»› Research and development (R&D) in SMEs: internal funding capacity determines scope of R&D expenditure

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The main factors that prevent SMEs from innovating are high costs, uncertainty of success and funding difficulties. This is because the particular characteristics of innovation projects are an obstacle to financing from external providers of capital. These characteristics are more pronounced when innovation activity is based on research and development (R&D).

The present analysis therefore explores the influence which SMEs' internal funding capacity and credit ratings have on whether they conduct R&D and how much they spend on it.

The key finding of the analysis was that SMEs' internal funding capacity positively influences the level of R&D expenditure. SMEs with high profit margins spend 14 % more on R&D than businesses with medium profit margins. However, these SMEs are only slightly more likely to actually conduct R&D. High internal funding capacity increases the likelihood of an SME conducting its own R&D by 2.2 percentage points. Its credit rating, on the other hand, has no such impact on R&D.

The results for R&D thus differ from those for capital expenditure. The level of capital expenditure in particular depends heavily on the enterprise's credit rating. Its internal funding capacity is only the second most important factor for capital expenditure.

The heavy dependence of R&D activity on enterprises' internal funding capacity is due to specific characteristics such as high uncertainty of success and the difficulty of assessment by external parties. Moreover, R&D projects generate only few material assets that would be suitable as collateral for bank loans. These factors hamper external financing, even for enterprises with a generally good credit rating.

Innovation is an important mechanism for a business to secure or expand its competitive position.[1] Numerous research studies have shown the positive effect of innovation on business performance.[2] Own research and development (R&D) is the linchpin of innovation activity. R&D in particular generates new knowledge that is often the source of radical innovation. Enterprises conducting R&D regularly bring forth innovations and are usually the first to introduce new products, services and production processes into the market.

The high importance of R&D for aggregate economic growth[3] and business performance[4] has also been demonstrated on many occasions.

Costs, risks and financing difficulties hamper innovation activity

But there are constraints to innovation activity – and, in particular, to R&D. Enterprises cite high costs, uncertainty of success and financing difficulties as the most frequent constraints (Figure 1). They refer not just to the general challenge that businesses must direct scarce resources to projects that promise the highest returns. More than anything, these criticisms probably indicate a failure of the market process. The result is that enterprises cannot access enough external finance for their innovation activity.

Figure 1: Constraints to innovation from 2012 to 2014

In per cent

Constraint	Per cent
High costs of innovation	50
High uncertainty of success	43
Lack of internal financing	39
Lack of external financing	36
Lack of skilled workers	30
Legislation, standards and norms	28
Bureaucratic procedures	26
Organisational problems	24
Lack of market information	17
Lack of technological information	12

Note: based on all SMEs that innovate and those which were completely prevented from innovating because of constraints

Source: KfW SME Panel, own calculations

The following analysis explores this assumption. It examines the importance which internal funding capacity and credit rating have for small and medium-sized enterprises' R&D activities in the short term. In order to determine the particular effect of these characteristics on R&D activity, we compared the influence of these two factors on R&D activity with their influence on capital expenditure.

External financiers are put off by the uncertainty about project success ...

Innovation projects exhibit specific characteristics that clash with external financing. These characteristics occur in R&D projects in concentrated form. R&D involves a particularly high uncertainty of success as possible profit usually contrasts with high uncertainty about the outcome.[5] In addition, the technology content, high complexity and individuality of R&D projects make it difficult for potential external providers of capital to assess them. The enterprise conducting R&D, however, is better able to judge the chances of success. Hence there is an uneven distribution of information between the enterprise and a potential external provider of capital. This constitutes a form of market failure that can be summed up as 'asymmetrical information distribution'.[6]

It makes external providers of funds less willing to provide finance for such projects. Providers of capital either demand excessively high returns (including an 'uncertainty premium') which then occasionally fails to bring about a financing agreement, or discourages them from providing finance.[7]

... and by the lack of collateral and unfavourable project volumes

This applies to loan financing in particular. After all, R&D projects are largely composed of personnel expenses. Only 8 per cent of R&D expenditure goes to such typical material investments as the purchase of buildings, machinery etc.[8] Hence R&D projects generate only few material assets that can be used to collateralise bank loans. Another constraint to credit financing of R&D is that a lender is also impacted by the high uncertainty about the project success (which is often tied to the success of the enterprise itself). However, because the interest rate is not tied to the outcome, the lender cannot participate in any high profits of a successful project. That makes it difficult to use successful exposures to offset portfolio losses and reduces the risk a lender can assume in a loan portfolio.

