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Financing of Innovation in SMEs

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Abstract

This licentiate thesis consist of two essays. Both essays deal with corporate finance and its impact on innovation investment.

In the first essay we use German Community Innovation Survey to identify financially constrained firms. Contrary to previous studies we find that the relationship between financial constraints and firm size is inverted u-shaped and that it is the group of medium sized firms which has the largest funding gaps. This is explained by the fact that these firms have high innovation capabilities but at the same time face high cost of capital. Furthermore, we test if financial constraints have an impact on firm productivity growth. We find negative effects from funding gaps on productivity, but only for investment in tangible capital and not for innovation investments.

The second essay investigates whether there has been a change in the productivity and funding mix of innovative SMEs post stricter bank regulations. Our result shows that the likelihood of using bank loans as a funding source has not changed for innovation investments nor for tangible investments after stricter capital regulations have been announced. On the other hand, sources such as subsidies have increased due to regulatory programs that have been implemented in the aftermath of the recent financial crisis. Furthermore, SMEs productivity has not changed post stricter bank regulations. Overall, the impact from different sources of funding on productivity is rather limited.

Keywords: Financial constraints, SMEs and innovation capability, Productivity, Funding mix, Bank regulation.
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Introduction

A firm has essentially two available sources for investment expenditures: internal funding and external funding. In its core essence internal funding originates from retained earnings while external funding consists of various debt contracts such as bank loans. Contrary to the Modigliani-Miller theorem, capital structure matters in imperfect capital markets with presence of information asymmetry. When supplier of credit have less information regarding the quality of a certain investment, they are forced to charge a risk premium reflecting the average risk of an investment project. This creates a wedge between the cost of internal and external capital. Thus, investors are faced with a hierarchy of funding sources were funds with lower cost will be used first. Hence, internal funding will be preferred over debt and debt over equity. Generally this is refereed to as the pecking order theory. Given that internal funding is finite, firms usually need to seek external funding. However, due to market imperfections firms with potentially profitable investment opportunities may not be able to acquire it. Thus, a firm is considered being financially constrained if investment is restricted by its access to internal funding due to the fact that it is unable to acquire sufficient external funding.

Financial constraint is in particularly relevant for young and small innovative firms. The availability of external funding has been acknowledge as a significant determination factor for hampering the growth of small and medium sized firms Jarvis (2000), Mina et al. (2013). Moreover, small firms are associated with higher operational risk and consequently with a greater likelihood of bankruptcy. In addition the younger and smaller the firm, the shorter is their track record and the less collateral is available. This creates obstacles for debt funding (Hall & Lerner 2010, Berger & Udell 1998, 2002, Guariglia 2008).

Furthermore, it has long been acknowledged that innovation activity is an essential determination factor for productivity, competitiveness and economic growth. The role of young firms' innovation capacity has been emphasized since their innovations generate structural change in the economy (Mina et al. 2013). Thus, it is of policy concern that restricted access to funding for innovation investments may hinder economic growth and job creation.

Innovation investments differ from tangible investment expenditures due to its intangible nature of the asset being created as well as due to a high degree of uncertainty. Accordingly, similarly to the case of SMEs, there is a lack of collateral that may be used as security for debt funding. These features of innovation investments make raising external funding for innovation projects more expensive in comparison to tangible investments (Hall 2010).

The empirical literature confirms that firms tend to use internal funds over external funds when financing innovation projects (Hall 1989, 1992, Himmelberg & Petersen 1994, Bougheas et al. 2003, Czarnitzki & Hottenrott 2011). Overall the theoretical and empirical literature suggest that financial constraints depend not only on information asymme-

tries and moral hazard problems but also on other firm characteristics (Petersen & Rajan 1995, Czarnitzki 2006, Czarnitzki & Hottenrott 2009, Brown et al. 2012) such as, borrower-lender relationship (Martinelli 1997, Berger & Udell 2002) and other institutional factors (Hall 1992, Bloch 2005, Bhagat & Welch 1995).

A neglected factor in the empirical literature is the concept of innovation capability. It is hypothesized that innovation capability has an impact on financial constraints for innovation investment. This implies that a firm's capacity to generate and achieve new innovation projects, is an important determinant of financial constraints.

In the first part of this thesis the link between innovation capability, firm size and financial constraints is investigated. The results show that relationship between firm size and financial constraints is inverse u-shaped were medium sized firms are the most constrained firms. There may be several explanations for this result. As outlined in the theoretical framework the demand for innovation funding depends on a firms' innovation capability, thus, the higher innovation capability, the flatter the demand curve for innovation funding. Accordingly, medium sized firms may have a higher innovation capability and thereby a higher funding need then their smaller counterparts. In the same time medium sized firms may also face higher marginal cost of capital in comparison to larger firms.

An additional concern that may affect the availability of external funding for innovative SMEs is the increased demand for stricter bank capital regulation. There is a view among scholars that the crisis was primarily a regulatory failure (Acharya et al. 2012). As a result, the Bank for International Settlements has introduced new regulations, generally referred to as Basel III, which seeks to seal the loophole that was exposed during the financial crisis. In its core essence, Basel III increases minimum capital ratios, tightens the definition of bank capital and requires tighter liquidity requirements (Cosimano & Hakura 2011).

While the benefits of higher capital requirements are rather clear in terms of lower leverage and thereby lower risk of bank defaults, there is less consensus regarding its disadvantages. One major concern is that higher capital requirements will increase the overall cost of capital and thereby increase lending rates[2] and mitigate economic activity[3] (Baker & Wurgler 2015). Theoretically higher lending rates should have a greater impact on innovative SMEs.

The second part of this thesis investigates whether there has been a change in the financing sources for tangible and innovation investments post implementation of Basel III. It investigates if the funding mix, and in particular the use of bank loans, has changed post Basel III and whether this has changed differently for SMEs in comparison to large firms. The result shows that the likelihood of using bank loan as a funding source has not changed post stricter bank regulation for neither tangible investments nor for inno-

[2] see Admati et al. (2013) for a detailed discussion regarding increased capital requirement and capital cost.

[3] see e.g Cummins et al. (1994), Philippon (2009), Gilchrist et al. (2013) for further discussion and evidence on how the cost of capital effects real investments.

vation investments. However, a change in the funding mix of the firms is observed as the probability of using sources such as equity, mezzanine capital and overdraft has decreased while the probability of using subsides has significantly increased. Moreover, strong evidence is found that firm size is an important determinant of the funding mix.

The main results of these two papers yield a better identification of financially constrained firms, which in turn allows for more precise and improved policy suggestions.

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Funding gap for innovation and firm size: an inverted u-shape relationship

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Abstract

Using the German Community Innovation Survey, we identify financially constrained firms using an ideal test. Contrary to previous studies we find that the relationship between financial constraints and firm size is inverted u-shape and that it is the group of medium sized firms which has the largest funding gaps. This is explained by the fact that these firms have high innovation capabilities but at the same time face high cost of capital. Furthermore we test which consequences funding gaps have for subsequent productivity growth of firms.We find negative effects from funding gaps on productivity, but only for investment in tangible capital, not for innovation.

Key Words: Financial constraints, SMEs and innovation capability
JEL codes: D22, D21, D24, O31, O32

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1 Introduction

Innovation activity is an essential determination factor for productivity, competitiveness and economic growth. The role of young firms' innovation capacity has been emphasized since their innovations generate structural change in the economy (Mina et al. 2013). Thus, it is of policy concern that restricted access to funding for innovation investments may hinder economic growth and job creation.

Furthermore, innovation investments differ from tangible investment expenditures as it is characterized by the intangible nature of the asset being created as well as associated with a high degree of uncertainty. Thus, there is a lack of collateral that may be used as security for debt funding. These features of innovation investments make raising external funding for innovation projects more expensive in comparison to tangible investments (Hall 2010). Empirical literature shows that firms tend to use internal funds over external funds when financing innovation projects (Hall 1989, 1992, Himmelberg & Petersen 1994, Bougheas et al. 2003, Czarnitzki & Hottenrott 2011). Overall the theoretical and empirical literature suggests that financial constraints depend not only on information asymmetries and moral hazard problems but also on other firm characteristics (Petersen & Rajan 1995, Czarnitzki 2006, Czarnitzki & Hottenrott 2009, Brown et al. 2012) such as, borrower-lender relationship (Martinelli 1997, Berger & Udell 2002) and other institutional factors (Hall 1992, Bloch 2005, Bhagat & Welch 1995).

A neglected factor in the empirical literature that may affect have an impact on financial constraints for innovation investment is the concept of innovation capability. That is a firms' capacity to generate and achieve new innovation projects is an important determinant of financial constraints. To the best of our knowledge Hottenrott & Peters (2012) were first to relate the concept of innovation capability to financial constraints. Their paper is based on innovation survey data from Mannheim that directly measures liquidity constraints on innovation investment. In the survey firms are offered additional hypothetical liquidity and asked whether they would invest in innovation projects or use the additional liquidity for other expenditures. If the firm chooses to invest in additional innovation projects it is an indication that the firm has unpursued investment opportunities, that are not profitable enough to be invested in with external funding. Their results

show that financial constraint depends on innovation capability.

This paper is a further development of the approach developed by Hottenrott & Peters (2012). First, we modify the methodology by using an additional survey question were the firm is offered credit with a comparatively attractive interest rate instead of additional exogenous equity. Adding this second question re-insures consistency in the firms' response. If the firm chooses to invest in innovation projects when offered additional equity and credit indicates that the firm have financial needs for internal funding and for discounted external funding. Thus, such firm is financially constrained. The fundamental argument is based on the pecking order theory were internal funding should be preferred over external funding since its less expensive (Myers & Majluf 1984). Thus, the firm chooses to still invest despite the more expensive source of funding. According to Hall & Lerner (2010), this is an ideal way of measuring financial constraint, as it is a direct measure derived from survey data.

Moreover, we focus on firm size in addition to innovation capability as a determination factor for financial constraints. Prior research shows that financial constraints tends to be more severe for smaller firms[1]. The fundamental argument is based on the fact that young firms are subject to greater informational asymmetries leading to credit rationing and moral hazard problems. Thus, younger firms are associated with higher operational risk, less collateral and shorter track records. Older firms can benefit from established bank lending relationships were asymmetric information can be reduced Berger & Udell (2002).

