we obtained a balance sample of matched firms that present the same profile in terms of their industry (three-digit SIC code) and their size. We removed 89 firms because no adequate correspondence firm was properly identified. The final sample is then comprised of 152 firms (see Table 1, panel A).

The Spanish manufacturing industry is a really interesting context for analysing the effect of TI efficiency on firm growth, because of manufacturing firms play a crucial role in the innovation investment made in Spain (Cruz-Cázares et al., 2013; Manzaneque et al., 2018a, 2018b). The Spanish manufacturing industry accounts for 44.1% of total TI expenditures in relation to other economic sectors (INE, 2012). In fact, 4 out of every 10 Spanish firms developing TI belong to the manufacturing industry (Fundación Cotec, 2012). These firms are particularly inclined to rely on innovation, due to their products are affected by a high degree of obsolescence (e.g. Kotlar et al., 2013).

Our sample of Spanish manufacturing firms is represented by 18 sub-industries[1] (see Table 1, panel B). Most of them come from "Chemical and pharmaceutical products" (15.79%), "Agricultural and industrial machinery" (13.16%) and "Foodstuffs and snuff" (10.53%).

(Insert Table 1 here)

[1] In the ESEE, the manufacturing industry is subdivided in 20 sub-industries. However, both the Timber and the Graphics sub-industries have been omitted because there were no firms belonging to these sub-industries that could be paired with other businesses.

3.2. Model

In this manuscript, we performed OLS regression analysis to examine the relative capability to translate TI efficiency on firm growth. Furthermore, we used interaction models to test the moderating effect of family involvement in management on the TI efficiency-firm growth relationship.

The interaction models have gained great attraction over the past few years, as they have been widely used to analyse different aspects and dimensions in family businesses (Gómez-Mejía et al., 2018; Hatak et al., 2016; Souder et al., 2017).

As indicated by Martínez-Romero (2018) and Vandekerkhof et al. (2015), based on Brambor et al. (2006), in an interactive model, the effect of any independent variable (X) on the dependent variable (Y) is not any single constant. The mentioned effect is contingent upon the coefficients (betas) of X and of the interaction term XM, as well as on the value of the moderator (M).

Therefore, it is of utmost importance to examine the marginal effect of the independent variable (TI efficiency) regarding to the dependent variable (firm growth), to see when and to what extent these effects are significant for the relevant values of the moderator (family involvement in management). In this respect, Brambor et al. (2006) and Schepers et al. (2014) claimed that marginal effects should always be calculated even if the interaction coefficient is significant.

Hence, by assuming a more simplified OLS model with an independent variable X_1, a moderator variable M, and the interaction term X_1M, it is possible to derive the marginal effect of X_1.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 M + \beta_3 X_1 M + \cdots + \in, and\ the\ marginal\ effect = \frac{\partial Y}{\partial X_1}$$

$$= \beta_1 + \beta_3 M$$

In this regard, the effect of X_1 on Y depends on β_1, β_3, and the value of M. The marginal effects can be tested by examining a plot of $\frac{\partial Y}{\partial X_1}$ and its 95% confidence interval over the range of M in the sample to test whether X and Y are statistically related (at that value of M), with the substantive significance of the relationship given by the direction and magnitude of the $\frac{\partial Y}{\partial X_1}$ estimate.

Thus, in light of the above, the following model is proposed, whose variables are explained below.

$$Firm\ growth = \beta_0 + \beta_1 TI\ efficiency + \beta_2 Family\ involvement\ in\ management + \beta_3 TI\ efficiency * Family\ involvement\ in\ management + \beta_4 Firm\ size + \beta_5 Firm\ age + \beta_6 Leverage + \beta_7 Subsidies + \beta_8\ Sub - industries + \varepsilon$$

3.2.1. Variables

Dependent Variable

Firm growth. To measure our dependent variable, we adopted sales growth, measured as the percentage change in sales from one year to the next. This performance indicator is more accessible and accurate than other accounting measures (Wiklund, 1999), having been widely used in the study of innovation and family businesses (Cruz et al., 2012; Sciascia & Mazzola, 2008). In fact, prior research (e.g. Bahadir et al., 2009; Uhlaner et al., 2013) has revealed that innovation is one of the most consistent and positive drivers of sales growth, being this performance measure highly appropriate for our study.

