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R&D and Firm Performance in a Transition Economy

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Non-technical Summary

Due to outcome uncertainty of R&D investments, it is a-priori unclear whether innovative activity leads to improved firm performance. The market value model represents a possibility to measure the returns to innovation by relating the valuation of firms at the stock market to R&D investment. The market value model has the advantage of bundling information and expectations concerning future firm values. It has the disadvantage that only a minority of companies can be used for this empirical test, as only a small share of firms in the business sector universe are publicly traded at stock markets.

As a complement to the market value approach, we propose the use of credit ratings which are available for almost every company. Credit ratings are not only based on current but also on future profits, as in many cases borrowers and other remittees have long-run connections to a firm in question. In addition, we use the future payment behavior as a variable describing default risk. Payment behavior is classified according to the average duration until payments are actually conducted. This variable ranges from "payments always being in time" to the worst possible scenario, which is bankruptcy.

The major purpose of this study is a comparison of R&D in Western and Eastern German firms with respect to its relationship to our proxy variables for financial returns. It turns out that investing in R&D is good for Western German firms and bad for East-German firms. While R&D contributes positively to future ratings in the West, the opposite is true in the East. Apparently the effect of risk when investing in R&D outweighs the potential benefits. If the receipt of subsidies is taken into account, R&D still influences ratings positively in the West. In Eastern Germany, R&D is at least not negatively affecting the credit rating, when firms obtain public money for such investments.

As a further step, we analyze future financial distress in order to test whether Eastern German companies are simply discriminated by the rating agency, or if they indeed face higher risk of bankcruptcy or defaults when engaging in R&D. The results show that Eastern German firms seem to have significantly more difficulties to translate R&D into viable products or cost-reducing processes. If R&D is conducted, they suffer higher likelihood of future financial distress and finally bankruptcy. In the case of subsidized R&D, we do not witness this negative effect.

In conclusion, we find that R&D has very different effects in Eastern and Western German companies. While R&D improves firm performance in the West, on average, every single unit

of R&D conducted in the East reduces future firm performance. Although the negative effect in the East is not found, when looking at R&D-subsidized firms, such investment seem not to pay-off for the Eastern German business sector. While R&D in subsidized Western German firms has also positive effects on future ratings and financial situation, there is no impact in the East.

These results call into question the high subsidization of Eastern German firms. If the resources are inefficiently used, policy makers should think about alternative ways to improve the competitiveness of the Eastern German business sector.

R&D and Firm Performance in a Transition Economy[1]

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Abstract

We estimate the effects of R&D on firms' credit ratings and on financial distress. The main purpose is the comparison of firms in Western Germany and Eastern Germany as a transitional economy. Innovative activity has a positive impact on firm value proxied by ratings in Western Germany, but a negative impact in Eastern Germany. We also consider future financial distress, and find that R&D in Eastern German firms leads to higher default risk, in contrast to Western Germany. There, R&D enhances future performance. This result is highly politically relevant, since the high level of subsidies present in Eastern Germany may be subject to misallocation.

Keywords: Transitional Economy, Credit Rating, Bankruptcy, Innovation, Policy
JEL-Classification: L33, O12, O31, O38, P27

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1 Introduction

The relationship between innovation and economic return is frequently discussed in economic literature. Among others, one approach is to relate the valuation by financial markets of a firm's assets to measures of innovation (see Griliches, 1981, as seminal paper, or Czarnitzki et al., 2006, for a recent survey). The market value model utilizes the evaluation by the stock market and is therefore characterized by a bundling of information and expectations. Additionally, this approach has advantages over the analysis of profits or productivity growth. Firstly, the financial market valuation avoids the problems of time lags between cost and revenues. Secondly, it is capable of forward-looking evaluation and, finally, one can compare the economic impact of various measures of innovation.[2]

The disadvantage of the market approach is that it is "[...] intrinsically limited in scope, because it can be used only for private firms and only where these firms are traded on a well functioning financial market [...]" (Hall, 2000, p. 177). The vast majority of companies are not publicly traded. Furthermore, such a sample is hardly representative – especially for continential Europe – because usually only large firms are traded at the stock exchange. Czarnitzki and Kraft (2004) proposed a complementary approach: the evaluation by a credit rating agency. Ratings are clearly important for most firms in an economy, and therefore the number of firms which could be analyzed is much larger than if only publicly traded companies are considered, and it is also representative for the economy as a whole. Credit ratings are associated with the market's assessment of future profits, but not directly. They are primarily driven by evaluation of default risk on various forms of debt, which has mostly to do with the firm's cost of capital, structure of the balance sheet and variance of cash flow.[3] Czarnitzki and Kraft (2004) have shown for a sample of Western German manufacturing firms that various measures of innovative activity are positively related with firms' credit ratings over a large range of the distribution of innovative activity. If, however, innovative activity exceeds a certain threshold level, such companies are downgraded, maybe because

[2] See e.g. Hall et al. (2005) who simultaneously investigate the value of R&D, the additional value of patented inventions, and, among those, the value of highly cited patents. Using patent citations in the market value equation allows to control for heterogeneous economic value of patents.

[3] Against the background of the New Basle Capital Accord, the relevance of such ratings will even increase in the future (cf. e.g. Secretariat of the Basle Committee on Banking Supervision, 2001).

their business strategy relies heavily on risky projects. For example, Czarnitzki and Kraft found that – while controlling for several other factors – R&D is positively correlated with credit ratings up to an intensity (R&D/Sales) of 14%. Firms that show a higher R&D intensity are rated more conservatively due to the inherent risk of failure their investment strategy faces.