Large established firms can take advantage of accumulated profits as well as build and extend on prior innovation projects while younger firms lack accumulated profits and may need to conduct more fundamental innovation that in turn may require more resources Czarnitzki & Hottenrott (2009). Moreover, bank funding may be more restricted for young small firms that engage in innovation conduction due to the due to high uncertainty of innovation project and the higher default risk of such firms Fritsch et al. (2006). In summery the literature suggests that innovation investment are subject to financial constraints. This may be even more severe for firms for small and/or young firms that may have higher capital cost in comparison to their larger counterparts. Thus, the em-

[1] see e.g Petersen & Rajan (1995), Berger & Udell (2002), Carpenter & Petersen (2002), Czarnitzki (2006)

pirical literature has had a focus on size classification mainly SMEs. However, to gain insight in how financial constraints can be tackled a higher degree of differentiation of size classes is needed. Moreover, new empirical evidence covering the post crisis period is necessary to investigate how the financial crisis has affected financial constraints and whether the impact was different for different size classes.

Furthermore, financial constraints can hamper productivity growth by impeding optimal resource allocation which ultimately may lead to reduced competition, capital investment and technology adoption.The channel of impact depends on type of financial friction and country. Thus, we empirically test whether financial constraints have an impact on a firms' productivity. Finally, we compare innovation investments with tangible investment expenditures and add the 2014 wave of the survey data. Theoretically financial constraints for investment in innovation projects should be more binding/severe since access to funding is particularly difficult for such projects due to greater information asymmetries and higher uncertainty.

Overall, these improvements yield a better identification of financially constrained firms which in turn allows for more precise and improved policy suggestions. Furthermore, we can study the change of financial constraints over time and how it is affected by various variables.

Our results show that the relationship between financial constraints and firm size is in fact inverted u-shaped. Moreover, being financially constrained for tangible investments reduces productivity level, while there is no impact on productivity for firms who are financially constrained for innovation.

The rest of the paper is organized as follows. Section 2 provides theoretical and empirical background. Section 3 contains data and model specification. Section 4 presents our estimation results. Section 5 provides discussion and conclusion.

2 Literature review

2.1 Theoretical framework

In principal a firm has two available funding sources namely, internal funding and external funding. Essentially internal funding consist of a firms retained while external

funding consists of various debt contracts. In an imperfect capital market the investment market will suffer from information asymmetries leading to credit rationing, moral hazard and adverse selection problems. Thus, if credit suppliers have less information regarding the quality of an investment project they are forced to charge a risk premium. This creates a wedge between the cost of internal and external funding. Firms face a hierarchy of financial funding sources were funds with lower cost will be used first. Thus, internal cash flow is preferred over debt and debt is preferred over equity (Myers & Majluf 1984, Hall et al. 2009). Given that internal cash flow is not infinite firms may need additional external capital however, because of market imperfections firms with potentially profitable investment opportunities may not be able to implement them. Thus, a firm is considered being financially constrained if investment is restricted by its access to internal funds due to the fact that it is unable to acquire sufficient external funding (Mina et al. 2013).

Problems of information asymmetries and hence financial constraints is in particularly relevant for young small firms. Thus, the availability of external funding has been acknowledge as a significant determination factor for hampering the growth of small and medium sized firms Jarvis (2000), Mina et al. (2013). Moreover, small firms are associated with higher operational risk and consequently with a greater likelihood of bankruptcy. In addition the younger and smaller the firm the shorter is their track record and the less collateral is available. Thus amplifying debt funding (Hall & Lerner 2010, Berger & Udell 1998, 2002, Guariglia 2008).

In order to illustrate how a firms innovation capability affects financial constraints a basic model is derived based on models of of firm investment behaviour by Howe & McFetridge (1976) and David et al. (2000).

In this model it is assumed that each firm has a set of innovation projects that in turn are determined by each firms' innovation capability (IC) that is, a firms' ability to create and implement innovation. These innovation projects are ranked according to their projected marginal rate of return in a descending order. Thus, the marginal rate of return is reflected by a downward sloping demand curve for innovation funding. This is illustrated in Figure 1 where the marginal cost of capital and marginal rate of return are plotted on the vertical axis and the amount of innovation projects on the horizontal axis.

The upward sloping marginal cost of capital reflects a firms' opportunity cost of investment. When innovation investment increases firms shift from internal funding (retained earnings) to external funding (debt and/or equity) which tends to push the marginal cost of capital upwards. This would be the case even if innovation investments would be financed entirely by internal funding. As firms' innovation investments increases firms would eventually have to fund their tangible investments with external funding. Thus, the flat range of the upwards slope of the marginal cost of capital in Figure 1 reflects internal use of capital while the increasing range reflects the use of external funding. For profit maximizing firms' innovation investment will occur to the point where the marginal rate of return equals the marginal cost of capital. Area A in figure 1 reflects potential innovation investment that's not profitable enough to be pursued with internal funding.

The marginal rate of return (MRR) may be described as a function of innovation expenditures (IE), innovation capability (IC) and other firm characteristics (FC). While marginal cost of capital (MCC) is a function of innovation expenditures (IE), alternative investment opportunities (IO), amount of available internal funds (IF) and other firm characteristics[2] (FC):

$$MRR_i = f(IE_i, IC_i, FC_i) \tag{1}$$

$$MCC_i = f(IE_i, IO_i, IF_i, FC_i). \tag{2}$$

If a firm receives additional exogenous equity capital[3], how does that affect innovation investments? If a firm has already reached its' optimal level of innovation investment using only available internal funds additional exogenous equity won't affect innovation investments. Thus, if a firm does not increase investments this may be due to i) the firm is faced with the same cost of capital indicating perfect capital market or ii) given the internal cost of capital the firm has no profitable innovation projects indicating an imperfect capital market. In both cases the firm is not financially constrained as in figure 1. However, if a firm would actually increase its innovation investments one can reject both hypotheses. Thus, the cost of internal and external funding is not the same indicating an imperfect capital market and implying that the firm is investing at a sub-optimal level

[2]Given an imperfect capital market, the cost of capital will be affected by other firm characteristics such as capital structure and creditworthiness.

[3]Assuming that this is not due to increased future demand

hence: the firm is financially constrained. Figure 2 illustrates a financially constrained firm who is exposed to exogenous equity capital, area A shows the potential innovation investments that could have been done but was not possible due to financial constraints.

Now, we consider two firms, A and B were firm A has a higher innovation capability. Meaning that, firm A has the ability to transform innovation ideas with a higher rate of return in comparison to firm B. Thus, firm A has a higher demand for funding hence, firm A has a flatter demand curve than firm B. The higher innovation capability the higher is the probability of innovation investment when given exogenous equity capital. Given that firm A and B receive the same amount of exogenous equity capital the impact will be larger for firm A than firm B. This is illustrated in Figure 3, where area A and B shows the set of innovation projects that are not profitable enough to pursue with external funding. Area A* and B* illustrates the additional innovation investment that is conducted given an exogenous equity shock.

Now instead we assume that both firm A and B have the same innovation capability however, firm A has a lower level of internal funding which essentially implies that firm A has a higher cost for external funding. Thus, if both firm A and B receive the same amount of external equity the effect will be larger on firms B innovation investment (see Figure 4).

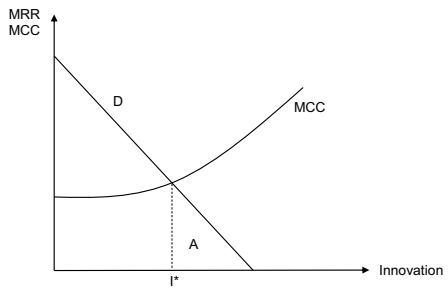

Figure 1: Unconstrained firm

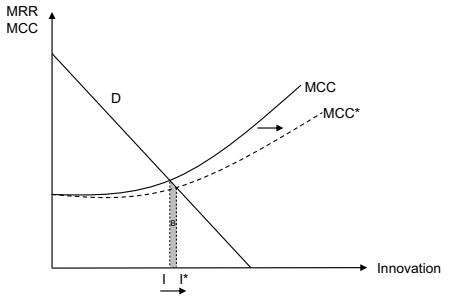

Figure 2: Constrained firm

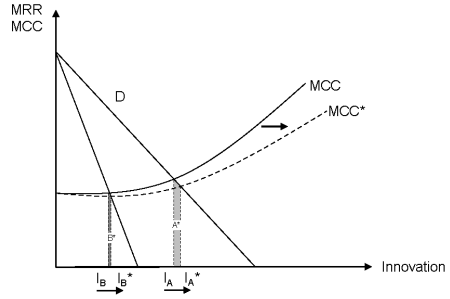

Figure 3: $IC_A > IC_B$

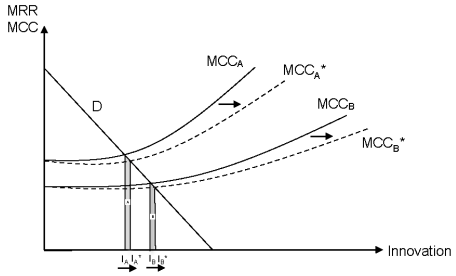

Figure 4: $IF_A < IF_B$

2.2 Empirical background

Empirical findings such as Himmelberg & Petersen (1994), Petersen & Rajan (1995), Berger & Udell (2002), Czarnitzki (2006), Ughetto (2008) and (Czarnitzki & Hottenrott 2009) shows that smaller firms (measured either as firm age, number of employees or assets) are more likely to be subject to financial constraints than their larger counterparts since they are not as capital intensive and can not provide as much collateral compared to their larger counter parts. On the other hand (Savignac 2008) uses french data to shows that financial constraints decreases with firm size and depends essentially on the firms ex-ante financing structure. Furthermore, according to Hyytinen & Toivanen (2005) small and medium firms who are dependent on external funding tend to have less innovation conduction in comparison to firms that are not dependent on external funding. Muller & Zimmerman (2008) Provide evidence that younger firms tend to have less equity capital which may increase interest rates that are demanded by suppliers of credit. Petersen & Rajan (1995) and Berger & Udell (2002) show that problems of asymmetric tend tend to be more severe for younger firms since they have not yet established a bank lending relationship. Thus, older firms benefit form long term borrower lender relationships as information asymmetric is mitigated. Moreover, using survey data Stoneman & Canepa (2002), Savignac (2008) and Schneider & Veugelers (2008) present that banks may be reluctant to finance innovation projects for younger firms due to the high default risk. Thus, Egeln et al. (1997) and Petersen & Rajan (1994) provide evidence for start ups being financial constrained.

