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Firm's cooperation activities: The relevance of public research, proximity and personal ties - A study of technology-oriented firms in East Germany

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Abstract:

Cooperation in innovation processes has become crucial for the competitiveness of many firms. This paper focuses on technology-oriented East German firms and analyses details of their cooperation behaviour by studying the relationships between geographic and social proximity, the importance and frequency of cooperative interaction and the attributes of innovation cooperation partners that influence the importance of cooperation. Data is collected in two questionnaires and analysed by regressions. It is found, among other results, that cooperation that is established via personal contacts is, on average, more helpful and important for firms but involves less frequent interaction.

Keywords: Cooperation, Firm, East Germany, Policy

JEL Codes: D 20, I 28, O 32, R 11

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I. Introduction

Within the scientific literature, regional innovation systems have received much attention in recent years (e.g. ASHEIM et al., 2011; SMITH and WATERS, 2011; TER WAL and BOSCHMA, 2009). Cooperation of firms with public research and their overall cooperation behaviour is one of the foci in this literature (e.g. BRENNER et al., 2011; PAIER and SCHERNGELL, 2011; TETHER, 2002). Specifications of and probabilities for cooperation are complex and depend on firm characteristic as well as firms' motives for the engagement in cooperative agreements (e.g. TETHER, 2002). ABRAMOVSKY et al. (2009) show for data from CIS 3 survey that firms engaged in cooperation activities are often supported through public funding and have a higher significance of external knowledge sources for their innovation activities. Among others, ARVANITIS and BOLLI (2009) find that the probability to cooperate with university is higher for firms with a high number of highly skilled workers and thus human capital. Additionally, a higher importance of external knowledge sources also positively impacts the probability of cooperation with universities and research institutes. Nevertheless, in such studies the focus has rarely been laid on factors such as the importance of different cooperation partner and different forms of proximity. One of the few exceptions is made by PETRUZZELLI (2011). He analyses European university-industry patents to account for the impact of previous cooperation and spatial proximity and finds positive influences of both factors on the success of cooperation in terms of patent citations.

Although the literature on innovation cooperation in general and on aspects of cooperation with public research has grown tremendously in recent years, research is still at the beginning of understanding the details of cooperation processes. Up to now, only few attempts have been made to mix aspects like the role of geographical proximity, prior research ties and success of cooperation (exceptions are the works of PETRUZZELLI, 2011 and SCHWARTZ et al., 2012). This paper aims to contribute to this emerging strand of literature by studying relationships between geographic and social proximity and the importance and frequency of cooperative interaction. In addition, it is studied how size and type of cooperation (partners) influence cooperation activities. Of specific interest is the interaction with universities and research institutes.

Obtained data is generated in the context of the policy measure "InnoProfile" launched by the German Federal Ministry for Education and Research. The program finances research groups at universities and research institutes for five years. Firms are not directly financially supported, but are indirectly involved as they are invited to workshops in order to disseminate research results. To this end, research groups that receive funding have to name relevant firms. In a period of three years, two questionnaires have been send to these firms to see if their attitude towards cooperation has

changed. This firm population is well suited for the present analysis for two reasons. First, due to the attachment to a governmental program the return rate of questionnaires is very high (above 50%). Second, firms involved in the program have characteristics that fit to research aims: they are innovative and entering into cooperation with public research is important for them. Hence, by using this firm sample 239 filled questionnaires are obtained that match research aims.

The paper is structured as followed. The following section focuses on aspects concerning the cooperation behaviour of firms and derives hypotheses. In section 3 data and methods used are described. In Section 4 results are presented and discussed. Section 5 concludes.

II. Cooperation behaviour of firms

Basic rationales for firms to engage in cooperation do not fundamentally differ between types of cooperation partners e.g. other firms or public research institutes. TETHER (2002) argues that firms mainly seek for cooperation to overcome uncertainties concerning the innovation process. Furthermore, missing knowledge and information are important reasons for firms to engage in cooperative agreements. This complementation of in-house knowledge may be less expensive then own research activities but also delivers specialized knowledge that is not present in the firm (TETHER, 2002). This is in line with theoretical arguments for cooperation of firms discussed in the literature (e.g. BECKER and DIETZ 2004; BOZEMAN, 2000; BROSTRÖM, 2010; MIOTTI and SACHWALD, 2003). On the one hand, PAIER and SCHERNGELL (2011) for example discuss resource-based theories, where collaboration takes place due to scarce resources. A better access to complementary resources and capabilities helps firms in the development of their innovation projects. In addition, the fact that risks of the innovation process are shared between different actors is important as innovation projects are highly uncertain in their outcomes (EBERS, 1997). Furthermore, it may be advantageous to leave certain parts of a project to a cooperation partner that is more efficient in this topic (e.g. EBERS, 1997; HUXHAM and VANGEN, 2005). As MIOTTI and SACHWALD (2003) state, the resource-based view implies that especially firms in high-tech sectors search for cooperation partners as their projects are uncertain, expensive and of high complexity. For example, FRITSCH and LUKAS (2001) approved this for high-tech firms with high R&D intensity in Germany. Nevertheless, also firms in more mature branches rely on the output of public research (e.g. COHEN et al., 2002). Thus, firms search for cooperation partners that are able to provide complementary resources and capabilities. On the other hand, organizational learning theories discuss the meaning of external knowledge and "joint knowledge production" (PAIER and SCHERNGELL, 2011) for the cooperation behaviour of firms. Many cooperation projects between organizational groups have the aim of mutual learning. Thus, these

