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Innovation Capabilities and Financing Constraints of Family Firms

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Abstract

Using the 2007 Mannheim innovation survey, we investigate whether family firms are more financially constrained than other firms and how this affects both innovation input as well as innovation outcomes such as market and firm novelties or process innovations. Based on the CDM framework, estimation of the recursive system of equations shows that family businesses are more likely to be constrained and have, on average, lower innovation input. Surprisingly, however, this does not reduce their innovation outcomes as, on average, family firms have the same level of innovation outcomes as non-family firms.

Keywords: Innovation, Capability, Financing Constraints, Family Firms, CDM
JEL: D32, G32, O32

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1 Introduction

In the wake of financial crisis, European countries continue to suffer sluggish growth. The financial industry is still in recovery and new regulatory frameworks have been recently introduced. Banks and other suppliers of external finance may be both more restrained and more cautious than they were prior to Lehman's insolvency. And yet, technological innovation is crucial for stronger growth in the future and such innovation cannot occur without funding. According to the Federal Association of German Industry, 90% of German firms are family-owned businesses. Family firms (*FB*) account for more than half of all jobs in Germany (Gottschalk et al. 2014). In light of these facts, the question of whether lack of financing hampers the innovation performance of family firms needs to be addressed. To the best of our knowledge, there is to date no research on this specific issue.

We thus investigate whether financial constraints have an impact on the innovation input of family firms. Our approach is based on the theoretical framework of Hottenrott & Peters (2012), which highlights the endogenous relationship between innovation capability and financing constraints. The fundamental idea is that financial constraints matter only for those firms, or are more likely to be felt by such firms, with a high innovation capability. "Innovation capability" is a firm's ability to launch innovations, and is assumed to be based on persistent research and development (R&D) activities and the embedded knowledge of a firm's staff.

Our paper utilizes this framework to identify the existence of financial constraints. Moreover, the empirical analysis builds on the CDM (Crépon et al. 1998) approach, which models the relationship between the decision to conduct R&D, level of innovation expenditure, and innovation outcome as a recursive system of equations. Using CDM, we formulate a system of equations where the first equation describes the likelihood of a firm of being financially constrained with regard to innovation input. The second equation describes how innovation input is affected by constraints and by being a family business, plus an interaction effect of those two effects. The third equation describes innovation outcomes as a function of innovation input and financial needs. We distinguish between market and firm novelties and also consider process innovations. The system is completed by a fourth equation describing the labor productivity of the firm as a function of innovation outcomes and being a family business.

The CDM model results confirm our conjecture that financial constraints are positively related to innovative capability, which is measured by the share of skilled labor and the firm's continuous R&D engagement. We also find that family businesses (*FB*s) are more likely to be financially constrained, that is, a larger fraction of *FB*s have a high latent financial need for funding additional innovation projects than do nonfamily businesses (*NFB*s). According to the underlying model, this implies that *FB*s face higher external financing costs.

A related study is Classen et al. (2014) which also utilizes the 2007 wave of the German innovation survey (Mannheim innovation panel). Employing a CDM framework estimated equation by equation, they find that *FB*s use less innovation input and that *FB*s create more process innovations. Another finding of that study is that *FB*s have lower labor productivity on average compared to *NFB*s. However, the authors' empirical approach considers neither endogenous financial constraints nor cross-equation correlations.

This paper makes three contributions to the literature. First, we adopt the framework of Hottenrott & Peters (2012) for measuring latent financial needs for innovation funding and apply it to the context of family firms. Second, we amalgamate the latent financial needs framework with the Crépon et al. (1998) CDM model and thereby take a novel approach to issues of selectivity and identification. Third, in contrast to other work, the system of mixed process equations (Roodman 2009) is estimated simultaneously and not equation by equation.

The remainder of the paper is structured as follows. Section 2 presents related literature. Section 3 outlines the theoretical framework. Section 4 presents the data and methodology. Section 5 presents estimation results. Section 6 concludes.

2 Related Studies

The question of whether innovation processes are different in family businesses (*FB*s) than they are in nonfamily businesses (*NFB*s) has attracted a great deal of scholarly attention, but with mixed results (De Massis et al. 2012), ranging from a negative association between family ownership and innovation productivity to the exact opposite. Another strand of literature investigates the existence of financial constraints for firms, particularly small and medium-sized enterprises (SME), and how financial constraints affect firm success (Mohnen et al. 2008, Canepa & Stoneman 2008, Silva & Carreira 2012). However, only a few contributions address the issue of whether *FB*s are especially financially constrained. No prior study analyzes how financial constraints and innovation capabilities affect the innovation input and output of family businesses versus nonfamily businesses.

In a recent study of the different stages of the innovation process within SMEs, Classen et al. (2014) find that family firms have a higher propensity to invest in innovation than do *NFB*s. However, among the group of investing firms, *FB*s invest less intensively than *NFB*s, and this is true even for large family firms (e.g., Block 2012). De Massis et al. (2015) and others (e.g. Chrisman et al. 2012) confirm the result of less innovation expenditure by family firms. Despite lower innovation input, Classen et al. (2014)) identify a positive effect of being a *FB* on process innovation outcomes, whereas *FB*s are found to be underperformers in terms of labor productivity.

Financial constraints are strongly linked to firms' innovation activity. On the one hand, expenditure on innovation may be difficult to finance externally because of information asymmetries between the firm and external financiers, as well as the high uncertainty in innovation success. Mitigating these obstacles with collateral may be impossible as innovation input often consists of intangible assets, for example, capable R&D employees, which can not be pledged as collateral. On the other hand, high innovation capabilities may create particularly large financial needs that may be difficult to satisfy. Lee et al. (2015) reveal that access to finance has been more difficult since the financial crisis, especially for innovative U.K. firms. Mina et al. (2013) identify for US and UK firms significant positive effects on demand for external finance when firms acquire technology, develop technology in collaboration with other firms, or face long and therefore highly uncertain pay-off periods. Indeed, the likelihood of obtaining external finance is especially negatively affected for those firms with large amounts of intangible assets and facing long pay-off periods. Silva & Carreira (2012) find that financial constraints severely reduce the amount invested in R&D by Portuguese firms. Czarnitzki & Hottenrott (2011) show that financial constraints play a more important role for investments in R&D than for productive investment. In addition, they find that external financial constraints affect the R&D expenses of smaller firms more than those of larger firms. Freel (2007) examines small firms' loan applications and finds that the most innovative businesses are less successful applicants than are less innovative firms. In their study of European firms, Canepa & Stoneman (2008) conclude that financial factors specifically affect the innovative activity of firms in the high-tech sector. In contrast, Bellucci et al. (2014) report that innovative Italian firms are less likely to be credit-rationed than are non-innovative businesses.

The question of whether *FB*s are expecially financially constrained is addressed in Gallo & Vilaseca (1996). They find that *FB*s work with lower leverages than their nonfamily peer firms. Gottschalk et al. (2014) report a similar result for German *FB*s. A higher equity ratio indicates that in the past a *FB* either demanded less debt finance or had less access to loans than a counterpart *NFB*. On the other hand, future financial access and low leverage are usually positively associated. Chen et al. (2014) report that the financial constraints of family firms depend on the firms' degree of transparency. Andres (2011) show that listed German firms with founding family ownership exhibit no specific investment-cash flow sensitivity compared to their nonfamily peers. In a recent study Crespi & Martin-Oliver (2015) find that, during the financial crisis, *FB*s were less subject to credit restrictions than *NFB*s.

Research on the existence of financial constraints in general faces an identification issue since observing an absence or a low level of external finance in a firm can be driven by demand and supply factors (Fazzari et al. 1988, Schiantarelli 1996, Hubbard 1998, Mairesse et al. 1999, Almeida et al. 2004, Schäfer & Talavera 2009, Banerjee & Duflo 2010). Identification is a crucial issue for our study also. We build on the theoretical framework of Hottenrott & Peters (2012) when identifying empirically whether family businesses are more financially constrained in funding innovation input. In a second step, we investigate the nature of the family versus nonfamily firm' innovation input-output relationship. In this aspect, our research is particularly closely related to Classen et al. (2014).