3 Empirical approach

3.1 Data

The Mannheim innovation panel data (MIP) is a database provided by Centre for European Economic Research (ZEW). The MIP database is conducted on behalf of the German Federal Ministry of Education and Research since 1993 and is a part of the European-wide Community Innovation Surveys (CIS). The annual innovation survey contains important information regarding new products, improved products, services and expenditures for innovation. We use the 2007 and 2014 waves since these contain the same questions regarding additional funding capital. The questions asked in the survey take into account the firms' investment behaviour of the past three years. Thus, the 2007 and 2014 wave contains the aggregated survey outcome of year 2004 - 2006 and 2011 - 2013 respectively.

Innovation projects are defined as new or significantly improved products, services and/or in-house processes. Other investment expenditures refer to any investments made in fixed and/or intangible assets. Table 1 provides the definitions of the variables used in the empirical model.

Table 1: Variable definitions

Variable name	Definition
fc	Financial constraint with $fc \in [0, 1, 2]$
tfp	Total factor productivity measured as value added
IC	Innovation capability measured by three categories
Size classes	Firm size by number of employees
Controls	Industry, firms size, located in east or west Germany, employees with university degree, age of a firm and firm type
Industry	NACE 2-digit industry code, 21 industries

The variable financial constraint (fc) is derived from the two following survey questions, i) assuming your company had at its disposal an unexpected additional profit or additional equity capital of 10% of last year's turnover. Which possibilities of resource-allocation would your enterprise choose most probably? ii) assuming instead of the un-

expected additional profit/additional equity capital, your company had access to a credit of the same amount and with a comparatively attractive interest rate. Would your enterprise implement the considered investments/innovation projects as well? The response options are presented in table 2. By selecting option, A and/or B in survey question one, that is implementation of additional investments/innovation project the firm insinuates that the marginal profit of such investment is expected to be higher than the other options. Moreover, it indicates that the firm has unpursued investment opportunities and a positive financial need for internal funding. A double selection of A and/or B in the first and second survey question indicates that the firm has a positive financial need for discounted external funding and indicates the firm is financially constraint. The fundamental argument is based on the pecking order theory were internal funding should be preferred over external funding since its less expensive (Myers & Majluf 1984). Thus, the firm chooses to still invest despite the more expensive source of funding offered. A firm will only double select if innovation capability exceeds available internal funds while, external funding is more expensive in comparison to the offered loan. Firms who only select option A and/or B in survey question one have a positive financial need only for additional internal funding. Any other combination of the response options indicates zero financial need. Thus, fc ranges from zero to two, $fc \in [0, 1, 2]$:

- Neither A nor B is selected in survey question one $fc = 0$
- A and/or B is selected in survey question one but not in survey question two $fc = 1$
- Double selection of A and/or B $fc = 2$

Table 2: Response option for survey question one and two

Response option for survey question one	
A	Implementation (of additional) investments
B	Implementation (of additional) innovation projects
C	Retention/accumulation of reserves
D	Payout of proprietors (incl. repayments of shareholders' loans)
E	Payment of liabilities (e.g payment of bank credits, supplier credit)
F	No estimation possible
Response option for survey question two	
A	Implementation of investments
B	Implementation of innovation projects
C	No, rather improbable
D	Estimation impossible

The variable innovation capability (IC) is a categorical variable derived from the third survey question and refers to a firm's capacity to generate innovation. This question shows how often a firm conducts in-house R&D were the response options are:

- Continuous R&D
- Occasional R&D
- No R&D activity

Furthermore, total factor productivity (tfp) is measured using Wooldridge (2009)'s approach. A set of control variables is used in the model. Following previous empirical literature financial constraints are assumed to be affected by firm size and firm age. In order to detect a possible non-linear relationship between firm size and financial constraint we add squared log employees in the estimation model as well as seven size classes (see table 3). This allows for testing various specifications of the size effect. Firm age is presented by a dummy variable indicating whether a firms is younger than 3 years. Firms

located in East Germany are subject to more subsides and might therefore face lower financial constraints (Czarnitzki 2006). We therefore include a dummy variable indicating the geographical location of a firm in either West or East Germany. Moreover, we control for differences of innovation and investment intensity across industries (Table 4). The primary expense for innovation investment consists of salaries for high skilled employees. Thus, we include the share of employees with a university education as a proxy for a firm's human capital intensity. Furthermore, we control for firm type, which refers to the legal company form. Table 5 presents the legal firm types separated by firm size. Different firm types have access to different sources of funding as for example public equity and bond markets are only available for listed corporations.

Table 3: Seven size classes by amount of employees

Number of employees	Size category
0< employees $\leq$ 19	1
20 $\leq$ employees $\leq$ 49	2
50 $\leq$ employees $\leq$ 99	3
100 $\leq$ employees $\leq$ 249	4
250 $\leq$ employees $\leq$ 499	5
500 $\leq$ employees $\leq$ 999	6
10000 $\leq$ employees	7

Table 4: Industry category by size for 2013 (%)

Industry	Firm size			
	<50	50-249	>250	All
Mining	3.2	4.4	5.7	3.9
Food, tobacco	4.7	5.5	3.7	4.8
Textiles	4.5	3.1	1.3	3.7
Wood, paper	3.2	4.7	1.9	3.4
Chemicals	2.3	4.0	5.4	3.2
Plastics	2.7	4.3	3.0	3.1
Glass, ceramics	2.0	2.6	3.8	2.4
Metals	6.8	8.4	5.8	7.1
Machinery	4.9	8.1	7.4	6.0
Electrical equipment	2.5	6.5	9.8	4.5
Medical, instruments	1.5	3.2	6.1	2.6
Transport equipment	6.2	7.2	3.4	6.1
Furniture	6.3	4.9	3.7	5.6
Wholesale	4.2	2.8	2.8	3.7
Retail, automobile	8.1	8.7	7.5	8.2
Transport, communications	5.1	4.6	2.6	4.6
IT, telecom	3.3	2.8	10.0	4.0
Technical services	7.4	3.1	1.3	5.4
Firm-related services	7.1	1.7	2.0	5.1
Other services	4.9	4.4	8.3	5.2
n.a.	9.1	4.9	4.4	7.4
Total	100.0	100.0	100.0	100.0
Obs	3,235	1,374	702	5,311

Table 5: Legal company forms for 2013 (%)

Legal	Firm size			
form	<50	50-249	>250	All
1	27.3	9.8	9.6	20.4
2	13.6	22.2	23.8	17.2
3	57.9	65.4	53.5	59.2
4	1.3	2.6	13.1	3.2
Total	100.0	100.0	100.0	100.0
Obs	3,232	1,372	701	5,305

1=sole proprietorship, partnership
2=trade partnership, limited company
3=limited liability corporation (GmbH)
4=listed corporation (AG)

3.2 Descriptive statistics

Tables 6 and 7 present the variable fc by year and firm size for innovation projects and investment expenditures respectively. In 2014 for innovation projects 48.2% of the firms reported that they were not financially constraint ($fc = 0$) which is an increase with 5.8% from year 2007. For tangible investment the amount of firms who reported that they were not financially constraint nearly doubled from 10.4% to 20.1%. For innovation projects we observe a reduction in ($fc = 1$) from 34.6% to 33.1% and a somewhat larger fluctuation for other tangible investments from 46.4% to 42.6%, which implies a decline in internal financial constraints. The amount of firms who would invest in further innovation projects and tangible investment projects if given additional external funding ($fc = 2$) declined from 23.0% to 18.8% for innovation projects and from 43.2% to 37.3% for other investment expenditures.

Overall, there has been a reduction in financial constraint for both innovation projects and tangible investment expenditures from 2007 to 2014. Moreover, comparing innovation projects with tangible investment expenditures one may observe that there are more unpursued tangible investment opportunities than innovation projects. Noteworthy is that, in 2014 more than twice as many companies reported ($fn = 2$) for tangible investment expenditures in comparison to innovation projects. Thus, indicating that tangible investment expenditures may be on average more financially constraint.

Evaluating the descriptive statistics according to size, in 2014 for innovation projects more than half (53.7%) of the smallest firms reported that they were not financially constraint ($fc = 0$) which is an increase with 6.3% from 2007. Thus, for innovation projects the smallest firms are least financially constraint. For tangible investment expenditures the opposite is observed were the largest firms reported least financial constraint ($fc = 0$). For innovation projects there has been a reduction in $fc = 1$ among size category 1 and 3 while an increase is observed for size category 2. Thus, $fc = 1$ is more common among medium-sized firms. For tangible investment projects a decrease is observed among all size categories were ($fc = 1$) is most common among the smallest firms. For all size categories a reduction in $fc = 2$ is observed for both innovation projects and tangible investment expenditures which is also strongest for medium-sized firms.

Table 6: Share of financially constraint firms (%) for investment expenditure by year and size

size	<50		50-249		>250		All	
year	2007	2014	2007	2014	2007	2014	2007	2014
fc1=0	11.3	21.9	8.4	13.6	11.5	26.4	10.4	20.1
fc1=1	47.6	43.4	44.0	42.7	47.2	37.8	46.4	42.6
fc1=2	41.2	34.7	47.6	43.7	41.3	35.8	43.2	37.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
#obs	1,392	1,444	813	646	436	246	2,641	2,336

Table 7: Share of financially constraint firms (%) for innovation expenditure by year and size

size	<50		50-249		>250		All	
year	2007	2014	2007	2014	2007	2014	2007	2014
fc2=0	47.4	53.7	40.1	38.2	32.7	42.5	42.4	48.2
fc2=1	31.1	30.1	34.4	38.4	44.2	36.3	34.6	33.1
fc2=2	21.5	16.2	25.5	23.4	23.1	21.2	23.0	18.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
#obs	990	1,047	593	458	364	212	1,947	1,717

Table 8 presents the variable innovation capability (IC) by year and size. Nearly two thirds of the firms reported that they have never conducted any R&D. There has been an increase in never conducting R&D while there has been an increase in for continuous and occasional engagement. The smallest firms are most likely not to be engaged in any R&D while the largest firms are the firms who are most likely to conduct continues R&D engagement. Occasional R&D is most common among medium-sized firms. while a reduction in continuous R&D is observed for the smallest firms an increase is observed for the size category medium-sized and large firms. Occasional R&D engagement has decreased among all size categories.