types of cooperation are characterized by additionality for cooperation partner through shared knowledge. Nevertheless, a firms' capacity to identify, absorb and exploit new knowledge from outside also determines learning processes and cooperation (COHEN and LEVINTHAL, 1990). All in all, cooperation seems especially important when firms are innovative and develop new products or processes as these processes especially profit from knowledge outside the firm (CASSIMAN et al., 2010; TETHER, 2002). Although the main reasons for cooperation with different types of partners are quite similar, there are differences in the reasons for firms' cooperation with public research and other firms (e.g. BERCOVITZ and FELDMAN, 2007). Generally firms chose their cooperation partners dependent on the resources needed (e.g. MIOTTI and SACHWALD, 2003). Nevertheless, two basic motives for cooperation with different types of partners dominate: The sharing of costs and skills (SAKAKIBARA, 1997).

In general, public research has a special role as a provider of knowledge-spillover and as cooperation partner (e.g. FRITSCH et al., 2008; TÖDTLING et al., 2006). AUTANT-BERNARD (2001) shows for French firms that externalities from public research have an impact on innovations in terms of patents. TÖDTLING et al. (2006) discuss the significance of different knowledge sources like customers, universities and others for firms with varied importance of technology and research. They find a high meaning of university research especially for high-tech firms and research oriented firms. Additionally, D'ESTE and IAMMARINO(2010) show that research quality of public research as well as geographical proximity of firms has an influence on the frequency of university-industry interactions in terms of the number of cooperation partners. In a recent study, COWAN and ZINOVYEVA (2012) highlight positive effects of newly established universities in Italy on the local innovation activity. Nevertheless, the so called "European Paradox" describes the still widespread discrepancy between a highly recommended research landscape in Europe and problems to bring these high-level research results to the market (e.g. VEUGELERS and CASSIMAN, 2005). One of the main problems is not a weak firm basis but weak links between research entities and firms.

Focusing on firm characteristics and the propensity to cooperate, MIOTTI and SACHWALD (2003) discuss the orientation towards R&D as one of the main drivers for cooperation. They find that firms in high-tech sectors and as well as firms close to the technological frontier cooperate more during their innovation processes. In addition, HALL et al. (2003) state that in terms of high uncertainty and fast technological change cooperation with universities might deliver new knowledge for the innovation process. This is in line with findings from BERCOWITZ and FELDMAN (2007) who find a greater probability for university-industry linkages for firms with a higher focus on exploratory research. Also other studies show an impact of orientation towards R&D on the propensity to collaborate (e.g.

LÓPEZ, 2008; NEGASSI, 2004; SEGARRA-BLASCO and ARAUZO-CAROD, 2008; VEUGELERS and CASSIMAN, 2005 among others). These findings suggest:

Hypothesis 1: Cooperation is more frequent and more important for firms with high R&D activity.

Especially for small and medium sized firms, research cooperation as direct contact to new knowledge seems to be of importance. These firms often do not have permanent in-house research capacities. Therefore, they may be able to overcome constraints in innovations processes due to their limited capacities through the establishment of cooperation (e.g. ABRAMOVSKY et al., 2009; LECHNER and DOWLING, 2003). Additionally, also for young firms access to a variety of factors may play a crucial role for their development. These include factors like external knowledge and expertise, skills and equipment (SCHWARTZ et al., 2012). Cooperation with public research is able to provide most of the factors needed. In the literature, most studies focus on the *use* but not on the *need or importance* of public science for certain innovative activities by different firms (e.g. COHEN et al., 2002; MALO, 2009). OKAMURO (2007) finds that for small and medium sized firms' cooperation with public research are less successful on the commercial side compared to cooperation with other firms. He sees a possible explanation in the higher complexity of innovation projects where public research is involved as well as projects that are quite far from commercialization and thus commercial success. FRITSCH and LUKAS (2001) state that larger companies tend to cooperate more compared to small and medium sized firms because their overall economic activity is higher. TETHER (2002) argues that awareness of possibilities as well as the engagement in a wider range or research and innovation activities is higher in large firms and thus leads to more cooperation. Hence, most studies find a positive influence of firm size on the propensity to cooperate (e.g. ARVANITIS and BOLLI, 2009; MIOTTI and SACHWALD, 2003) due to better endowment with resources for cooperation. Thus, large firms are more often involved in cooperation, but cooperation seems to be more important for small and medium sized firms due to scarce resources (e.g. ABRAMOVSKY et al., 2009). Therefore, it is expected:

Hypothesis 2: Cooperation with public research on innovation projects is more important for smaller and medium sized firms than for larger firms.