Independent Variable

Technological innovation efficiency. Following the arguments of Cruz-Cázares et al. (2013) who consider that an optimal measure of innovation efficiency should include

both, innovation input and innovation output, we use the ratio of number of product innovations (innovation output) over R&D intensity (innovation input) as a proxy of TI efficiency. On the one hand, we use the number of product innovations and not the number of patents as innovation output as most of previous literature has done (e.g. Franco et al., 2016), since the number of patents may undermine the innovative capacity of SMEs, because these firms are often afraid that their new ideas might be appropriate by others (Deng et al., 2013) or just because they could not afford the long time necessary to overcome the patenting process (Kalantaridis & Pheby, 1999). In this vein, drawing on Oslo Manual, product innovation is defined as "the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses*"* (OECD, 2005, p. 48). On the other hand, we used lagged R&D intensity measured as the ratio of the firm's R&D expenses over total sales (e.g. Manzaneque et al., 2018a), based on the assumption that R&D activities are a long-term process and their results are obtained in the following years after their execution (Liang et al., 2013). Therefore, the use of a ratio to measure TI efficiency allows us to reveal the real efficiency obtained by these firms (e.g. Floros et al., 2014).

Moderating variable

Family involvement in management. We employ family involvement in management as a moderating variable. We follow the study of Kotlar et al. (2014), that consider both family ownership and family involvement in top management as factors that influence family firms decision-making, for the election of an objective measure of family management. For all family firms, the ESEE provides the number of owners and their relatives that hold top management positions. Thus, to measure family management, we build a continuous variable that includes the number of family members occupying top managerial positions (Filser et al., 2018; Kotlar et al., 2013; Manzaneque et al., 2018b).

Control variables

In our regression model, we also incorporate several control variables that might affect firm growth. First, as growth depends on firms' life stages (Coad et al., 2016), we control for *firm age*. Firm age is measured as the natural logarithm of the number of years from the creation of the firm (Ashwin et al., 2015; Matzler et al., 2015). To the extent that large firms often present advantages over small firms in terms of financial and economic resources or market power (Cohen & Klepper, 1996), which are expected to be beneficial in increasing firm growth, we control for *firm size* measured as the natural logarithm of total assets (Huang et al., 2016; Schmid et al., 2014). Furthermore, we control for *industry effect*. Since business sectors may have different degrees of propensity towards innovation and growth (Diéguez-Soto et al., 2018b), we include 18 sub-industries dummy variables as a further control in our analysis. Additionally, considering that firms with higher financial resources have greater financial flexibility to experience growth, we control for firm *leverage* measured as the debt to total assets ratio (Chen et al., 2013; Manzaneque et al., 2017). Finally, we also account for the received innovation *subsidies* (Antolín-López et al., 2015; Raymond et al., 2010), because of their influence on firm growth. In this vein, the dummy variable subsidies takes the value 1 if the business inform that it received subsidies for innovation and 0 otherwise.

Additionally, all the variables used in this study are classified according to their typology and scale (see Appendix).

4. Data analysis and results

The means, standard deviations and others descriptive statistics are shown in Table 2. On average, our sampled firms have a ln_size of 17.13 (or about 115.90 millions) and

are on average 41.18 years old. In this sense, ln_size ranges from 13.35 to 21.60 (or the amount from 624.9 thousands to 2.4 billions) and firm age varies between 5 and 120 years old.

(Insert Table 2 here)

The correlation matrix (Table 3) shows the bivariate effects of the analysed variables that are considered to influence firm growth. Firm age and leverage are negatively and significantly correlated to growth, while TI efficiency and family management are positively although non-significantly correlated to the dependent variable. Table 3 reveals no indications of multicollinearity, since the highest correlation coefficient was 0.26 being far below the range of 0.80 above which multicollinearity hazards could emerge (Gujarati & Porter, 2008). The graph of standardized residuals versus predicted values (Field, 2013) showed that our data fulfilled the linearity and homoscedasticity assumptions. Thus, we found no evidence of heteroscedasticity.