Table 8: Innovation capability by size and year

size	<50		50-249		>250		Total	
year	2007	2014	2007	2014	2007	2014	2007	2014
never	77.5	81.8	62.4	61.9	42.8	45.3	67.0	71.8
occasionally	11.2	7.3	16.1	12.6	11.6	8.3	12.7	8.8
continuously	11.4	10.9	21.2	25.5	45.6	46.4	20.3	19.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
#obs	3051	3235	925	1374	580	702	4556	5311

Table 9: Descriptive statistics of variables in the model

variable	N	mean	sd	min	max
fc1	3227	1.28	0.68	0	2
fc2	2415	0.76	0.78	0	2
logemp	3380	3.79	1.62	0	11.64
logemp^2	3380	16.97	14.26	0	135.4
r&d never	3380	0.63	0.48	0	1
r&d cont	3380	0.23	0.42	0	1
r&d occas	3380	0.13	0.34	0	1
human cap	3380	18.28	22.79	0	100
east	3380	0.36	0.48	0	1
fambes	3380	0.61	0.49	0	1
young	3380	0.03	0.17	0	1
firmtype=1	3380	0.16	0.37	0	1
firmtype=2	3380	0.19	0.39	0	1
firmtype=3	3380	0.62	0.49	0	1
firmtype=4	3380	0.03	0.17	0	1

3.3 Empirical model

Equation (3) describes a firms' financial constraints for investment expenditures and innovation projects at time t as a function of innovation capability (IC), size (measured by number of employees), $employees^2$ and controls. Following previous research our control variables consist of industry type, firm type, firm age, amount of employees with university degree and weather a firm is located in west or east Germany. Financial constraint (fc) is a ordinal categorical variable, $fc \in [0, 1, 2]$ thus, the use of a ordinal probit model were fc_t^* were denotes the latent financial constraints for investment expenditures and fc_t^* the latent financial constraints for innovation projects.

$$fc_{kt}^* = f(IC, employees, employees^2, controls) + \varepsilon_{kt} \tag{3}$$

where:

$$fc_t = 0 \text{ if } fc_t^* \leq \mu_1$$

$$fc_t = 1 \text{ if } fc_t^* \ \mu_1 < fc_{it}^* \leq \mu_2$$

$$fc_t = 2 \text{ if } fc_t^* \leq \mu_2$$

Roodman's conditional mixed process (CMP) is applied in STATA[4] to estimate equation (3). The CMP model has several advantages. First, it is a seemingly unrelated regression (SUR) estimator which allows several equations to be estimated simultaneously using a system approach were the error terms are allowed to be correlated. Taking such correlation into account mitigates omitted variable bias. Furthermore, it's a flexible model were the dependent variable may be binary, censored, interval, or continuous and also allows each equation to vary by observations.

Equation four describes a firm's productivity as a function of financial constraints (fc), size and control variables. Thus, tfp_{t+1} denotes total factor productivity for tangible investment expenditures and innovation projects. In order to estimate how financial constraints, affect firm productivity the equations are forwarded one-time period. Thus, for the survey period 2011-2013, $t+1$ refers to year 2014. However, for the survey period 2004-2006, $t+1$ refers to year 2008 due to lack of data for year 2007. Furthermore, an essential issue in estimating production functions is the concern of endogeneity that may occur due to correlation between unobserved productivity shocks and observed input levels, resulting in a biased estimates from OLS. In order to avoid this bias Wooldridge (2009) estimation method is used were material cost is used as a proxy for intermediate inputs yielding a dynamic OLS model with robust standard errors accounting for both serial correlation and heteroskedasticity.

$$tfp_{t+1} = f(fc_t^* \, size, controls) + \epsilon_t \tag{4}$$

4 Results

4.1 Estimation Results

Equation three is estimated using an ordinal probit model solved in a simultaneous equation system for both tangible investments and innovation projects. Table **??** presents the estimation result, were fc_1 denotes the financial constraints for tangible investments and

[4]See eg.Roodman (2009)

fc_2 XY. The positive and significant $atanh_(\rho_{12})$ denotes the correlation between the error terms which confirms the importance of using a system estimator. The negative and significant year coefficient indicates that financial constraints have decreased relative to year 2007 for both investment projects and tangible investment expenditures. In the first column we control for firm size as a continuous and squared variable while column two size as a categorical variable with seven classes. Column three adds bank loan (bank) and internal funding (cash) as control variables.

$ln(emp)$ is positive and significant while $(ln)emp^2$ is negative and significant. This implies that the relationship between financial constraint and firm size is not linear but in fact inverse u-shaped for both tangible investments and innovation projects. This is result is confirmed in column two (Table **??**) were the probability of being financially constraint is highest among medium-sized firms and lowest among the smallest and largest firms. The relationship between firm size and financial constraints is a well explored field within investment literature (Fazzari et al. 1988, Kadapakkam et al. 1998, Carpenter & Petersen 2002) were smaller firms are more financially constrained then their larger counterparts . However, the majority of previous research has been based on U.S manufacturing data. Thus, there is a lack of research investigating in detail how firm size affects financial constraints using non-manufacturing European data.

The innovation capability coefficient is positive and significant entailing that the probability of being financially constraint is positively related to innovation capability. Firms with occasional and continuous R&D re more financially constraint than firms with no R&D conduct. This result is in line with Hottenrott & Peters (2012). However, there is no significant difference between firms which perform R&D continuously and firms which perform R&D occasionally.

The coefficient for share of employees with university degree is negative and significant for tangible investment expenditures. However it is insignificant for innovation projects. This implies that for tangible investment expenditures the probability of being financially constrained decreases as the share of employees with university degree increases. While it has no affect for innovation projects.

For tangible investment expenditures the probability of being financially constraint increases if a firm is located in East Germany. For innovation projects the coefficient is

insignificant.

In the next step we analyze how financial constraints affect productivity. Table 11 presents the estimation result as specified in equation (4). A Hausman test has been performed which shows that random effects model is not rejected. Thus, we use between, fixed and random effects. Financial constraints for tangible investment expenditures reduces productivity level, while there is no impact on productivity for innovation expenditures. The insignificant year coefficient indicates that there has been no change in the level of productivity. Moreover, productivity increases with firm size. This result is inline with the previous literature.

In sum, there has been a reduction in unpursued investment opportunities, thus financial constraints have decreased since year 2007. However, firms with higher innovation capability are more likely to face financial constraints. Moreover, the relationship between firm size and financial constraints is inverse u-shaped. Furthermore, there has been no change in the level of productivity. However, firms who are financially constraint for tangible investment expenditures have a lower level of productivity while financial constraints for innovation projects have no impact on productivity.

Table 10: CMP estimation of equation system

labelCMP	(1)	(2)	(3)
Equation 1: fc1			
year 2013	-0.286***	-0.302***	-0.155***
	[0.052]	[0.053]	[0.050]
ln(emp)	0.252***	—	0.188***
	[0.056]		[0.059]
$\ln(emp)^2$	-0.024***	—	-0.019***
	[0.006]		[0.006]
size 50-249	—	0.210***	—
		[0.056]	
size $\geq$250	—	-0.055	—
		[0.077]	
cash=yes	—	—	-0.101
			[0.064]
bank=yes	—	—	0.368***
			[0.049]
r&d cont	0.199***	0.243***	0.163**

	[0.069]	[0.069]	[0.065]
r&d occa	0.226***	0.244***	0.160**
	[0.073]	[0.074]	[0.069]
humancap	-0.005***	-0.006***	-0.003**
	[0.001]	[0.001]	[0.001]
east=yes	0.199***	0.192***	0.130**
	[0.052]	[0.052]	[0.051]
fambes=yes	0.177***	0.152***	0.169***
	[0.052]	[0.052]	[0.051]
young=yes	0.222	0.204	0.310**
	[0.138]	[0.138]	[0.140]
firmtype=2	-0.149*	-0.082	-0.124
	[0.085]	[0.084]	[0.088]
firmtype=3	-0.119*	-0.067	-0.096
	[0.070]	[0.069]	[0.073]
firmtype=4	-0.050	0.014	-0.022
	[0.155]	[0.154]	[0.146]
industry FE	yes***	yes***	yes
firm RE	yes***	yes***	no
Equation 2: fc2			
year 2013	-0.119**	-0.132**	-0.006
	[0.057]	[0.057]	[0.071]
ln(emp)	0.127**	—	0.071
	[0.060]		[0.077]
$\ln(emp)^2$	-0.011*	—	-0.009
	[0.007]		[0.008]
size 50-249	—	0.118*	—
		[0.061]	
size $\geq$250	—	-0.086	—
		[0.082]	
cash=yes	—	—	-0.137
			[0.107]
bank=yes	—	—	0.321***
			[0.090]
r&d cont	0.885***	0.930***	0.352***
	[0.097]	[0.100]	[0.086]
r&d occa	0.837***	0.852***	0.266***
	[0.098]	[0.099]	[0.089]
humancap	0.002	0.001	-0.001
	[0.001]	[0.001]	[0.002]

east=yes	0.013	-0.001	0.075
	[0.056]	[0.056]	[0.070]
fambes=yes	0.291***	0.270***	0.265***
	[0.060]	[0.060]	[0.069]
young=yes	0.484***	0.471***	0.694***
	[0.153]	[0.153]	[0.191]
firmtype=2	0.050	0.094	0.133
	[0.097]	[0.096]	[0.133]
firmtype=3	0.104	0.132	0.198*
	[0.083]	[0.082]	[0.117]
firmtype=4	0.107	0.164	0.296
	[0.161]	[0.158]	[0.180]
industry FE	yes***	yes***	yes*
firm RE	yes***	yes***	no
μ_{11}	-0.943***	-1.416***	-1.020***
	[0.174]	[0.154]	[0.190]
μ_{12}	0.616***	0.151	0.492***
	[0.172]	[0.135]	[0.189]
μ_{21}	0.983***	0.727***	-0.093
	[0.217]	[0.178]	[0.308]
μ_{22}	2.142***	1.890***	1.280***
	[0.261]	[0.222]	[0.309]
$\log \sigma_1$	-0.699**	-0.665**	—
	[0.283]	[0.270]	
$\log \sigma_2$	-0.860*	-0.843*	—
	[0.498]	[0.487]	
atanh ρ_{12}	0.806***	0.798***	0.790***
	[0.126]	[0.126]	[0.041]
Observations	3380	3380	2738
df(m)	64	64	68
χ^2	243.68	240.61	322.25
p	0.000	0.000	0.000