Firms cooperate with all types of partners. Three kinds of cooperation partners are often explicitly discussed: firms along the vertical axis such as suppliers and customers, firms along the horizontal axis, meaning competitors, and public research actors such as universities and research institutes (e.g. TÖDTLING et al., 2006). The choice of partners for collaboration depends on the requirements and prospects of the firms. If they need complementary resources and information about the needs of clients and markets, cooperation takes place on the vertical axis. If the aim is to pool research and development capacities, collaboration with competitors is also possible (e.g. MIOTTI and SACHWALD,

2003; NEGASSI, 2004). MIOTTI and SACHWALD (2003) found that cooperation with competitors is more likely in high-tech sectors whereas collaboration with suppliers and clients is also found in mid-tech sectors. TÖDTLING et al. (2006) show a high importance of knowledge from universities for high-tech and research oriented firms. For cooperation with public research complementary resources are the key factors as firms normally do not only cooperate with public research but also with other partners (VEUGELERS and CASSIMAN, 2005). Firms search for up-to-date knowledge steaming from research conducted at research institutes and universities (MIOTTI and SACHWALD, 2003). This applies especially to high-tech sectors where innovation plays an important role (TÖDTLING et al., 2006; VEUGELERS and CASSIMAN, 2005). Since the firms in the sample are all involved in high-tech developments, it is not possible to adequately separate between different levels of high-tech firms. Focus might be laid on the involvement in own R&D processes. However, two contradicting arguments apply: On the one hand, stronger R&D activities imply technologically more developed products and, thus, more interaction with public research. On the other hand, stronger R&D activities imply more own research capabilities and, thus, less dependence on public research. Thus, it can be stated:

Hypothesis 3: Cooperation with public research might be a) more important or b) less important for firms with high R&D activities.

Cooperation is also shaped by various other factors. Proximity has been discussed widely in the literature. Especially when knowledge is not easy to transfer, proximate partner have an edge over distant partner. Given that there are different types of proximity that all influence the outcomes and effects of cooperation (BOSCHMA, 2005), focus has been laid on geographic and social proximity. Geographical proximity is discussed as being relevant for knowledge diffusion processes and the transmission of tacit knowledge without being the only relevant aspect (e.g. PAIER and SCHERNGELL, 2011). Nevertheless, geographic proximity still is seen as important as it "facilitates learning, most likely by strengthening the other dimensions of proximity" (BOSCHMA, 2005: 43). Furthermore, SCHWARTZ et al. (2012) assume that spatial proximity promotes social closeness. However, they do not find a statistically significant impact of geographical closeness on the success of a cooperation project. In contrast, D'ESTE and IAMMARINO (2010) show for cooperation in the United Kingdom that spatial closeness has a positive influence on university-industry linkages. Thus, there are circumstances that allow non-regional collaborations to be effective, but especially for the initiation of cooperation geographic proximity seems to be of importance given that random and unscheduled meetings are more frequent that might lead to new cooperation (e.g. D'ESTE and IAMMARINO, 2010). Previous studies have also shown that firms close to knowledge sources are more successful than other firms (e.g. ARUNDEL and GEUNA, 2004; AUDRETSCH and FELDMAN, 1996). Nevertheless, depending on the knowledge and skills needed from cooperation partners, choices of partners may be

guided rather by excellence than by spatial proximity (D'ESTE and IAMMARINO, 2010). Spatially closer cooperation also leads to lower costs and time required for communication and travelling (e.g. SCHWARTZ et al., 2012), which should allow for a higher frequency in interaction. Therefore, it is expected:

Hypothesis 4: Interaction within cooperation is more frequent if the partner is located in proximity.

Above it is argued that cooperation with nearby partners is more frequent to be established by chance and is easier to be maintained. This should imply that such nearby cooperation is established independent of whether it is of low or high importance, while cooperation with far away partners is only established if it is of high importance (D'ESTE and IAMMARINO, 2010). Therefore, it is expected:

Hypothesis 5: Cooperation links with nearby partners are, on average, less important than cooperation links with far away partners.

BOSCHMA (2005) defines social proximity "in terms of socially embedded relations between agents at the micro-level. Relations between actors are socially embedded when they involve trust based on friendship, kinship and experience." (BOSCHMA, 2005: 66). An important argument for the influence of trust on cooperation involves the reduction of transaction costs for cooperation partners if they know each other and trust each other (e.g. ADOBOR, 2006). Thus, cooperation between these partners may be more likely (PAIER and SCHERNGELL, 2011). Concerning personal ties, ROST (2011) refers to the point that especially for tasks in connection to innovations strong ties are of importance given the need of tacit knowledge in the innovation process. Nevertheless, if ties become too strong negative effects may occur (e.g. GRANOVETTER, 1973). ADOBOR (2006) notes that personal ties between cooperation partners also "may provide the impetus for alliance formation" (ADOBOR, 2006: 475) and add to results and payoff of cooperation due to better sharing of information. This is in line with findings from OKAMURO (2007) who identifies positive effects for Japanese small and medium sized firms of a certain familiarity before the beginning of the project on the technological success of cooperation. Furthermore, the maintenance of collaborations may be easier if the collaborators know each other (GOERZEN, 2007). Hence, cooperation partners who trust each other are able and willing to maintain a connection even if interaction is rare. It is expected:

Hypothesis 6: If cooperation is established via personal contacts, interaction is, on average, less frequent.

