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EXAMINING THE IMPACT OF FAMILY MANAGEMENT ON PATENT APPLICATIONS FOR GERMAN INDUSTRIAL FIRMS

Wolfgang Burr
University of Stuttgart, Germany. Email: wolfgang.burr@bwi.uni-stuttgart.de

Johann Valentowitsch
Corresponding Author: University of Stuttgart, Germany.
Email: johann.valentowitsch@bwi.uni-stuttgart.de

Christopher Sauerhoff
AGOR GmbH, Germany. Email: sauerhoff@agor.de

Abstract

Elaborating the innovation behavior of family-owned businesses, prior research primary focused on the impact of ownership structure on innovation. However, surprisingly little attention has been given to understand the role of family management in this context. Our study contributes to literature closing this research gap. Using the number of applied patents as proxy for R&D outcome, our findings show that family management affects R&D output negatively. The empirical results of the study are in line with expectations drawn from agency and stewardship perspectives supposing substantial differences in research and development strategies of family and non-family managers.

Keywords: Family Management, Family-Owned Business, Research & Development

1. Introduction

In continental Europe family-owned businesses represent by far the dominant form of business organization (Kraus *et al.* 2012; La Porta *et al.* 1999).There is much evidence in literature to suggest that family-owned businesses differ in a substantial way from other types of businesses, especially with respect to the unique interplay among individual family members, the family 'system', and the business 'system' (Kellermanns *et al.* 2008). Although scholars often characterize family-owned businesses as conservative (Sharma *et al.*1997) pointing out that family owned businesses are resistant toward structural and organizational change, in the case of Germany they are often highly innovative promoting substantial economic growth by expanding the business and creating new jobs (IfM Bonn, 2012). Innovation in family business context is therefore of special interest to researchers.

Elaborating the unique innovative character of family-owned businesses, prior research primarily focused on the impact of family ownership on innovation (Schmid *et al.* 2014; Kraus *et al.* 2012; Kim *et al.* 2008). However, surprisingly little attention has been given to understand the role of family influence in management in this context (Jell *et al.* 2015). For our purpose, a

firm is labeled as family-managed, if at least one seat in the management or supervisory board is occupied by a family member. Note that family involvement in ownership does not necessarily require a family member managing the firm. Thus, family-owned businesses with non-family managers are also possible.

This paper contributes to literature by quantifying the impact of family management on R&D outcome, which we proxy by the number of applied patents. Measuring R&D output through applied patents is a commonly used technique in scientific literature partially reflecting the commercial usefulness of knowledge (Block *et al.* 2013). Examining the impact of family management on patent applications, we close existing research gaps and provide valuable insights on the role of family management with respect to innovation. Using annual panel data on big German firms, we provide evidence that family managed firms apply less patents relative to non-family managed businesses. As we can show, our results are robust to changes in estimation methods, model specification and sample size.

The paper is organized as follows. We first give a short description of family business characteristics. Then, using agency and stewardship perspectives, we develop the theoretical framework for our work. A description of the data is presented next, followed by the methodology. Finally, empirical findings are reported. We conclude by indicating some major limitations.

2. Family Firm Characteristics

The family business literature provides many examples for the unique character of family-owned businesses (Chen and Hsu, 2009; Schulze *et al.* 2003; Ward, 1988). Family involvement in ownership and management has been discussed as a source of numerous benefits, such as loyalty and trust (Eddleston and Kellermans, 2007). Closeness among family members fosters trust building (Sundaramurthy, 2008) and thus consequently lowers monitoring incentives and agency costs. Since familial relationships are characterized by low social distance, family members often share a common identity that creates group cohesion and promotes altruistic behavior. Although altruism may exist in any organization, the intensity of altruistic behavior is expected to be higher in family-owned businesses (Kellermanns and Eddleston, 2004; Schulze *et al.* 2001). Making each employed family member a de facto owner of the firm (Schulze *et al.* 2002), altruism fosters communication and cooperation within the family business reducing thereby information asymmetries. Deriving personal benefits from the prosperity of the business, family members act for collective good of the firm. Since families take care of their members (Kepner, 1991), altruism may retard relationship conflicts (Eddleston and Kellermans, 2007) and facilitate reciprocity (Lubatkin *et al.* 2005). Moreover, as some researchers argue "from the perspective of a family shareholder, the firm is not just an asset which might be sold easily, as the firm symbolizes the heritage and tradition of the family and is therefore part of the family identity" (Block and Thams, 2007, p.7).

