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Early Patent Disclosure and R&D Investment in Family Firms

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This paper shows that the American Inventor's Protection Act, which introduced the disclosure of patent applications after 18 months, that is, before a grant decision is taken and, hence, before it is known whether the respective technology will receive legal protection, is associated with a reduction of family firms' research and development (R&D) investment. This suggests that early disclosure of patent applications is perceived as a threat to family firms' innovation activity and discourages their R&D investment. This finding deserves our attention because family firms account for a large share of the US economy, and a reduction in their R&D investment can have long-term consequences.

Introduction

Undisclosed knowledge remains secret, diffuses slowly, and tends to stay within corporate boundaries (Baruffaldi and Simeth, 2020; Hall, Rogers and Sena, 2014). Limiting the spread of valuable knowledge appeals to family firms (FFs) because it allows them to keep control over important knowledge assets, which is in line with consideration of their socio-emotional wealth (SEW), defined as non-financial, family-related benefits (e.g. Al-Tabbaa *et al.*, 2023; Gao, Liu and Wang, 2022; Gomez–Mejia *et al.*, 2014; Wu and Yu, 2022). In order to receive legal protection against the expropriation of their knowledge by third parties through patents, however, the underlying knowledge needs to be codified and disclosed to the society in exchange for temporary legal protection. The decision to patent is, hence, difficult for FFs and they must weigh the benefits of legal protection against the risks of knowledge disclosure and a loss of control (Chirico *et al.*, 2020). Nevertheless, FFs often decide to apply for patents (Duran *et al.*, 2016), especially when patent protection is in line with their business model (Bannò, 2016), when they have a focus on internationalization (Tsao and Lien, 2013), or when they thrive on an open innovation strategy (Kotlar *et al.*, 2013).

The US Patent and Trademark Office (USPTO) used to publish a patent application only after the grant decision was taken. The American Inventor's Protection Act (AIPA) of 1999, one of the most far-reaching legal reforms of the US patent system (Campbell Jr, 2001; Ergenzinger Jr, 2006), introduced the disclosure of patent applications 18 months after the filing date, irrespective of whether the patent had been granted or not (Graham and Hegde, 2015; Johnson and Popp, 2003). The idea behind the early disclosure was to harmonize patent law in the United States with that in the rest of the world and to increase the visibility and timely diffusion of inventions to spur technological progress (Baruffaldi and Simeth, 2020; Graham and Hegde, 2015).

Prior studies document positive effects of the AIPA, such as timely knowledge diffusion (Baruffaldi and Simeth, 2020), easier navigation through technology markets (Hegde and Luo, 2018), reductions of duplicated research (Lueck *et al.*, 2020), easier switching of bank relationships resulting in a lower cost of debt (Saidi and Žaldokas, 2021), and access to venture financing (Mohammadi and Khashabi, 2021). A recent

A free video abstract to accompany this article can be found online at: https://www.youtube.com/watch?v=Rsmdkx_0q9A

study by Kim and Valentine (2021) suggests, however, that the AIPA was followed by a decline in corporate innovation because firms aimed at avoiding the risk of sharing unprotected knowledge.[1]

Existing research has not yet paid attention to firm ownership or to family ownership in particular. We address this research gap and analyse whether R&D is differently affected if the firm is controlled by a family. Early patent disclosure heightens threats to SEW because FFs lose control over valuable, legally unprotected knowledge assets. This is why we investigate the question: *What is the effect of early patent disclosure on the R&D investments of FFs?*

We focus on the impact of early disclosure of patent applications on FFs' R&D investment because FFs constitute a large share of the US economy, accounting for 87% of all business tax returns, 59% of private sector employment, and 54% of the private sector gross domestic product (Pieper, Kellermanns and Astrachan, 2021). Owing to the importance of FFs for the US economy, a reduction of their R&D in response to the AIPA could significantly harm the innovativeness of the US economy in the long term.

Our investigation focuses on Standard & Poor's (S&P) 500 firms. The focus on these large, successful firms, which are heavily involved in R&D, allows us to examine how the early disclosure of patent applications impacts R&D investment in the absence of the financial constraints that smaller firms face (Block, 2012; Garms and Engelen, 2019).

We employ a difference-in-difference approach, which compares the R&D response of FFs to that of non-FFs. Our results show that, as compared to non-FFs, FFs reduced their R&D investment after the AIPA. We find that this effect is more pronounced for FFs controlled by the founding generation, which is in line with prior literature arguing that SEW considerations are most prominent for the founding generation (Berrone, Cruz and Gomez-Mejia, 2012; Arrondo-García, Fernández-Méndez and Menéndez-Requejo, 2016; Bozec and Di Vito, 2019; Tsao, Chang and Koh, 2019; Issah *et al.*, 2023).