Small and young enterprises are at a particular disadvantage in obtaining external financing for R&D projects. The development of new products and processes with the aid of R&D largely has the character of fixed costs. In small enterprises, development costs not related to enterprises size are therefore spread across relatively low business turnover. Hence the relative burden from R&D is higher for small businesses than for large SMEs. That gives small businesses no possibilities for risk diversification. Failure of a project therefore often jeopardises the survival of the whole enterprise.

From the perspective of the lender, on the other hand, the volumes requested by small and young enterprises are comparatively low. That means an unfavourable transaction cost-return ratio for the lender, so it is often not worthwhile to seek more information and, in this way, dissolve the

information asymmetry. This problem complex is particularly pronounced in young enterprises that have no track record against which to assess its quality.

Analysis: influence of credit rating and internal funding capacity on R&D and capital expenditure

The following analysis explores the influence of credit ratings and internal funding capacity on

1. whether an SME conducts R&D of its own and

2. how much an SME that conducts R&D spends on R&D.

The results of the analysis were compared with the role these factors play for investment activity. The aim was to identify the particular characteristics of R&D funding described above (in contrast with capital expenditure). The Creditreform credit rating index (Box 1) served as an indicator of credit worthiness. Internal funding capacity is measured by the profit margin (= profit before taxes in relation to business turnover) reported by businesses in the KfW SME Panel.[9] In order to isolate the influence of these two factors on R&D and investments, a multivariate analysis was conducted (Box 2 at the end).

> **Box 1: Creditreform credit rating**
> The Creditreform credit rating is based on a total of 15 criteria. They include information on the financial status and liquidity (data on the annual statements), structural risks (branch of industry, company size and age, productivity) and soft factors (payment history, order book and orders received, management quality). The credit rating is indicated on a scale of 100 to 600, with 100 being the highest achievable credit rating.[10]

Enterprises with high profit margins spend more on R&D

The key finding of the analysis is that SMEs with a high profit margin spend more on R&D than those with average or low profit margins. R&D expenditure (by enterprises conducting R&D) is 14 % higher when the profit margin is just under 16 % (90 % quintile) instead of 3.6 % (median, below that of enterprises conducting R&D in each case). Measured in euros, that means a rise from EUR 83,400 to EUR 95,100 (Figure 2). By contrast, a company's credit rating cannot be found to have a significant influence – in a statistical sense – on the level of R&D expenditure. It is true that a marginally positive correlation exists between a company's credit rating and the level of R&D expenditure. However, this correlation lies below the margin of statistical uncertainty of the survey and will therefore not be discussed further.

Figure 2: Influence of credit rating and profit margin on level of R&D expenditure

In EUR, enterprises conducting R&D
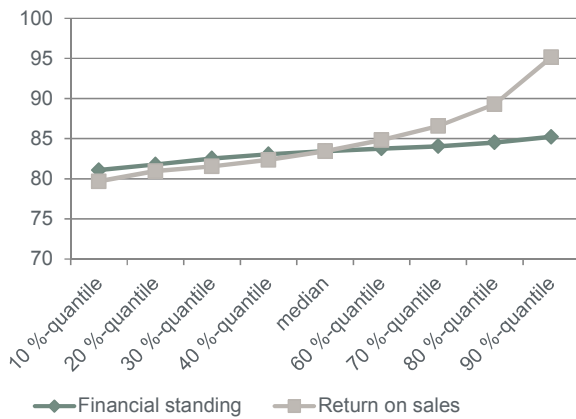
Source: KfW SME Panel, own calculations

Credit rating more important for capital expenditure than profit margin

The findings for capital expenditure were different. Capital expenditure (by companies that invest) rises by only 5.3 % when their profit margin is high, specifically, when the profit margin corresponds with the 90 % quantile instead of the median. In return, capital expenditure is more strongly dependent on the credit rating. When the credit rating rises from the median to the 90 % quantile, the volume of capital expenditure increases by a good 21 % (Figure 3).[11]