Unfortunately, research literature on family-owned businesses with respect to innovation is controversial. Chen and Hsu (2009) for instance, report a negative impact of family ownership on R&D investments, speculating that family ownership may discourage risky long-term R&D investment. However, other authors state in contrast that family-owned businesses invest more in R&D projects (Kim *et al.* 2008; Tribo *et al.* 2007). Moreover, further empirical findings show that family-owned businesses have better abilities in leveraging their capabilities into innovative outcomes (Craig and Dibrell, 2006) and demonstrate higher organizational innovativeness (Dibrell and Moeller, 2011) relative to non-family businesses.

In conclusion, family-owned businesses offer a unique framework for business activities in general and innovative entrepreneurship in particular. As we will argue in the following section, stewardship attitudes are more likely to occur when there is no separation of ownership and management (Davis *et al.* 1997). Hence, agency costs are considered low in family managed businesses.

3. Agency and Stewardship Perspectives

Agency problems are typical for publicly held businesses as well as family-owned businesses with separated management and ownership structures (Eisenhardt, 1989; Jensen and Meckling, 1976;Berleand Means, 1932). From a theoretical point of view, the agency problem arises due to divergent interests of two parties (Jensen and Meckling, 1976; Ross, 1973). Agents are supposed to be rational, self-interested and opportunistic, maximizing their own personal utility in the best possible way (Perrow, 1986). Since asymmetric information is assumed, principals are not able to fully rely on their decisions agents (Ross, 1973). Thus, on their part a strong monitoring incentive exists (Fama and Jensen, 1983).

Different reasons for managerial opportunism were discussed in the literature. We will focus on the argument that managerial opportunism may be caused by fast fluctuation on top management positions (Block and Thams, 2007). The average CEO tenure in publicly held businesses is said to range between three and four years (Miller and Le Breton-Miller, 2006) hinting on a growing lack of planning reliability. Moreover, fast fluctuation of top management personnel prevents the development of organizational relatedness or a feeling of deep connectedness to the business, which is well-known as psychological ownership in the management literature (Pierce *et al.* 2001).

However, as already mentioned, family-owned businesses are embedded in social environments that build on closeness, trust and altruism. We thus suppose agency problems to be less pronounced in family businesses. Moreover, we expect family managers to be emotionally linked to their business. Therefore, family managers are supposed to act less like self-interested agents and more like altruistic organizational stewards (Wasserman, 2006). Further work with the stewardship approach requires a brief definition. According to Hernandez (2012), stewardship may be defined "as the extent to which an individual willingly subjugates his or her personal interests to act in protection of others' long-term welfare" (p.174). Following this definition, stewards are intrinsically motivated to pursue organizational interests, even if they contradict their own. However, the stewardship approach is not new in management research. A growing literature suggests that family managers are not only motivated by individual goals (Henssen *et al.* 2014; Miller *et al.* 2014; Davis *et al.* 2010; Zahra *et al.* 2008), but often act for the collective good of their firm (Miller and Le Breton-Miller, 2006). Since "stewardship theory is rooted in psychology and sociology […] the managerial opportunism explanation for short-term behavior becomes meaningless" (Block and Thams, 2007, p.11).

Our thoughts are summarized in Table 1. As we suppose, stewardship attitudes are more likely to occur in case of combined ownership and management as depicted in the lower left quadrant of the matrix. This presumption gets even more weight due to the fact that most family manager own a substantial share of the company they manage (Block and Thams, 2007). In this case, interests of management are chiefly aligned with those of owners. Hence, agency conflicts do not occur. To simplify the situation we refrain from distinguishing all other conceivable combinations of ownership and management shown in Table 1 assuming that they are commonly characterized by low stewardship attitudes and high agency costs.