3 Conceptional Framework

3.1 Hypotheses on Financial Need and Innovation Input of Family Firms

Theory enables us to link a family firm's innovation capability to its financial need and innovation input (see also Hottenrott & Peters 2012). Consider two firms, $i = A$ and $i = B$. Let firm A be the family firm and firm B the nonfamily firm. Firm i owns a range of innovation projects with expected marginal internal rate of return. It ranks its projects according to the expected rate of return in descending order. The ranking indicates a demand for funding function $D_i(I, IC, X)$, which is decreasing in the innovation input I and increasing in the firm's innovation capability IC. The vector X consists of additional demand-shifting factors representing the firm's innovation environment. Let ICK_i be the constant marginal costs of internal funds F_i and $MCC_i(I, R^{t,f}, W, F)$ the firm's marginal cost of external capital. Because of borrower-lender information asymmetry, MCC_i increases constantly with the amount borrowed, $\partial\, MCC_i/\partial I > 0 | I > F_i$, and depends positively on opportunity costs $R^{t,f}$ and negatively on the firm's creditworthiness W and internal funds F_i.[1] We assume a financial "pecking order": firms draw first on cheap internal funds before resorting to more expensive external financing.

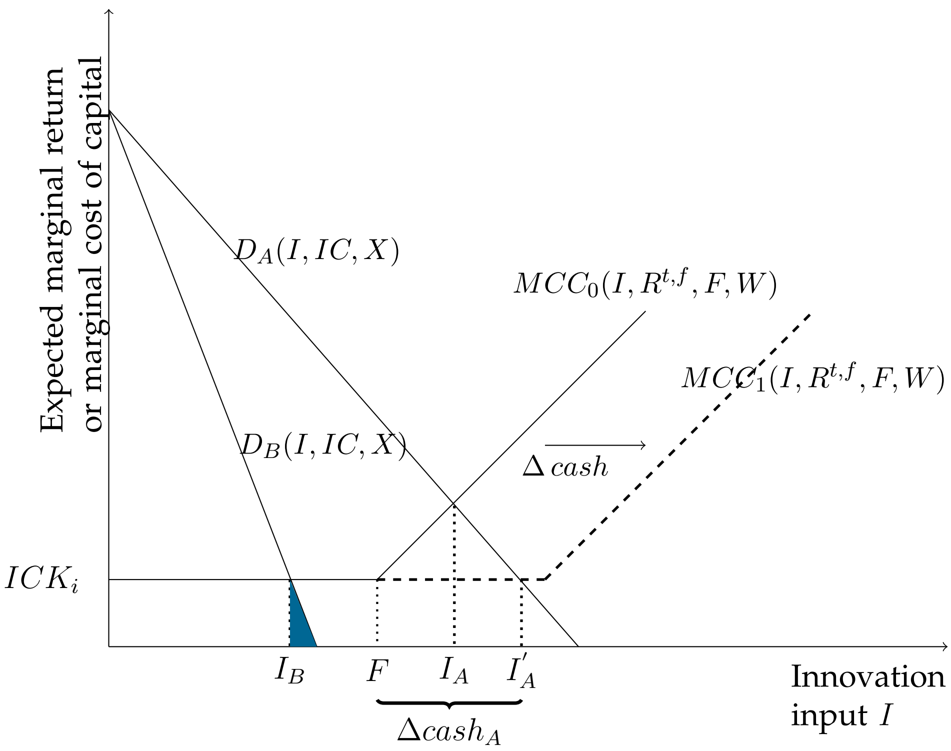
Figure 1(a) illustrates the situation of two firms, A and B, which have equally sized internal funds: $F_{A,B} = F$. Firm A's innovation capability IC is moderately higher than firm B's capability, therefore, $D(\cdot)_A > D(\cdot)_B$. While F is large enough to finance all profitable innovative projects of firm B (I_B) at the internal marginal cost ICK_i, internal funds F are insufficient to completely finance firm A's profitable projects. The shaded area in the figure represents firm B's negative net return projects: $D_B < ICK_i$. Apparently, because of superior innovation capabilities, firm A has a higher financial need than firm B. The difference $I_A - F$ is funded externally at marginal cost $MCC_0 > ICK$. Note that firm A realizes the higher innovation input, $I_A > I_B$, despite its financial constraints.

Assume now that both firms had access to additional funds ($\Delta\, cash$) at low marginal cost ICK_i. Denote a firm's financial need $fn = 0$ if the firm foregoes using $\Delta\, cash$ for increasing innovation input, $fn = 1$ if the firm's constraints create a financial need of $\Delta\, cash_i \leq \Delta\, cash$ and $fn = 2$ if its constraints create a financial need of $\Delta\, cash_i \geq \Delta\, cash$. The cheap fund shifts the marginal cost

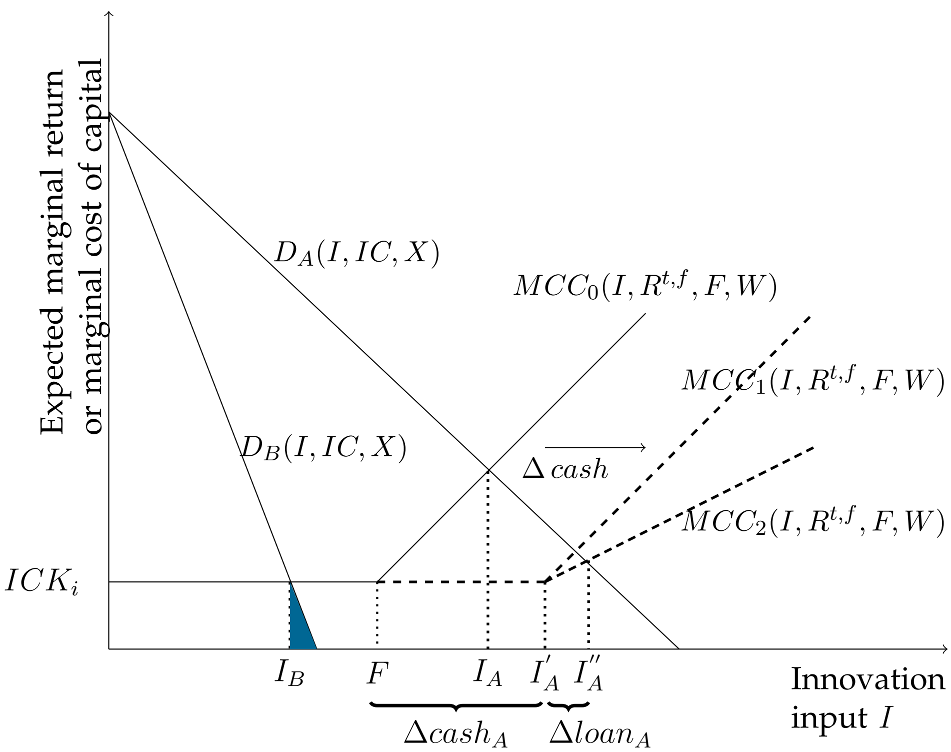
[1]Opportunity cost is the marginal return of alternative investments in tangible or financial assets.

Figure 1: **Superior innovation capabilities induce financial need**

(a) Small difference in innovation capabilities and subsequent financial need



(b) Large difference in innovation capabilities and subsequent financial need



curve to $MCC_1(\cdot)$ in Figure 1(a). Obviously, firm B stays with its already optimal innovation input $I_B < F$. Firm B's financial need fn equals zero. In contrast, the constrained firm A uses $\Delta\, cash_A < \Delta\, cash$, to shift its innovation input from the already high level I_A to the even higher level $I_A^{'}$: $fn = 1$.

Figure 1(b) illustrates the situation of two firms, A and B, with equal internal funds F, but now firm A's innovation capability IC is much stronger than firm B's capability. Assume that both firms had access to a cheap loan with marginal costs $MCC_2(\cdot) < MCC_1(\cdot)$ on top of $\Delta\, cash$ at low marginal cost ICK. Apparently, firm A would use both $\Delta\, cash_A + \Delta\, loan_A > \Delta\, cash$ to expand its innovation input to $I_A^{''}$. The increase in innovation expenditure reflects firm A's strong financial constraints which create a high positive financial need: $fn = 2$.

What can we learn from this illustration? First, all else equal, firm A is more constrained and has a higher financial need fn than B. Second, the high originally observed innovation expenditure I_A reflects the high financial need fn arising from A's superior innovation capabilities.