Background

The patent disclosure function of the AIPA

Prior to the AIPA of 1999, patent applications at the USPTO were not disclosed to the public until they were granted (Johnson and Popp, 2003). The underlying technological content and the details of a patent application, such as the details and scope of the specific patent claims, were only disclosed after the grant date (Johnson and Popp, 2003; Okada and Nagaoka, 2020). Proprietary information about the new invention and the patent specification could, hence, be kept secret until there was clarity about whether patent protection was granted (Berger and Hann, 2007; Glaeser, 2018).

After the AIPA, disclosure of pending patent applications within 18 months after the filing date was mandated (Baruffaldi and Simeth, 2020; Graham and Hegde, 2015). The AIPA was motivated partly by the need for uniformity with other patent systems such as the European patent system, which already had an early disclosure rule in place (Graham and Hegde, 2015). In addition, early patent disclosure was expected to facilitate the diffusion of inventions and the emergence of new ideas (Baruffaldi and Simeth, 2020; Williams, 2017).

Despite the positive intentions, there were concerns about potential negative effects of the AIPA, especially for small firms and individual inventors (Modigliani, 1999). Opponents reasoned that financially constrained firms and individual inventors produce most breakthrough inventions, which spend a considerable amount of time in the patenting process, so that these inventors suffer most from early disclosure (Johnson and Popp, 2003). They argued that the AIPA could undermine the value of the patent system for intellectual property (IP) protection and disincentivize breakthrough inventors (Johnson and Popp, 2003), hampering the creation of knowledge (Gallini, 2002).

The effect of the AIPA on R&D investment

R&D investment is key to innovation, firm productivity, and financial performance. At the same time, R&D is risky, with high initial investments and uncertain long-term returns (Arrow, 1962).

Although proponents of the AIPA underscored its possible positive effects for the creation of new ideas, there is very little empirical evidence showing whether and how the AIPA's disclosure function stimulated R&D investment (Williams, 2017). Yet, there are reasons why the pre-grant disclosure of patent information might reduce R&D investment, as early disclosure imposes proprietary costs on patent holders and exposes them to the risk of imitation (Kim and Valentine, 2021). A recent survey showed that 38% of the contacted scientists who were skilled in the relevant technology domain believed that it was possible to recreate inventions based on the information contained in the published patents document, after having been asked to read those patent documents (Ouellette, 2011). Undoubtedly, patents remain a source of technical information that can help individuals with state-of-the-art knowledge to reengineer and invent around prior inventions and, thus, reduce inventors' profits from their R&D.

[1] For firms whose rivals disclose more than the focal firms themselves, an increase in R&D investment was observed (Kim and Valentine, 2021).

Furthermore, lead time advantages and pivoting fast along the learning curve enhances the competitive advantage of R&D-oriented firms (Levin *et al.*, 1987). Keeping an invention secret for a specific time period provides firms with the lead time to further develop the invention or a related product without the threat of competition (Hurmelinna-Laukkanen and Puumalainen, 2007). This advantage is lost or significantly reduced with the AIPA (Kim and Valentine, 2021).

The arguments above suggest that mandatory patent disclosure imposes proprietary costs on firms, which can, in turn, disincentivize R&D investment (e.g. Aghamolla and Thakor, 2022; Aoki and Spiegel, 2009). Recent empirical work provides evidence in line with this suggestion (Kim and Valentine, 2021).

The Effect of Early Patent Disclosure on FFs' R&D Investment

Firms invest in R&D in pursuit of inventions and innovations with the long-term aim of generating a competitive advantage and increasing profitability. However, R&D is risky, complex and uncertain, with high rates of failure (Arrow, 1962). The FF literature has documented how R&D investment can cause SEW losses (Choi *et al.*, 2015; De Massis *et al.*, 2018; Gomez–Mejia *et al.*, 2014). First, R&D often requires substantial external financial capital. This impedes family control and independence in decision making (Gomez–Mejia *et al.*, 2014; Shaw, He and Cordeiro, 2021), which are fundamental dimensions of SEW (Gao, Liu and Wang, 2022; Gómez-Mejía *et al.*, 2007; Wu and Yu, 2022). Second, R&D demands external expertise, which requires firms to reveal strategic information to external professionals (Miller and Cardinal, 1994). This can lead to the loss of family control over R&D decisions (Chrisman and Patel, 2012; Gomez-Mejia, Makri and Kintana, 2010). Third, because of the high rates of failure of R&D projects, extensive R&D expenses increase the bankruptcy risk (Miller and Bromiley, 1990), which can be interpreted as a total loss of SEW. The risk of bankruptcy is higher for FFs than for non-FFs because FFs are undiversified and the personal wealth of the family is often invested in the firm (Anderson, Duru and Reeb, 2012; De Massis *et al.*, 2018). This implies that the failure of R&D projects in which the family has invested a substantial share of its wealth may lead to the collapse of the FF. Fourth, R&D investment reduces the resources available for alternative undertakings, which restrains the independence or discretion of the family (De Massis *et al.*, 2018).