We assume that stewardship attitudes are more likely to occur in case of combined family ownership and management. Interpreting family managers as selfless organizational stewards (Davis *et al.* 1997), we expect them to focus on long-run qualitative goals (Anderson and Reeb, 2003). As Jell *et al.* (2015) stated "family managers are more likely than non-family managers to introduce management processes that are long-term oriented and help the firm to survive as a family firm across generations," (p.186). Being partly independent of performance-based evaluations and keeping long-term development objectives of the business in mind (Craig and Dibrell, 2006), stewards are more willing to invest in long-run research and development projects. We thus conclude that the number of applied patents should be lower in family-managed businesses. A lower patent output, however, does not necessary mean a lower research and development activity or even lower patent quality.

Table 1. Manifestations of Agency and Stewardship Behavior

ownership structure	management team: family	management team: non-family
non-family	not noteworthy	high agency costs low stewardship attitudes
family	low agency costs high stewardship attitudes	high agency costs low stewardship attitudes

On the contrary, we consider non-family managers as self-interested agents (Block andThams, 2007; Davis *et al.* 1997). Focusing on short-run performance of the firm to reach high performance-based bonus payments for instance, agents are expected to be less interested in the long-term success of the business (Block, 2012; Narayanan, 1985). Thus, by seeking fast success, agents are expected to pursue quantitative short-term goals in research and development generating high patent output. This argument is even stronger given the fact that agents possess intense signaling incentives due to asymmetric information. More generally speaking, agents depend on the signaling mechanism in order to provide short-term results to the shareholders, e.g. via quarterly or annually reports (Block and Thams, 2007). According to the findings of Duchow and Sloan (1991) CEOs spend less on R&D in their final years in office in order to improve short-term earning performance. Since agents have no intentions to cut annual bonus payments in the hope of higher payments in the future, they prefer investments in applied research and development over long-lasting basic research (Cherensky, 1994) generating high R&D output. Non-family managers (agents) are thus associated with higher patent output.

4. Data and Methodology

Our sample consists of hand-collected data on big German family and privately-owned businesses. The data was gathered from different sources, including the German Patent and Trade Mark Office and firms' annual reports. Our final sample covers the period from 2005 to 2012 and a total of 120 observations. There are no missing observations in our data, hence our analysis relies on a balanced panel dataset. Descriptive statistics of the data are reported in Table 2.The initial distribution of patent applications is inclined to the left with a skewness of 1.81 and kurtosis of 5.89. We thus use a logarithmic transformation to normalize the data. By doing so, the values of skewness and kurtosis change to 0.15 and 2.28. To achieve a valid industry cross-section, data from different high technology branches with high values of R&D spending as well as high patent output were included. In particular our data covers the following industries: automotive (including manufacturer and supplier), engineering, semiconductor, optics, personal care, and home appliance. Additional, data on several multi-industry companies were gathered. Observations from automotive industry are predominant in our data reflecting the leading role of this industry in Germany. We use this fact to obtain a sector-specific subsample in further analysis.

Table 2. Descriptive Statistics

Variables	units	mean	median	st. dev.	min.	max.	1st qu.	3rd qu.
Patent Applications	log	6.23	6.36	0.93	4.73	8.29	5.67	6.73
Stock Market	binary	0.92	1.0	0.28	0.0	1.0	1.0	1.0
Organizational Age	log	4.35	4.60	0.89	1.79	5.11	4.30	4.89
Organizational Size	log	9.75	9.64	1.39	7.54	12.17	8.31	10.95
Family Management	binary	0.6	1.0	0.49	0.0	1.0	0.0	1.0
Share of R&D-Expenditures	log	2.93	2.93	0.52	1.54	3.93	2.57	3.33
Share of R&D-Employment	log	-2.45	-2.45	0.43	-3.56	-1.49	-2.69	-1.49

Notes: Sample size is 120 and all results rounded to two decimal places.

Our dataset includes several variables that characterize firm-specific R&D activities. In particular we observe the total number of applied patents, the share of R&D employment in total employment and R&D spending as a share of sales. Moreover, since we are interested in the impact of family management on R&D output, we specify a binary dummy variable that is coded as 1 if at least 1 seat in the management or supervisory board is occupied by a family member and 0 otherwise. Furthermore, we specify a stock market dummy to show whether a firm is listed in the German stock exchange. Additionally, our panel includes organizational age measured in years since foundation and annual sales as proxy for organizational size.