The purpose of this paper has two dimensions: On one hand, we apply the approach introduced by Czarnitzki and Kraft (2004) to a sample of Eastern German manufacturing firms, and, on the other hand, we extend the rating model by a second equation dealing with financial distress and bankruptcy. This is particularly interesting for two reasons: first, Eastern German manufacturing is predominantly composed of small and medium-sized enterprises that were newly founded after the German re-unification in 1990. The vast majority is not publicly traded. We ask the question whether investment in R&D is valued as in Western Germany, or if agencies rate such firms more conservative, because young firms lack a corresponding track record on which the rating could be based. Second, innovation in a transition economy like Eastern Germany might suffer from lacking experience with both the current technological frontier and mechanisms at place in a market economy. For example, outdated human capital could often leads to duplicate research (by accident), or firms could rely only on imitation (on purpose). In combination with high demand uncertainty and lacking experience in marketing strategy, investments in R&D may not lead to (expected) returns. Those could be necessary to survive for start-up firms.

Furthermore, this study could be highly relevant for innovation policy. Eastern German firms receive relatively more subsidies than their Western German counterparts. The German government intends to foster the transformation process from a planned economy to a viable market economy by, among other policies, an intensive support for innovative activities in order to strenghten the competitiveness of the Eastern German regions. If, however, innovation activities in the East do not lead to successful products and market success, but fail or, in the worst case, put firms at the risk of bankruptcy, this policy strategy may be an inefficient allocation of resources. Consequently, we will analyze both subsidized and non-subsidized firms.

Our study is an extension of the (few) existing studies on the effects of innovations in transition economies. Aghion et al. (2002) as well as Carlin et al. (2004) investigate the effect of innovations on growth of a sample of 2,245 respectively 3,288 firms from 24 Eastern European countries. The main emphasis is on the interaction of competition and innovation. It

is found that some competitive pressure is good for innovativeness, but too much can be counterproductive (Carlin et al., 2004). Innovativeness has a positive impact on growth. However, it is not tested whether innovations have also a positive effect on profitability. Konings and Xavier (2002) utilize information concerning innovation and use the ratio of intangible assets to total fixed assets as an exogenous variable explaining survival and growth for a sample of 2,813 Slovanian firms over the time period from 1994 to 1998. It turns out that the innovation variable has negative, yet insignificant, coefficients both in the growth and the survival equations. However, this is a first indication that innovation might not support growth and survival of firms in a transition economy. This stands in contrast to the usual empirical results estimated for firms in non-transition countries (Hall, 1987, Cefis and Marsili, 2006). We are not aware of a study that directly compares non-transition and transition countries.

The remainder of the paper is as follows: Section 2 summarizes the conceptual background, Section 3 describes the data, and the econometric study is presented in Section 4. The final section concludes.

2 Conceptual Framework

The advantage of using ratings is that almost every firm which is looking for either bank loans or supplier credits is classified. The data basis is much broader and a selectivity effect, if still present at all, is clearly smaller than if only publicly traded, joint-stock companies are considered. Similarly to the studies based on stock market evaluation of firm values, accounting practices do not distort the rating and lags are of minor importance.[4] The disadvantage is that whilst thousands of participants evaluate a firm's value in the stock market, here it is done by a single rating agency.

The firm value is expected to reflect the value of both tangible assets and intangible assets, in particular the stock of innovative knowledge, i.e. the intangible assets created by R&D activity. The effect of innovative activity on the rating of a firm might be ambiguous. A rating takes into account business and financial risks, such as industry characteristics, competitive position, management, productivity, profitability, liquidity as well as financial policy and

[4] See Fisher and McGowan (1983) for problems associated with the use of accounting data.

flexibility. Thus a rating reflects both currently observable firm characteristics and expectations regarding future developments.

The statement that innovative activity is a risky undertaking is close to triviality. Risk is expected to affect the rating negatively, as the lender faces a higher probability of failure. However, innovation is a driving force for economic success and therefore an innovative firm may achieve a good rating. There might well be an internal optimum which means that “some“ R&D is useful, whilst too much R&D does not maximize the present firm value. Thus a 'moderately' successfully R&D performing firm is expected to have high revenues and a good financial performance. Although R&D does not influence the rating directly, a rating agency could indirectly react to innovative activity because of the economic success (or failure).

The effect of R&D on credit ratings is a priori unclear. Given the aim of the rating agency to evaluate the probability of defaults, any risk should be negatively valued. However, without any innovative effort a firm will loose market share and its competitiveness will suffer. In the long run an innovative firm may have better chances to survive, if investments into these activities are not too large.

Aside of the general relevance of evaluating the effect of R&D activity on ratings, it is of specific interest in the case of Eastern Germany. We are able to compare the market economy of Western Germany with an economy in transition where both have the same currency unit, the same legal system, the same economic system and all other important contributions to the business environment. It should be noted, though, that more than 15 years after the unification, wages are still lower in Eastern Germany, on average.

After the German reunification in 1990, the East German industrial sector more or less collapsed. The existing larger firms (the "combinates") were sold to new (private) owners and a restructuring process took place. In order to speed up the convergence process, a number of policy measures were introduced. Those covered the whole range of taks: improving infrastucture, active labor market policies, and also support targeted on private firms, like investment and innovation programs.

Fostering innovation is clearly intended to improve the competitiveness of the companies in question and this was highly needed for the former producers in a centrally governed planning society. In order to be a successful stimulus to the catching-up process, the subsidies must be used efficiently within the firm. Necessary conditions are, among others, a skilled workforce

and an efficient organization system. It is unclear whether the East German firms succeeded in building up an effective production system in order to allocate scarce resources in general and innovative assets in specific. The East German companies used to be run by pursuing very different principles than those relevant for a capitalistic economy with darwinistic structures. A comparison of the performance of today's Western and Eastern German firms seems to be an interesting test on the question whether the firms in the East and the West behave similar and whether the subsidies are efficiently used or not. Our idea to consider the impact of innovative assets on credit ratings of the Eastern German firms is of particular use as most of them are small privately owned businesses that are rarely quoted at the stock exchange market.