While FFs can expect SEW gains in the event of a successful R&D project (Gomez–Mejia *et al.*, 2014), these gains are uncertain. Losses in SEW, such as weakened control and independence arising from the use of external financial capital and expertise, are certain. Facing this dilemma, FFs are likely to be more strongly influenced by the certainty of SEW losses (Chrisman and Patel, 2012; Hughes *et al.*, 2018). This typical behaviour of FFs is referred to as loss aversion, which describes a situation in which an individual or an organization is more focused on avoiding losses than on deriving gains (Chrisman and Patel, 2012; Kahneman and Tversky, 1979). The focus on SEW losses alters FFs' R&D decisions in support of lower R&D investment levels (Chrisman and Patel, 2012; Gomez–Mejia *et al.*, 2014). However, in specific circumstances the gain perspective can lead FFs' decisions. Choi *et al.* (2015), for instance, find that, when expecting growth opportunities, FFs increase their R&D investment. Zahra (2005) argues that it is not the family involvement but the tenure of the CEO that limits FFs' risk-taking.

Protecting inventions through patents can be a way to safeguard returns from R&D. In fact, the chance of receiving temporary legal protection for an invention establishes a major incentive for R&D investment (Levin *et al.*, 1987). In exchange for legal protection, firms need to detail the technology (Guellec and de la Potterie, 2000), which fosters the risk of imitation and reverse engineering (Kim and Valentine, 2021). FFs, therefore, carefully consider the potential benefits and costs of patent protection and often decide against patenting (Chirico *et al.*, 2020).

We acknowledge that the AIPA exposes all firms to the same negative risks (Kim and Valentine, 2021). We further argue, however, that FFs are more affected by the early disclosure function introduced by the AIPA than non-FFs because they face the threat of SEW losses in addition to financial losses. We hence investigate the research question:

What is the effect of early patent disclosure on the R&D investments of FFs (as compared to non-FFs)?

Data, variables and methodology

Data

In constructing our data sample, we rely on S&P 500 firms as of July 2003 (e.g. Block, 2012; Garms and Engelen, 2019). To distinguish between FFs and non-FFs, we follow the definition of the BusinessWeek (2003) and Anderson and Reeb (2003), who describe FFs as firms in which the family has more than 5% control or in which a member of the family serves on the board.

The S&P firms are supplemented with financial information retrieved from Compustat. Further, we link the firm data to their patent records at the USPTO using the NBER patent database.

We supplement the sample with information about changes in the strength of state-level trade secret protection through the Unified Trade Secret Act (UTSA) (Png, 2017a, 2017b). Png (2017a, 2017b) provides a trade se-

Table 1. Variables

Variable	Measurement
R&D/ASSETS	R&D investment over firm assets
FAM	Binary variable, which takes the value of one for FFs and of zero otherwise
AIPA	Measured as a discrete change in the year of the AIPA, 1999
UTSA	Index for the strength of trade secret protection developed by Png (2017a, 2017b)
AGE	Years since firm foundation
ROA	Return on assets
TOBIN'S Q	Logarithm of Tobin's Q
DEBT/ASSETS	Debt to asset ratio
PATENTS/ASSETS	Patent application stock over total assets, using a depreciation rate of knowledge of 15%.
CITATIONS/PATENTS	Citation stock over the patent stock, using a depreciation rate of knowledge of 15% for both.
CASH/ASSETS	Free cash over total assets
INVESTMENT RATE	capital investment over replacement value
SALES VOLATILITY	Mean of the squared deviations from the two-digit industry level for the past ten years
NEW FIRMS	Number of new firm foundations with more than five employees in the same two-digit industry and year, divided by 1000
INDUSTRY PATENTS/ ASSETS	Number of patents applied for per year by firms in the same 2-digit industry class
NON-REPORTED R&D	Dummy variables for observations with missing information for R&D
INDUSTRY DUMMIES	Dummy variables for the 2-digit SIC industry
STATE DUMMIES	Dummy variables for the firm location
YEAR DUMMIES	Dummy variables

cret protection index, which ranges from zero to one (see Table 1 in Png, 2017a, p. 169).[2]

We focus on the time period 1993—2006, including 6 years before and after the AIPA. We exclude earlier and later years because a change of R&D investment in those earlier or later years would be unrelated to the AIPA. This leaves us with an unbalanced sample of 6509 observations, 36.40% of which correspond to 170 FFs.[3],[4]

To make sure that FFs and non-FFs are comparable, we also use a matched sample. We match based on ten different firm age classes defined along the firm age distribution, ten different firm size classes defined along the firm size distribution, and a dummy variable indicating whether the firm reported R&D or not. Our matched sample consists of 6133 observations, corresponding to 145 FFs and 244 FFs.