Figure 2(a) shows two firms, A and B, with equal innovation capabilities, $D_{A,B}(\cdot)$, but in this case firm A has slightly smaller internal funds than firm B: $F_A < F_B$. Firm B is unconstrained with innovation input $I_B < F_B$. In contrast, firm A's low internal funds F_A are insufficient. Expensive external funds at marginal cost MCC_0 are borrowed to fund input I_A. Apparently, in the case of equal capabilities, the original innovation input is lower for the constrained firm A. Access to additional funds ($\Delta\, cash$) at marginal cost ICK_i relaxes firm A's constraint and induces additional innovation input $I_B - I_A$. The same amount of cheap cash would induce no change in firm B's input. Financial need is $fn = 1$ for firm A but zero for firm B.

In Figure 2(b) firms A and B have equal innovation capabilities but the size of firm A's internal fund (F_A) is much smaller than firm B's. Firm A is thus required to use more expensive external funds for realizing its constrained optimal investment I_A. Firm A shows a financial need $fn = 2$ since the firm would use the entirety of its cheap funds ($\Delta\, cash$) for innovation purposes and take, on top, a cheap loan ($\Delta\, loan_A$) of marginal cost $MCC_2(\cdot)$ to expand its innovation input to I_A''.

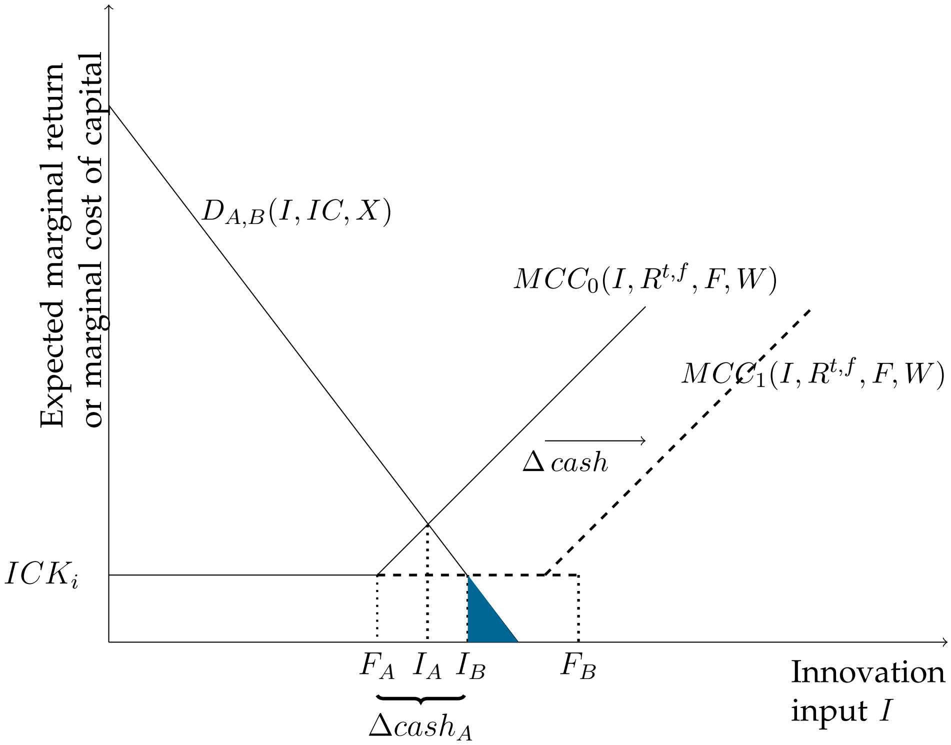
Figure 2(c) shows two firms, A and B, with equal innovation capability and equal internal funds. Firm A faces higher external marginal financing costs than does firm B: $MCC_{0A} > MCC_{0B}$. Firm A is thus more constrained than firm B and its observed innovation input is lower $I_A < I_B$. If additional funds ($\Delta\, cash$) at internal marginal cost ICK_i were accessible, firm A's would expand its innovation input from I_A to $I_A{}'$. The same additional funds ($\Delta\, cash$) would induce firm B to invest $I_B = I_A'$ instead of I_B, and then to stick with its already cheap bank loan with $MCC_{1B} < MCC_{2A}$ to realize input I_B'. Firm B's financial need is $fn = 1$. Note that the shaded area represents B's innovation projects with internal rate of return smaller than MCC_{1B}. In contrast, firm A's financial need is higher, $fn = 2$. Access to an additional loan of marginal cost MCC_{2A} would induce firm A to use both, cash and loan, and expand its innovation input to I_A''.

To summarize, theory predicts, first, that given equal financing conditions, firms with higher innovation capabilities are more constrained and have higher financial need. At the same time, the observed original innovation expenditure for the firm type with more innovation projects is higher than for the type with lower capabilities. Second, if firms have equal innovation capabilities but different financing conditions, those firms with lower internal funds and/or higher marginal costs for external funds exhibit a higher financial need. However, in this case, the revealed higher financial need is accompanied by lower originally observed innovation expenditure.

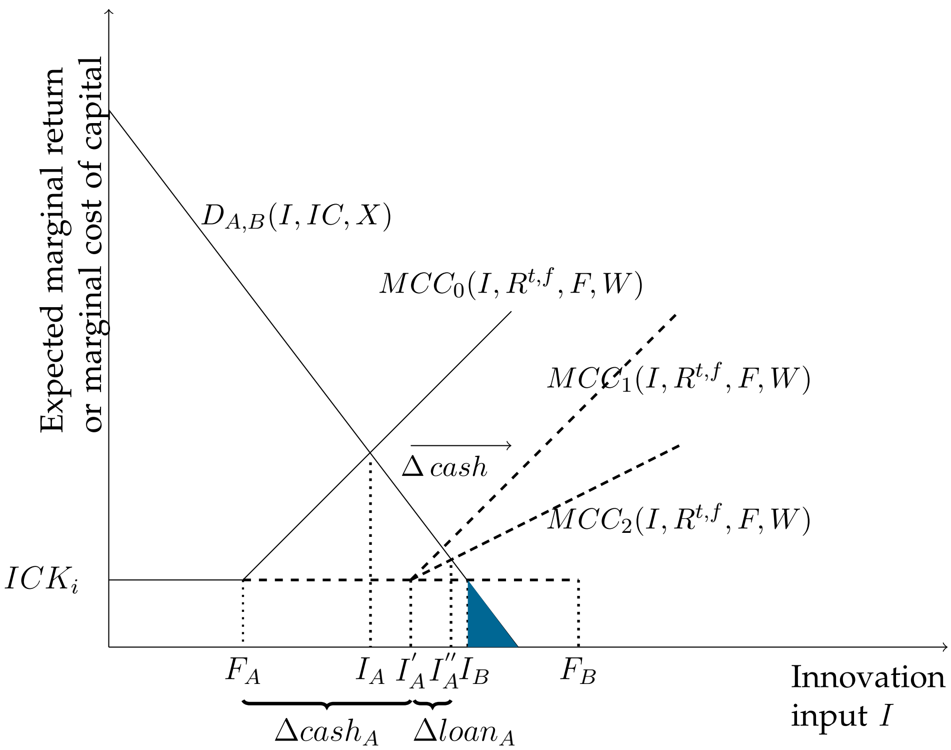
These theoretical predictions enable us, first, to empirically identify which firm type is the constrained one and, second, why this firm type is more constrained and has a higher financial need. If empirical analysis reveals that family