(Insert Table 3 & Table 4 here)

The proposed hypotheses were tested using OLS regression analysis. The regression results are shown in Table 4, considering firm growth as the dependent variable. In order to check for the absence of multicollinearity, we verified that the variance inflation factor (VIF) did not surpass 1.64, which is well below the 10 threshold. Therefore, there is sufficient evidence to rule out multicollinearity in the data (Belsley et al., 1980; Hair et al., 1999).

Model 1 is the baseline model and only includes control variables. It shows that the dependent variable is negatively and significantly related to firm age (β=-0.055; p<0.05). Model 2 is a variant of model 1 in which we include the variable TI efficiency.

The coefficient of TI efficiency is positively and significantly related to firm growth (β=0.111; p<0.05). Thus, this result provides support for H1.

In order to test the hypothesized moderation effect, we built a third model in which we enter the moderator (family involvement in management) independently. The beta coefficient of family management becomes non-significant in model 3. Nevertheless, the direct effect of the moderating variable is not relevant to testing the moderator hypothesis (Baron & Kenny, 1986); conversely, when the moderator is not related with the dependent variable, the interpretation of the interaction term is easier (Martínez-Romero, 2018; Michiels et al., 2014). In this sense, what we want to examine is when and to what extent family involvement in management through the development of long-standing relationships, social capital and tacit knowledge enhances the capability to better translate TI efficiency into firm growth.

Accordingly, to capture the effect of family management on the TI efficiency-firm growth relationship, we entered the moderating effect in Model 4. The interaction coefficient is positive and significant (β=0.250; p<0.01). In short, the results of Model 4 strongly support H2.

Furthermore, to provide a more fine-grained picture of the moderating effect of family management on the TI efficiency-growth relationship, we use the Johnson-Neyman technique (Field, 2013) and build the graph represented in Figure 2, based on the following equation (∂Firm growth/∂TI efficiency= β_1 + β_3Family involvement in management).

Therefore, Figure 2 graphically shows the marginal effect of TI efficiency on firm growth as family involvement in management increases, illustrated by the solid line. The dotted lines surrounding the solid line represent the 95% confidence interval. This

effect is significant when the top and bottom bounds of the confidence interval are above (or below) the zero line, which occurs for almost the 33% of the total sample.

(Insert Figure 2 here)

Figure 2 reveals that the positive marginal effect of TI efficiency on firm growth is stronger as family involvement in management increases. Hence, Figure 2 strongly supports H2.

Finally, to further illustrate the moderating effect of family management on the TI efficiency-firm growth relationship, Figure 3 shows the interaction effect by estimating the predicted values of firm growth under different conditions i.e. high and low values of TI efficiency and high and low values of family management, making the different effects visible (Pesch et al., 2016). Thus, this plot shows a positive slope for TI efficiency and firm growth in firms with high family involvement in management. Moreover, Figure 3 also reveals a slightly negative slope for TI efficiency and firm growth in firms with low level of family involvement in management. These results are in line with the marginal effect graph and therefore, provide greater support for our study.

(Insert Figure 3 here)

4.1. Robustness tests

To consolidate the achieved results, we executed some robustness checks, using an alternative measure of the dependent variable. Specifically, we used *positive firm growth*. That is, whether the percentage change in sales is greater than 0, then *positive firm growth* is coded as a continuous variable. On the contrary, if the percentage change in sales is negative, the variable is set to 0, thus the variable is left-truncated (Chrisman & Patel, 2012; Patel & Chrisman, 2014).

Table 5 shows the robustness tests regression results. Models 6 and 7 reveal that TI efficiency exerts a positive and significant impact on *positive firm growth* (β=0.150; p<0.05). Moreover, the interaction of TI efficiency and family management is positively and significantly related to *positive firm growth* (β=0.269; p<0.10), as shown in model 8. To better interpret this moderating effect, we calculate both the marginal and the interaction effect of TI efficiency on the alternative dependent variable again. The obtained results are comparable to those presented in Figure 2 and Figure 3 (Figures are not reported).

