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Impact of international and home-based research and development (R&D) on innovation performance

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Abstract

The recent decade has shown a surge of firms globalizing their innovation activities. A major motive underlying the decision to shift corporate R&D activities abroad is that the internationalization of R&D increases chances to participate in international knowledge sharing. Absorbing knowledge from abroad is aimed at enhancing the innovativeness of firms and consequently their competitiveness. This paper addresses the question whether international R&D is conducive to a firm's innovation performance by using two different innovation output measures. It analyzes first whether a firm that conducts international R&D is more likely to introduce (different types of) new products and second whether it achieves a higher sales growth with innovative products. The study further contributes to the literature by investigating how different degrees of R&D internationalization impact on the innovation indicators. It employs a large data set from the Mannheim Innovation Panel which represents the German part of the Community Innovation Survey, and it retains about 2100 observations. The econometric results show that firms with both domestic R&D and foreign R&D activities are more likely to launch new products (firm and market novelties) than firms with home-based R&D only. They furthermore tend to be more successful in terms of sales growth with firm novelties. However, no differences could be found for sales growth with market novelties. The degree of R&D internationalization has an inverse u-shaped effect on both innovation output measures. A moderate number of R&D locations abroad have the strongest influence on innovation outcome and sales growth with new products while sales growth with firm novelties benefits from a high number of R&D locations.

Keywords: Globalization, R&D, Innovation performance, decentralization

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Introduction

The competiveness of the firm depends to a great extend on its innovativeness. Therefore firms should make use of globally available resources to foster their innovation outcomes (Kotabe, 1990). Today, the internationalization of R&D is a growing phenomenon among corporations (UNCTAD, 2005). This can be observed for both large multinational firms and international SMEs. In Germany, about 3% of innovative firms without foreign R&D activity in 2005 planned to start it in 2006/2007 (Rammer and Schmiele 2008).

The literature stresses that firms may have two main motives for locating their R&D activities abroad (Granstrand et al., 1993, Zedtwitz and Gassmann, 1998, Belderbos et al. 2008) On the one hand, firms want to adapt their existing technologies to local demand and manufacturing conditions (exploitation strategy). On the other hand, by setting up foreign R&D subsidiaries firms may get access to local science and technology resources and thus are able to source, absorb and integrate knowledge from abroad into their innovation process (home-base augmenting strategy). It has been emphasized that an effective innovation strategy needs to balance the exploitation of existing knowledge with non-local knowledge exploration for new knowledge (Levinthal and March, 1993). In this vein it has been also proved that putting existing pieces of knowledge together often leads to innovations (Grant, 1996; Arora and Gambardella, 1990; Cohen and Malerba, 2001). The decentralization of innovation activities can lead to the combination of existing knowledge from the firm's knowledge stock with foreign knowledge from foreign local staff and spillovers from the firms' foreign business environment such as cooperating firms, competitors, customers and suppliers. If the diffusion of new knowledge is geographically localized, firms that perform R&D activities only in their home country will be less likely to have access to these foreign sources of knowledge. Although learning by exporting was one assumption how firms could benefit from foreign countries' expertise by engaging in local markets and interacting with customers it is pointed out that knowledge can often not overcome national boundaries (Kogut, 1991) when it is not codified and embedded in routines and therefore hard to transfer.

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Despite the trend to internationalize R&D the wisdom about the effectiveness of foreign R&D in terms of innovation output is rather scarce and limited to patents. But patent-based indicators have been heavily criticized as being a poor yardstick for innovative outcome (see, e.g., Scherer, 1965; Griliches, 1990). This paper addresses the question whether international R&D is conducive to a firm's *innovation performance.* The research aims at extending the existing literature in two ways. First, it uses two alternative well-established innovation output measures. It will show how potential gains from foreign R&D influence the introduction of new products ("*innovation outcome*") and whether firms with foreign R&D achieve a higher sales growth with innovative goods ("*innovation success*"). It supposes that these effects may differ according to the type of new products (market novelties versus firm novelties). Since firms are expanding their number of international research locations it secondly investigates the effect a greater decentralization of R&D locations abroad has on the innovation performance of firms. The added value of international R&D to national R&D in comparison with only domestic R&D activities in terms of innovation performance is interesting both to scholars and practitioners.

This paper will continue in the following outline: section 2 will present the existing literature and relevant theoretical concepts which will lead to the development of hypotheses in section 3. Section 4 explores the dataset and the empirical methods which are used to test the hypotheses. Section 5 will set forth the results of the econometric analysis and section 6 concludes with a discussion of the retrieved results and management recommendations.