The approach is in our view also a useful extension of the earlier research concerning the possible substitutionability of publicly financed R&D (cf. Almus and Czarnitzki, 2003, Czarnitzki and Licht, 2006). While this kind of research examines the impact of public subsidies on the total R&D budget, our present approach tests on the effectiveness of R&D. Non-substitution between private R&D and public subsidies is a necessary condition for effectiveness. In addition, a productive use of these resources is needed in order to achieve an efficient allocation of scarce tax financed public expenditures.

As mentioned above, credit ratings are constructed in order to assess possible default risk for potential investors. Although this may well be used as a performance indicator of businesses, this measure is different from a market value. Therefore, we investigate in a second step of our analysis whether the results we find with respect to the rating are also reflected in other performance indicators. Since Eastern German firms are, on average, much younger and smaller than Western German firms, they face higher market uncertainty. This could result in more conservative ratings simply due to lacking track records and experience with such businesses.

In order to assess a potential downward bias for non-economically motivated reasons by the rating agency, we verify our finding on the credit rating by an estimation of a second equation. As an alternative to the rating, we consider the risk of financial distress. Although we observe actual bankcruptcy, too, we prefer to use a broader measure of financial distress, because firm bankruptcies are rare events, and the econometric analysis of such is difficult. Financial distress is described by the payment behavior of firms. A default is certainly an incidence that a lender definitely wants to avoid, but late payments are also a problem and usually related to financial losses and, in addition, it may be a warning that more serious

problems could arise in the near future. Therefore, we believe that payment behavior is an objective measure concerning the risk of borrowers or other remittees, and that it directly translates into liquidity of firms.

Our variable characterizing the financial situation takes on six different categories, which describe the payment behavior (or liquidity): the best is the observation that the firm under consideration usually pays its bills before they are due in oder to realize a discount. The categories in-between refer to payment of bills "within the term of credit" through "regularly long delays" in payments, and the worst category is bankruptcy. This variable shows more variation than a dummy variable indicating bankruptcy only. If we find that the effect of R&D on the payment behavior (called "financial distress" henceforth) is different from that on the rating, the agency would actually discriminate Eastern German firms and possibly hamper their access to external capital unwarrentedly. If, however, R&D shows a similar effect on financial distress, the rating agency anticipates R&D outcome Eastern German firms correctly, on average. In this case, R&D projects in Eastern German firms either fail to a large extent or such companies miss to utilize R&D results at the market. With respect to the East-West comparison, our analysis allows to conclude the following: if there is no difference to be found, both types of firms show the same level of efficiency, when dealing with innovation resources. If they are dissimilar, however, the use of innovative assets is of higher value in one region of the country than it is in the other.

Consequently, we estimate two equations: first we consider the market value equation represented by the credit rating (*RATING*), and, second, we investigate the effect of R&D on the future firm performance in terms of financial distress (*DISTRESS*):

$$RATING_{i,t+1} = f\left(RDINT_{it},\ X_{it}\right), \tag{1}$$

$$DISTRESS_{i,t+1} = g\left(RDINT_{it}, X_{it}\right) \tag{2}$$

where *RDINT* is the R&D intensity (R&D/SALES) of firm *i* in period *t*, and *X* represents a vector of covariates to be described below.

3 Data

The data basis for our research is the Mannheim Innovation Panel (MIP) which is an annual German innovation survey conducted by the Centre for European Economic Research (ZEW) since 1992. We use data from 1994, 1996, 1998 and 2000 on German manufacturing firms, as those waves of the panel include questions on the receipt of R&D subsidies. The information from the MIP is merged with the database of "Creditreform" which is the largest German

rating agency. This database contains a credit rating and related data of most firms in Germany. The resulting sample after merging the two databases comprises 3,167 observations on Western German firms and 1,158 on Eastern German firms. Note that we do not have a panel dataset in the econometric sense. About 60% of the firms in both regions are only observed once in the sample. This is partly due to the merging of both databases, but also due to the fact that German firms are reluctant to provide information about their enterprises voluntarily. A considerable share of firms does not participate regularly in the MIP survey, and hence we can only conduct a pooled cross-sectional analysis, but not make use of panel data econometrics (see Table 6 in the appendix for information on the panel structure).

As described above, we choose firms' credit ratings as a market performance indicator and relate it to innovative activity. The credit rating is an index which ranges from zero to 500, where 500 represents the best rating.[5] However, Creditreform interprets this rating score not as a linear index, but as an ordered variable with 5 categories:

1) insufficient, 2) weak, 3) average, 4) good, 5) very good.

Thus, our dependent variable takes values from zero to four and is specified as a one-period lead ($RATING_{i,t+1}$). The lead is used to ensure that the causality runs from innovation to the rating. Moreover, the rating agency may need some time to react to changes in firm activities. The distribution of ratings is shown in Table 1.

Table 1: Distribution of ratings in the sample

	Western Germany		Eastern Germany	
Rating category	# of obs.	in %	# of obs.	in %
Insufficient	35	1.08	35	3.04
Weak	65	2.01	52	4.51
Average	1,243	38.38	875	75.89
Good	1,678	51.81	188	16.31
Very good	218	6.73	3	0.26
Total	3,239	100.00	1,153	100.00

It turns out that only a few firms in the sample have weak or insufficient ratings. This may be due to a firm size restriction in the survey. Firms are only sampled if they have at least five employees. Table 1 shows clearly, however, that Eastern German firms have worse ratings

[5] In the original Creditreform data the rating ranges from 100 to 600 where 100 represents the best rating. For our analysis, we simply rescaled the rating as described above.

than Western German firms, on average. While almost 8% of Eastern German firms have a weak or worse rating, this applies only to about 3% in the West. Whereas almost 60% of Western German firms have a good or very good rating, this is only the case for less than 17% of Eastern German firms.