Pairwise correlations and variance inflation factors (Marquardt, 1970) are reported in Table 3. The pairwise correlations refer to Pearson's correlation coefficient. By calculating variance inflation factors for all independent variables used in the analysis, we indicate no serious problems related to multicollinearity. Except for binary dummies all variables were log-transformed to reduce error heteroscedasticity. Note that since we use log-transformed predictor and regressor variables estimated coefficients have to be interpreted as elasticities. We begin our regression analysis by estimating a pooled OLS model. By doing so, we ignore the panel structure of the data and may thus lose valuable information. Nevertheless, we obtain more precise parameter estimates by pooling the data relative to simple cross-sectional OLS. Our pooled model has the following form:

$$y_{it} = \beta_0 + \sum_{k=1}^{K} \beta_k x_{k,it} + \varepsilon_{it} \quad (1)$$

index $i = 1, \dots, N$ refers to cross-section observations and $t = 1, \dots, T$ to time-series observations, β_0 denotes the intercept, y_{it} the dependent variable and ε_{it} the disturbance term of the model. The sum $\sum_{k=1}^{K} \beta_k x_{k,it}$ includes all independent variables and their coefficients. Since we use panel data, we include time fixed effects in the next step to control for unobserved heterogeneity over time. We capture time fixed effects with an additional set of year dummy variables D_t. In the literature, this method is known as LSDV or least squares dummy variable approach (Hsiao, 1986). Following the notation above, the LSDV model may be written as:

$$y_{it} = \beta_0 + \sum_{k=1}^{K} \beta_k x_{k,it} + \sum_{t=1}^{T} \alpha_t D_t + \varepsilon_{it} \quad (2)$$

Since the family management dummy is time-invariant, perfect multicollinearity would occur by adding a set of firm-specific dummies. Hence, we do not specify two-way fixed effects on firm level to avoid the dummy variable trap. However, multicollinearity issues can be avoided by specifying industry fixed effects instead of firm-specific dummies. The two-way fixed effects model has the following form:

Table 3. Correlations

Variable	x_1	x_2	x_3	x_4	x_5	x_6	VIF
x_1: Family Management	1						1.62
x_2: Stock Market	0.37***	1					1.22
x_3: Share of R&D-Employment	-019*	0.09	1				2.99
x_4: Share of R&D-Expenditures	-0.29**	0.08	0.78***	1			3.41
x_5: Organizational Age	0.14	-0.00	-0.17	-0.07	1		1.11
x_6: Organizational Size	0.45***	0.09	-0.07	-0.37***	-0.14	1	1.69

Notes: Sample size is 120. Significance codes: * p < 0.05, ** p <0.01, *** p < 0.001.
Calculation of VIFis based on model 1.

$$y_{it} = \beta_0 + \sum_{k=1}^{K} \beta_k x_{k,it} + \sum_{t=1}^{T} \alpha_t D_t + \sum_{j=1}^{J} \gamma_j D_j + \varepsilon_{it} \quad (3)$$

where index $j = 1, \dots, J$ refers to industry, D_j to industry-specific dummies and γ_j denotes the dummy coefficients. Specifying the model with industry fixed effects is rooted in several econometric benefits. On the one hand it helps to reduce the omitted variables bias. On the other hand all unobserved and industry-invariant effects get eliminated. Note that high values of R^2_{adj} do not necessarily indicate biases in our regression models, since dummy variables will provide a good fit to data inducing therefore high values of R^2_{adj}.