Standard errors in brackets

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.2 Robustness check

We perform a set of robustness checks. In the first step capital structure is used as an additional control variable. The estimation result is only significant for tangible investments. The negative tangible coefficient implies that firms with high leverage are less

Table 11: Productivity effects of financial constraints

	(1) tfp BE	(2) tfp FE	(3) tfp RE
$fc1_{t-1}$	-0.092***	-0.048	-0.090***
	[0.027]	[0.126]	[0.026]
$fc2_{t-1}$	0.005	-0.030	0.006
	[0.026]	[0.121]	[0.026]
year 2014	0.047	0.112	0.054
	[0.037]	[0.099]	[0.035]
size=2	0.036	-0.100	0.022
	[0.050]	[0.428]	[0.050]
size=3	0.286***	0.021	0.271***
	[0.054]	[0.848]	[0.054]
size=4	0.379***	0.003	0.378***
	[0.054]	[1.029]	[0.054]
size=5	0.551***	0.264	0.534***
	[0.070]	[0.820]	[0.069]
size=6	0.692***	0.302	0.671***
	[0.096]	[0.750]	[0.093]
size=7	0.949***	0.000	0.921***
	[0.105]	[.]	[0.106]
Constant	0.785***	0.934**	0.789***
	[0.045]	[0.388]	[0.044]
Observations	1051	1051	1051
df(m)	9	996	9
χ^2			200.79

Standard errors in brackets

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Hausman test: XY

financially constrained which is counter intuitive. A possible explanation for this could be that highly leveraged firms have obtained loans and thereby performed all planned investment opportunities.

An additional survey question is used where the firm is asked if their company did not implement innovation projects due to lack of financial resources. We find a positive correlation between financial constraints and no implementation. Thus, there is correspondence between the hypothetical ideal test and real decisions.

5 Conclusions

This paper investigates the relationship between firm size and funding gap using the Mannheim innovation panel. We use the approach developed by Hottenrott & Peters (2012) were high innovation capability is assumed to be the major driving force funding gap for innovation. However, we extend the approach of Hottenrott & Peters (2012) in several ways. We add an additional survey question in order re-insure consistency in the firms response question. Innovation investments are distinguished from tangible investments were theoretically innovation investments should be more financially constrained [5]. We add the 2014 wave of the survey to see changes over time and furthermore we test whether financial constraints have an impact on firm productivity.

Our results show that the relationship between firm size and funding gap is inverse u-shaped were the middle sized firms are the most constrained firms. There may be several explanations for this result. As outlined in the theoretical framework the demand for innovation funding depends on a firms' innovation capability, thus, the higher innovation capability, the flatter the demand curve for innovation funding. Accordingly, medium sized firms may have a higher innovation capability and thereby a higher funding need then their smaller counterparts. In the same time medium sized firms may also face higher marginal cost of capital in comparison to larger firms.

Furthermore, there seems to be a larger amount of unpursued tangible investment opportunities which could be an indication that tangible investment projects are more financially constraints. However, a possible explanation is that we do not control for the size of the investment project. Thus, tangible investments may in average be large and therefore require a larger amount of debt and hence, affect the probability of receiving debt funding. Finally, our results show that, funding gaps for tangible investments reduce productivity of firms while we do not find this adverse effect on productivity from funding gaps for innovation investments.

[5] see Hall & Lerner (2010) for a theoretical overview.

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Financing of Innovation: Has the Funding Mix Changed After Stricter Banking Regulation?

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Abstract

We study whether stricter banking regulation has changed the funding mix of innovative SMEs. For this purpose we employ data from the Mannheim innovation panel. Our results show that the likelihood of using bank loans as a funding source has not changed for tangible investments and innovation investments after stricter capital requirement regulations have been announced. However, the probability of using other external funding sources such as mezzanine capital and overdraft has decreased. On the other hand, subsidies have increased due to programs that have been implemented in the course of the financial crisis. Strong evidence is found that medium sized firms use more bank loans than both smaller and larger firms. Furthermore, SMEs' productivity has not changed post making banking regulation stricter. Overall, the impact from funding sources on productivity is rather limited. However, firms that have used mezzanine capital or subsides exhibit significantly lower productivity.

Key Words: SMEs, funding mix, innovation investment, productivity, bank regulation
JEL codes: D22, D21, D24, O31, O32

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1 Introduction

In the wake of the recent financial crisis, there has been an increased demand for firmer and stricter capital regulations. There is a view among scholars that the crisis was primarily a regulatory failure (Acharya et al. 2012). As a result, the Bank for International Settlements has introduced new regulations, generally referred to as Basel III, which seeks to seal the loophole that was exposed during the financial crisis. In its core essence Basel III increases minimum capital ratios, tightens the definition of bank capital and requires tighter liquidity requirements (Cosimano & Hakura 2011).

As the benefits of higher capital requirements are rather clear in terms of lower leverage and thereby lower risk of bank defaults there is less of a consensus regarding its disadvantages. One major concern is that higher capital requirements will increase the overall cost of capital and thereby increase lending rates[1] and mitigate economic activity[2] (Baker & Wurgler 2015).

Furthermore, higher lending rates should theoretically have a greater impact on small and medium firms as well as on firms who are engaged in R&D and innovation activity. The fundamental argument is driven by the accepted view that SMEs access to external funding is restricted (Guariglia 2008). Smaller firms are associated with higher operational risk and consequently with greater probability of bankruptcy. Moreover, there is a positive correlation between firm age and size. Thus, younger firms tend to have less collateral and shorter track record making it more difficult to raise external funding. In addition, younger firms lack accumulated profits that can be used for funding investment projects. Older firms are not subject to such constraint in the same manner. Older firms may also benefit from established borrower lender relationship which diminishes information asymmetries (Petersen & Rajan 1995, Berger & Udell 2002). The availability of external funding has been acknowledged as a significant determination factor for hindering the growth of SMEs (Mina et al. 2013).

Moreover, raising external funding for innovation investments may be more restricted in comparison to tangible investment expenditures. The intangible nature of innovation projects and the unknown value of outcome restricts external funding. Thus, banks prefer tangible collateral which can be liquidated in case of a default. Furthermore, innovation projects do not generate immediate returns which exacerbates debt funding since debt financing requires a steady cash-flow (Hall & Lerner 2010).

The aim of this paper is to investigate whether there has been a change in the financing sources for tangible and intangible investments post implementation of Basel III. Thus, we investigate if the funding mix, and in particular the use of bank loans, has changed post Basel III and whether this has changed differently for SMEs in comparison to large firms. Finally, we test if different sources of funding have an impact on produc-

[1] see Admati et al. (2013) for a detailed discussion regarding increased capital requirement and capital cost.

[2] see e.g Cummins et al. (1994), Philippon (2009), Gilchrist et al. (2013) for further discussion and evidence on how the cost of capital effects real investments.

tivity. Any restriction on the funding of investments may lead to firms having to reduce profitable investment opportunities. This can in turn hamper competition and impair capital investment and reduce technology adoption, which ultimately leads to hampering optimal resource allocation.

The empirical analysis uses the Mannheim innovation panel. Germany is interesting as a case as it is one of Europe's largest economies where SMEs are considered being the backbone of the economy. Our results show that the likelihood of using bank loans as a funding source has not changed for tangible and innovation investments post stricter bank regulations. However, the probability of using other external funding sources such as mezzanine capital and overdraft has decreased. On the other hand subsidies have increased due to programs that been implemented after the financial crisis. Strong evidence is found that medium sized firms use more bank loans than both smaller and larger firms. Furthermore, productivity has not changed post stricter bank regulation. Firms that have used mezzanine capital or subsides exhibit significantly lower productivity afterwards. The overall impact of other funding sources on productivity is rather limited.

The rest of the paper is organized as follows. Section 2 provides theoretical background. Section 3 contains data and model specification. Section 4 presents the estimation results. Section 5 provides discussion and conclusion.

2 Background

A firm has essentially two available sources for investment expenditures: internal funding and external funding. Internal funding originates from retained earnings while external funding consists of various debt contracts such as bank loans or equity. In an imperfect capital market information asymmetries and taxes related to capital structure matters. When suppliers of capital have less information about the quality of an asset or a security they are forced to charge a risk premium reflecting the information asymmetry of an investment project. This creates a gap between the cost of internal and external funding. Firms face a hierarchy of financial funding sources were funds with lower cost will be used first. Thus, internal cash flow is preferred over debt and debt is preferred over equity (Meyer & Kuh 1957, Myers & Majluf 1984). Generally, this ranking is refereed to as the pecking order theory. Despite extensive empirical research investigating the explanatory power of the pecking order theory there is no consensus reached among scholars yet. Shyam-Sunder & Myers (1999) find strong support for the pecking order theory for continuously traded mature firms during the time period of 1971-1989. However, using the same methodology with a more comprehensive data set Frank & Goyal (2003) find a weak explanatory power of the pecking order theory. On the other hand Agca & Mozumdar (2007); Bulan & Yan (2009); Lemmon & Zender (2010); De Jong et al. (2011) find support for the pecking order theory. The majority of the literature investigating the pecking order theory is based on large listed U.S firms. Studies using European firm data are more scarce. Gaud et al. (2007) use data from 13 European countries and

conclude that that the pecking order theory is not an appropriate description of capital structure policies in European firms. On the other hand, Mateev et al. (2013) present results for Central and Eastern European firms which are in great support of the pecking order theory.