Finally, we performed an additional test by using a binary measure of family management. This variable takes the value 1 if there is a family with majority ownership in the firm and at least one member of that family is actively involved in top managerial teams, and 0 otherwise (Diéguez-Soto et al., 2018b; Kotlar et al., 2014). The obtained results are similar to those achieved with the continuous measure of family management (results are available from the authors).

In summary, these tests allow us to ensure the consistency of our results.

(Insert Table 5 here)

5. Discussion and conclusions

TI activities and processes have been the subject of a growing number of studies in the management field (e.g. Ozturk, 2018), and particularly in the family firm area (e.g. Calabrò et al., 2018). Family firms have realised that whether they want to remain competitive, even in crisis periods, they must increase their TI development (Manzaneque et al., 2018a). Unfortunately, innovation research has overlooked the impact of TI efficiency on firm performance, as well as, the moderating effect of family management on such relationship (Diéguez-Soto et al., 2018a; Martínez-Alonso et al.,

2018). Our article substantially contributes to clarify this debate and it is the first empirical attempt to shed light on these issues. Specifically, we checked the influence of TI efficiency on firm growth and, by drawing on the RBV and resource orchestration, we examined when and to what extent family involvement in management moderates the ability to transform TI efficiency into firm growth. To address this issue, we carried out an OLS regression analysis to a sample of 152 Spanish manufacturing firms.

Regarding the first hypothesized relationship, the findings show that TI efficiency positively influences firm growth. In this respect, firms that optimally manage their innovation resources and capacities are able to obtain greater TI efficiency and thus, achieve superior growth. Hence, our results support prior research (e.g. Cruz-Cázares et al., 2013), emphasizing that firms obtaining greater efficiency in the conversion of their innovation resources into innovation output, are able to experience higher performance than those that do not. Thus, the findings corroborate that what indeed enhances firm growth is the efficiency with which innovation inputs are converted into innovation outputs. As suggested by Cruz-Cázares and colleagues, the executed innovation investment is not the main issue, what really matters is what could be obtained with such investment.

With respect to the second analysed hypothesis, the results reveal that family involvement in management reinforces the positive effect that TI efficiency exerts on firm growth. As abovementioned, family-managed firms possess a pool of idiosyncratic resources and capacities such as tacit knowledge or social capital, that favours the innovate behaviour of family managers. All these aspects lead to a high commitment of family managers with the firm, resulting in a major involvement in decision-making processes concerning the improvement of firms' viability and growth. Therefore, family managers by properly managing and combining innovation resources are extremely

capable of improving their ability to translate TI efficiency into firm growth. In this vein, our results show that as family involvement in management increases, the positive effect that TI efficiency exerts on firm growth is strengthened. What is more, our findings reveal that when family involvement in management is high, TI efficiency leads to greater growth. On the contrary, when family involvement in management is low, TI efficiency is translated into minor growth. Hence, firms with high family involvement in management are able to achieve higher growth given a certain level of TI efficiency than firms with low family involvement in management. Accordingly, our results are in line with previous studies (e.g. Diéguez-Soto et al., 2016) confirming that family-managed firms are more proficient and manage better their TI efficiency (Diéguez-Soto et al., 2018a; Duran et al., 2016; Martínez-Alonso et al., 2018), which favours the obtaining of superior growth (Rosenbusch et al., 2011). Moreover, the greater innovative ability of family-managed firms combined with their desire of preserving the business in the long-term (Brigham et al., 2014; Rojo-Ramírez, 2009), reinforces the effect of TI efficiency on firm growth.

Our study provides new knowledge to the TI field (De Massis et al., 2013) and, in particular, to the flourishing literature on family involvement in innovation management (Chrisman et al., 2015; Kotlar et al., 2013). On the one hand, while previous studies (e.g. Cruz-Cázares et al., 2013) have primarily related TI efficiency to performance indicators such as ROA, we examine the consequences of TI efficiency on firm growth. On the other hand, to the best of our knowledge, this is the first paper that empirically analyses the interaction effect of family involvement in management on the relationship between TI efficiency and firm growth. Thereby, we respond to the call for more research on both the TI efficiency-firm performance relationship and the role of family

management as a moderator on such relationship (Diéguez-Soto et al., 2016; Martínez-Alonso et al., 2018).