Several statistical methods were applied to test our regression model specifications. We first perform the Goldfeld-Quandt test to confirm variance homogeneity (GoldfeldandQuandt,1965). According to the test results, the null hypothesis of homoscedasticity cannot be rejected at all common significance levels. Thus, constant variance of the disturbance term for all models is assumed. Additionally, the Jarque-Bera normality test was applied to check the assumption of normal distribution (Bera and Jarque, 1980). Comparing measures of sample skewness and kurtosis, no violations of the assumption were identified, except model one and two (Table 4). However, since models one and two are not our preferred specifications, we ignore bad test results in this case. All models were estimated using the open source statistical programming language R (R Development Core Team, 2008). In particular, methods from the following packages were applied: "car" (Fox and Weisberg, 2011), "lmtest" (Zeileis and Hothorn, 2002) and "plm" (Croissant and Millo, 2008).

5. Empirical Results and Discussion

Panel regression results are presented in Table 4. The first column shows estimates of our basic pooled OLS model. The pooled model indicates a negative but not significant effect of family management on patent applications. By estimating a least squares dummy variable model, we achieve almost identical coefficient and standard error estimates in model 2. Note that controlling for time fixed effects does not change the size and sign of the family management coefficient that much.

However, we can show that our main variable of interest becomes significant when we re-estimate the LSDV model including industry fixed effects (model 3). As mentioned earlier, the two-way fixed effects model is rooted in several methodological advantages and is thus our preferred specification. As expected, the estimated sign remains negative indicating an adverse and highly significant ($p < 0.001$) impact of family management in model 4.

These findings support our earlier assumption that family management has a negative impact on R&D output. Moreover, in line with our theoretical considerations, stock market listing seems to affect patent applications in a positive way (models 4-6). Driven by necessity to

provide short-term results, publicly-traded companies focus on quantitative goals promoting high patent output.

Table 4. Panel Regression Results

	Full sample estimate				Automotiveind.		Financialcrisis	
	Pooled (1)	LSDV (2)	LSDV (3)	LSDV (4)	Pooled (5)	LSDV (6)	Pooled (7)	LSDV (8)
Constant	2.45***	2.50***	1.54***	1.39***	3.01***	3.08***	1.44	1.44
	(0.60)	(0.64)	(0.39)	(0.41)	(0.68)	(0.58)	(0.86)	(0.91)
x_1: Family Management	-0.19	-0.18	-1.55***	-1.58***	-1.45***	-1.09***	-0.38*	-0.39*
	(0.13)	(0.13)	(0.12)	(0.13)	(0.17)	(0.17)	(0.18)	(0.18)
x_2: Stock Market	-0.26	-0.27	0.49***	0.51***	0.43***	0.26*	-0.21	-0.20
	(0.19)	(0.20)	(0.12)	(0.13)	(0.12)	(0.11)	(0.30)	(0.30)
x_3: Share of R&D Employment	-0.35	-0.37	0.26*	0.28**	0.16	-0.63*	-0.73**	-0.73*
	(0.20)	(0.20)	(0.10)	(0.11)	(0.25)	(0.30)	(0.27)	(0.28)
x_4: Share of R&D Expenditures	0.77***	0.78***	0.37***	0.35***	0.49*	0.87***	1.10***	1.10***
	(0.17)	(0.18)	(0.09)	(0.09)	(0.23)	(0.22)	(0.26)	(0.27)
x_5: Organizational Age	-0.13*	-0.13*	-0.21***	-0.20***	-0.32***	-0.34***	-0.14	-0.14
	(0.06)	(0.06)	(0.03)	(0.03)	(0.06)	(0.05)	(0.09)	(0.09)
x_6: Organizational Size	0.63***	0.63***	0.78***	0.79***	0.71***	0.64***	0.75***	0.76***
	(0.05)	(0.05)	(0.03)	(0.03)	(0.04)	(0.04)	(0.07)	(0.07)
Time Dummies	no	yes	no	yes	no	yes	no	yes
Industry Dummies	no	no	yes	yes	no	no	no	no
R^2_{adj}	0.68	0.66	0.94	0.94	0.95	0.96	0.71	0.67
F	42.6***	18.7***	149.5***	96.4***	150.8***	98.9***	24.6***	15.6***
GQ	0.45	0.45	1.01	1.02	0.53	1.21	0.42	0.43
χ^2	8.67**	8.98**	1.13	0.68	1.15	0.18	4.39	4.85

Notes: The dependent variable in all models is number of applied patents (log-transformed).
Significance codes: * p < 0.05,** p <0.01, *** p < 0.001, standard errors in parentheses.
χ^2refers to Jarque-Bera normality test.