Personal contacts might also keep actors cooperating if the cooperation is of less importance for them. This would imply that cooperation with social proximity is, on average, less important for the cooperation partners than cooperation without social proximity. However, there is also an argument

for the contrary: As stated in the literature, cooperation with social proximity involves, on average, a higher level of trust and is, thus, more efficient and effective. As a consequence, such cooperation might also be more supportive for a firm and, thus, more important. Hence, the direction of the relationship between social proximity and importance of cooperation is unclear:

Hypothesis 7: Cooperation that is established via personal contacts is, on average, a) more or b) less important.

To conclude, cooperation between inter-organizational actors is shaped by numerous factors. Characteristics of firms, their partners and the various kinds of proximity between the partners are influencing factors for establishing and maintaining collaborations. While it is well studied in the literature which kinds of cooperation take place more or less frequent, focus is laid on how these cooperative activities are structured here. Especially, the frequency and importance of cooperative interactions is studied. Additionally, it is analysed how they are related to partner types and proximity. These relationships are so far not extensively studied in the literature.

III. Data and methodical issues

The data is gathered in connection with the policy program "InnoProfile". Therefore, first the program is described followed by a description of the data.

"InnoProfile" is part of the program series "Unternehmen Region", which is conducted by the German Federal Ministry for Education and Research in order to promote economic development in East Germany. Due to developments after reunification, there are still differences between East and West Germany regarding firm size distribution and cooperation activities between firms and research entities. For example, in East Germany firm sizes are biased to small and medium sized firms. Dominating sectors include less research intensive industries compared to West Germany. Also research capacities in firms have been considerably reduced after reunification. Missing private investments in R&D are to some extent compensated by higher investments of public research. Connections between firms and universities are especially important for the regional development but are often still quite weak (GÜNTHER et al., 2010).

The policy measure “InnoProfile” was launched in 2005 with the aim to establish public research that fits to the regional economic profile in order to enhance cooperation and connections between the regional firm base and public research in East Germany. It promotes research at universities and research institutes that can be useful for regional firms that have a similar focus in their development

and production. Firms are assumed to profit from public research without being funded themselves. It is expected that knowledge gathered at universities and research institutes spills over to firms in the region, e.g. via cooperation (e.g. PAIER and SCHERNGELL, 2011), and helps firms to overcome technological constraints and problems due to missing in-house research capacities. An initiative that is financed by the "InnoProfile"-program consists of a group of young academics that are fully financed for the duration of 5 years. To illustrate economic and regional relevance of their research, research groups have to name companies in geographic proximity that might benefit from their research, independent of whether they cooperate with these firms or not. The study focus on those companies that are named by the 32 initiatives that are funded in the first two rounds of the program (BMBF, 2009).

Questionnaires have been send to these firms in 2008 and again in 2010 or 2011. In both inquiries firms have been picked and contacted by the “InnoProfile” initiatives. In 2008 130 firms responded the questionnaire which corresponds to a return rate of 57%. In 2010/2011 109 firms responded with a return rate of 62%. 53 firms completed the questionnaire in both years. 74% of these have been answered by the same person. All 239 completed questionnaires are used in the analyses, including a dummy to control for differences between the two waves.

To investigate cooperation behaviour and patterns of the interrogated firms, firms were asked to state for their 10 most important cooperation partners (in innovation projects) the following characteristics: where are they located, how contact was made and what type of the partner it is (e.g. university, research institute, client, supplier and so on). Additionally, they were asked about cooperation frequency and degree to which these partners are supportive or necessary for the firms’ innovation projects. Logistic regression models are employed to analyze the impact of different factors on cooperation frequency. Factors that influence the importance (supportive or necessary) of the cooperation for a firm are analyzed with linear regression models. All regressions are conducted with cooperation links as observational unit, so that 1055 observations are used (the firm named in the 239 completed questionnaires, on average, 4.4 cooperation partners).

All variables deployed in the analysis are listed in Table 1 and are drawn from the questionnaires.