5.1. Limitations and future research directions

The contributions of this study are no free of limitations, which, in turn, may provide opportunities for future research.

First, it is important to highlight that the obtained conclusions are valid only for the assumptions of the variables' representation utilized in this article. Furthermore, this study is limited by the choice of the sample used. We focus on the Spanish manufacturing industry, controlling by 18 sub-industries. Thus, our results could be affected by country-specific bias and consequently, it would be interesting to conduct further research in other regions or contexts to corroborate the obtained findings. Moreover, although the manufacturing industry is a strategic sector for the Spanish economy, it would be very fruitful to examine the proposed relationships in alternative industries.

Second, although cross-sectional designs in this type of research are currently standard practice (Barasa et al., 2019; Cassia et al., 2011; Llach & Nordqvist, 2010), assertions regarding causality could not be substantiated with such a method. Thereby, future research may test the robustness of our findings via a panel design.

Third, we have distinguished between firms that have family members in managerial positions from those that do not have family members in managerial positions. However, we have not considered the heterogeneity between family managers. In this respect, the socioemotional wealth literature (Berrone et al., 2012; Gómez-Mejía et al., 2007; Martínez-Romero & Rojo-Ramírez, 2016) has widely acknowledged that family managers differ in terms of their family goals and values (Martínez-Romero & Rojo-

Ramírez, 2017), and consequently have heterogeneous behaviours (Kotlar et al., 2014). In this sense, it would be useful to analyse the heterogeneous behaviour of family managers on the ability to translate TI efficiency in firm growth. For instance, future studies could rely on qualitative research to examine such behaviour.

Finally, our study presents another limitation related to the measurement of our variables. In this regard, the ESEE contains information on the quantity but not on the quality of product innovations. Thus, future studies should consider a combination of both the quality and the quantity of product innovations when calculating TI efficiency, in order to evaluate its possible consequences on firm growth. Moreover, limitations with our database have made it impossible to control by other interesting variables such as the level of family ownership, the generation in charge or the existence of family governance practices.

5.2. Implications for practice

Our findings are also important for practitioners due to the importance of obtaining superior efficiency in TI activities and the consequences it entails for the viability and growth of any firm (Dyer, 2006). Therefore, a deeper understanding of the translation of TI efficiency into firm growth is essential for managers and policy makers.

Our results show that firms with high level of family involvement in management are more likely to obtain superior growth, given certain level of TI efficiency. This favourable effect of family management on the TI efficiency-growth relationship may be enhanced by disseminating tacit knowledge among family members, increasing social capital, fostering external collaborations with specialised stakeholders and by maintaining skilled employees. Moreover, family managers should avoid nepotism and altruistic behaviours, which could damage the positive relationship between TI efficiency and firm growth. In this vein, the inclusion of external directors on the board,

can be an antidote to prevent family-managed firms from letting altruistic considerations get the upper hand in innovative management decisions (Goel et al., 2013; Vandekerkhof et al., 2015).

6. Conclusion

In conclusion, this study reveals that TI efficiency positively influences firm growth and that this relationship is strengthened as family involvement in management increases. Thus, our study reveals that family managers have a substantial influence on the way in which TI efficiency is managed and how that efficiency is translated into firm growth. Besides the recent findings in both TI and family firm literature, our study provides valuable insights into theory and practice, as well as enlightening future researchers on some promising research avenues.