Figure 2: **Inferior financing conditions induce financial need**

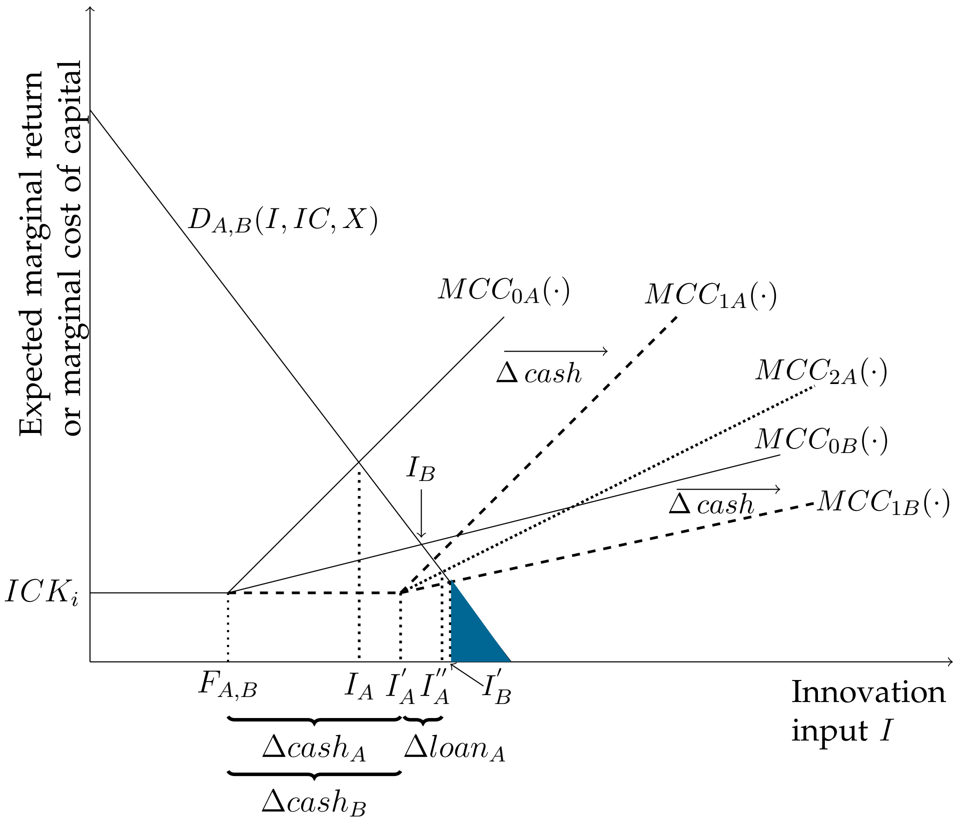
(a) Small difference in internal funds and subsequent financial need



(b) Large difference in internal funds and subsequent financial need



(c) Large difference in marginal external funding costs cause distinct financial need



businesses are more likely to have a high financial need than nonfamily businesses, and *FB*s show lower innovation expenditure, it means that *FB*s have higher marginal funding costs. Accordingly, we test the following hypotheses for identifying the firm type:

1. *FB*s are more likely than *NFB*s to have a high financial need.

2. *FB*s with high financial need have, ceteris paribus, on average lower innovation input because they face, on average, higher financing costs compared to *NFB*s.

In the next section, we develop our hypotheses regarding the innovation productivity of *FB*s versus *NFB*s.

3.2 Hypotheses on the Innovation Productivity of *FB*

Hypothesis 2 raises the immediate follow-up question of whether *FB*s lower innovation input induces also a lower level of innovation output (Classen et al. 2014). Important in this regard is *innovation productivity*, which is the ratio of innovation output relative to innovation input. For example, if *FB*s had levels of innovation output similar to that of *NFB*s but use less innovation input, *FB*s' innovation productivity would be higher. One theoretical explanation for *FB*s' higher innovation productivity could be that *FB*s do not suffer as much from agency problems as do *NFB*s (e.g., Chrisman et al. 2004, and Villalonga & Amit 2006)), and therefore are able to engage in innovation projects more cost efficiently. Cost efficiency of *FB*s is expected due to the alignment of owner-managers' interests, implying a more conservative and careful resource allocation relative to that of *NFB*s (Jensen & Meckling 1976). Accordingly, we hypothesize

3. *FB*s have on average a higher innovation productivity than *NFB*s.

Higher innovation productivity means that one unit of innovation input generates, on average, more innovation output. While *FB*s might have on average a higher innovation productivity, *FB*s with high financial need (*fn*) might still generate less innovation output because of financial constraints. Thus we hypothesize:

4. *FB*s with a high latent financial need have on average less innovation output compared to *NFB*s.

In addition, a number of studies suggest that *FB*s tend to engage in incremental innovation projects instead of more radical, thus more risky, projects (e.g., Naldi et al. 2007). One reason for this caution is that all of the family wealth is invested in a single firm (e.g., Andres 2008), implying that *FB*s tend to avoid high-risk projects (e.g., De Massis et al. 2015).

Our CDM approach allows us to study firms' ability to increase productivity by generating innovation output. Market innovations and firm novelties open up new business opportunities and, accordingly, a firm's value added increases. Furthermore, process innovations result in cost savings and a firm's value added should increase from this sort of activity too. *FB*s are expected to be more effective in turning innovation outcomes into higher labor productivity because of a better alignment of owners' and managers interest. Accordingly, Hypothesis 5 reads:

5. *FB*s generate higher firm productivity from a given level of innovation outcomes.

4 Empirical Approach

4.1 Data

We use the 2007 wave of the Mannheim innovation panel (MIP) to study the effects of financial constraints on the innovation activity of family versus nonfamily firms. MIP is the German contribution to the annual European-Wide Community

Innovation Surveys (CIS), which provide essential information about new products, services, and processes, innovation input, and ways to achieve economic success with new products, services, and improved processes.[2] In the 2007 wave, approximately 4,000 German firms responded to specific questions about funding sources for innovation and about whether the firm considers itself a family business. This study focuses on 2,000 firms from the manufacturing and services sectors.

We use the questions that allow us to distinguish between family firms and nonfamily firms, as well as those that provide information on firms' innovation capability. We also use questions on innovation expenditures (input) as well as those that allow us to identify the firm's financial need for potential innovation projects. The variables used in our empirical model are listed in Table 1. Company size is measured using seven categories based on the number of employees (see Table 2). Industry is a categorical variable that determines in which of 22 aggregate economic sectors the firm is active (see Table 3).

4.2 Measurement of Financial Constraints and Innovation Capability

Following Hottenrott & Peters (2012), we employ a so-called ideal test, proposed by Hall (2005) for identifying financial constraints. Hall (2005) suggests that by exogenously providing additional resources to a company, it is possible to infer how financially constrained the company is when it comes to innovation. By observing what the company would do with those additional funds, it is possible to discover if there were unexploited investment opportunities that were not profitable when using more costly external capital.

To implement this test, we take advantage of answers to the survey question

[2] The Center for European Economic Research (ZEW) has been collecting data on innovation in Germany through the MIP survey since 1993, commissioned by the German Federal Ministry of Education and Research (BMBF).

on what firms would do with an extra 10% of their previous year's turnover. In answering, companies could choose spending this $\Delta cash$ at internal marginal funding costs on innovation projects and/or other types of investment, payment of dividends or debt, or retain it as reserve funds. In addition, we employ a question on how the firm would use extra funds from a cheap loan of the same amount (10% of their previous year's turnover). Similar to the previous question, the answer choices include *use them for innovation projects and/or other uses*. If the firm responded that it would use additional funds for innovation projects, it means that the firm is financially constrained and therefore has a positive financial need.

Based on the theory outlined in Section 3.1, we define two distinct levels of financial need. The financial need variable (*fn*) equals 1 if the hypothetical extra cash would be used for innovation. The financial need variable *fn* equals 2, if the firm answered that it would use even a cheap loan for innovation projects.

Another pillar of the empirical framework rests on defining innovation capability (IC) as the firm's capacity to generate innovation. We proxy *IC* with four variables: proportion of staff with a university degree (*UD*), training expenditures over total turnover (*TE*), R&D expenditures over turnover (*RDexpenditure*), and how often the company engages in R&D (*RDengagement*). The latter variable has three levels: *continuously, occasionally*, or *never*.

4.3 Empirical Model

A recursive system with unidirectional dependency among the endogenous variables is defined that consists of four equations: (1) financial need, (2) innovation expenditure (= innovation input), (3) innovation output (= market, firm, or process innovation), and labor productivity. The major advantage of using a recursive system is that we do not need to consider the endogeneity issue of right-hand side dependent variables from other equations. In fact, in a recursive system, the estimation can be based on the observed values of endogenous variables and not on predicted values (Roodman 2009, 2014).