Variable	**Description**
COOPFREQ	Dummy that takes the value of 1 if cooperation frequency is more than one time per month
SUPP	How supportive cooperation partners are, from 1= not so supportive to 6= very supportive

NECESS	How necessary cooperation partners are, from 1= not so necessary to 6= very necessary
YEAR	Dummy that takes the value of 1 if information is from the year 2010/2011
PROX	Distance function that decays linearly with 1/km and takes the value of 1 for cooperation partners in the same municipality
UNIRES	Dummy that takes the value of 1 for all cooperation partners that are universities or research institutes
CLIENT	Dummy that takes the value of 1 for all cooperation partners that are clients
TECH	Dummy that takes the value of 1 if the cooperation partner is a partner for the development of technologies (0 if the cooperation partner is a partner for basic research, applied research, product/process development or technology improvement)
CONTACT	Dummy that takes the value of 1 if the cooperation partner was searched for by the firm (0 if the cooperation partner was found by accident or the firm was searched by the cooperation partner)
PERS	Dummy that takes the value of 1 if the cooperation partner was found through personal contacts (0 if the cooperation partner was found through search in the internet, associations, formal networks or academic studies)
PERS_WAS SEARCHED	Dummy that takes the value of 1 if the cooperation partner was found through personal contacts and the firm was searched by the cooperation partner (0 otherwise)
PERS_ACCI-DENTAL	Dummy that takes the value of 1 if the cooperation partner was found through personal contacts and by accident (0 otherwise)
PERS_ SEARCHED	Dummy that takes the value of 1 if the cooperation partner was found through personal contacts and was searched for by the firm (0 otherwise)
R&D EMPL	Ratio between R&D employees and total number of employees in the year of interrogation

Table 1 Variables employed in the models

V. Results

V.1 Interaction frequency

To the knowledge of the authors it is not studied in the literature why some collaboration involve frequent interaction, while other collaborations are based on less frequent interaction. In general, a higher cooperation frequency is associated with deepened relationships as cooperation partner spend more time with each other (e.g. MCFADYEN and CANNELLA, 2004). Nevertheless, too frequent meetings might result in lock-in. In that case, cooperation does not bring new knowledge into the firm and thus may have a negative influence on the effects of cooperation and knowledge creation (e.g. BATHELT et al., 2004; MCFADYEN and CANNELLA, 2004; ROST, 2011). To advance knowledge about factors that influence cooperation frequency, logistic regression models are employed to analyze these factors for two different thresholds of cooperation frequency (Table 2). On the one hand, cooperation where firms report a weekly contact with their research partners is analysed. On the other hand, collaborations where the firms do have at least every 2 to 3 month contact with their cooperation partners are studied. This means that causes of extremely frequent interaction (every week) and over-average frequency (at least every 2-3 months) are analysed.

A natural expectation is that more important collaborations involve more frequent interaction. Indeed, Table 2 shows that collaborations that are evaluated as more supportive or as more necessary are characterized by a higher frequency of interaction. However, a higher necessity does not imply a higher probability for weekly interaction. Necessary cooperation seems to require or cause a certain frequency of interaction, but does, on average, not require an extremely frequent (i.e. weekly) interaction.

	Model 1	Model 2
COOPFREQ	**Every week**	**Every 2-3 months or more often**
Independent Variables		
SUPP	1.02512***	0.49295**
NECESS	0.01520	0.36327 **
PROX	-0.32356	-0.61618
YEAR	-0.66116 *	0.81446 *
UNIRES	-0.31934	0.18128
CLIENT	0.84442*	0.62974
CONTACT	0.01284	-0.09269
PERS	-0.53584*	-0.03729
TECH	-0.25836	0.06041
R&D EMPL	-1.11197*	-1.04937*
AIC	389.06	316.65
Log Liklihood	-183.5305	-147.3246

0.001 *** , 0.01 **, 0.05 * , 0.1 .

Table 2 Results of the logistic regression models

Hypothesis 1 states that firms with high R&D activities should interact more frequently with their cooperation partner than firm with low R&D activities. This is not confirmed by the analysis. In contrary, the share of R&D employment shows a negative relationship with cooperation frequency. However, the argument behind Hypothesis 1 is that cooperation should be more important for firms with high R&D activities and that this should lead to higher interaction frequencies. The latter relationship, between importance and frequency, is confirmed in the analysis: supportive and necessary cooperation are marked by a high frequency of contacts. This is in line with findings from literature given that the influence of R&D intensity is not always found as important for cooperation frequency (e.g. LÓPEZ, 2008).

A significant positive relationship is found between the CLIENT-dummy and the very high frequency of interaction (Model 1). This means that collaborations with clients are, on average, more often found among the collaborations with weekly interactions. Assumedly, this is associated with the close

coordination that is necessary for the development of products together with clients (e.g. MIOTTI and SACHWALD, 2003). Collaborations with universities and research institutes do not significantly deviate in their interaction frequency from other collaborations. The findings for the variable PERS are discussed below.