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Appendix

Table A1. Variables classification

Variable	Variable type	Scale used
Firm growth	Quantitative	Interval scale
TI efficiency	Quantitative	Interval scale
Family involvement in management	Quantitative	Reason scale
Firm age	Quantitative	Interval scale
Firm size	Quantitative	Interval scale
Industry effect	Categorical	Nominal scale
Leverage	Quantitative	Interval scale
Innovation subsidies	Categorical	Nominal scale

Figure 1. Theoretical model and hypotheses

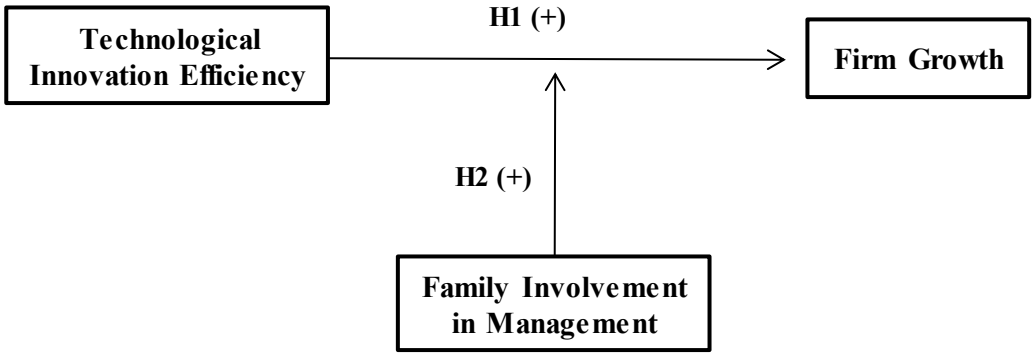

Table 1. Sample selection and description

Panel A. Sample selection process		
Firms with available data for the analysed variables in 2012		598
Firms that do not develop R&D investments		(-357)
Firms without correspondence with another businesses		(-89)
Final sample of matched firms		152
Panel B. Sample of companies by industry type		
	N	%
Meat industry	2	1.32
Foodstuffs and snuff	16	10.53
Drinks	8	5.26
Textiles and clothing	10	6.58
Leather and footwear	2	1.32
Paper Industry	2	1.32
Chemical and pharmaceutical products	24	15.79
Rubber and plastic	8	5.26
Non-metallic mineral products	4	2.63
Ferrous and nonferrous metals	4	2.63
Metal products	14	9.21
Agricultural and industrial machinery	20	13.16
Computer, electronic and optical products	4	2.63
Electrical machinery and material	10	6.58
Motor vehicles	14	9.21
Other transport equipment	4	2.63
Furniture industry	4	2.63
Other manufacturing	2	1.32
	152	100.00

Table 2. Descriptive statistics of the variables

Continuous variables	Mean	Std. Dev.	0.25	0.75	Min	Max	Skewness	Kurtosis
Firm growth	-0.04	0.18	-0.13	0.04	-0.62	0.60	-0.10	1.88
Ln_size	17.13	1.63	16.05	17.99	13.35	21.60	0.24	0.12
Firm age[a]	41.18	23.18	24.00	54.50	5.00	120.00	0.20	0.81
Leverage	0.48	0.22	0.31	0.64	0.03	1.00	0.19	-0.45
TI efficiency[b]	0.06	0.26	0.00	0.02	0	2.68	8.43	7.88
Family involvement in management	0.57	0.92	0.00	1.00	0.00	4.00	1.49	1.30
Categorical variables		N	%					
Subsidies								
Subsidized credits		45	30.00					
Non-subsidized credits		107	70.00					
Total		152	100.00					

N = 152
[a]Natural logarithm used in the regression model
[b]TI efficiency has been rescaled by multiplying it by .0001.

Table 3. Pairwise correlations

Variables	1	2	3	4	5	6	7
1. Firm growth	1						
2. Firm size	-.087	1					
3. Firm age	-.145**	.228***	1				
4. Leverage	-.107*	.131*	-.160**	1			
5. Subsidies	-.067	.260***	.079	.023	1		
6. TI efficiency[a]	.083	.095	.004	-.099	-.062	1	
7. Family involvement in management	.064	-.307***	.013	-.118*	-.054	-.053	1

N = 152. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$
[a]TI efficiency has been rescaled by multiplying it by .0001.
Sub-industry dummies have been omitted from this table for space reasons but are available from the authors upon request.