Empirical research on SME funding indicates that SMEs main source of finance is the entrepreneurs' private wealth and retained earnings (Ou & Haynes 2006, Vos et al. 2007, Ughetto 2008). Furthermore, SMEs' capital structure is not static but tends to change over its life cycle. Younger firms tend to prefer internal funds as a main source of finance, however, as they grow older, access to external finance becomes easier. This change in access is linked to the growth of firms' assets which can be used as collateral. Collateralizable assets may decrease the degree of information asymmetry (Berger & Udell 1998, 2006). In principle, innovation funding follows the same pattern as SME funding. Firms tend to use internal funds over external funds when financing innovation projects (e.g. Hall 1989, 1992, Himmelberg & Petersen 1994, Bougheas et al. 2003, Czarnitzki & Hottenrott 2011).

Furthermore, in Europe external funding tends to be bank based to a large extent. In Europe the ratio of bond funding over total corporate credit funding is less than 50 percent while in the U.S it is about 70 percent. Thus, European firms are highly dependent on bank funding (Franke & Krahnen 2016). Moreover, banks are preparing for stricter capital regulation. This process has caused banks to reduce their lending. Accordingly, the banking sector is expected to shrink substantially. This requires other financial intermediaries and institutions to supply the credit needs of the economy Wehinger (2012). Considering these facts it is assumed that stricter capital requirements on bank loans will have an affect on firms funding mix as firms may have to shift from bank funding to other funding sources. In fact, stricter capital requirements could make equity and other sources of funding from outside the banking sector less expensive relative to bank loans and thus, cause a rearrangement of the funding mix of a firm. In this case the effect could be stronger for firms with more capital demand or riskier investment projects. Thus, one can assume that for innovation investments this affect will be amplified for firms with high innovation capability. Innovation capability referees to a firm's ability to generate and launch new products or processes.[3]

Furthermore, restricted access to funding may have a negative impact on a firms' productivity. Any funding constraint that could lead to firms reducing profitable investment may also lead to hampering completion and capital investment which in turn may have an adverse effect on optimal recourse allocation Heil (2017).

[3]See (Hottenrott & Peters 2012) for a detailed discussion.

3 Empirical approach

3.1 Data

Funded by the Federal Ministry of Education and Research, the Center for European Economic Research (ZEW) has collected annual data since 1993 regarding the innovation behaviour of German firms. Thus, the Mannheim innovation panel data (MIP) is a survey database provided by ZEW containing information about new products, services innovation and investment expenditures as well as factors that promote and hamper innovation activity. To be able to analyze how the use of different funding sources and if firm productivity has changed pre and post the resent financial crisis we use the 2007 and 2014 wave of the survey data.The questions asked in the survey take into account the firms' investment behaviour of the past three years. Thus, the 2007 and 2014 wave contains the aggregated survey outcome of year 2004 - 2006 and 2011 - 2013 respectively.

Table 1 presents the definitions of the variables used in the empirical model. SMEs are defined according to the classification of the European Commission that is, firms with less than 250 employees. Thus, 2 presents firm size, measured based on the amount of employees.

Table 1: Variable definitions

Variable name	Definition
SMEs	Firms with less than 250 employees. Defined according to the European Commission
fs	Financial sources with $fs \in [0, 1]$
tfp	Total factor productivity measured as value added
IC	Innovation capability with $fc \in [0, 1, 2]$
Controls	Industry, firms size, located in east or west Germany, employees with university degree, age of a firm and firm type
Size classes	Firm size by number of employees
Industry	NACE 2-digit industry code, 21 industries

Table 2: Size classes by amount of employees

Number of employees	Size category
0< employees $\leq$ 49	1
50 $\leq$ employees $\leq$ 250	2
$\geq$ 251 employees	3

Two survey questions are used were the first question regards which financial sources that are used to finance innovation projects and tangible investment expenditures. The variable fs is derived from the first survey question which is a binary variable depended

on whether a firm has selected a financial source or not, hence: $fs \in [0,1]$. Table 3 presents the definition of the response options available for the first survey question. Firms who responded that they did not use any of the financial sources are excluded from the data set. Mezzanine capital is a hybrid instrument and may be described as subordinated debt or preferred equity. Mezzanine capital is considered as the highest-risk form of debt since it's subordinated to any other form of debt but yet senior common equity. Due to the higher risk it also yields a higher rate of return. Overdraft is form of bank/account credit with a higher interest rate in comparison to traditional bank loans.

Table 3: Definition of funding sources

Funding source	Definition
Cash flow	On-going business operation (profit/surplus, reserves)
New equity	New equity, admission of new shareholders, participation of other enterprises
Mezzanine capital	Shareholders' loans, dormant equities, participation certificates
Bonds	Issue of bonds and debt obligations
Overdraft	Earmarked bank credit
Public loans	Publicly subsidized loan programs
Subsidy	Public allowance/bonus
Factoring	Factoring, leasing and supplier credit line

The second survey question refers to innovation capability, IC. Innovation capability is a firms' ability to create and implement innovation. Each firm has a set of innovation ideas. These innovation projects are ranked according to their projected marginal rate of return in a descending order. This yields a downward sloping demand curve for innovation funding, reflected by the marginal rate of return. Hence, the higher innovation capability the higher is the demand for innovation funding[4]. IC is a dummy variable derived from the survey question of how often a firm conducts in-house R&D were the response options are, i) continued ii) occasionally iii) no R&D research at all. Thus, a firm conducting R&D occasionally or continuously has a positive IC. No R&D activity implies $IC = 0$. Consequently, IC can be either zero or 1, $IC \in [0,1]$:

- Continued R&D $IC = 1$
- Occasional R&D $IC = 1$
- No R&D conduction $IC = 0$.

Furthermore, tfp is measured using the Wooldridge (2009) approach. Following previous empirical literature a set of control variables are employed. We control for industry

[4]See Hottenrott & Peters (2012) for a detailed discussion.

and firm type were firm type referees to the legal form of a company. Firms in different industries may be more or less dependent on a certain type of funding source. For example the real estate industry is more dependent on debt funding rather than equity funding. Moreover, different firm types have access to different sources of funding as for example public equity and the bond market is only available for listed firms. In order to control for firms' innovation capability, we use share of employees with university degree as a proxy for human capital intensity. Firms located in East Germany have traditionally been subject to subsidies and we therefore include a dummy variable indicating the geographical location of a firm. Firm age is controlled for as a dummy variable indicating whether a firm is older or younger than three years.

3.2 Descriptive statistics

Table 4 presents the average source of funding by year. Internal funding is the most important source of financing for both tangible investments and innovation expenditures pre and post financial crisis. However, for innovation expenditures the use of internal funding (cash flow) has decreased from 91.4% to 84.0% in the post crisis period while for tangible investments the decline has been more modest (from 82.9% to 80.4%).

For tangible investments, external funding is the second most important source of funding were bank credit is the most common choice followed by overdraft, mezzanine capital and bonds. The use of external funding has declined somewhat after the financial crisis. Governmental subsides is the third most important source were an increase is observed for the post-crisis period. The role of equity funding is rather minor and is ranked as the fourth most important source. Note that equity has declined post financial crisis. This ranking is consistent with the pecking order theory were internal funding is preferred over debt funding and debt funding preferred over equity funding.

For innovation funding, subsidies are the second most important funding source and external funding the third most important source. In the after math of the financial crisis the capital structure of innovation funding has undergone an important alteration. External funding has declined were expensive credits have lost importance. This is due to increased governmental support programs that took place after the financial crisis to stimulate innovation investment. The use of subsides increased from 16.8% to 28.26%. Equity funding is the fourth most important source. Also this ranking is in line with the pecking order theory.

Table 5 presents the average source of funding for tangible investments by year and size. Internal funding is the most important source of funding for all size classes. However, the larger the firm, the more important becomes internal financing. The use of new equity declined from 72.5% to 52.0% for the smallest firms after the financial crisis. However, it still remains the second most important funding source. Equity funding has a rather negligible role for medium and large firms (4.2% and 5.5% respectively). External funding is the third most important funding source for the smallest firms and the second

most important source for medium sized and large firms. The use of external funding has declined post financial crisis for all firm sizes with one exception. For the largest firms the use of bank credit has increased. Furthermore, subsides is the fourth most important source of funding for the smallest firms and third most important for medium sized and large firms. While the use of subsides has increased for small firms and medium sized firms post-crisis it has decreased for the largest firms.

Table 4: Funding sources for investments by size and year

size	<50		50-249		>250		All	All
year	2006	2013	2006	2013	2006	2013	2006	2013
cash	77.7	75.0	86.4	84.9	93.4	92.3	83.7	80.8
equity	7.1	5.2	7.5	3.9	7.0	7.0	7.2	5.1
mezzanine	14.6	11.5	13.6	10.8	11.6	9.4	13.7	10.9
bond	0.2	0.3	0.3	0.3	1.6	2.8	0.5	0.7
bank	36.4	34.3	37.2	35.7	22.8	25.4	33.8	33.3
overdraft	29.2	28.0	24.6	23.5	19.4	19.0	25.7	25.2
publicloan	12.4	12.1	14.1	16.1	9.7	12.2	12.4	13.3
subsidy	9.9	12.6	18.4	18.5	13.8	14.2	13.4	14.7
factoring	—	17.8	—	19.7	—	21.5	—	19.0
						#obs	3,383	3,319

Table 5: Funding sources for innovation by size and year

size	<50		50-249		>250		All	All
year	2006	2013	2006	2013	2006	2013	2006	2013
cash	88.1	80.8	92.6	84.4	95.8	92.1	91.9	84.8
equity	8.2	4.1	5.4	3.8	5.2	4.1	6.4	4.0
mezzanine	13.7	10.0	10.2	5.8	6.6	7.9	10.4	8.1
bond	0.3	0.2	0.5	0.2	1.2	1.8	0.6	0.6
bank	12.2	11.9	14.5	15.3	10.4	13.0	12.4	13.3
overdraft	20.6	16.5	20.6	14.5	14.6	11.8	18.8	14.7
publicloan	7.1	7.0	7.6	10.7	8.3	9.5	7.6	8.9
subsidy	13.4	30.7	15.9	28.8	15.8	24.0	14.9	28.4
factoring	—	6.1	—	7.7	—	7.7	—	7.0
						#obs	1,747	1,563

Table 6 presents the average source of funding for innovation investment. For all firm sizes internal funding is by far the most important source of funding. Following the same pattern as tangible investments, the larger the firm the more important is internal funding. For the smallest firms and medium sized firms there has been an important change in the capital structure after the financial crisis. Even though external funding keeps its rank as the second most important source of funding for the smallest firms, one can observe a significant decline in the use of expensive credit. Instead there has been a large increase in the use of subsides which has increased from 16.0% to 32.1%

and is ranked as the third most important source of funding for the smallest firms. For medium sized firms, subsidies are the second most important source post financial crisis and external funding the third most important source. For the largest firms, external funding is the second most important source and subsides the third most important one. Note that the overall external funding has decreased from medium sized and large firms with the exception of bank credit where a slight increase can be seen.