As already mentioned, observations from the automotive industry are predominant in our data. We use this fact to construct a subsample of firms related to this industry including manufacturer and supplier. Since the sample size reduces, we apply the regression equation specification error test (RESET) to detect potential misspecification problems (Ramsey, 1969). The RESET test was performed using second and third powers of the independent variable. According to test results, model 6 does not suffer from omitted variables or wrong functional form ($RESET = 1.48, p > 0.1$) and is thus statistically trustworthy. Unfortunately, model 5 provides much poorer test results ($RESET = 5.91, p < 0.001$). However, bad test results are not surprising, since panel structure is ignored in the pooled model. In fact that the least squares dummy variable approach (model 6) achieves better test scores, we do not pay much attention to this.

Confirming our theoretical expectations drawn from agency and stewardship perspectives the family management variable gets highly significant ($p < 0.001$) and negative.

Since the automotive industry is one of the most active patent applicants in Germany, stewardship orientation gets particularly significant in this context. According to results of our regression analysis, family management is associated with significant lower patent output in automotive businesses. Based on previous argumentation, family managed firms focus more on basic research projects generating thus a lower patent output. Although adverse effects of family management are supposed to exist in other innovative industries as well, our data is not sufficient to achieve reliable results constructing further industry-specific samples.

In a second step, we change the time period of our sample focusing on effects of the financial crisis. Theoretically, there are many reasons for a separate analysis of the crisis period. Undoubtedly, great economic turbulence in recent years changed framework conditions for innovation forcing companies to reconsider their innovation strategies (Borowiecki and Dziura, 2010). Although one might think that negative economic shocks lower innovation activities, there are strong hints suggesting that the opposite is true (Rammer, 2011). Ignoring that Lehman Brothers marked the beginning of a downward economic spiral already in 2007 (Hausman and Wesley, 2014), we compute the crisis subsample including observations from 2009 to 2012 thus modeling a time-lagged impact of the crisis on patent applications. A multi-year time lag is reasonable since R&D is considered a long-term process that provides visible output only after a long period of time. Once again, estimates of the family management variable suggest a negative and significant effect on patent output (model 7 and 8), as hypothesized by our theoretical framework.

Finally, we subject our findings to a partial sensitivity analysis. The estimated impact of family management changes when model variables and the constant are dropped stepwise. However, to prevent strongly biased estimates, measures of organizational age and size were respectively included. Although estimates vary a little, the range remains negative in all cases confirming our theoretical implications.

To sum up, the results of our empirical study suggest a negative impact of family management on patent applications. Our findings complement prior research which has shown that family ownership is associated with lower levels of R&D output in terms of patents and patent citations (Block *et al.* 2013). Since the negative sign of our family management dummy persists after controlling for time fixed effects and sub-sampling, our main results are robust to changes in estimation methods, model specification and sample size. Moreover, testing for misspecification, multicollinearity and heteroskedasticity indicates no serious statistical problems (except model 3) confirming the trustworthiness of our models.

6. Limitations and Further Research

However, we cannot say for sure that family management has a negative effect on patent applications. Our results, for instance, may partly reflect different patent strategies in family and non-family managed firms indicating stronger patent selection process in family managed firms. It is also conceivable that non-family managers are more efficient compared with their non-family counterparts generating more patent applications.

Moreover, by using a binary dummy variable to measure family management, we probably lose information on the complexity of the real management structure. In particular, we do not look at the personal characteristics of the management team, such as experience, gender or age. Thus, further research is needed to complete our understanding. Despite our efforts to randomize the data selection process, we cannot fully exclude potential selectivity bias. Hence, a large-scale survey is needed to confirm our empirical findings.

Furthermore, our findings may be restricted to Germany, showing country specific characteristics of family-managed businesses. There are strong hints to believe that German family-owned businesses differ significantly, especially from Anglo-Saxon countries. Nevertheless, the study provides valuable insights on the relationship between family management and R&D output in terms of applied patents supposing substantial differences in research and development strategies of family and non-family managers.

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