The second dependent variable is financial distress in period t+1 which is described by the payment behaviour of firms ($DISTRESS_{i,t+1}$). This variable is also categorial and is defined as follows:

0) early payments in order to utilize discount
1) payments within term of credit
2) payment mostly within term of credit
3) several incidents of late payments
4) regularly late payments; payments only after (several) dunning letters
5) insolvency (bankcruptcy)

The distribution of this financial distress measure is shown in Table 2. The frequency distribution in the East and West differ mainly in the good categories. While 46% of Western German firms are located in the best category of earliest payments, the Eastern German proportion in this class is only about 11%. The vast majority of firms in Eastern Germany show payment within the term of credits, though. However, the relative frequency of insolvency in the East is more than twice as high than in the West.

Table 2: Distribution of financial distress (payment behavior) in the sample

	Western Germany		Eastern Germany	
Payment category	# of obs.	in %	# of obs.	in %
Early payments in order to utilize discount	1,484	45.82	129	11.19
Payments within term of credit	1,444	44.58	809	70.16
Payment mostly within term of credit	179	5.53	116	10.06
Several incidents of late payments	48	1.48	31	2.69
Regularly late payments; payments only after (repeated) dunning letters	4	0.12	5	0.43
Insolvency (bankcruptcy)	80	2.47	63	5.46
Total	3,239	100.00	1,153	100.00

The exogeneous variable of our main interest is R&D intensity which is measured as R&D expenditure divided by sales (*RDINT = R&D/SALES * 100*). We also test quadratic functional forms of R&D intensity, because there might well be an internal optimum. Two issues should be noted about this variable:

- In market value studies, scholars usually intend to measure the knowledge stock calculated by R&D or patents through the perpetual inventory method from a time series of annual expenditures or patents. In our case, we do not have the information necessary to do so. Therefore, we only consider current R&D expenditure. Due to the high adjustment cost of R&D activities, the current expenditure is expected to represent a good proxy-variable for the R&D stock.
- In the second equation on financial distress, current expenditure is actually what we consider as the relevant measure. Current expenses will have a direct effect on future liquidity. Using a one-year lead of the dependent variable also avoids endogeneity problems of current R&D.

As we are especially interested in differences among regions, we use a dummy variable identifying Eastern German firms (EAST), and consider two interaction terms of R&D to allow for differences in the impact of R&D on our dependent variables:

$RDINT\_WEST = (1 - EAST) * RDINT$, and

$RDINT\_EAST = EAST * RDINT$.

Furthermore, the rating may be affected by other factors besides innovativeness. We include several control variables: Firm age is an important variable as, for young firms, the rating may also indicate the likelihood of survival, and not only economic wealth. Moreover, lacking track record may yield worse ratings. This is particularly important in our context, because the Western German firms are located in an established market economy and some of them may be very old. In contrast, the vast majority of Eastern German firms has been newly founded after the German re-unification in 1990. We distinguish four age groups in the analysis: firms being older than 15 years are considered as old firms in the context of our East-West comparison. As we will highlight in the upcoming econometric exercise, such firms are very different from the younger (Eastern German) firms, and we will present estimations for subsamples of younger firms separately. The other three age groups concern firms from 1 to 5, 6-10 and 11-15 years in business.

As significant as the age difference in the two parts of Germany is the innovation policy. Since the re-unification firms in Eastern Germany are heavily subsidized in order to accelerate the catching-up process to the West. Since the emphasis in this study is on R&D activities and their contribution to firm performance, we take public R&D subsidies into account. We found that it is critically important to split the sample into subsidized and non-subsidized firms. This

is done by a dummy variable that indicates whether a companies has received subsidies in the corresponding period.

Other controls are total sales volume (*SALES*) and its squared value (in billion DM) to control for size effects. Sales are used instead of physical assets, because this is in line with the construction of the rating, in our case. The sales per employee (in million DM) controls for productivity differences among firms (*SALES/EMP*). We have also experimented with different liability-limiting legal forms, and include a dummy for joint stock companies (*JSTOCK*), and one for other liability-limiting legal forms (*LTD*). In addition, firms that are associated with a group may have better access to capital than stand-alone companies, and thus we include a dummy variable for such firms (*GROUP*). Twelve industry dummies capture sectoral differences and three time dummies shift intertemporal changes. Descriptive statistics of the variables used (except time and industry dummies) are given in Table 3.

On average, Eastern German firms show a higher R&D intensity (2.6%) than Western German firms (1.7%), but this is not due to higher R&D investment, but less sales on average. The average Western German firm employs 436 people (median: 156), while this figure amounts to 129 (median: 62) in the East. Furthermore, Western German firms achieve higher sales per employee (the median of sales per employee is 0.23 in the West vs. 014 in the East), and are more likely to be associated with a group (39% versus 30% in the East).

Table 3: Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max
		Western Germany (*N* = 3,239)		
$RATING_{i,t+1}$	2.611	0.691	0	4
$DISTRESS_{i,t+1}$	0.729	0.952	0	5
$RDINT_{it}$ *(=R&D/SALES*100)*	1.678	3.390	0	59.559
D(R&D Subsidy received)$_{it}$	0.172	0.377	0	1
$SALES_{it}$ (in billion DM)	0.126	0.321	0.0004	4.292
$SALES/EMP_{it}$ (in million DM)	0.277	0.188	0.042	1.634
Employees in 1,000s (EMP_{it})	0.436	1.188	0.002	28.4
D(*AGE* = 1–5 years)$_{it}$	0.068	0.252	0	1
D(*AGE* = 6–10 years)$_{it}$	0.103	0.303	0	1
D(*AGE* = 11–15 years)$_{it}$	0.093	0.291	0	1
D(*AGE* = more than 15 years)$_{it}$	0.736	0.441	0	1
$JSTOCK_{it}$	0.057	0.232	0	1
LTD_{it}	0.881	0.324	0	1
$GROUP_{it}$	0.385	0.487	0	1
		Eastern Germany (*N* = 1,153)		
$RATING_{i,t+1}$	2.062	0.580	0	4
$DISTRESS_{i,t+1}$	1.274	1.077	0	5
$RDINT_{it}$ *(=R&D/SALES*100)*	2.613	6.350	0	69.601
D(R&D Subsidy received)$_{it}$	0.442	0.497	0	1
$SALES_{it}$ (in billion DM)	0.033	0.139	0.0004	3.311
$SALES/EMP_{it}$ (in million DM)	0.187	0.158	0.035	1.609
Employees in 1,000s (EMP_{it})	0.129	0.304	0.002	7.832
D(*AGE* = 1–5 years)	0.430	0.495	0	1
D(*AGE* = 6–10 years)	0.485	0.500	0	1
D(*AGE* = 11–15 years)	0.009	0.093	0	1
D(*AGE* = more than 15 years)	0.076	0.266	0	1
$JSTOCK_{it}$	0.014	0.117	0	1
LTD_{it}	0.917	0.276	0	1
$GROUP_{it}$	0.303	0.460	0	1