Variables

We use firms' yearly R&D investment as the dependent variable, which we normalize by total assets (*R&D/ASSETS*) to account for the skewness of the distribution of this variable (e.g. Block, 2012). For one of our approaches, we employ a dummy variable that takes the value one if R&D was not reported (*NON-REPORTED R&D*).

Our first independent variable (FAM) is a binary variable, which takes the value one for FFs and zero for non-FFs (see Anderson and Reeb, 2003; Andres, 2008; Hussinger and Issah, 2019).

Our moderating variable, *AIPA*, is a binary variable that takes the value one from the year 1999 onwards and equals zero in earlier years.

We control for the strength of trade secret protection (*UTSA*) using the index developed by Png (2017a, 2017b). Firms may revert to trade secret protection after it became more attractive (Hussinger and Issah, 2022). Furthermore, we control for firm age (*AGE*) (Block, Hansen and Steinmetz, 2022), firm performance measured as return on assets (*ROA*) (Hussinger and Issah, 2022), *TOBIN'S Q* (Fang *et al.*, 2018), and leverage (*DEBT/ASSETS*), capturing the operational risks (Shim and Okamuro, 2011). We account for past patent productivity and quality using measures for the patent application stock over total assets (*PATENT/ASSETS*) and the patent citation stock over the patent stock (*CITATIONS/PATENTS*). Free

[2]Png's (2017a) index is the sum of the scores for the following six items, divided by six. Substantive law: (a) whether a trade secret must be in continuous business use, (b) whether the owner must take reasonable efforts to protect the secret, and (c) whether mere acquisition of the secret is misappropriation; Civil procedure: (d) the limitation on the time for the owner to take legal action for misappropriation; Remedies: (e) whether an injunction is limited to eliminating the advantage from misappropriation, and (f) the multiple of actual damages available in punitive damages.

[3]Three firms were dropped from the sample for being outliers regarding some of their characteristics, namely Amgen, Medimmune, and Danaher. Two firms could not be matched to Compustat. After deleting firms that are not affiliated with the manufacturing or service sector, we are left with 468 firms.

[4]We do not take a survival bias of the S&P 500 firms into account. We do not believe that our results are driven by a survival bias because 80.51% of our observations belong to firms that we observe in each year.

Table 2. Descriptive statistics

Variables	Mean	SD	P25	P50	P75	N
AIPA	0.54	0.50	0.00	1.00	1.00	6509
FAM	0.36	0.48	0.00	0.00	1.00	6509
AGE	41.65	41.75	14.00	14.00	62.00	6509
TOBIN'S Q	0.32	0.16	0.24	0.33	0.42	6509
ROA	0.05	0.08	0.02	0.05	0.09	6509
DEBT/ASSETS	0.18	0.15	0.06	0.16	0.28	6509
PATENT/ASSETS	0.03	0.07	0.00	0.00	0.03	6509
CITATIONS/PATENTS	6.72	10.74	0.00	3.92	8.71	6509
FREE CASH/ASSETS	0.09	0.07	0.05	0.09	0.12	6509
INVESTMENT RATE	0.22	0.14	0.13	0.20	0.27	6509
SALES VOLATILITY	26.01	20.64	9.23	22.73	37.43	6509
NEW FIRMS	0.50	0.64	0.00	0.00	0.93	6509
INDUSTRY PATENTS/ASSETS	0.03	0.04	0.00	0.01	0.05	6509
UTSA	0.20	0.25	0.00	0.00	0.44	6509
NON-REPORTED R&D	0.45	0.50	0.00	0.00	1.00	6509

cash (*FREE CASH/ASSETS*) (Block, 2012) and the *INVESTMENT RATE* (Bond, Harhoff and Van Reenen, 2005) control for the available financial means for R&D. *SALES VOLATILITY* indicates the extent of competition for market shares (Li, Lin and Zhang, 2018; Irvine and Schuh, 2005; Anderson, Asdemir and Tripathy, 2013; King and Slotegraaf, 2011; Nath and Bharadwaj, 2020). *NEW FIRMS* foundations capture new opportunities arising in the sector (Crane and Decker, 2019). The variable is created using the National Establishment Time-Series (NETS) database. We also use the industry average of patents per firm (*INDUSTRY PATENTS/ASSETS*) to control for the taste of firms in a specific environment to patent and the costs associated with patenting in the specific field (Mansfield, 1968). Lastly, we use *YEAR DUMMIES* to control for time effects as well as *STATE DUMMIES* to control for possible firm location effects, and *INDUSTRY DUMMIES which account for different operational environments and production processes*. The variable definitions are presented in Table 1.

Methodology

We employ a difference-in-difference model (Angrist and Pischke, 2008) to test the effect of early disclosure on the R&D investments of FFs vis-à-vis non-FFs:

$$\frac{R\&D}{ASSETS_{i,t}} = \beta_0 + \beta_1 AIPA_t + \beta_2 (AIPA_t * FAM_i) + control\ variables_{i,t} + f_i + e_{i,t}$$

The variable $AIPA_t$ shows the reaction of all firms to the AIPA. The FF status FAM_i does not vary over time so that it is included in the time-invariant fixed effects. The interaction term $AIPA_t$ * FAM_i is our parameter of interest, as it shows the reaction of *FFs* to the AIPA compared with the control group of non-FFs.