Figure 3: Influence of credit rating and profit margin on level of capital expenditure

In EUR, in investing enterprises
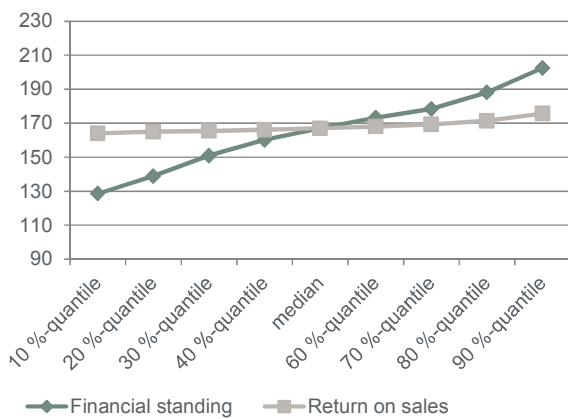
Source: KfW SME Panel, own calculations

Thus, the results for R&D differ significantly from those for capital expenditure, for which the credit rating plays a more important role than the profit margin. With regard to the level of R&D expenditure, on the other hand, the profit margin is more important while the company's credit rating cannot be

found to have a significant effect. These results are consistent with the considerations initially presented that high uncertainty of success and asymmetrical information between the enterprise conducting R&D and an external financier constitute a constraint for external financing of R&D. The results of the analysis show that even a good credit rating does not help to overcome the adverse impact of information asymmetry.

A high profit margin increases the probability of own R&D

Similar results were also found for the likelihood of conducting R&D or making capital expenditure. Another finding of the analysis is that SMEs with a high profit margin conduct more R&D. The likelihood of an enterprise undertaking R&D activities of its own is 2.2 percentage points higher when it has a profit margin of just under 22 % (90 % quantile in the overall sample) than when it has a profit margin of 4.3 % (median of total sample). For an enterprise's credit rating, in turn, no significant difference (in a statistical sense) could be found (Figure 4).

Figure 4: Influence of credit rating and profit margin on the probability of conducting R&D

Probability in per cent
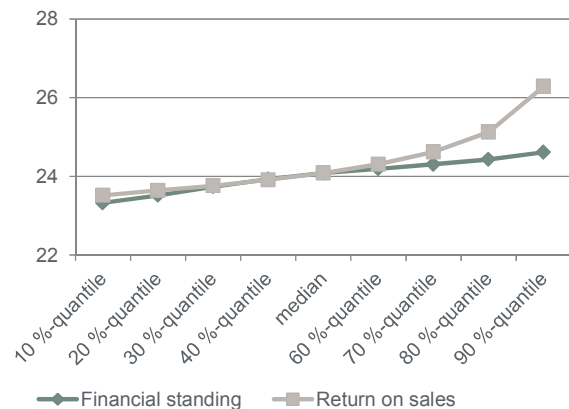
Source: KfW SME Panel, own calculations

With respect to the probability of investing, both the profit margin and the credit rating were found to have positive effects. Thus, the probability of investing increases by 3.2 percentage points when the profit margin took the value of the 90 % quantile instead of the median. In addition, the probability of investing increases by 1.7 percentage points when the credit rating rises from the median to the 90 % quantile (Figure 5). It must be noted here, however, that the effects of credit rating and profit margin on the respective probability are relatively low. Table 1 provides an overview of the influences found.

Figure 5: Influence of credit rating and profit margin on the probability of investing

Probability in per cent
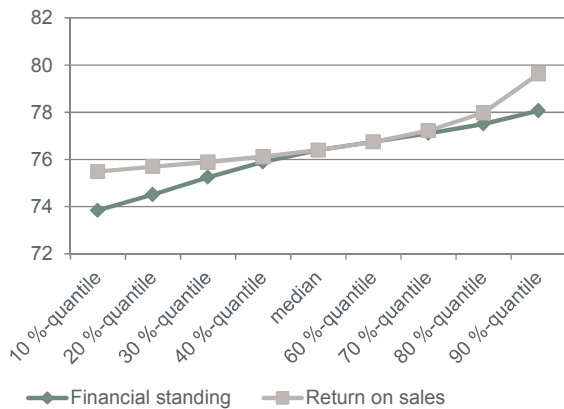
Source: KfW SME Panel, own calculations

Conclusion

SMEs report high costs, risks and difficulties in funding innovations. This paper therefore examined the short-term influence of profit margin and corporate credit rating on whether SMEs conduct R&D and on the level of R&D expenditure (by enterprises conducting R&D). In order to identify the characteristics of R&D funding, the results were compared with the results obtained for capital expenditure.