The significant findings for the year dummy are worth some further discussion. It is especially interesting that a significant negative relationship with weekly interactions and the significant positive relationship with the over-average frequency of interaction are found. This means that in the firm sample the share of collaborations that involve an extremely frequent (weekly) interaction has decreased with time, while the share of collaborations with an over-average frequency (at least every 2-3 month) of interaction has increased. Thus, it seems that the distribution of time for cooperation has changed. MCFADYEN and CANNELLA (2004) discuss the importance of the number of cooperation partner given that a too high number of collaboration contacts might not be beneficial due to the increasing costs for maintaining these relationships. Assuming that the collaboration attitude of firms has, in general, not changed much from 2008 to 2010/11, the finding might be connected to the "InnoProfile" program. This would imply that the governmental program has an impact on the cooperation behaviour of firms. This is also confirmed by the fact that an increase in the importance of universities and public research institutes as cooperation partners is found (see below). However, a more detailed analysis would be necessary to substantiate this statement, which is beyond the scope of this paper.

V.2 Importance of cooperation

Another so far rarely studied aspect is the relevance that the various cooperation activities have for cooperation projects of firms (e.g. TÖDTLING et al., 2006). Therefore, it is analyzed which factors are related to the degree of supportiveness and necessity of cooperation partners. Several expectations are formulated above in Hypotheses 1, 2 and 3.

In order to check these hypotheses, a linear regression with the degree of supportiveness and necessity as dependent variables is conducted. In Table 3 results of the linear regression models are presented.

	Model 3 **SUPP**	Model 4 **NECESS**
Independent variables		
COOPFREQ	0.58611***	0.780290 ***
YEAR	0.14338 .	0.008346
PROX	0.02633	-0.181517
UNIRES	0.15616 .	0.289384*
CLIENT	-0.125	-0.005971
TECH	0.09489	0.214442 .
PERS_WAS SEARCHED	0.28843 *	0.042264
PERS_ACCIDENTAL	-0.15715	-0.060136
PERS_SEARCHED	0.37887 **	0.385408 *
R&D EMPL	-0.03975	-0.239431
R^2	0.09588	0.1056
KS p-value	0.002584	0.000004811
N	219	219

0.001 =***, 0.01=**, 0.05=*, 0.1= .

Table 3 Results of the linear regression models for the supportiveness and necessity of cooperation

Hypothesis 1 states that the relevance of collaborations should depend on the R&D activities of firms. This is not confirmed by the analysis. Two interpretations are possible: 1) independent of their R&D activities all firms might have a number of collaborations that are very important for them. This explanation is in line with MCFADYEN and CANNELLA (2004). Or: 2) the difference within the firm sample is small because mainly firms are included in the questionnaire with high R&D activities.

Hypothesis 2 states that cooperation with universities and public research institutes is more important for small and medium sized firms. In order to check this hypothesis the above regression is conducted for three firm size classes separately. The results are shown in Table 4.

	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
	SUPP			**NECESS**		
	Firm size (num. of employees)			**Firm size (num. of employees)**		
	Small (0-9)	**Medium (11-49)**	**Large (50-249)**	**Small (0-9)**	**Medium (11-49)**	**Large (50-249)**
Independent variables						
COOPFREQ	0.76112***	0.64808***	0.59685***	0.45904 *	0.834896***	0.87661 ***
YEAR	-0.032001	0.16370	0.235840 .	-0.03975	0.114893	-0.08143
PROX	-0.259897	0.26969	-0.319006	-0.06695	0.336196	-0.63007
UNIRES	0.030697	0.09301	0.241788	1.17718**	0.143522	0.06692
CLIENT	-0.537574	0.00117	-0.076959	0.97749 *	-0.006487	-0.40178
TECH	0.121712	0.14784	-0.001656	0.40102	0.102833	0.14292
PERS_WAS SEARCHED	0.002697	0.45627 *	-0.271241	-0.53874	0.180045	-0.07663
PERS_ACCIDENTAL	-0.115833	-0.31766	0.516841	0.32754	-0.344891	0.38299
PERS_SEARCHED	0.519399 .	0.41685 *	0.287709	0.35030	0.616536*	-0.27396
R&D EMPL	-0.280021	0.38543	-0.300141	-0.23519	0.187413	-0.20201
R^2	0.1468	0.1037	0.08049	0.1345	0.08533	0.09781
KS p-value	0.0717	0.002917	0.1238	0.6261	0.002824	0.005657
N	47	110	62	47	110	62

0.001=***, 0.01=**, 0.05=*, 0.1= .

Table 4 Results of the linear regression models for the supportiveness and necessity of cooperation for different firm sizes

The results confirm Hypothesis 2 partly. While no difference between firm size classes for the supportiveness of universities and public research institutes is found, cooperation with universities and research institutes is more necessary for small firms. This confirms the frequently stated claim that small firms rely in their innovation activities more on public research. Small firms often do not have permanent in-house research capacities and profit from knowledge of their cooperation partners (e.g. LECHNER and DOWLING, 2003). This also fits the finding that small firms rely more on collaboration with their clients. Other findings from the literature that show a higher propensity to

cooperate with public research for large firms often do not account for the importance of cooperation but only for the simple chance of cooperation (e.g. FRITSCH and LUKAS, 2001). Small firms often do not have the capacity to search for cooperation but need support in their innovation activities (TETHER, 2002).