We use linear fixed effects regressions for the sample of firms that report R&D. In addition, following Anderson, Duru and Reeb (2012), Gomez–Mejia *et al.* (2014) and Chi *et al.* (2020), we set missing values for R&D to zero and add a dummy variable indicating that R&D was not reported to the list of regressors. Here, we estimate random effects tobit models to account for the fact that the dependent variable has many zero values.

Results

Descriptive statistics

Table 2 shows the descriptive statistics. Fewer than half of the firms are FFs, as shown by the mean of 0.36. Table 3 presents the correlation coefficients of our variables.

Regression results

Main results. Our research question asks whether the AIPA has affected the R&D investment of FFs more negatively than that of non-FFs. Table 4 shows results from fixed effects linear models for the matched sample of firms that report R&D (model 1) and for the full sample of firms that report R&D (model 2), as well as random effects tobit models for the matched (model 3) and full (model 4) samples.

The different models 1–4 consistently show a negative estimated effect of the interaction term *AIPA * FAM*, which indicates that FFs invest less in R&D after the AIPA as compared to non-FFs.

Regarding our control variables, we find that *AGE*, *TOBIN'S Q*, *ROA*, *DEBT/ASSETS*, *PATENT/ASSETS*, *FREE CASH/ASSETS*, *INVESTMENT RATE* and *SALES VOLATILITY* have a statistically significant effect on *R&D/ASSETS*.

Table 3. Correlations

	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	AIPA	1													
2	FAM	−0.01	1												
3	AGE	−0.01	−0.25***	1											
4	TOBIN'S Q	−0.04***	0.22***	−0.02*	1										
5	ROA	−0.05***	0.05***	0.12***	0.27***	1									
6	PATENT/ASSETS	−0.05***	0.04***	0.23***	0.21***	0.02*	1								
7	CITATIONS/PATENTS	−0.19***	0.02*	0.08***	0.14***	0.10***	0.21***	1							
8	FREE CASH/ASSETS	−0.02	0.12***	0.05***	0.35***	0.52***	0.14***	0.13***	1						
9	INVESTMENT RATE	−0.12***	0.20***	−0.11***	0.30***	0.15***	0.16***	0.19***	0.24***	1					
10	SALES VOLATILITY	0.33***	−0.12***	−0.04***	−0.10***	−0.15***	0.03**	−0.05***	−0.08***	0.04***	1				
11	NEW FIRMS	−0.06***	0.08***	0.44***	0.19***	0.12***	0.45***	0.19***	0.13***	0.10***	−0.09***	1			
12	INDUSTRY PATENTS/ASSETS	−0.08***	0.08***	0.33***	0.29***	0.06***	0.64***	0.25***	0.18***	0.24***	0.05***	0.70***	1		
13	UTSA	−0.02	−0.00	0.08***	−0.03**	0.04***	0.00	−0.02	−0.04***	−0.15***	−0.08***	0.10***	−0.03***	1	
14	NON-REPORTED R&D	−0.04***	−0.10***	−0.41***	−0.28***	−0.11***	−0.40***	−0.20***	−0.21***	−0.19***	0.09***	−0.42***	−0.56***	0.05***	1

Statistical significance level: *$p < 0.10$. **$p < 0.05$. ***$p < 0.01$.

Table 4. The effect of early disclosure on the R&D investment of FFs

	Only reported R&D		Non-reported R&D replaced	
	Matched sample	Full sample	Matched sample	Full sample
	Linear fixed effects models		Random effects tobit models	
Variable	Model 1	Model 2	Model 3	Model 4
AIPA	−0.004	−0.004	−0.005*	−0.005*
	(0.003)	(0.003)	(0.003)	(0.003)
FAM*AIPA	−0.004**	−0.005**	−0.007***	−0.007***
	(0.002)	(0.002)	(0.002)	(0.002)
FAM			−0.001	−0.001
			(0.006)	(0.005)
AGE			−0.000***	−0.000***
			(0.000)	(0.000)
TOBIN'S Q	−0.040***	−0.040***	−0.043***	−0.042***
	(0.007)	(0.006)	(0.008)	(0.008)
ROA	−0.093***	−0.092***	−0.097***	−0.097***
	(0.007)	(0.007)	(0.008)	(0.008)
DEBT/ASSETS	−0.041***	−0.041***	−0.054***	−0.052***
	(0.007)	(0.007)	(0.008)	(0.008)
PATENTS/ASSETS	0.114***	0.114***	0.121***	0.122***
	(0.013)	(0.013)	(0.013)	(0.013)
CITATIONS/PATENTS	0.000	0.000	−0.000	−0.000
	(0.000)	(0.000)	(0.000)	(0.000)
FREE CASH/ASSETS	0.054***	0.054***	0.061***	0.061***
	(0.010)	(0.010)	(0.011)	(0.011)
INVESTMENT RATE	0.013**	0.013***	0.016***	0.016***
	(0.005)	(0.005)	(0.006)	(0.006)
SALES VOLATILITY	−0.000***	−0.000***	−0.000***	−0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
NEW FIRMS	0.003	0.003	0.001	0.001
	(0.002)	(0.002)	(0.003)	(0.003)
INDUSTRY PATENTS/ASSETS	−0.053	−0.058	−0.135**	−0.124**
	(0.055)	(0.053)	(0.063)	(0.056)
UTSA	0.017	0.017	0.006	0.006
	(0.020)	(0.020)	(0.016)	(0.016)
Constant	0.076***	0.075***	0.095	0.091
	(0.007)	(0.007)	(91.128)	(99.246)
TIME DUMMIES	Yes	Yes	Yes	Yes
INDUSTRY DUMMIES			Yes	Yes
STATE DUMMIES			Yes	Yes
N	3470	3568	6133	6509