The key result of the analysis is that both the likelihood of an enterprise conducting R&D and the level of R&D expenditure depend on an enterprise's profit margin and, thus, on its internal funding capacity. SMEs with high profit margins spend 14 % more on R&D than businesses with medium profit margins. The likelihood of conducting R&D, however, increases only marginally. A high internal funding capacity increases the likelihood of an SME conducting its own R&D by 2.2 percentage points. Its credit rating, in turn, does not significantly influence R&D activity (in a statistical sense).

Thus, the results for R&D activity differ significantly from those for capital expenditure. The level of capital expenditure in particular depends heavily on a good credit rating and only to a limited extent on the profit margin. Furthermore, the credit rating and profit margin have a positive influence on the likelihood of investing. These results underscore the high

importance of credit financing for capital expenditure, whereas internal funding sources dominate in innovation and R&D projects.[12]

The results are consistent with considerations that information asymmetries exist between enterprises conducting R&D and potential external providers of capital – given the particular characteristics of R&D projects. The consequence is that these projects can hardly be financed with external sources of finance, especially bank loans.

SMEs' dependence on their own funds for R&D activity has substantial drawbacks because these resources, too, are limited. Hence the danger exists that SMEs 'invest' too little in R&D.

Another danger is that their dependence on internal funds influences the type of projects they conduct. Being dependent on the momentary financial situation may cause enterprises to rather prefer carrying out short-term projects. Fundamental innovations, on the other hand, which require a longer development period and are marked by even higher uncertainty, are less likely to be created.

It is also conceivable that – in economically difficult times, for example – the outflow of workers from enterprises leads to a permanent loss of important expertise when R&D activity must be scaled back because of reductions in profit. A resumption or (renewed) expansion of R&D is then all the more difficult because workers who have the expertise required for innovation can hardly be recruited in the labour market.

With regard to economic-policy implications, it can be stated that financing difficulties due to asymmetrical information justify intervening in the market process in order to better harness untapped potential. The finding of the present analysis is that improved access to funds is most likely to increase R&D expenditure of enterprises already conducting R&D. However, this has only a limited influence on the number of SMEs conducting R&D – at least in the short term. The analysis thus confirms older studies that emphasise how important SMEs' 'capacity to innovate' (meaning their ability to create R&D and innovation projects) is for innovation activity.[13] ∎

Table 1: Overview of influences of credit rating and profit margin

	Likelihood of ...		Amount spent on ...	
	... conducting R&D	... investing	... R&D	... investments
Profit margin	Strong, positive influence	Low, positive influence	Low, positive influence	Low, positive influence
Credit rating	No influence	Low, positive influence	No influence	Strong, positive influence

Source: KfW SME Panel, own calculations

Box 2: Methodology and database

The analysis examined how strongly R&D activity (and investment activity) depend on an enterprise's profit margin and credit rating. In addition to profit margin and the Creditreform credit rating index, it took into account the following characteristics: Number of employees (in full-time equivalents), age of company (both logarithmised), employment of university graduates, sales region, collective industry to which it belongs, group to which it belongs, turnover growth, legal status, KfW support status, region of company's registered office and time of survey. All data of the time-varying variables refer to the time prior to the measurement of R&D activity (and investment activity).

The analysis was conducted using Heckman correction models for R&D and capital expenditure (Table 2 in the Annex). It involved simultaneously determining the probability of conducting R&D (or investing) and the funds spent on R&D (or investing) in enterprises conducting R&D (or investing). The analysis of R&D activity was based on a good 9,000 observations of more than 5,400 different enterprises. The corresponding figures for the analysis of capital expenditure were just under 10,700 and close to 5,700, respectively. The standard errors were computed taking into account the fact that one enterprise may make several observations.[xiv] The observation period for R&D (and capital expenditure) covers the years 2013 to 2015.