Our first equation describes financial need (*fn*) as a function of the firm's innovative capability (*IC*), family firm status ($FB \in [0,1]$), and control variables. Financial need is a ordered categorical variable with $fn \in [0,1,2]$. The second equation describes innovation input (*I*) which depends on financial need, family firm status and controls. We control for company size, the industry, whether the firm is located in West or East Germany, the equity ratio in 2006, the return on sales and whether or not the firm is export oriented. The dependent variable of the third equation (*InnoOutput*) is defined in terms of one of three possible innovation outputs. *InnoOutput* is measured either by (1) the share of turnover from market novelties (*InnoNovel*), (2) the share of turnover from new or clearly improved products (*InnoFirm*),[3], or (3) the reduction of average costs by means of process innovations (*InnoProcess*). The left-hand side of the fourth and last equation is the logarithm of firm's labor productivity explained by innovation output and control variables ($\log LP$). As mentioned above, these four equations constitute a recursive equation system and the errors are allowed to be correlated across equations:

$$fn_i = f(IC_i, FB, controls) + \epsilon_i \quad (1)$$

$$I_i = f(fn_i, FB, fn_i \times FB, controls) + \upsilon_i \quad (2)$$

$$InnoOutput_i = f(I_i, FB, I_i \times FB, fn_i, fn_i \times FB, controls) + \omega_i \quad (3)$$

$$\log LP_i = f(InnoOutput, FB, InnoOutput \times FB, fn_i, controls) + \eta_i \quad (4)$$

where ϵ_i, υ_i, ω_i and η_i are iid error terms from a multivariate normal distribution.[4]

[3]The variables *InnoNovel* and *InnoFirm* are fractions and thus censored with a lower-bound value of 0.

[4]We employ David Roodman's CMP (conditional mixed processes) procedure implemented in STATA for the estimations (Roodman 2009, 2014). The method has the advantage of allowing for mixed processes; that is, it permits different types of dependent variables in the system (binary, censored, interval, and continuous variables). It also allows parameters to be fixed or random, and it does not exclude missing values listwise, but conditions on each available observation and

From a computational point of view, CMP can be interpreted as a seemingly unrelated regressions (SUR) estimator and its parameter can be consistently estimated in a recursive system equation by equation using observed values of right-hand side endogenous variables. Nonetheless, the joint estimation of the full equation system takes into account the full covariance structure and is therefore more efficient (Roodman 2009, 2014).

Note that the estimate for variable FB in Equation 1 provides a test of Hypothesis 1. Hypothesis 2 can be investigated from the coefficient of the interaction term $fn \times FB$ in Equation (2). The interaction effect $I_i \times FB$ in Equation (3) corresponds to Hypothesis 3, while the interaction term $fn \times FB$ in Equation (3) provides an answer to Hypothesis 4. Finally, the interaction term *InnoOutput* $\times$ FB in Equation 4 provides a statistical test of Hypothesis 5.

5 Results

5.1 Descriptive Statistics

We start by describing some of the chief characteristics of our sample. Table 2 shows that *FB*s are, on average, smaller than *NFB*s; however, both types of firms are similarly likely to have some type of innovation (product, process, organization, distribution). Table 3 shows the distribution of firms across industries. While *FB*s can be found in almost all industries, the fraction of *FB*s in technical and business consulting, as well as in financial industries (banks, insurance), is significantly lower compared to *NFB*s. On the other hand, more *FB*s are found in low- to medium-tech manufacturing such as wood and paper, plastics, food and tobacco. Furthermore, *FB*s are found in IT, telecom, and business-related services, and in banking and insurance industries, to a lesser extent than are *NFB*s.

estimates simultaneous equation systems using maximum likelihood (ML). For an alternative estimation approach, see Baum et al. (2015).

Table 4 shows that *FB*s have on average only about half the R&D expenditures (share of turnover) of *NFB*s. However, the fraction of *FB*s that never engage in R&D is similar to that of *NFB*s (about two-thirds of both types never engage in R&D). If they do engage in R&D, *FB*s are less often engaged *continuously* than *NFB*s, and slightly more *occasionally*. As R&D is also a cost to firms, this means that *FB*s invest less than *NFB*s in knowledge generation; perhaps, however, they are simply more cost avoidant than *NFB*. This evidence supports Hypothesis 3.

Table 4 also shows that *FB*s employ a significantly lower share of staff with university degree *UD* (15% vs. 24%). This lower level of skilled employees appears to be related to the industry distribution of *FB*s, which have a lower share (compared to *NFBs*) active in knowledge-intensive services. Although *FB*s have slightly lower innovation input *I* (4% vs. 5%), they seem to produce the same amount of innovation outputs; share of turnover with market novelties, firm novelties, and cost reductions (process innovations) is shown in Table 5. However, one can also see that *FB*s, on average, have a lower labor productivity, measured as value added per employee.

Table 6 set out the firms' financing sources for innovation and regular investment revealing that for innovation funding, internal cash is the most important source for both *FB* and *NFB*; 60.8 % for *FB*s and 60.1 % for *NFB*s. Note that a statistical test regarding the difference turns out to be insignificant; thus *FB* and *NFB* depend equally on internal funds. For *FB*s, the second most important funding source is overdraft credits, which are presumably more expensive than earmarked bank loans. In contrast to *FB*s, the second most important funding source for *NFB*s is public allowances, which are low cost funds. For *FB*s, shareholder loans, bank credits and overdraft credits are more relevant sources for funding innovation, whereas public subsidies are less mentioned by this type of firm. Overall, these different funding sources imply higher financing costs in funding innovation for *FB*s.

Table 7 displays specifically summary statistics for financial needs (*fn*), the variable of main interest. *FB*s have, on average, higher latent financial needs, and thus would engage in more innovation projects if additional cash or cheap loans were available. While the first category, "somewhat constrained", is similar for *FB*s and *NFB*s (*fn* $= 1$ is around 35% for both), the second category, "more constrained" (*fn* $= 2$), shows a greater difference between *FB*s and *NFB*s (26% vs. 19%).

From the descriptive statistics one can see that *FB*s tend to have fewer employees with a university degree, lower innovation expenditure, and lower research and development expenditures. Despite having lower levels of innovation input, however, *FB*s seem to have similar levels of innovation output.

5.1.1 Estimation Results

We now turn to the results of the econometric estimation, which are shown in Table 8. The fact that the ρ coefficients reported at the end of Table 8 are significant in most cases means that the error terms of equations are correlated and thus estimation as a system of equations is appropriate. Equation (1) estimates reveal that the likelihood for a positive financial need is positively related to innovation capability *IC*, $\frac{\partial fn}{\partial IC} > 0$, as Figure 1 predicts. Hypothesis 1 is confirmed as *FB*s are more likely to have a high financial need *fn*: the coefficient of *FB* is positive. Table 9 shows the marginal effects of selected variables in Equation (1) and one can see that firms that are using internal funds for innovation purposes have the highest probability of belonging to the group of firms with a high latent financial need *fn*. Furthermore, firms that rely on overdraft credits, and the majority of these firms are *FB*s, have the second highest marginal probability of belonging to the group of firms with high financial need.

Model (A)in Table 9 shows that among the indicators of innovative capability IC in our model, investment in training employees, is the one that most increases the probability of increased financial needs. A one unit change in the proportion of training expenditures over turnover increases the probability of having a financial need *fn*$=2$ by 0.453. The same pattern is observed in Models (B) and (C). We also notice that there is overall greater sensitivity of the probability of *fn*$=2$ in Model (B) when the output is *InnoFirm*. Financial needs is more affected when the firm is producing firm novelties because because this type of output may require more resources and capabilities to innovate than other types of innovation output.

In Equation (2), the positive coefficient on *fn* reveals that firms with high financial need are more likely to have higher innovation input. Our theory, as outlined in Section 3.1, allows both $\frac{\partial I}{\partial fn} \geq 0$ (see Figure 1) and $\frac{\partial I}{\partial fn} \leq 0$ (see Figure 2), but apparently the first term outweighs the second one for all firms. On average, firms expressing higher *fn* have superior innovation capabilities and – for this reason – are more financially constrained than firms expressing lower *fn*. The statistical test on a positive association between *FB* and innovation input is also performed in Equation (2), but is rejected as *FB* is insignificant in this equation, implying that, if all other influences are controlled for, the family businesses in the sample spend on average the same amount on innovation as do other firms.

The coefficient on the interaction effect *fn* $\times$ *FB* is negative. Family firms indicating high financial need have lower innovation input (*I*). The interaction term's sign is consistent with Hypothesis 2. According to Figure 2 the negative coefficient indicates that a high financial need of family firms is caused by higher marginal funding costs rather than innovation capabilities. This finding is consistent with Table 4 where the descriptives show that family firms have a significantly lower share of employees with university degrees, and R&D expenditure is significantly less as well. In other words, *FB*s face inferior financing conditions in innovation funding.