Besides this, no clear pattern of differences between firm size groups is found. The only other difference that is found relates to those collaborations that are the result of a search process via personal contacts. These collaborations are more supportive and more necessary in the case of medium sized firms. At least one weekly significant positive relationship of this kind is found for small firms. No such relationship is found for large firms. Large firms thus appear to be more independent from searching cooperation partners. These findings correspond to results that attribute a better endowment with resources for cooperation to large firms (e.g. ARVANITIS and BOLLI, 2009; MIOTTI and SACHWALD, 2003, among others). Due to these resources personal ties become less important.

For the relevance of universities and research institutes for firms with high R&D activities two contradictory hypotheses were formulated: Hypothesis 3a predicting a higher relevance and Hypothesis 3b predicting a lower relevance. The results (Table 3) show that cooperation partners that are universities or public research institutes are characterised, on average, by a higher supportiveness and necessity of the collaboration contact. This confirms findings in the literature (e.g. TÖDTLING et al., 2006). Universities and research institutes seem to be important cooperation partners for firms. The significance is higher for necessity than for supportiveness. Thus, knowledge produced by public research actors is a crucial input for innovation processes of firms. The results in Table 4 show that this finding is mainly driven by small firms. Given the high importance of university and research institutes, regressions for these types of cooperation partners are conducted separately in order to check Hypotheses 3a and 3b. The results are shown in Table 5.

	SUPP		**NECESS**	
	Cooperation between		**Cooperation between**	
	firms and public research institutes	**firms and other firms**	**firms and public research institutes**	**firms and other firms**
Independent variables				
COOPFREQ	0.59712 ***	0.61056***	1.026454***	0.50448**
YEAR	0.18430 .	-0.03699	-0.001961	-0.17125
PROX	0.08548	-0.11823	-0.031441	-0.43039
CONTACT	0.20188 .	0.10364	0.152354	0.03868
PERS	0.36729 ***	0.31841**	0.387210**	0.20104
TECH	0.16947	0.25268 .	0.340368.	0.53299**
R&D EMPL	-0.05038	-0.13832	-0.141634	-0.29480
R^2	0.1422	0.1034	0.1768	0.06396
KS p-value	0.004937	0.03288	0.01724	0.008154
N	219	219	219	219

0.001 =***, 0.01=**, 0.05=*, 0.1= .

Table 5 Results of the linear regression models for the supportiveness and necessity of cooperation for different types of cooperation partners

Nevertheless, significant results for the share of R&D employment and thus for firms with high R&D activities are not found. Thus, neither Hypothesis 3a nor Hypothesis 3b is confirmed.

Besides this, only a few differences are found between collaborations with universities and research institutes and collaborations with other partners. For cooperation with public research it seems more important to establish collaboration through personal contacts. One possible explanation is that the results of collaborations with public research are more basic in nature and thus more uncertain. Knowing the cooperation partner reduces uncertainty (e.g. ADOBOR, 2006; OKAMURO, 2007). It is also thinkable that competitors, clients and suppliers are known to firms because of their business activities, while research activities in public research are often only known if a personal connection exists. Another clear difference between the two types of cooperation partners concerns those collaborations that involve technological developments. In principle, collaborations involving

technological developments are more necessary for firms (see Table 3). However, this finding holds mainly for collaborations with other firms (see Table 5).

V.3 Geographical and social proximity

Hypothesis 4 states that collaborations with nearby partners should involve a higher frequency of interaction. The results (Table 2) do not confirm this hypothesis. Significant results for proximity and the estimated coefficients rather point into the opposite direction: A higher proximity comes together with a lower frequency of interaction. However, this is not significant, so that it is not possible to make a final statement on the relationship between interaction frequency and proximity.

Hypothesis 5 states that collaborations with nearby partners are, on average, less important. A significant relationship between proximity and the supportiveness or necessity of cooperation is not found (see Table 4). Thus, if firms really need knowledge and support of a certain actor, the distance to the cooperation partner does not play an important role. This is in line with findings from D'ESTE and IAMMARINO (2004). Hence, other forms of proximity may play a crucial role (BOSCHMA, 2005).

Hypothesis 6 states that collaborations with a personal connection involve less frequent interaction. In order to check this hypothesis, focus has been laid on collaborations in which the contact with cooperation partners has been made through personal channels. Other options in the questionnaire have been that contact was made through search in the internet, associations, formal networks or academic studies. In some cases, in order to go more into detail, it is distinguished between three ways of partner search: The firm was searched by the cooperation partner, the partner was found by accident and the cooperation partner was searched by the firm.

Hypothesis 6 is partly confirmed by the results (Table 2). At least, the highest frequency of interaction (weekly) is less often found in collaborations that have been established via personal channels. This might be interpreted as follows. Partners that are of high importance and with whom weekly interaction is necessary are chosen independent of personal links, simply because they are necessary. Links with other actors are more likely to be established if personal connections are underlying.