Another major difference is the age of businesses: In the West, the majority of firms is more than 15 years in business (73%), while 92% of the Eastern German firms are younger than 15 years. This is, of course, caused by the German re-unification in 1990. The Government's efforts of forstering the transformation process of the Eastern German economy is clearly reflected in the level of R&D subsidies: in the West, 17% of manufacturing firms in the sample have received R&D subsidies. In Eastern Germany, however, this figure amounts 44%. If one only considers R&D-performing firms this difference becomes even more striking: in the West 58% (= 1,868 obs.) and in the East 54% (= 624 obs.) of firms conduct R&D. However, in the West only 28% (= 530 obs.) of such are subsidized with respect to

their R&D activities, whereas 75% (= 471 obs.) of Eastern German R&D performers received public funding.

4 Regression results

As the previous section outlined, there are some fundamental differences between the two German regions. First, Eastern German firms are much younger than those in the West, on average. Second, there is a large difference in the supply of public R&D funding among the East and West. These facts led to following estimation strategy: as the dependent variables in our study indicate financial performance and we are interested in the relationship to R&D activities, we split the sample into subsidized and non-subsidized firms. R&D in firms that are not subsidized may be different from that in non-supported firms: on one hand, firms that use only their own funds may have a project portfolio with higher expected private return as the government aims to pick those projects for subsidization that show a high expected social return, but not necessarily a high private return. This would be in line with the theory on external effects introduced by Arrow (1962) according to which any R&D activity creates knowledge spill-overs. As a result, the firm cannot appropriate the full returns from its knowledge creation, but third parties and in the end society benefits from such investments. In turn, there may be projects that have very high social returns, but the private returns do not cover the private cost. A profit-maximizing firm will surely choose only those projects with highest expected private return, and the government aims to pick such projects for public support that do not cover the private cost. Hence, projects is subsidized firms may generate less private profit, on average. On the other hand, the subsidized firms undertake research not with their own funds, at least partly. Thus, failures of projects may not have such a negative impact on the financial situation as they might have in firms that use only their own funds (see Hall, 2002, for a survey on financing constraints, and Czarnitzki, 2006, for a recent study on financing of R&D in Eastern and Western Germany).

The large difference in age of firms leads to an estimation using the full sample where we control for age by using three dummy variables. Furthermore, we consider subsamples of firms younger than 16 years.

4.1 Innovative activity and credit ratings

We first present the regression results on the "market value" equation as outlined in Section 2 for both Eastern and Western Germany. The specification is based on Czarnitzki and Kraft

(2004) who performed the same regressions with a similar dataset for Western German companies. The regressions are Ordered Probit models with known threshold values. Recall that the credit rating is originally an index between 0 and 500 which is only categorized for better interpretation. Use of the true threshold values allows us to identify the variance of the model (and the constant term). In such a case, the estimated coefficients can be directly interpreted as coefficients in a linear regression model, i.e. as marginal effects in the "true" latent model.[6] The four models correspond to different samples:

A) Full sample of firms that did not receive an R&D subsidy;

B) Subsample of firms that did not receive R&D subsidies and that are less than 16 years in business;

C) Full sample of firms that received R&D subsidies;

D) Subsample of firms that received R&D subsidies and that are less then 16 years in business.

The estimation results are presented in Table 4. First, we discuss model A: as in the earlier study, we find that R&D has a non-linear impact on the future ratings of Western German firms. The relationship is inversely u-shaped and the curve peaks at 8.2% of R&D intensity. Thus, for the most part of the distribution (more than 97% of observations), R&D has a positive impact on firm performance measured by the credit rating. Only if firms engage in R&D largely (beyond 8.2% R&D intensity) they are perceived as risky investment opportunities by the rating agency, so that such firms are evaluated more conservatively. For the Eastern German firms, however, the relationship between future ratings and R&D is completely different: we did not find any non-linearity, but a negative linear correlation. As soon as Eastern German companies perform R&D they are downgraded, because the perceived risk of financial distress or even bankrupty outweighs the potentially positive benefits of R&D. A change from zero to 10% of R&D intensity would reduce the rating index by almost 23 points, on average. Beyond the effect of R&D, it turns out that Eastern German firms ceteris paribus achieve worse ratings than firms in the West. On average, the rating index of Eastern German firms is 21.3 points lower.

[6] Verbeek (2000, pp. 192-4) provides a good example of the Ordered Probit model for this case.