The results for the third and fourth equation show that the outcome of the knowledge production function *InnoOutput* is significantly explained by the amount of innovation input (*I*) and *fn*. There is a consistent pattern of positive significant coefficients for all three types of innovation outputs: *InnoNovel*, *InnoFirm* and *InnoProcess*. Thus, $\frac{\partial InnoOutput}{\partial fn}$ >0 appears to be a robust result. Because of $\frac{\partial fn}{\partial IC}$ >0, this finding should be caused by $\frac{\partial InnoOutput}{\partial IC} > 0$. Higher innovation capability actually translates into more innovation output by creating an increased demand for funding appropriate resources that then enable the firm to exploit those capabilities.

*FB*s translate innovation input into market novelties (*InnoNovel*) to a significantly smaller extent than do *NFB*s, as shown by the negative and significant coefficient of the interaction term *FB*×*Innovation input (I)*. Thus, *FB*s' innovation productivity in terms of market novelties is lower and for this type of innovation output, Hypothesis 3 is not supported. However, the significant positive coefficient on the interaction term in Model (C) (*InnoProcess*) shows that *FB*s are more efficient in turning input (*I*) into cost-reducing process innovations; thus Hypothesis 3 is confirmed for process innovations. Regarding Hypothesis 4, we find no evidence that *FB* with financial needs have on average lower innovation output. Thus, while financial constraints lead to lower innovation expenditures for *FB*s they do not reduce innovation output. The results for the fourth equation $\log LP$ reveal that *FB*s have significantly lower labor productivity. However, we find no significant difference between *FB*s and *NFB*s with respect to a higher effectiveness of *FB* in turning innovation output into higher productivity. Thus, we cannot confirm Hypothesis 5.

It should be noted that the classical CDM contains a first selection equation that predicts whether a firm has positive R&D or innovation expenditures. This prediction is used to correct for selection effects in the second and third equations, which are only modeled for firms having positive outcomes in those equations. In contrast to this approach, we include all observations, even those that have zero innovation expenditure or zero innovation outcome. The reason for doing so is that one can observe positive innovation outcomes even for those firms that have no innovation expenditure, thus excluding the zero expenditure firms leads to upward biased estimates regarding the innovation input-output relationship. Note also that instead of employing a probit equation for indicating which type of firms have positive expenditures, we use the financial need equation to capture a firm's latent innovation propensity. In fact, it turns out that this variable has predictive power and thus contains information on selection of firms into innovative and non-innovative ones even in the fourth equation for labor productivity.

In summary, we find evidence that the lower innovation expenditure of *FB*s is caused by structural differences. *FB*s are on average smaller and more prevalent in low- to medium-tech industries and relatively less represented in IT and business services. Accordingly, the share of employees with university degrees is smaller in *FB*s. They are also more likely to have latent financial needs for innovation projects. However, we find no evidence that the innovation output of *FB*s is lower than that of *NFB*s once those structural differences are controlled for. *FB*s appear to be less able to turn innovation expenditures into market novelties, as indicated by the significant negative interaction effect, but they are better than *NFB*s in implementing process innovations, as indicated by the positive significant interaction effect in Equation (3). One interpretation for this finding is that the owner's involvement in the family firm leads to stronger cost sensitivity. The lower R&D innovation input of *NFB*s yielding the same amount of innovation output is consistent with this explanation. We also find some evidence that *FB*s have a stronger focus on process innovation than do *NFB*s. Remember that *FB*s are rarely found in R&D-intensive high-tech sectors. Perhaps *FB*s are more risk averse than *NFB*s and thus reluctant to become involved in industries characterized by fast-changing technology, for example, the pharmaceuticals or electronics sectors. As a result, *FB* are more prevalent in traditionally more stable industries. In summary, Hypotheses 1, 2, and 3 (partly) are supported by the empirical findings; Hypotheses 4 and 5 are not. The differences between *FB*s and *FB*s regarding financial needs are more pronounced compared to the differences of the R&D-innovation-performance relationships. Thus, *FB*s are not very different from *NFB*s in terms of innovation inputs and outputs, but are quite different in terms of how innovation expenditures are financed.

5.1.2 Robustness Checks

We conducted a series of tests to check the robustness of our results. First, we tested whether financial need has out-of-sample predictive power beyond 2007. To this end, we estimated the same model using variables from the 2009 survey based on firms that were also observed in 2007, and keeping *FB* status and financial need measurement as of year 2007.[5] The results for 2009 are very similar to those for 2007, especially regarding the significance of financial need in the equations, implying that financial need has some predictive power that holds even in an out-of-sample application.

Second, following the suggestions made by CMP procedure description, we defined *fn* as a latent variable instead of an observed one.[6] This means that *fn* is replaced by predicted values from Equation (1) in the system estimation. Using the predicted instead of observed values, we find that the first two equations on financial needs and innovation input remain very similar in the estimated coefficients, while *fn* is no longer significant in the third and fourth equations for innovation output and labor productivity.[7]

Third, we estimated our model by using an equation-by-equation approach to

[5] We do not include the respective table but it is available from the authors upon request.

[6] Again, as mentioned above, in a recursive system of equations the estimations can be based on observed values of right-hand side endogenous variables, not on instrumented ones.

[7] Note that the explanation for this change of significance is that predicted *fn* is more strongly correlated with the other explanatory variables and therefore is less significant when instrumented, while on the other hand it should be robust regarding endogeneity issues if the other explanatory variables are truly exogenous.

investigate how the system CMP estimation affects the results (see Table 10). We find that *FB* remains positive and significant in the financial need equation, and that *fn* is significant and positive for the innovation input equation for all three indicators for the innovation output. While the interaction term between *fn* and *FB* is not significant in the single-equation model, and thus Hypothesis 2 is no longer supported, there is still support for Hypothesis 3. This observation proves that it is important to estimate the entire system instead of taking an equation-by-equation approach.

6 Conclusions

The aim of our paper is to investigate whether financial constraints matter for family firms and how financial constraints depend on innovation capability. Furthermore, we shed light on the question of how financial constraints affect innovation input and outcomes of *FB*s in comparison to *NFB*s. We thus utilize the approach for measuring latent financial needs suggested in Hottenrott & Peters (2012) and formulate a recursive system of equations in the spirit of CDM (Crépon et al. 1998) that addresses the issue of selectivity via an equation that is formulated regarding financial needs.

The descriptives show that both *FB*s and *NFB*s mainly use internal funds for financing innovation, but that for *FB*s external funds such as bank loans and overdraft credits play an important role. This implies that external financing costs are higher for *FB*s than they are for *NFB*s.

Estimation of the equation system suggests that *FB*s have on average higher financial needs. This is caused by higher marginal funding costs rather than by higher innovation capabilities. We also find that *FB*s have, again on average, a lower innovation productivity with respect to market novelties (i.e., radical innovations), but they are generally more efficient with respect to process innovations (i.e., in achieving cost reductions). This may be due to a better alignment of owner-managers' interests in *FB*s, resulting in more efficient resource utilization (Jensen & Meckling 1976). Overall, and somewhat surprisingly, we find no evidence that *FB*s have generally lower innovation output as a consequence of financial constraints. Finally, we do not find evidence that *FB*s are superior in achieving higher productivity gains from their innovation output.

From a policy perspective our results provide some interesting insight. *FB*s are more likely to have a high latent financial need and are consequently on average financially more constrained. Yet, the group of *FB* with a high financial need achieves similar results in terms of innovation output. Apparently, those firms can compensate for higher marginal financing costs by being more efficient. Whether relaxing financial constraints for family businesses (and, potentially, other types of businesses) would boost innovation performance remains an open question worth pursuing in future research.