3.3 Empirical model

Equation one describes a firms financial source (fs) for tangible investments and innovation expenditures at time t as a function of innovation capability (IC), firm size measured by number of employees and controls. Following previous empirical literature, we control for industry and firm type, firm age, geographical location and human capital measured as amount of employees with university degree [5]. Financial sources is a binary variable were $fs \in [0, 1]$. In order to estimate our model we use a multivariate probit model.

$$fs_{kt} = f(IC, employees, controls) + \varepsilon_{kt} \tag{1}$$

Equation 1 is estimated using Roodman's (2011) conditional mixed process (CMP) procedure in STATA. One of the key advantages of the CMP model is that it is a seemingly unrelated regression (SUR) estimator which allows several equations to be estimated simultaneously using a system approach were the error terms are allowed to be correlated across equations. Taking such a correlation in to account is in particularly beneficial as the choice of financial sources are taken simultaneously. Moreover, it mitigates omitted variable bias. Furthermore, it is a flexible model were the dependent variable may be binary, censored, interval or continuous and also allows each equation to vary by observation.

Equation 2 describes a firm's productivity as a function of bank credit, size measured as amount of employees and control variables. Total factor productivity for tangible investments and innovation expenditure is denoted tfp_{tk+1}. To estimate how productivity is affected by bank credit with lag the explanatory variables by one time period. In order to avoid a bias in the estimation of tfp, Wooldridge (2009)'s estimation method is used were material cost is used as a proxy for intermediate inputs yielding a dynamic OLS model with robust standard errors accounting for both serial correlation and heteroskedasticity.

$$\log tfp_{t+1} = f(fs_t\, employees, controls) + \epsilon_t \tag{2}$$

[5] See section 3.1 for a detailed description of the control variables used in equation one and two.

4 Result

4.1 Estimation Results

Table 6 presents the estimation results for tangible investments as described in equation one. The negative year coefficient for cash, equity, mezzanine, bank and overdraft indicates that the probability of using internal funding external funding and equity funding has decreased relative to year 2007. The positive coefficient for subsidies and public loans indicate that the probability of using governmental subsidies has increased. Note that this result is only significant for equity, mezzanine and subsidy funding. Furthermore, the larger the firm, the greater is the probability of using internal funding. The probability of using equity funding decreases as firms become larger. Firms with 50-249 employees have the grates probability of using bank loan as a funding source whereby the largest firms have the greats probability of using bank loan as a funding source. The probability of using overdraft as funding source decreases as firms become larger. Medium sized firms have a greater probability of using subsidies than the smallest and largest firms. Public loans is most common among medium sized firms. Furthermore, firms with occasional R&D have the highest probability of using internal funding as a source whereby firms with continues R&D have the next highest probability. The higher innovation capability (R&D engagement) the higher is the probability of using equity funding. The use of external funding (mezzanine and bank loan) decreases as innovation capability increases[6]. The higher innovation capability (R&D conduction) the greater is the probability of using subsidies (including public loans) as a funding source in comparison with no R&D engagement.

The change in the funding mix and more specifically the increase in the use of subsidies is due to a range of governmental programs that were implemented after the economic crisis in order to support SMEs conduction of innovation. In 2008-2009 a second economic stimulus package was presented in Germany referred to as Konjunkturpaket II. According to evaluations of the program this changed the foundation of innovation funding of SMEs. During the governmental subsidy program R&D expenditures for SMEs increased with 35 percent, which was a significantly larger growth than its larger counterparts Belitz & Lejpras (2015).

Table 7 presents the estimation results for innovation investments. Following the same pattern as for tangible investments the negative year coefficient for cash and equity indicates that that the probability of using internal funding and equity funding has decreased relative to year 2006. The probability of using bank loan has increased while the use of mezzanine capital and overdraft has decreased while the use of subsides including public loans has increased.

The larger the firm the greater is the probability of using internal funding. Note, that this result is only significant for the largest firms. The use of equity funding and

[6]Note, mezzanine and overdraft coefficients are not significant.

mezzanine capital decreases as firms become larger. The probability of using bank loan is highest among firms with 50-249 employees.The use of overdraft decreases as firms become larger. The probability of using subsidies as a funding sources is highest for firms with 50-249. However,the use of public loans (a type of a subsidy) increases as firms become larger.

Firms with occasional R&D have the highest probability of using internal funding. While firms with continuous R&D have a larger probability of using equity funding. The probability of using mezzanine capital is largest among firms with occasional R&D conduction. As a firms innovation capability increases (R&D conduction) the using of bank loan and overdraft as funding source decreases. The probability of using subsides including public loans increases as firms a firms innovation capability increases.

Table 8 and 9 presents the correlation of the error term for tangible investments and innovation investments respectively. There is a negative and significant correlation between internal funding and all other sources of finance for both tangible investments and innovation investments. Thus, as internal funding increases the use of both external funding and equity funding decreases, indicating that external funding, equity funding and subsides are substitutes of funding sources. This result is inline with the pecking order theory. There is a positive and significant correlation between equity funding and all sources of external funding, implying the firm is in need of funding and that external funding equity funding and subsides are compliments of sources of financing. Table 10 (see appendix) presents different funding sources effects on productivity. The first column (Innoexp) shows fraction of innovation expenditures over turnover. The positive and significant equity, bank loan and subsidy coefficient indicates that access to either one of these sources increases innovation expenditures. Moreover, higher innovation capability indicates higher innovation expenditures. Column two presents the effect of funding sources on productivity. The results shows that that the effect of different sources of productivity one year later is limited with the exception of mezzanine capital and subsidies which indicates a negative impact on productivity.

Table 6: Multivariate Probit Model Funding Sources for Investment

	internal cash	equity	mezza-nine	bank loan	over draft	subsidy	public loan
year 2013	-0.017	-0.242***	-0.146***	-0.025	-0.055	0.135**	0.015
	[0.050]	[0.069]	[0.054]	[0.044]	[0.045]	[0.055]	[0.052]
50≤ emp < 249	0.305***	-0.036	-0.071	0.098**	-0.108**	0.402***	0.091
	[0.056]	[0.074]	[0.059]	[0.048]	[0.050]	[0.062]	[0.057]
>250 emp	0.649***	-0.006	-0.134*	-0.083	-0.287***	0.327***	-0.139*
	[0.086]	[0.094]	[0.079]	[0.065]	[0.069]	[0.085]	[0.081]
r&d conti	0.146**	0.208**	-0.016	-0.242***	-0.011	0.414***	0.101
	[0.071]	[0.083]	[0.070]	[0.060]	[0.061]	[0.072]	[0.071]
r&d occas	0.269***	0.092	-0.034	-0.229***	0.041	0.232***	0.011
	[0.079]	[0.096]	[0.078]	[0.065]	[0.066]	[0.083]	[0.078]
human cap	0.005***	0.002	0.001	-0.006***	-0.003**	0.001	-0.001
	[0.001]	[0.002]	[0.001]	[0.001]	[0.001]	[0.002]	[0.002]
East Germany	-0.134***	0.137**	-0.01	0.161***	-0.134***	1.038***	0.075
	[0.052]	[0.067]	[0.056]	[0.045]	[0.048]	[0.057]	[0.054]
family firm	-0.160***	0.044	0.134**	0.262***	0.249***	-0.150***	0.054
	[0.055]	[0.069]	[0.057]	[0.046]	[0.048]	[0.058]	[0.056]
young firm	-0.014	0.577***	0.614***	-0.247*	-0.061	-0.174	0.067
	[0.146]	[0.144]	[0.128]	[0.132]	[0.132]	[0.170]	[0.152]
trade partnership	0.281***	-0.038	0.603***	-0.256***	-0.157**	-0.252**	-0.137
	[0.085]	[0.119]	[0.106]	[0.076]	[0.078]	[0.104]	[0.090]
limited liability	0.282***	0.031	0.556***	-0.262***	-0.224***	-0.159*	-0.185**
corporation	[0.068]	[0.099]	[0.094]	[0.063]	[0.064]	[0.083]	[0.075]
listed corporation	0.377**	0.400**	0.271	-0.342***	-0.302**	-0.102	-0.370**
	[0.170]	[0.159]	[0.180]	[0.131]	[0.138]	[0.159]	[0.171]
Constant	0.669***	-1.656***	-1.966***	0.078	-0.464***	-1.658***	-0.721***
	[0.132]	[0.175]	[0.165]	[0.110]	[0.118]	[0.150]	[0.127]
#Obs: 4284, df=223, chi2=1517.2, p-value=0.000							