Regression results are illustrated using model calculations. The influence of a characteristic on the likelihood of conducting R&D and on the level of R&D expenditure can be described by varying a characteristic in the model calculations while leaving all other business characteristics unchanged. The information on the quantiles refers to the sample used to analyse R&D activity.

Table 2: Regression results of simultaneous Heckman model for R&D and capital expenditure

	R&D		Capital expenditure	
	Level of R&D expenditure		Level of capital expenditure	
	Coefficient	robust t-value	Coefficient	robust t-value
Credit rating / 100	-0.0701	-0.58	-0.4909	-8.13
Profit margin	1.2423	2.62	0.5490	2.19
Turnover growth rate	0.0145	0.12	0.2871	4.84
Log(employees in FTEs)	0.8499	15.95	0.8688	27.78
Group affiliation: Subsidiaries	0.1785	1.71	0.2390	4.29
Log(age)	-0.0652	-1.04	0.1552	5.19
Sales market:				
50 km-region	Reference category		Reference category	
Sales across Germany	0.5442	2.41	-0.0541	-0.88
Outside Germany as well	1.5762	6.33	0.1277	1.91
Proportion of employees with a tertiary degree	2.2501	10.70	-0.0159	-0.15
Legal form: Limited liability	0.4875	2.91	0.1990	3.44
Sector to which the enterprise belongs:				
Manufacturing	Reference category		Reference category	
Construction	-0.9999	-5.33	-0.1627	-2.68
Trade	-0.4202	-2.63	-0.1891	-3.24
Services	-0.2653	-1.91	0.2537	4.05
Other	-0.4506	-0.81	1.1860	8.01
Reference year of variable to be explained:				
2013	Reference category		Reference category	
2014	0.0404	0.55	-0.0754	-2.34
2015	-0.0541	-0.73	-0.0894	-2.49
Region of registered office: Eastern Germany	0.0375	0.39	-0.1780	-3.70
Promotional status: not promoted	0.1699	1.63	-0.4258	-8.70
Constant	5.6552	10.35	9.1257	36.63

Table 2 (cont'd): Regression results of simultaneous Heckman model for R&D and capital expenditure

	R&D		Capital expenditure	
	Likelihood of R&D		Likelihood of capital expenditure	
	Coefficient	Robust t-value	Coefficient	Robust t-value
Credit rating / 100	-0.0578	-0.89	-0.1476	-3.30
Profit margin	0.5117	2.02	0.6322	4.06
Turnover growth rate	0.1361	2.58	0.2055	4.24
Log(employees in FTEs)	0.1698	7.26	0.4135	23.11
Group affiliation: Subsidiaries	0.0604	1.05	0.0587	1.29
Log(age)	-0.0940	-2.88	0.0472	2.16
Sales market:				
50 km-region	Reference category		Reference category	
Sales across Germany	0.4210	5.71	0.0920	2.24
Outside Germany as well	1.0737	14.78	0.0919	1.97
Proportion of employees with a tertiary degree	1.1798	12.90	0.2687	3.66
Legal form: Limited liability	0.2645	3.95	-0.0394	-0.96
Sector to which the enterprise belongs:				
Manufacturing	Reference category		Reference category	
Construction	-0.6907	-8.00	-0.0409	-0.74
Trade	-0.7654	-12.15	-0.1410	-2.98
Services	-0.6879	-10.91	0.1069	2.09
Other	-0.7359	-4.15	0.4078	3.76
Reference year of variable to be explained:				
2013	Reference category		Reference category	
2014	0.2420	6.53	-0.0371	-1.40
2015	-0.1199	-3.21	0.0657	2.19
Region of registered office: Eastern Germany	0.0020	0.04	-0.0641	-1.82
Promotional status: not promoted	-0.1387	-2.64	-0.1179	-3.33
Constant	-1.6882	-6.94	-0.5672	-3.49
/athrho	0.3751	3.54	0.3947	4.28
/lnsigma	0.3262	9.21	0.3466	17.48
rho	0.3585		0.3754	
sigma	1.3857		1.4142	
lambda	0.4967		0.5309	
Number of observations	9.040		10.673	
Wald test (all explanatory variables =0)	chi2(18)=626.38		chi2(18)=1,554.06	
Wald Test (rho=0)	chi2(1)=12.56		chi2(1)=18.32	
Log likelihood	-5470.24		-17981.16	

Source: KfW SME Panel, own calculations

[1] This study was conducted in a partnership between Creditreform Rating AG, Neuss, and KfW Research, the economics department of KfW Group.