Table 4. Regression analysis results

Dependent Variable			Firm growth	
Variables	Model 1	Model 2	Model 3	Model 4
Main effect				
TI efficiency[a] (β1)		**0.111** (0.060)**	**0.111** (0.061)**	0.044 (0.070)
Moderator				
Family involvement in management (β2)			0.010 (0.016)	0.003 (0.017)
Interaction effect				
TI efficiency **x** Family involvement in management (β3)				**0.250*** (0.130)**
Controls Variables				
Firm size (β4)	-0.003 (0.010)	-0.005 (0.010)	-0.003 (0.026)	-0.004 (0.010)
Firm age (β5)	**-0.055** (0.026)**	**-0.055** (0.026)**	**-0.056** (0.059)**	**-0.063** (0.026)**
Leverage (β6)	-0.107 (0.068)	**-0.116* (0.067)**	**-0.113* (0.067)**	**-0.110* (0.067)**
Subsidies (β7)	0.027 (0.033)	0.029 (0.033)	0.028 (0.033)	0.033 (0.033)
Sub-industry dummies (β8)	yes	yes	yes	yes
Constant	0.257 (0.166)	**0.291** (0.166)**	0.261 (0.174)	**0.294** (0.509)**
R-squared	0.205	0.226	0.229	0.251
F statistic	2.860**	3.040***	2.878**	3.062***

N = 152. Robust standard error in parenthesis.
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$
[a]TI efficiency has been rescaled by multiplying it by .0001.

Figure 2. Marginal effect of technological innovation efficiency on firm growth as family involvement in management increases

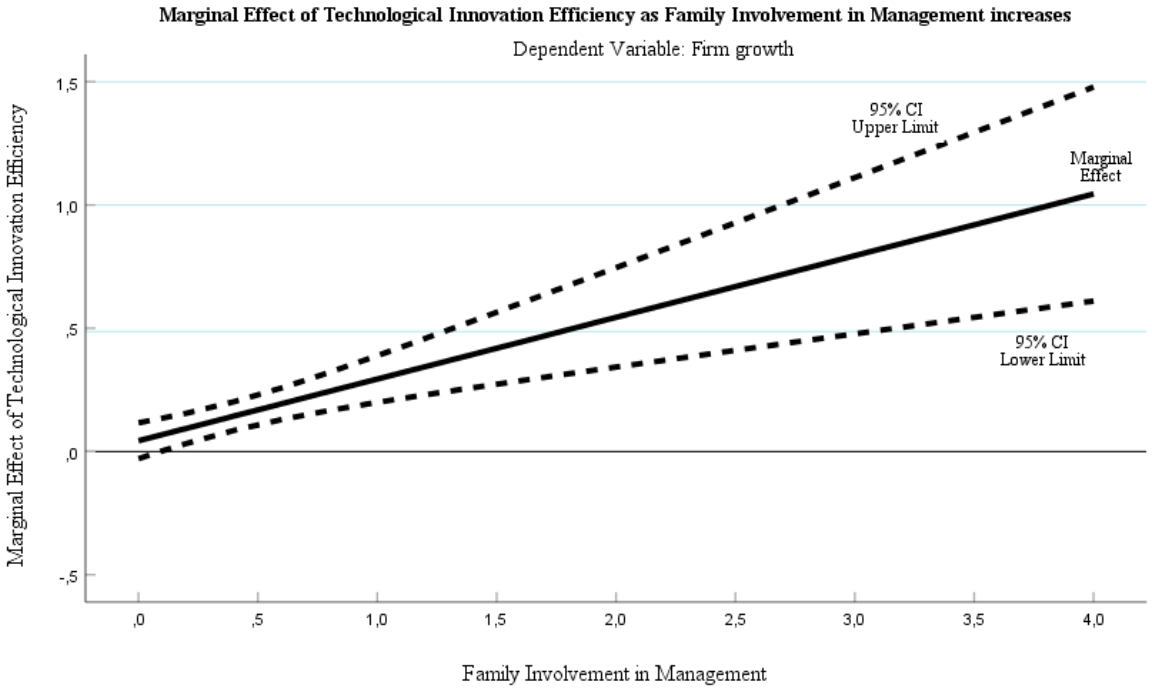

Figure 3. Interaction effect of family involvement in management on the relationship between technological innovation efficiency and firm growth.