Coefficients are reported; standard errors are in parentheses.
*p < 0.10. **p < 0.05. ***p < 0.01.

Further analysis. We further distinguish between founder-led and later generation-led FFs. Block (2012) observes that SEW preservation is strongest in founder-controlled FFs (see also Arrondo-García, Fernández-Méndez and Menéndez-Requejo, 2016; Berrone, Cruz and Gomez-Mejia, 2012; Bozec and Di Vito, 2019; Issah *et al.*, 2023; Tsao, Chang and Koh, 2019). SEW considerations reduce as FFs age and get passed on to heirs (Eddleston *et al.*, 2013). Large heir-controlled FFs behave in conformity to industry standards in terms of strategic practices for the sake of legitimacy (Miller, Breton-Miller and Lester, 2013). Large founder-controlled FFs, in contrast, are more likely to defy conformity by avoiding risky actions (Miller, Breton-Miller and Lester, 2013).

This is why we run additional analyses using only founder-controlled and only heir-controlled FFs and compare these different types of FFs to non-FFs. Table 5 shows the results, which indicate that only founder-controlled FFs react more negatively to the AIPA than non-FFs.[5]

[5]Note that the tobit regressions only converge for the full sample. Because the main results in Table 4 are very similar for the full and matched sample, we are confident that this would also be the case for this further analysis.

Table 5. The effect of early disclosure on the R&D investment of founding-controlled and later-generation FF*s* (only reported R&D)

	Founding-controlled FFs		Later-generation FFs	
	Matched sample	Full sample	Matched sample	Full sample
	Linear fixed effects models			
Variable	Model 1	Model 2	Model 3	Model 4
AIPA	−0.004	−0.004	−0.006**	−0.006**
	(0.003)	(0.003)	(0.003)	(0.003)
FAM∗AIPA	−0.011***	−0.011***	0.004∗	0.004
	(0.003)	(0.002)	(0.002)	(0.002)
TOBIN'S Q	−0.040***	−0.040***	−0.039***	−0.039***
	(0.008)	(0.008)	(0.006)	(0.006)
ROA	−0.098***	−0.097***	−0.067***	−0.066***
	(0.008)	(0.008)	(0.007)	(0.007)
DEBT/ASSETS	−0.048***	−0.047***	−0.036***	−0.036***
	(0.008)	(0.008)	(0.007)	(0.007)
PATENTS/ASSETS	0.108***	0.109***	0.041**	0.043***
	(0.014)	(0.014)	(0.016)	(0.016)
CITATIONS/PATENTS	−0.000	−0.000	−0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
FREE CASH/ASSETS	0.061***	0.061***	0.051***	0.052***
	(0.011)	(0.011)	(0.010)	(0.010)
INVESTMENT RATE	0.012**	0.012**	0.015***	0.015***
	(0.006)	(0.006)	(0.006)	(0.005)
SALES VOLATILITY	−0.000***	−0.000***	−0.000***	−0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
NEW FIRMS	0.002	0.002	0.007***	0.007***
	(0.003)	(0.003)	(0.002)	(0.002)
INDUSTRY PATENTS/ASSETS	−0.058	−0.064	−0.096*	−0.099∗
	(0.063)	(0.061)	(0.056)	(0.053)
UTSA	0.021	0.021	0.010	0.010
	(0.021)	(0.021)	(0.024)	(0.024)
constant	0.084***	0.083***	0.067***	0.066***
	(0.008)	(0.008)	(0.007)	(0.007)
TIME DUMMIES	Yes	Yes	Yes	Yes
N	2854	2952	2636	2734

Coefficients are reported; standard errors are in parentheses.
*p < 0.10. **p < 0.05. ***p < 0.01.