Furthermore, we do not find unexpected results, since the other covariates are already explicitly taken into account in the construction of ratings by the agency: firms that are associated with a group achieve better ratings. On average, such firms obtain an 11-points higher rating index than stand-alone companies. The interaction term between *GROUP* and *EAST* does not yield a difference among regions. As hypothesized, younger firms are more conservatively rated than more established firms. The three dummies indicating firms between 1-5, 6-10 and 11-15 years in business are significantly negative (reference category are firms that are longer than 15 years in business). Wald tests show that the youngest firms (1-5 years) are significantly rated worse than the other categories, but that there is no significant difference among firms that are between 6-10 and 11-15 years old. Sales increase the ratings. Not surprisingly the quadratic specification shows a decreasing effect with increasing size. In line with sales, the value added per employee has a positive effect on future ratings. The legal form dummies are (jointly) insignificant.

Model B only considers the subsample of firms that are less than 16 years in business and that did not receive R&D subsidies. This specification has been motivated by the fact that the vast majority of firms in Eastern Germany has been newly founded since the German unification in 1990, whereas the Western German industry has many firms being much older. Therefore, a separate regression for the subsample of younger firms is worth to investigate. There are interesting differences in results: In contrast to model A, R&D does no longer have a positive effect on future ratings in Western German young companies. It seems that there is more risk involved in R&D in younger firms, such that those are not better rated than young firms without own R&D which may reflect a less risky business strategy. However, we still find that Eastern German firms are downgraded if they pursue risky investments like R&D. Thus, the basic results holds: R&D in Eastern German firms is regarded as more risky than in Western German firms. On average, Eastern German firms are generally rated worse than Western German one (17 points). The other results are very similar to those obtained in model A except that the GROUP dummy and the remaining two age dummies become insignificant. There is no difference among very young and other firms that are less then 16 years in business.

Model C only considers firms that have received R&D subsidies. In principle, we find comparable results to the regression based on non-subsidized firms (model A). An important difference concerns R&D activity, though: R&D is again positively valued in Western German companies. In Eastern German firms, however, it is no longer negatively influencing

the rating. It seems that subsidized research where firms do not risk their own money (at least to less extent) is not regarded as critically as R&D conducted on solely own resurces.

Table 4: Ordered Probit models with known threshold values on future credit ratings

Variable	Model A	Model B	Model C	Model D
$RDINT\_WEST_{it}$	2.256 ***	2.303	1.726 **	1.386
	(0.802)	(1.538)	(0.867)	(2.901)
$(RDINT\_WEST_{it})^2$	-0.137 ***	-0.126	-0.065 ***	-0.114
	(0.049)	(0.106)	(0.025)	(0.137)
$RDINT\_EAST_{it}$	-2.258 ***	-2.019 ***	-0.303	-0.281
	(0.719)	(0.729)	(0.319)	(0.339)
$EAST_i$	-21.270 ***	-17.485 ***	-22.815 ***	-13.330
	(3.651)	(4.421)	(7.355)	(13.359)
$SALES_{it}$	97.154 ***	116.804 ***	51.575 ***	61.697
	(9.279)	(18.836)	(12.510)	(45.956)
$(SALES_{it})^2$	-29.805 ***	-44.749 ***	-14.582 ***	-17.156
	(3.505)	(8.459)	(3.851)	(28.179)
$SALES/EMP_{it}$	15.244 ***	31.475 ***	5.912	40.770
	(5.482)	(8.692)	(14.889)	(24.788)
$D(AGE$ = 1–5 years$)_{it}$	-28.035 ***	-5.570	-28.440 ***	10.877
	(3.394)	(4.763)	(6.550)	(11.005)
$D(AGE$ = 6–10 years$)_{it}$	-18.432 ***	2.077	-24.746 ***	11.214
	(2.982)	(4.421)	(6.316)	(10.614)
$D(AGE$ = 11–15 years$)_{it}$	-23.138 ***		-44.699 ***	
	(3.576)		(8.489)	
$JSTOCK_{it}$	9.716	5.770	15.514	-14.787
	(6.131)	(12.009)	(11.047)	(26.685)
LTD_{it}	-4.086	-3.491	0.218	-0.017
	(3.677)	(6.357)	(9.015)	(15.912)
$GROUP_{it}$	11.343 ***	5.272	12.394 **	13.994
	(2.305)	(4.463)	(5.097)	(11.803)
$GROUP_{it} * EAST_i$	-0.847	0.177	7.172	2.896
	(5.294)	(6.593)	(7.448)	(12.968)
Intercept	408.401 ***	386.653 ***	403.665 ***	345.359 ***
	(5.337)	(9.811)	(14.357)	(25.355)
Test on joint significance of industry dummies	$\chi^2(12)$ = 55.64 ***	$\chi^2(12)$ = 17.91	$\chi^2(12)$ = 47.95 ***	$\chi^2(12)$ = 29.65 ***
Test on joint significance of time dummies	$\chi^2(3)$ = 52.12 ***	$\chi^2(3)$ = 12.00 ***	$\chi^2(3)$ = 16.91 ***	$\chi^2(3)$ = 12.12 ***
# of obs.	3,325	1,315	1,067	604
Log-Likelihood	-3,147.55	-1,152.63	-1,018.79	-548.87

Notes: *** (**, *) indicate a 1% (5%,10%) significance level.
Model **A)** full sample of firms that did not receive an R&D subsidy; **B)** subsample of firms that did not receive R&D subsidies and that are less than 16 years in business; **C)** full sample of firms that received R&D subsidies; **D)** subsample of firms that received R&D subsidies and that are less then 16 years in business.

Finally, model D looks at young firms that received R&D subsidies. Here, we basically find no significant effect of any covariate on ratings except heterogeneity among industries and time.

We also experimented with an interaction term of R&D in Eastern Germany and time. It would have been possible that Eastern German firms improved the utilization of R&D over time. Therefore, we checked if an interaction of R&D with the time dummy indicating the year 2000 shows results in that respect. It turned out, however, that the interaction variable is insignificant and that all previous results remain unchanged. Hence, there is no evidence for substantial improvement with respect to R&D management between 1994 and 2000.