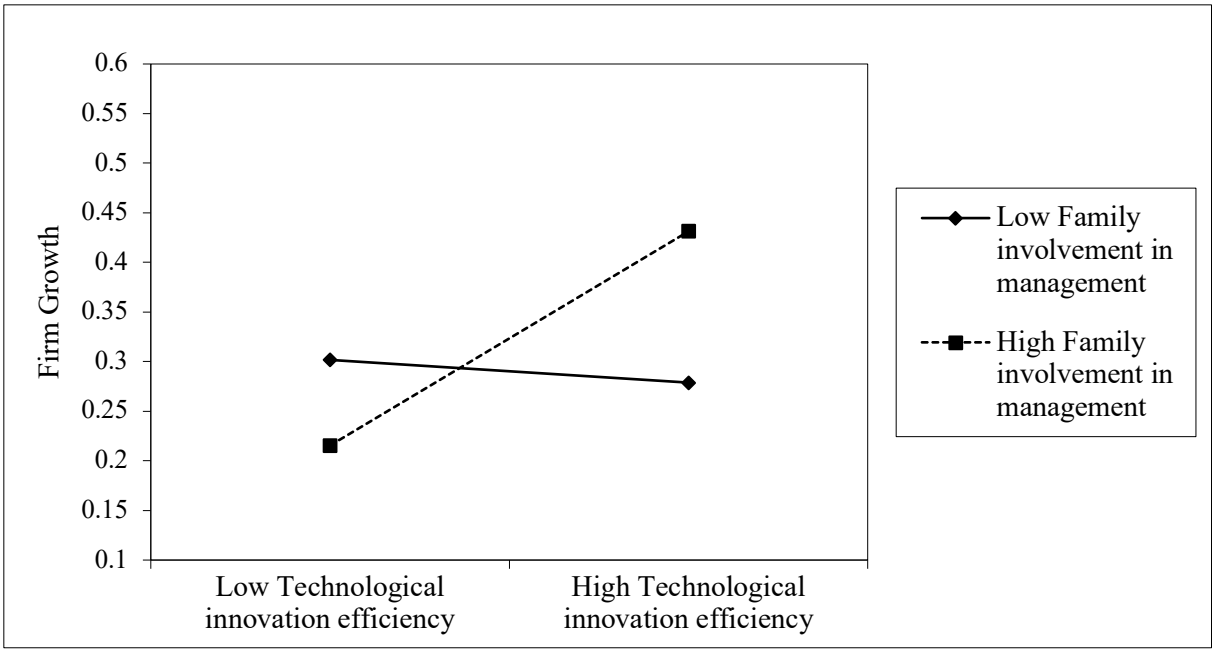

Table 5. Robutness tests

Dependent Variable	Positive firm growth			
Variables	Model 5	Model 6	Model 7	Model 8
Main effect				
TI efficiency[a] (β1)		**0.150** (0.080)**	**0.150** (0.080)**	0.014 (0.107)
Moderator				
Family involvement in management (β2)			0.004 (0.000)	-0.002 (0.009)
Interaction effect				
TI efficiency **x** Family involvement in management (β3)				**0.269* (0.142)**
Controls Variables				
Firm size (β4)	-0.005 (0.006)	-0.007 (0.006)	-0.006 (0.006)	-0.006 (0.006)
Firm age (β5)	-0.012 (0.013)	-0.021 (0.014)	-0.021 (0.014)	-0.019 (0.014)
Leverage (β6)	-0.026 (0.038)	-0.034 (0.038)	-0.033 (0.038)	-0.027 (0.038)
Subsidies (β7)	-0.021 (0.018)	-0.020 (0.018)	-0.020 (0.018)	-0.021 (0.019)
Sub-industry dummies (β8)	yes	yes	yes	yes
Constant	0.155 (0.120)	**0.218* (0.126)**	0.206 (0.130)	0.188 (0.130)
R-squared	0.185	0.213	0.214	0.236
F statistic	1.435	1.575*	1.503*	1.584*

N = 152. Robust standard error in parenthesis.
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$
[a]TI efficiency has been rescaled by multiplying it by .0001.