However, this result might require further discussion because deviating results are found in the literature (PETRUZZELLI, 2011). Given that personal ties are often much stronger than contacts through other channels it could be also expected that cooperation contacts are much more frequent if personal ties exist. In contrast, results confirm the considerations made above: Personal connections are often the basis for collaborations that are not based on weekly interaction.

Above, the theoretical considerations did not lead to a conclusive answer on whether such links based on personal channels are more frequent among the more or less important collaborations. Two

alternative hypotheses 7a and 7b are formulated. The various analyses (see Table 3, Table 4, Table 5) confirm Hypotheses 7a: Collaborations that are established on the basis of personal contacts are, on average, more supportive and more necessary. The highest value of both, the supportiveness and necessity of cooperation, shows cooperation that has been established through personal contacts where the cooperation partner has been searched by the firms. The supportiveness of cooperation is also higher if the firm was searched for by its collaborator via personal contacts. Collaborations with partners that are found not accidently via personal contacts are, on average, the most important collaborations for a firm. A possible reason may be that people establishing cooperation through personal contacts already know each other. People then know better if a cooperation partner supports their firm in the right way. Likewise, it is also possible that such contacts are much more based on trust. As a consequence, these collaborations may function better or profit from the "cost saving benefits of trust" (GOERZEN, 2007:490). On the other hand, it seems feasible that these contacts are only used for cooperation if people are sure about a good working atmosphere and thus positive surroundings. These findings show the importance of personal links in a professional environment.

To conclude, Table 6 shows an overview over the results for the Hypotheses.

Hypotheses:	**Supported**	**Partially supported**	**Not supported**
1: Cooperation is more frequent and more important for firms with high R&D activity.			√
2: Cooperation with public research is more important for innovation projects for smaller and medium sized firms than for larger firms.		√	
3a: Cooperation with public research might be more important for firms with high R&D activities.			√
3b: Cooperation with public research might be less important for firms with high R&D activities.			√
4: Interaction within cooperation is more frequent if the partner is located in proximity.			√
5: Cooperation links with nearby partners are, on average, less important than cooperation links with far away partners.			√
6: If cooperation is established via personal contacts, interaction is, on average, less frequent.		√	
7a: Cooperation that is established via personal contacts is, on average, more important.	√		
7b: Cooperation that is established via personal contacts is, on average, less important.			√

Table 6 Summary of results for hypotheses

Hypothesis 7a is confirms, whereas Hypothesis 2 and 6 are partially confirmed. Especially for the importance of cooperation for firms with high R&D activities, no significant results have been found. Also the role of proximity or distance for cooperative behaviour has not been validated. However, the results show that personal contacts are of high importance for cooperation processes. Also the significance of public research for small and medium sized firms that has been seldom under investigation yet has been show.

VI. Conclusions

In this paper different aspects of cooperation behaviour of firms as well as relationships between them are analyzed. Findings from the literature suggest that geographic and social proximity as well as frequency of cooperation play a crucial role for the success of cooperation. Nevertheless, the influence of these aspects on the importance of cooperation has rarely been in the focus of studies.

Therefore, this paper focused on the relationships between different firm sizes, share of R&D activities, geographic proximity and personal ties and the importance and frequency of cooperation. Special attention has been given to universities and public research institutes as cooperation partner given that these have been financed by the policy measure “InnoProfile”.

Findings show that cooperation frequency is significantly related to the supportiveness and necessity of cooperation. Especially cooperation with clients seems to be very frequent. Collaborations with high supportiveness or necessity are those in which the aim is technological development and those with partners that are found through personal contacts. Especially for small firms cooperation with public research and clients is necessary due to often missing in-house research capacities. Altogether it seems that knowledge from universities and public research institutes has an important influence. In contrast, significant results for an influence of the share of R&D employment are not found. Similarly, no significant results are found for the relevance of geographic distance. In contrast, clear findings for social proximity have been found: Collaborations that are established via personal contact have a higher necessity and supportiveness.

The findings have different implications for policy. First of all, a high relevance of cooperation establishment via personal contacts is found. Hence, existing personal ties should be utilised if policy aims to establish helpful networks. Furthermore, it is found that especially small firms require collaboration with public research. At the same time, especially small firms lack the resources to engage in extensive collaborative activities. Policy support might be very helpful for them.

East Germany has a higher share of small and medium sized firms. Hence, a measure that supports public research actors in their cooperation activities with small firms seems to be an adequate approach. The results provide some evidence that the “InnoProfile” program is able to change the cooperation behaviour of public research actors and firms. However, a more detailed analysis of these aspects would be necessary to draw final conclusions.

Furthermore, the study is based on a firm sample from East Germany with specific characteristics. Hence, it is necessary to check whether results remain valid for other firms. It was deliberately decided to analyse firms that are research-intensive and have a certain connection to public research. Thus, about these kinds of firms statements are possible. Furthermore, the sample contains firms from very different industries. However, on the regional level the firm sample is quite limited and the study should be repeated with firms from other countries to check the generality of the results.

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