Notes: Standard errors in brackets, * p<0.10 ** p<0.05 *** p<0.01

Table 7: Multivariate Probit Model Funding Sources for Innovation

	internal cash	equity	mezza-nine	bank loan	over draft	subsidy	public loan
year 2013	-0.362***	-0.416***	-0.176**	0.037	-0.306***	0.546***	0.032
	[0.083]	[0.114]	[0.088]	[0.079]	[0.075]	[0.072]	[0.088]
50≤emp <249	0.082	-0.217*	-0.189**	0.242***	0.036	0.180**	0.177*
	[0.093]	[0.118]	[0.095]	[0.089]	[0.081]	[0.087]	[0.102]
>250 emp	0.400***	-0.281**	-0.340***	0.16	-0.169*	0.115	0.288**
	[0.128]	[0.139]	[0.119]	[0.108]	[0.100]	[0.106]	[0.120]
r&d contin	0.136	0.426***	0.031	-0.234**	0.204**	0.646***	0.307***
	[0.104]	[0.133]	[0.103]	[0.096]	[0.090]	[0.101]	[0.115]
r&d occas	0.198*	0.071	-0.201*	-0.044	0.114	0.283**	0.305**
	[0.115]	[0.150]	[0.116]	[0.100]	[0.095]	[0.112]	[0.123]
human cap	0.003	0.002	0.001	0.001	-0.003	0.005**	0.002
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
East Germany	-0.169*	0.148	-0.033	0.122	0.059	0.822***	0.214**
	[0.087]	[0.104]	[0.088]	[0.081]	[0.075]	[0.077]	[0.092]
family firm	0.103	-0.216**	0.127	0.256***	0.280***	-0.106	0.199**
	[0.087]	[0.104]	[0.088]	[0.082]	[0.075]	[0.076]	[0.092]
young firm	0.068	0.691***	0.516***	-0.112	-0.159	-0.117	-0.146
	[0.236]	[0.197]	[0.182]	[0.223]	[0.199]	[0.217]	[0.258]
trade partnership	0.284*	-0.109	0.709***	-0.473***	-0.468***	0.06	-0.181
	[0.165]	[0.212]	[0.215]	[0.151]	[0.144]	[0.166]	[0.182]
limited liability	0.243*	-0.093	0.592***	-0.421***	-0.357***	-0.02	-0.202
corporation	[0.140]	[0.184]	[0.203]	[0.132]	[0.127]	[0.149]	[0.165]
listed corporation	0.22	0.326	0.15	-0.324	-0.388*	0.345*	-0.518*
	[0.229]	[0.237]	[0.309]	[0.211]	[0.202]	[0.205]	[0.275]
Constant	1.026***	-2.050***	-1.906***	-0.583**	-0.606**	-2.015***	-1.539***
	[0.294]	[0.478]	[0.309]	[0.240]	[0.244]	[0.289]	[0.298]
#Obs: 2,149, df= 219, chi2=751.1, p-value=0.000							

Notes: Standard errors in brackets, * p<0.10 ** p<0.05 *** p<0.01

Table 8: Residual Correlations of Estimations Table 6

	intern cash	equity	mezza-nine	bank loan	over draft'	public loan	subsidy
intern cash	1.000						
equity	-0.256***	1.000					
mezzanine	-0.222***	0.392***	1.000				
bank loan	-0.382***	0.106	0.012	1.000			
over draft	-0.210***	0.204***	0.250***	0.276***	1.000		
public loan	-0.230***	0.141***	0.074**	0.277***	0.042	1.000	
subsidy	-0.295***	0.178***	0.035	0.406***	0.162***	0.486***	1.000

Notes: * p<0.10 ** p<0.05 *** p<0.01

Table 9: Residual Correlations of Estimations Table 7

	intern cash	equity	mezza-nine	bank loan	over draft'	public loan	subsidy
cash	1.000						
equity	-0.396***	1.000					
mezzanine	-0.380***	0.544***	1.000				
bank	-0.421***	0.188***	0.092**	1.000			
over draft	-0.159***	0.191***	0.289***	0.358***	1.000		
public loan	-0.390***	0.121***	-0.037	0.242***	0.047	1.000	
subsidy	-0.335***	0.329***	0.235***	0.508***	0.246***	0.365***	1.000

Notes: see previous Table

Table 10: Funding Sources and Productivity

	(1) InnoExp	(2) log tfp
year 2014	0.001	0.040
	[0.005]	[0.023]
internal cash	-0.008	0.052
	[0.008]	[0.076]
equity	0.049***	-0.054
	[0.012]	[0.104]
mezzanine	0.003	-0.209***
	[0.009]	[0.078]
overdraft	0.002	-0.042
	[0.007]	[0.060]
bank loan	0.014**	-0.077
	[0.007]	[0.068]
public loan	0.001	0.119
	[0.009]	[0.078]
subsidy	0.040***	-0.205***
	[0.006]	[0.055]
turninno	—	0.002
	—	[0.002]
turnfirm	—	-0.002
	—	[0.001]
r&d conti	0.102***	-0.036
	[0.006]	[0.057]
r&d occas	0.042***	0.051
	[0.007]	[0.076]
Constant	0.020**	0.789***
	[0.010]	[0.093]
Size effects	yes***	yes***
Random effects	yes***	yes***
Observations	1325	710
df_m	16	18
chi2	474.5	551.0

Notes: see previous Table. InvExp denotes investments for innovation, Innoexo innovation expenditures. (1) and (3) are Tobit models with firm-level random effects (RE). (2) and (4) are panel RE models.

5 Conclusions

The purpose of this paper is to investigate whether there has been a change in the probability of using bank loans for funding tangible and innovation investments post stricter bank regulation such as Basel III. Moreover, we analyze if the funding mix of sources has changed and whether it has affected SMEs differently in comparison to larger firms. Finally, we test if different sources of funding have a different impact on productivity.

Our results show that the likelihood of using bank loan as a funding source has not changed post stricter bank regulation for neither tangible investments nor for innovation investments. However, a change in the funding mix of the firms is observed. The likelihood of using other sources such as equity, mezzanine capital, and overdraft has declined for both tangible and innovation investments. For innovation investments, the probability of using internal cash flow has decreased. Instead the probability of using subsidies has increased for both types of investments. However, this increase has been significantly larger for innovation investment compared to tangible investments. Meanwhile, bank funding is much more of an important funding source for tangible investments than for innovation expenditures.

Furthermore, we find strong evidence for different mix of funding depending on the size of a firm. Thus, medium sized firms use more bank loans than both smaller and larger firms. Medium sized firms also have higher probability of using subsides. On the other hand, the probability of equity and mezzanine financing decreases as firms become larger.

In addition, we find that the funding mix of firms is related to innovation capability as our result shows that the probability of using equity financing for innovation increases as innovation capability increases, while the likelihood of bank financing decreases as innovation capability increases. This implies, that innovation investors are more risk averse towards bank loans.

The results show that innovation expenditures as a share of turnover have not changed post stricter bank regulation. We find that equity, bank loan, subsidies and innovation capability have a significant positive impact on innovation expenditures. Moreover, firms that use equity funding for innovation have a significantly higher expenditures in comparison to firms that use bank loans. In conclusion we do not find that financing conditions of SMEs, in particular with regard to bank loans, have worsened due to stricter bank regulation.

Similarly, firms' productivity is not adversely affected by stricter bank regulation, though firms that have used mezzanine capital or received subsidies exhibit a significantly lower productivity one year later. In the case of subsidies it might be the case that lower productivity firms have better prospects to receive subsidies. On the other hand, mezzanine capital might be a rather expensive source of funding and therefore constraints a firm's long-term growth. Whether capital costs is the mechanism that explains the negative impact from mezzanine on firm productivity, has to be left for future

research.

A Appendix

Table A.1: Correlation matrix for financial sources used for investments

	internal cash	equity	mezza-nine	bank loan	over draft	public loan	sub-sidy
intern cash	1						
equity	-0.0439*	1					
mezzanine	-0.0747***	0.0901***	1				
bank loan	-0.247***	0.0225	-0.0038	1			
over draft	-0.125***	0.0552**	0.0860***	0.158***	1		
public loan	-0.0970***	0.0784***	0.0271	0.236***	0.0787***	1	
subsidy	-0.0534**	0.0899***	0.0402*	0.103***	0.0166	0.205***	1
#obs	3,319						

* $p < 0.05$, * $p < 0.01$, *** $p < 0.001$

Table A.2: Correlation matrix for financial sources used for innovation, year 2013

	internal cash	equity	mezza-nine	bank loan	over draft	public loan	sub-sidy
intern cash	1						
equity	-0.124***	1					
mezzanine	-0.157***	0.0964***	1				
bank loan	-0.176***	0.0458	-0.0192	1			
overdraft	-0.0367	0.00849	0.0501*	0.152***	1		
public loan	-0.144***	0.0977***	0.0148	0.281***	0.106***	1	
subsidy	-0.181***	0.0900***	0.0271	0.0498*	0.0078	0.102***	1
#obs	1,563						

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A.3: Industry category by size for 2013 (%)

Industry	Firm size			
	<50	50-249	>250	All
Mining	3.2	4.4	5.7	3.9
Food, tobacco	4.7	5.5	3.7	4.8
Textiles	4.5	3.1	1.3	3.7
Wood, paper	3.2	4.7	1.9	3.4
Chemicals	2.3	4.0	5.4	3.2
Plastics	2.7	4.3	3.0	3.1
Glass, ceramics	2.0	2.6	3.8	2.4
Metals	6.8	8.4	5.8	7.1
Machinery	4.9	8.1	7.4	6.0
Electrical equipment	2.5	6.5	9.8	4.5
Medical, instruments	1.5	3.2	6.1	2.6
Transport equipment	6.2	7.2	3.4	6.1
Furniture	6.3	4.9	3.7	5.6
Wholesale	4.2	2.8	2.8	3.7
Retail, automobile	8.1	8.7	7.5	8.2
Transport, communications	5.1	4.6	2.6	4.6
IT, telecom	3.3	2.8	10.0	4.0
Technical services	7.4	3.1	1.3	5.4
Firm-related services	7.1	1.7	2.0	5.1
Other services	4.9	4.4	8.3	5.2
n.a.	9.1	4.9	4.4	7.4
Total	100.0	100.0	100.0	100.0
Obs	3,235	1,374	702	5,311

Table A.4: Legal company forms for 2013 (%)

Legal	Firm size			
form	<50	50-249	>250	All
1	27.3	9.8	9.6	20.4
2	13.6	22.2	23.8	17.2
3	57.9	65.4	53.5	59.2
4	1.3	2.6	13.1	3.2
Total	100.0	100.0	100.0	100.0
Obs	3,232	1,372	701	5,305

1=sole proprietorship, partnership
2=trade partnership, limited company
3=limited liability corporation (GmbH)
4=listed corporation (AG)

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