In general, the results show that R&D in Western Germany contributes positively to firm value. If the subsample of younger firms is employed, it does not harm the ratings in the West, but in Eastern German firms the negative risk effect of R&D outweighs its potential benefits regarding better market positioning of firms. It seems that R&D leads to less useful results in the East than in the West. If R&D is subsidized, that is, risk of bankruptcy should be alleviated, we find that it is at least not downgrading firms' ratings in the East.

4.2 Innovative assets and financial distress

The negative relationship between R&D and ratings in Eastern Germany could be due to two different reasons. Either the East-German firms are unfairly treated and become discriminated or they are using innovative resources less efficiently. The question on the reason for the observed difference can be investigated with data concerning future financial distress as a (negative) outcome of business activity. As described above future financial distress is measured by the payment behavior of firms in period t+1. The exogenous variables are the same as in the previous estimation. We again separate the sample into groups A, B, C and D. The estimation results are presented in Table 5. Note that a higher value of *DISTRESS* corresponds to worse liquidity than a lower value.

Again, we find the same interesting effect: in Model A, R&D relates positively to payment behavior. The estimated effect between *DISTRESS* and R&D is nonlinearly and negatively, where the minimum is at 8.75% of R&D intensity. Thus, for almost all firms (about 98%) R&D decreases the risk of bankruptcy. In Eastern Germany, R&D has the opposite effect, though. We found a positive linear relationship between future distress and R&D. It seems that the effect of the riskiness of the investment outweighs its potential future benefits. Thus, Eastern German firms may have been less successful to translate R&D into viable products or

cost-reducing processes during the 1990s, on average. Every unit spent for R&D increases the time period needed for payment of bills. Hence the companies of the new German "Länder" are not discriminated, they are really different from their Western counterparts. The *EAST* dummy is also positive which accounts for the fact that Eastern German firms ceteris paribus face a higher risk of bankrupty. The other control variables are similar to the first regression on future credit ratings.

Table 5: Ordered Probit models on future financial distress

Variable	Model A	Model B	Model C	Model D
$RDINT\_WEST_{it}$	-0.035 **	-0.052	-0.042 **	0.007
	(0.017)	(0.032)	(0.018)	(0.058)
$(RDINT\_WEST_{it})^2$	0.002 *	0.003	0.001 ***	-0.0001
	(0.001)	(0.002)	(0.0001)	(0.003)
$RDINT\_EAST_{it}$	0.048 ***	0.048 ***	0.0001	-0.0001
	(0.018)	(0.018)	(0.006)	(0.007)
$EAST_i$	0.438 ***	0.506 ***	0.526 ***	0.567 **
	(0.074)	(0.092)	(0.151)	(0.269)
$SALES_{it}$	-0.826 ***	-1.158 ***	-0.392	-0.984
	(0.209)	(0.414)	(0.272)	(0.950)
$(SALES_{it})^2$	0.226 ***	0.428 **	0.126	0.226
	(0.080)	(0.181)	(0.083)	(0.582)
$SALES/EMP_{it}$	-0.420 ***	-0.576 ***	-0.154	-0.631
	(0.121)	(0.187)	(0.313)	(0.509)
$D(AGE$ = 1–5 years$)_{it}$	0.350 ***	-0.135	0.532 ***	-0.385 *
	(0.070)	(0.100)	(0.134)	(0.222)
$D(AGE$ = 6–10 years$)_{it}$	0.245 ***	-0.197 **	0.506 ***	-0.378 *
	(0.063)	(0.093)	(0.130)	(0.213)
$D(AGE$ = 11–15 years$)_{it}$	0.438 ***		1.042 ***	
	(0.075)		(0.173)	
$JSTOCK_{it}$	0.032	-0.030	0.245	0.480
	(0.133)	(0.258)	(0.231)	(0.544)
LTD_{it}	-0.133 *	-0.015	-0.024	0.098
	(0.077)	(0.133)	(0.186)	(0.310)
$GROUP_{it}$	-0.183 ***	-0.085	-0.215 **	-0.074
	(0.051)	(0.095)	(0.109)	(0.237)
$GROUP_{it} * EAST_i$	-0.008	-0.106	-0.192	-0.346
	(0.108)	(0.138)	(0.153)	(0.261)
Test on joint significance of industry dummies	$\chi^2(12)$ = 64.61***	$\chi^2(12)$ = 21.21**	$\chi^2(12)$ = 59.50***	$\chi^2(12)$ = 38.09***
Test on joint significance of time dummies	$\chi^2(3)$ = 11.52***	$\chi^2(3)$ = 0.61	$\chi^2(3)$ = 1.71	$\chi^2(3)$ = 1.72***
# of obs.	3,325	1,315	1,067	604
Log-Likelihood	-3,330.723	-1,342.400	-1,058.226	-611.339

Notes: *** (**, *) indicate a 1% (5%,10%) significance level.
Model **A)** full sample of firms that did not receive an R&D subsidy; **B)** subsample of firms that did not receive R&D subsidies and that are less than 16 years in business; **C)** full sample of firms that received R&D subsidies; **D)** subsample of firms that received R&D subsidies and that are less then 16 years in business.

In Model B where older firms are excluded from the sample, the results are also comparable to the regression on the ratings. While there is no longer a positive effect of R&D in the West, the estimated relationship for Eastern German firms is the same as in Model A. R&D leads to longer time intervals needed for payments, and finally to higher risk of bankruptcy. Again, the Eastern German firms are confronted with higher liquidity problems than Western German firms ceteris paribus.

Model C and D consider firms that receive subsidies, and the results from the previous regressions on ratings are confirmed. In the full sample, R&D leads to better payment behavior in the future. In the East, however, there is no such effect. In the case, R&D is subsidized, it, at least, does not exhibit a negative effect on the future financial situation of firms. Yet, the *EAST* dummy indicated that Western German firms perform better than their Eastern counterparts all else constant. This effect even persists when only the subsample of younger firms (Model D) is used.