Parallel trends. It is important for a difference-in-difference analysis to show parallel trends before the event. Figures 1 and 2 show that we observe a parallel trend of R&D over assets before the AIPA for all FFs (Figure 1) and founder-controlled FFs (Figure 2). The figures also show that founder-controlled FFs react more strongly to the AIPA than do non-FFs (both in relation to non-FFs).

Discussion and conclusion

Discussion

We examine the effects of early disclosure of patent applications at the USPTO on the R&D investment of FFs. We find that FFs reduce their R&D investment after the AIPA as compared to non-FFs, which is in line with the view that the strategic actions of FFs are, next to financial considerations, aimed at preserving SEW. Early disclosure of patent applications can constitute a threat to SEW because it facilitates imitation and the reverse engineering of unprotected inventions.

Our further analysis shows that heir-controlled FFs are not affected by the AIPA in different ways than non-FFs, which is in line with the notion that SEW-related motives, which are more prevalent in FFs (Arrondo-García, Fernández-Méndez and Menéndez-Requejo, 2016; Block, 2012; Bozec and Di Vito, 2019; Issah *et al.*, 2023; Tsao, Chang and Koh, 2019), are responsible for the reduction of R&D by FFs, rather than a less diversified portfolio or lower R&D investments by heirs.

Contribution to research

Our study makes four contributions to the literature. First, we draw attention to the differential responses of FFs to innovation policies, which typically aim at the average firm in an economy. An extant literature

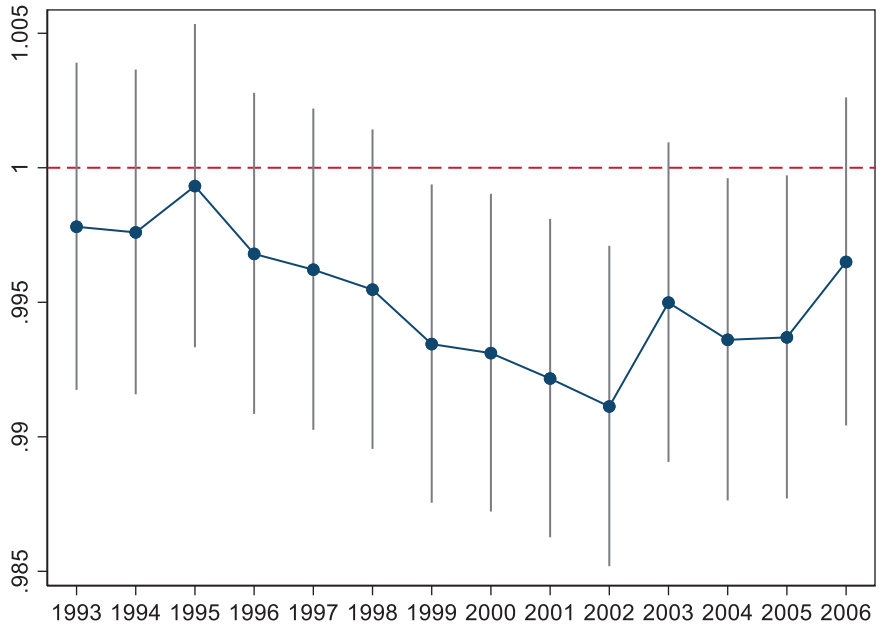

Figure 1. R&D investments of FFs relative to non-FF*s [Colour figure can be viewed at wileyonlinelibrary.com]*

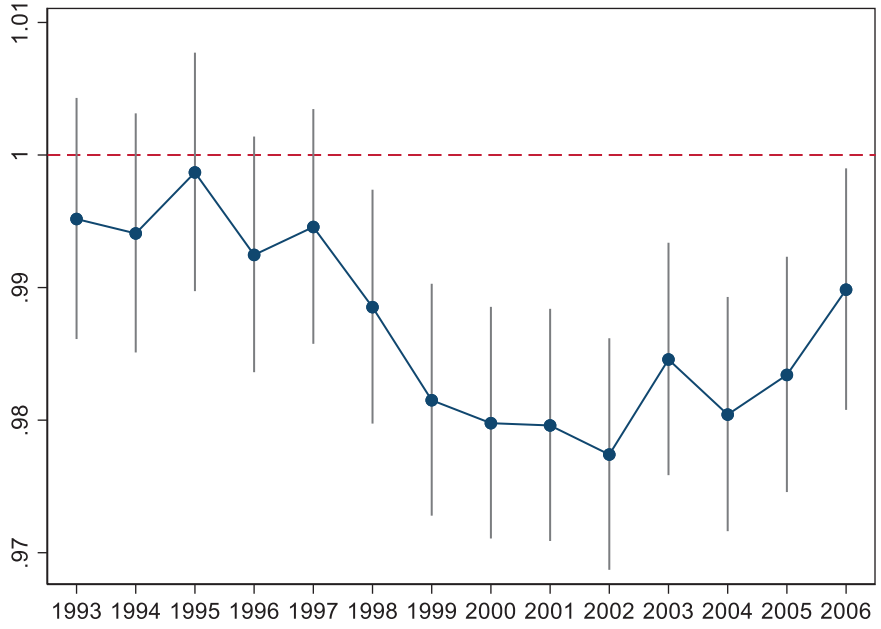

Figure 2. R&D investments of founder-controlled FFs relative to *n*on-FF*s [Colour figure can be viewed at wileyonlinelibrary.com]*