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Appendix

Tables

Descriptive Statistics

Table 1: Variable definitions

Variable name	Definition
FB	Family firm
NFB	Non-family firm
fn	Financial need with $fn \in [0,1,2]$
IC	Innovation capability: *UD*, *TE*, *RD expenditure* and *RD engagement*
UD	Percentage of employees with university degree (%)
TE	Share of training expenditures over total turnover (%)
RD expenditure	Research and development (R&D) expenditure over turnover (%)
RD engagement	Research and development (R&D) frequency of engagement: *Continuously*, *occasionally* or *never*
I	Innovation input: innovation expenditure over turnover (%)
InnoOutput	Innovation output: *InnoNovel*, *InnoFirm* and *InnoProcess*
InnoNovel	Share of turnover from market novelties (%)
InnoFirm	Share of turnover from firm novelties (%)
InnoProcess	Reduction in average unit cost by process innovations (%)
$\log LP$	Natural logarithm of labor productivity (turnover over number of employees)
Controls	Industry, size classes, located in West or East Germany, equity ratio in 2006, return on sales, whether or not being export-oriented
Size classes	Company size by number of employees
Return on sales	Return on sales in the last two years
Export-orientation	Geographic activities: basically regional turnover, national turnover or international turnover (exports)
Innoexp	Total innovation expenditure over turnover (innovation intensity)
Industry	NACE 2-digit industry code (Rev. 1)

Table 2: Size classes (%)

	NFB	*FB*
$0 <$ employees ≤ 19	30.7	37.3
$20 \leq$ employees ≤ 49	17.5	19.7
$50 \leq$ employees ≤ 99	13.1	14.4
$100 \leq$ employees ≤ 249	14.9	13.7
$250 \leq$ employees ≤ 499	9.1	6.9
$500 \leq$ employees ≤ 999	5.6	3.6
≥ 1000 employees	9.1	4.4
Total %	100	100
# obs	2029	2665
χ^2	77.8	
p-value	0.0	

Table 3: Industry (%)

	NFB	*FB*
Mining	7.9	3.2
Food, tobacco	1.7	6.0
Textiles	2.0	4.1
Wood, paper	1.5	4.6
Chemicals	3.6	3.9
Plastics	1.7	5.4
Glass, ceramics	1.8	3.9
Metals	5.4	8.6
Machinery	5.4	6.8
Electrical equipment	4.0	6.6
Medical instruments	3.2	2.5
Transport equipment	4.1	5.6
Furniture	8.7	3.0
Wholesale	3.7	5.5
Retail, automobile	8.0	8.8
Transport, communications	4.8	4.9
Banking, insurance	6.0	2.7
IT, telecom	8.0	2.2
Technical services	10.6	5.1
Firm-related services	4.5	2.3
Other services	3.3	4.2
Total %	100	100
# obs	1891	2457
χ^2	464.9	
p-value	0.0	

Table 4: Innovation inputs: innovation capability and innovation expenditure

	UD		**TE**		**I**		**RD expenditure**		**RD engagement**		
	NFB	*FB*	*NFB*	*FB*	*NFB*	*FB*	*NFB*	*FB*		*NFB*	*FB*
mean	24.8	15.0	1.5	1.7	5.3	4.1	2.6	1.3	*Nev*	66.5	66.0
sd	25.9	21.1	4.2	5.4	17.0	12.0	13.6	6.0	*Con*	22.1	19.7
									Occ	11.4	14.3
# obs	1855	2387	1643	2097	1715	2324	1815	2389		2011	2639
t	13.6		-0.8		2.6		4.3		χ^2= 10.7		
p-value	0.0		0.4		0.0		0.0		0.0		

Con: continuously, *Occ: occasionally*, *Nev: never*
FB: Family Business, *NFB*: Non-family Business

Table 5: Innovation outputs and labor productivity

	InnoNovel		*InnoFirm*		*InnoProcess*		log*LP*	
	NFB	*FB*	*NFB*	*FB*	*NFB*	*FB*	*NFB*	*FB*
mean	3.2	3.0	12.6	13.0	2.2	2.6	-1.2	-1.5
sd	11.7	9.5	22.3	21.4	6.6	7.0	1.0	0.9
# obs	1599	2096	1557	2057	1368	1797	1889	2493
t	0.7		-0.5		-1.6		9.4	
p-value	0.5		0.6		0.1		0.0	

FB: Family Business, *NFB*: Non-family Business

Table 6: Importance of financial sources for investment and innovation (%)

Source	**Investment**			**Innovation**		
	NFB	*FB*	z-test	*NFB*	*FB*	z-test
Cash flow	73.0	67.6	3.8	60.1	60.8	-0.4
Increase in equity capital	6.4	6.1	0.4	4.7	3.9	1.1
Shareholder loans	10.0	13.1	-3.0	6.1	8.3	-2.3
Bonds	0.4	0.5	-0.1	0.7	0.5	0.7
Overdraft credits	16.3	25.2	-6.9	9.0	15.8	-5.5
Earmarked bank credits	21.3	32.0	-7.7	5.7	9.7	-4.0
Public loans	9.5	10.4	-1.0	4.4	5.1	-0.9
Public allowances	14.0	8.6	5.5	12.1	7.9	3.9
Other sources	1.1	1.8	-1.8	1.4	0.8	1.5

FB: Family Business, *NFB*: Non-family Business

Table 7: Financial need (*fn*) (%)

	NFB	*FB*
Without financial need *fn*=0	45.8	38.7
Financial need *fn*=1 (cash)	35.7	35.0
Financial need *fn*=2 (cash and loan)	18.5	26.3
Total %	100	100
# obs	827	1208
χ^2	19.1	
p-value	0.0	

Estimation Results

Table 8: CMP estimation of recursive system

	Model (A) *InnoNovel*	Model (B) *InnoFirm*	Model (C) *InnoProcess*
Equation 1: Financial need (*fn*)			
Family business (*FB*)	0.280***	0.289***	0.275***
	[0.075]	[0.074]	[0.074]
Employees with university degree (*UD*)	0.353*	0.424**	0.355*
	[0.182]	[0.181]	[0.181]
Training expenditures	1.682**	1.570**	1.620**
	[0.751]	[0.742]	[0.742]
Continuously R&D	0.465***	0.483***	0.499***
	[0.098]	[0.097]	[0.097]
Occasionally R&D	0.377***	0.385***	0.393***
	[0.099]	[0.098]	[0.098]
East Germany	-0.111	-0.101	-0.104
	[0.079]	[0.078]	[0.078]
Cash flow	0.575***	0.592***	0.593***
	[0.087]	[0.087]	[0.087]
Raising equity capital	0.542***	0.608***	0.605***
	[0.157]	[0.155]	[0.155]
Credits loans	0.194	0.205*	0.217*
	[0.125]	[0.123]	[0.123]
Bonds and notes	0.049	-0.065	0.033
	[0.384]	[0.378]	[0.379]
Overdraft credits	0.351***	0.364***	0.332***
	[0.099]	[0.098]	[0.098]
Restricted bank credits	0.394***	0.408***	0.392***
	[0.125]	[0.124]	[0.124]
Public and publicly subsidized credits	0.335**	0.316**	0.335**
	[0.139]	[0.138]	[0.138]
Public subsidies and allowances	0.157	0.171	0.138
	[0.114]	[0.113]	[0.113]
Other sources	0.487	0.508	0.625*
	[0.354]	[0.349]	[0.349]
Equation 2: Innovation input (*I*)			
Family business (*FB*)	-0.001	-0.000	-0.001
	[0.014]	[0.015]	[0.015]
Financial need (*fn*)	0.067***	0.071***	0.069***
	[0.012]	[0.012]	[0.012]
Family business (*FB*)× Financial need (*fn*)=1 (cash)	-0.030*	-0.033*	-0.030*
	[0.017]	[0.017]	[0.017]
Family business (*FB*)× Financial need (*fn*)=2 (cash and loan)	-0.047**	-0.043*	-0.041*
	[0.024]	[0.025]	[0.025]
Equity ratio in 2006	0.0003**	0.0005***	0.0004**
	[0.00016]	[0.0002]	[0.0002]
Return on sales last 2 years	-0.004	-0.004	-0.004
	[0.002]	[0.002]	[0.003]
Constant	-0.046	-0.047	-0.039
	[0.032]	[0.033]	[0.033]
Equation 3:			