In summary, we argue that R&D in Eastern Germany is perceived as more risky rather than beneficial for firm value. In the West, the opposite is true. However, the regressions on future financial distress measured by the payment behavior (time elapsing until payment of bills) indicate that Eastern German firms are not discriminated by the rating agency. R&D does indeed lead to liquidity problems in the future rather than to improved successful products or cost reductions in production. Clearly the question arises, how this provocative result is explained. One reason is presumably the lower R&D productivity estimated by Czarnitzki and Licht (2006). They considered the impact of (subsidized and non-subsidized) R&D on the number of patent applications. According to their study Eastern German firms achieve only less than 50% of the Western German productivity level. Hence the R&D management has to be improved. More general, Czarnitzki (2005) analyzed the productivity deficiency in Eastern Germany by using the average gap in value added between Eastern and Western German firms. Although this gap is gradually closing over time, it remained still large in the year 2000. Furthermore, the study of Czarnitzki (2005) shows that innovating Eastern German firms perform relatively worse than non-innovating firms when compared to a relevant control group from the West. The productivity gap between the East and West is larger for innovating firms than for others.

These results call into question the high subsidization of Eastern German firms. If the resources are inefficiently used, policy makers should think about alternative ways to improve the competitiveness of the Eastern German business sector.

5 Conclusion

This paper reports the results of an empirical study concerning the effects of innovative activity on credit ratings of firms. Previously, the effects of innovation have often been investigated by market valuation of firms present at the stock market, which is a small subsample of firms in the population. In contrast to this, the credit rating approach can be applied to almost all firms in the economy. The credit rating approach is extended by an objective variable concerning the financial status of firms. We use the time taken until payment obligations are fulfilled. Although bankruptcy would be an alternative and more stringent measure of failure, payment behavior has a larger variance than defaults and is therefore better suited for an econometric analysis.

This paper is an extension of our earlier study, Czarnitzki and Kraft (2004), with a very different emphasis. We compare the performance of Western and Eastern German firms which have a very different history, but are now subject to the same currency and legal system, wage determination rules and all other important foundations of an economy. The Western German firms have developed in a traditional market economy while, in contrast, the Eastern German firms face the transformation process from a formerly planned economy. It is by no means clear that both firm types behave in the same way with respect to the outcome of R&D activity despite the common environment. However, this is the unique opportunity to evaluate the pure “transition” effect without any confusion with specific country effects.

Unfortunately, it turns out that the Eastern German firms are very dissimilar to the Western German ones. They perform worse. Any R&D effort leads to a lower credit rating, hence the rating agency distrusts these firms. An examination of the payment behavior (as an indicator for financial distress) shows that the rating agency does not discriminate Eastern German firms with respect to ratings. Innovative activity increases future financial distress in Eastern Germany. The firms invest in R&D without getting corresponding returns afterwards. It remains a demanding task for future work to explain why this phenomenon occurs in Eastern Germany. If R&D is subsidized, we find that it contributes positively to performance in the West, but not in Eastern German firms. However, in the case of subsidy receipt, R&D does at least not harm the economic performance in the East.

It would as well be interesting to expand the basis of our research to Eastern European countries. According to international comparative statistics the Eastern European countries show much less innovative activity than e.g. the EU average (cf. Aralica and Bacic, 2005).

This might be good or bad. If the firms are not skilled enough to handle R&D processes it is good that they recognize this. Adoption of established processes and products in connection with product variation and competitive production possibilities are an attractive alternative to innovation[7]. However most observers ask for more R&D in these countries and for policies to ease innovation in order to increase growth (see e.g. Aralica and Bacic, 2005, as well as Tournemine and Muller, 1996). In our view much more empirical research is needed before such a policy recommondation can seriously be made. Preliminary results by Paasi (1998) point to lower efficiency of the transition economies with respect to the management of innovation.

However, those policy intervention are not only subject of theoretical discussions. Subsidies granted by the European Commission in member countries, like the sixth framework program, are also relevant for the accession countries of the European Union. Perhaps R&D subsidies are partly wasted if granted in an early stage of the transformation process and could be used in a more productive way. It might be the case that instead of conducting research and development firms in these areas are better off by the production of established products at lower costs than in the Western countries. The answers to these questions would surely be helpful for the policy design for transformation processes.

Another interesting extension of this research would disentagle R&D into original research and research mainly aiming at imitation of existing products in established markets. On the one hand, Eastern German firms could mainly focus on imitation which would possibly explain the less successful outcome of R&D in such firms. On the other hand, they may well come up with market novelties, but those may either lack sufficient demand or do not achieve the quality necessary to succeed in (international) markets.

[7] In the case of Hungary the fact that only a low share of foreign-owned exporting firms conduct R&D in Hungary at all is a hint that multinational firms have this view (cf. Havas 2002). Similarly Paasi (2000) reports that in Estonia the foreign firms have lower R&D intensities than the Estonian ones.

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Appendix

Panel structure

Table 6: Panel structure

Western Germany						
Observed patterns						
1994	1996	1998	2000	Freq.	Percent	Cum.
X				578	28.11	28.11
	X			257	12.50	40.61
		X		225	10.94	51.56
			X	198	9.63	61.19
X	X			132	6.42	67.61
		X	X	111	5.40	73.01
	other patterns			555	26.99	100.00
Total				2056	100.00	
Eastern Germany						
Observed patterns						
1994	1996	1998	2000	Freq.	Percent	Cum.
X				161	22.90	22.90
	X			110	15.65	38.55
		X		71	10.10	48.65
			X	58	8.25	56.90
X	X			58	8.25	65.15
		X	X	39	5.55	70.70
	other patterns			206	29.30	100.00
Total				703	100.00	

Note: Total sample amounts to 3,239 observations in Western Germany and 1,153 in Eastern Germany.