[2] Cf. Zimmermann, V. (2009): The Impact of Innovation on Employment in Small and Medium Enterprises with Different Growth Rates. Jahrbücher für Nationalökonomie und Statistik 229(2+3), p. 313–326 or Zimmermann, V. (2014): Innovation und Beschäftigung. Die Beschäftigungswirkung verschiedener Arten von Innovationen in expandierenden und schrumpfenden mittelständischen Unternehmen *[Innovation and employment. The employment impact of different types of innovation in expanding and shrinking SMEs – in German]*, in: Journal of Business Economics (Zeitschrift für Betriebswirtschaft), ZfB-Special Issue 4/2013, p. 131–149 or Zimmermann, V. (2015): KfW SME Innovation Report 2014. Standstill in Europe is slowing down innovation. KfW Research.

[3] Zimmermann, V. (2015): An international comparison of R&D: Germany benefits from industrial research strength, Focus on Economics No. 105, KfW Research.

[4] Cf. Zimmermann, V. (2016): SME business performance – research and development pays off, Economics in Brief No. 106, KfW Research, or Zimmermann, V. (2017): Success factors of high-growth enterprises, Focus on Economic No. 177, KfW Research.

[5] Cf. Scherer, F. M. and Harhoff, D. (2000): Technology policy for a world of skew-distributed outcomes, Research Policy 29(4–5), 559–566.

[6] Cf. Czarnitzki, D. and Hottenrott, H. (2010): Financing constraints for industrial innovation: What do we know? Review of Business and Economic Literature 55(3), p. 346–263; Kerr, W. R. and Nanda, R. (2015): Financing Innovation, Annual Review of Financial Economics 7(1), p. 445–462.

[7] Cf. Myers, S. C. and Majluf, N. E. (1984): Corporate Financing and investment decisions when firms have information that investors do not have, Journal of Financial Economics 13, p. 187–221; Myers, S. C. (1984): The capital structure puzzle, Journal of Finance 39, p. 575–592; Stiglitz, J. E. and Weiss, A. (1981): Credit Rationing in Markets with Imperfect Information, The American Economic Review 71(3), p. 393–410.

[8] Cf. Kladroba, A. (2013): FuE Datenreport 2013. Tabellen und Daten. Essen: Stifterverband für die Deutsche Wissenschaft (in German).

[9] It should be noted, however, that credit rating and profit margin are not entirely independent from each other. But because the credit rating involves numerous factors, the profit margin cannot be translated to the credit rating one-to-one. In considering the credit rating and profit margin at the same time, we followed the practice customarily adopted in the literature. Cf. Czarnitzki, D. and Hottenrott, H. (2011): R&D Investment and financing constraints of small and medium sized firms, Small Business Economics 36(1), p. 65–83 or Hottenrott, H. and Peters,

B. (2012): Innovative capability and financing constraints for innovation – more money, more innovation?, Review of Economics and Statistics 94(4), p. 1126–1142.

[10] Values of 500 indicate a massive default in payment and 600 the suspension of payments. In order to exclude enterprises that were already experiencing massive payment difficulties, the analysis included only enterprises with a credit rating not worse than 400.

[11] This is consistent with the values of the credit rating index of 217 index points (median) compared with 175 index points (90% quantile).

[12] Cf. Zimmermann, V. (2014): KfW SME Panel 2013: How SMEs finance their innovations, Focus on Economics No. 50, KfW Economic Research.

[13] Cf. Hottenrott, H. and Peters, B. (2012): Innovative capability and financing constraints for innovation – more money, more innovation? Review of Economics and Statistics 94(4), p. 1126–1142.

[xiv] Cf. Huber, P. J. (1967): The behaviour of maximum likelihood estimates under non-standard conditions, Proceedings of the Fifth Berkley Symposium on Mathematical Statistics and Probability 1, p. 221–233 and White, H. (1982): Maximum Likelihood Estimation on Misspecified Models, Econometrica 50, p. 1–25.