. . . continued

	Model (A) ***InnoNovel***	Model (B) ***InnoFirm***	Model (C) ***InnoProcess***
Innovation output (*InnoOuput*)			
Family business (*FB*)	0.751	-0.424	0.078
	[1.004]	[1.663]	[0.644]
Innovation input (*I*)	56.420***	72.679***	7.384**
	[4.651]	[9.847]	[3.108]
Family business (*FB*)×Innovation input (*I*)	-12.704***	5.362	5.362**
	[3.757]	[7.683]	[2.486]
Financial need (*fn*)	1.769**	9.228***	2.658***
	[0.840]	[1.461]	[0.558]
Family business (*FB*)×	-1.026	-0.268	-0.074
Financial need (*fn*)=1 (cash)	[1.203]	[1.999]	[0.807]
Family business (*FB*)×	-1.428	-4.468	-1.039
Financial need (*fn*)=2 (cash and loan)	[1.735]	[2.875]	[1.164]
Constant	1.876	5.227	2.367*
	[2.081]	[3.450]	[1.367]
Equation 4: Labor productivity $\log LP$			
Family business (*FB*)	-0.216***	-0.223***	-0.231***
	[0.043]	[0.050]	[0.048]
Financial need (*fn*)	0.078*	0.103**	0.073
	[0.040]	[0.048]	[0.047]
InnoNovel	-0.001		
	[0.005]		
InnoFirm		-0.003	
		[0.003]	
InnoProcess			-0.005
			[0.009]
Family business (*FB*)×	-0.002		
InnoNovel	[0.003]		
Family business(*FB*)×		-0.000	
InnoFirm		[0.002]	
Family business(*FB*)×			-0.002
InnoProcess			[0.005]
East Germany	-0.320***	-0.324***	-0.279***
	[0.040]	[0.040]	[0.044]
Regional turnover	-0.463***	-0.439***	-0.551***
	[0.065]	[0.065]	[0.072]
National turnover	-0.215***	-0.204***	-0.254***
	[0.052]	[0.051]	[0.060]
Constant	-0.522***	-0.510***	-0.448***
	[0.123]	[0.124]	[0.134]
Parameters $\operatorname{atanh}\rho$ and $\ln\sigma^{c}$			
$\ln\sigma_2$	-1.754***	-1.752***	-1.753***
	[0.019]	[0.019]	[0.019]
$\ln\sigma_3$	2.518***	3.008***	2.023***
	[0.030]	[0.024]	[0.021]
$\ln\sigma_4$	-0.373***	-0.366***	-0.374***
	[0.019]	[0.022]	[0.022]
$\operatorname{atanh}\rho_{12}$	-0.144***	-0.176***	-0.166***
	[0.054]	[0.055]	[0.055]
$\operatorname{atanh}\rho_{13}$	0.018	-0.144***	-0.184***
	[0.047]	[0.052]	[0.056]

...continued

	Model (A) ***InnoNovel***	Model (B) ***InnoFirm***	Model (C) ***InnoProcess***
atanh ρ_{14}	-0.109*	-0.117*	-0.105
	[0.065]	[0.068]	[0.073]
atanh ρ_{23}	-0.544***	-0.231***	-0.098
	[0.066]	[0.087]	[0.069]
atanh ρ_{24}	-0.092**	-0.076	-0.088**
	[0.038]	[0.053]	[0.041]
atanh ρ_{34}	0.113*	0.208***	0.094
	[0.067]	[0.075]	[0.103]
Industry effects	Yes	Yes	Yes
Size effects	Yes	Yes	Yes
Observations	1889	1883	1849
df_m	142	142	142
χ^2	1393.13	1471.62	1273.50
p-value	0.000	0.000	0.000

[a] Standard errors in brackets, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ [b] Model (A)=share of turnover with market novelties *InnoNovel*, model (B)=share of turnover with firm novelties *InnoFirm* and model (C)=Reduction of costs by process innovations *InnoProcess* [c] $\text{atanh}\,\rho$ and $\ln \sigma$ are transformations of parameters ρ and σ, respectively, into an unbounded scale, that eliminates the possibility that in the course of its search, course of its search, Maximum Likelihood will submit impossible trial values for the parameters, such as negative value for a σ (Roodman 2011). [d] $._{ij}$ stands for equations *i* and *j*

Table 9: Average marginal effects for equation (1)

	(A) Model: *InnoNovel*	**(B) Model: *InnoFirm***	**(C) Model: *InnoProcess***
Family business (*FB*)	0.075***	0.077***	0.069***
	[0.020]	[0.019]	[0.018]
Eastern Germany	-0.030	-0.027	-0.026
	[0.021]	[0.020]	[0.019]
Continuously R&D	0.125***	0.130***	0.126***
	[0.026]	[0.025]	[0.024]
Occasionally R&D	0.101***	0.103***	0.099***
	[0.026]	[0.026]	[0.024]
Employees with university degree (*UD*)	0.095*	0.114**	0.090**
	[0.049]	[0.048]	[0.046]
Training expenditures	0.453**	0.423**	0.411**
	[0.201]	[0.198]	[0.187]
Observations	740	731	596

Standard errors in brackets
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 10: Individual equations

	(1) Financial need	(2) *Innoexp*	(3) *InnoNovel*	(4) log ***LP*** ***InnoNovel***	(5) *InnoFirm*	(6) log***LP*** ***InnoFirm***	(7) *InnoProcess*	(8) log***LP*** ***InnoProcess***
Family business (*FB*)	0.263***	-0.027	-2.972	-0.211***	-4.256	-0.221***	-1.169	-0.227***
	[0.075]	[0.021]	[3.266]	[0.043]	[2.945]	[0.049]	[2.053]	[0.048]
Employees with university degree (*UD*)	0.264							
	[0.182]							
Training expenditures	1.604**							
	[0.762]							
Continuously R&D	0.421***							
	[0.097]							
Occasionally R&D	0.381***							
	[0.100]							
Eastern Germany	-0.125			-0.331***		-0.338***		-0.289***
	[0.079]			[0.041]		[0.041]		[0.044]
Cash flow	0.595***							
	[0.087]							
Raising equity capital	0.444***							
	[0.153]							
Credits loans	0.196							
	[0.125]							
Bonds and notes	0.114							
	[0.388]							
Overdraft credits	0.387***							
	[0.099]							
Restricted bank credits	0.365***							
	[0.126]							
Public and publicly subsidized credits	0.372***							
	[0.139]							
Public subsidies and allowances	0.106							
	[0.113]							
Other sources	0.398							

…continued

	(1) Financial need	(2) *Innoexp*	(3) *InnoNovel*	(4) log ***LP*** ***InnoNovel***	(5) *InnoFirm*	(6) log***LP*** ***InnoFirm***	(7) *InnoProcess*	(8) log***LP*** ***InnoProcess***
	[0.359]							
Family business (*FB*)×		0.030	4.670		7.506**		3.284	
Financial need (*fn*=1) (cash)		[0.023]	[3.344]		[3.184]		[2.237]	
Family business (*FB*)×		-0.021	0.324		-3.323		-0.966	
Financial need (*fn*=2) (cash and loan)		[0.033]	[4.623]		[4.527]		[3.114]	
Financial need (*fn*)		0.091***	11.120***	0.022	14.733***	0.017	6.965***	0.020
		[0.013]	[1.815]	[0.025]	[1.793]	[0.025]	[1.227]	[0.027]
Equity ratio 2006		0.001***						
		[0.000]						
Return on sales last 2 years		-0.004						
		[0.003]						
I			44.215***		67.031***		7.555**	
			[6.337]		[7.144]		[3.738]	
Family business (*FB*)×*Innoexp*			-17.051*		15.503		11.419**	
			[8.697]		[11.211]		[5.614]	
InnoNovel				0.002				
				[0.002]				
InnoFirm						0.001		
						[0.001]		
InnoProcess								> 0.001
								[0.004]
Family business (*FB*)×*InnoNovel*				-0.001				
				[0.003]				
Regional turnover				-0.459***		-0.436***		-0.535***
				[0.065]		[0.066]		[0.073]
National turnover				-0.209***		-0.203***		-0.243***
				[0.052]		[0.052]		[0.061]
Family business (*FB*)×*InnoFirm*						0.000		
						[0.002]		
Family business (*FB*)×*InnoProcess*								-0.003
								[0.005]

…continued

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Financial need	***Innoexp***	***InnoNovel***	log ***LP InnoNovel***	***InnoFirm***	log***LP InnoFirm***	***InnoProcess***	log***LP InnoProcess***
Constant		-0.172***	-35.012***	-2.352***	-20.280***	-2.390***	-14.075***	-1.213***
		[0.046]	[6.861]	[0.154]	[5.920]	[0.151]	[3.876]	[0.168]
cut1 Constant	1.076***							
	[0.237]							
cut2 Constant	2.272***							
	[0.242]							
Sigma Constant		0.214***	23.775***		27.988***		15.839***	
		[0.005]	[0.876]		[0.724]		[0.622]	
Industry effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Size effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1197	1402	1421	1475	1403	1457	1215	1232
df_m	42	33	33	34	33	34	33	34
χ^2	321.69	362.31	405.82		715.55		290.52	
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Standard errors in brackets
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[a] Standard errors in brackets, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ [b] Each equation was estimated individually using the regression models as specified as follows, not in a system of equations: model (1)=ordinal probit, (2), (3),(4) and (5)=tobit, (6),(7) and (8)=OLS