that evaluates the effects of innovation policies (e.g. Czarnitzki and Hussinger, 2018; Hussinger, 2008; Png, 2017a; Zúñiga-Vicente *et al.*, 2014) coexists side-by-side with a large literature that investigates FFs' innovation behaviour (e.g. Block, Hansen and Steinmetz, 2022; De Massis *et al.*, 2018), but little attention has been paid to a potentially differential response of FFs to innovation policies (see Hussinger and Issah, 2022, for an exception). We contribute to the literature by exploring the intersection between innovation policy and the FF literature. Therewith, we point to a field of opportunities for reflecting upon how public policy reforms affect the innovation activities of FFs differently.

Second, we contribute to the scarce literature on the effects of the AIPA on corporate innovation (Kim and Valentine, 2021; Williams, 2017). We show that FFs react more sensitively to the AIPA than non-FFs and reduce their R&D investment in response. FFs tend to be less diversified, and a large share of the personal wealth of the family is invested in the firm, thereby intensifying the risks of financial and SEW losses (Anderson, Duru and Reeb, 2012). We hence extend the evidence on the

impact of the AIPA to include FFs as a distinctive type of firm ownership.

Third, we extend the literature on SEW by showing how SEW can create distinctive responses to legislative changes of IP protection. Heir-controlled FFs, for which SEW-related motivations are less pronounced as compared to founder-controlled FFs (Arrondo-García, Fernández-Méndez and Menéndez-Requejo, 2016; Block, 2012; Bozec and Di Vito, 2019; Tsao, Chang and Koh, 2019), are affected by the AIPA in the same way as non-FFs, while first-generation FFs react more sensitively. This is in line with the interpretation that SEW-related motives, which are more prevalent in first-generation FFs, are responsible for the reduction of R&D by FFs rather than a less diversified portfolio or lower R&D investments by heirs.

Practical implications

There have been calls on the US government to start analyzing FFs separately owing to their importance for the US economy (Astrachan and Shanker, 2003; Pieper, Kellermanns and Astrachan, 2021). Our study shows how the AIPA affects R&D disadvantageously for this important segment of the economy. Hence, we present an important reason why policy makers should expedite actions towards a special focus on FFs, which contribute significantly to innovation and economic growth (Memili *et al.*, 2015).

For FFs, our results show that they are more careful when it comes to R&D investment than non-FFs and that they react more strongly to changes in patent legislation. While in the short run this protects their SEW, in the long-run competitors might be able to secure a competitive advantage because of larger R&D investments. FFs should take these potential long-run disadvantages into account when making their R&D investment decision.

Non-FFs can learn from our results that FFs react differently. Their strong reaction to the AIPA shows their hesitation to disclose innovation activities. This means that non-FFs should keep in mind that it is difficult to be aware of the full innovation potential of FFs.

Limitations and future research

Our sample focuses on the S&P 500 firms. Our choice is motivated by the fact that these firms are heavily engaged in R&D so that they have some discretion when it comes to strategic decisions about their R&D investment. Nevertheless, we are mindful that the observed reduction in R&D investment might be of a different size for smaller FFs. It is plausible that smaller FFs reduce their R&D investment even further, but this needs to be empirically shown in future research.

Another limitation is that we cannot control for changes of the ownership structure over time owing to data limitations (Skorodziyevskiy, Memili and Chrisman, 2022). Our analysis also does not allow us to directly disentangle the effects of different motivations, such as SEW and poorly diversified portfolios. This is an interesting avenue for future research.

Another promising topic for future research is the intersection between innovation policies and family ownership of firms. A recent study has shown that FFs react differently from non-FFs to changes in trade secret protection (Hussinger and Issah, 2022). Here, we add evidence on the different reaction of FFs to a change in patent legislation. This leaves a lot of room to investigate further innovation policies and law changes and how they affect the sensitive R&D investment decision of FFs.

Conclusion

At the intersection of innovation policy studies and the FF literature, our study provides empirical evidence for a reduction of FFs' R&D investment in response to the early disclosure of patent applications through the AIPA, one of the most far-reaching legislative reforms of the US patent system (Campbell Jr, 2001; Ergenzinger Jr, 2006). As we do not find an equal response by non-FFs, we underline the different behaviour of FFs and raise awareness of the fact that the AIPA had an unintended negative effect on FFs.

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