Internationalization of R&D Activities - Current status

Possible Benefits of International R&D

Multinational Enterprises (MNE) are said to be the drivers for globalization by increasing the interdependency and relatedness of geographically dispersed actors (Archibugi and Immarino, 2002). The internationalization of internal research and development activities has been following the internationalization of production and other market-related business processes. Though R&D still shows the least degree of internationalization of all business processes, it is an increasing phenomenon (see Hemmert 1996, UNCTAD 2005). A range

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of driving forces to internationalize corporate research and development has been identified in the literature. The motivations of firms to internationalize their R&D have been distinguished into market seeking, technology seeking and efficiency seeking purposes. It has been pointed out that firms are often not driven only by one but all three motivations (DeMeyer, 1993). The internationalization of R&D enables firms to both widen and deepening the firms' technological scope(Pearce and Papanastassiou, 1996) due to improved technical learning which is fostered by international R&D activities (DeMeyer, 1993).

Moderating Factors of Firms' Benefits of international R&D

The above mentioned studies highlight the range of opportunities associated with the internationalization of R&D activities. The actual level of innovation performance though can only be as high as the international R&D performing firms realize and use the chances of these ventures. The lynchpin is the organization and integration of international subsidiary knowledge into the corporate innovation process. It has been argued that the usage of the potential global know-how does not depend on the presence of R&D labs in many parts of the world per se but more importantly on the internal firm mechanisms to integrate the knowledge across the R&D organization (Singh, 2008). Leveraging the capabilities and resources across divisions and locations of subsidiaries has been put forward to be essential for the global success of firms (Barlett and Ghosal, 1989; Frost, 2002; Nobel and Birkinshaw, 1998). A number of factors have the potential to moderate the benefits of international R&D labs.

Foreign R&D subsidiaries mandates. The roles and tasks which are assigned to the innovating subsidiaries abroad may affect their importance for the firms' innovation output (Iwasa and Odagiri, 2004). The different mandates of subsidiaries abroad have been distinguished by their level of R&D orientation and their focus on production support. While some R&D labs abroad have the task to absorb new knowledge and help to produce new products and work as 'knowledge augmenting' units ('international creators'), others are characterized as 'local adaptors', 'knowledge exploiting' units or 'support laboratories'. The second category is designed to support local production and to assimilate

market knowledge and to apply it to customers' satisfaction (Pearce and Papanastassious, 1996).

Management of Global R&D. The type of R&D that is carried out at foreign subsidiaries also determines the international R&D organization (Chiesa, 1996). Gassmann and Zedtwits (1999) confirm the trend of an increasing number of R&D subsidiaries abroad and name the applicability of certain organization schemes to the aim of R&D activities. Hemmert (2003,2004) compares the impact of different R&D organizations on innovation output in MNEs and argues that firms that have vertically integrated R&D units in the host country experience the strongest influence of flows of technological knowledge from the host to the home country.

Extent of R&D internationalization. The degree to which firms internationalize their R&D, meaning the number of different R&D locations, may also affect of how much the headquarter can benefit from a global or local innovation network. A central R&D organization is conducting all the necessary work to develop new products in one location (Malecki, 1980). Some scholars have argued that centralization of R&D facilities is the better R&D organization for research purposes (Malechi, 1980; Gassman et al., 2004). One reason might be the existence of economies of scale in R&D. The findings by Silberman and Argyres (1994) corroborate this point of view. Using patent citations and US firm information to measure the importance of innovations, their findings suggest that firms with centralized R&D organizations generate innovations with greater technological impact (number of citations). However, they also show that more decentralized R&D shows a greater influence on the innovations' impact than firms with only slightly decentralized R&D.

Absorptive capabilities. The integration of R&D abroad requires a certain stage of R&D activeness of the firm at home. Firms should carry out R&D to keep up with technological developments (Tilton, 1971) and therefore increase their ability to identify, absorb and exploit existing information (Cohen and Levinthal, 1989).

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Knowledge Complementarity. Another moderating factor is the originality of knowledge that can be gathered at the foreign R&D sites. A firm that sources knowledge form the host country is likely to benefit from these activities when the foreign knowledge complements existing knowledge in its R&D labs in the home country. The concept of complementarity suggests that two activities carried out together are more promising than only one activity carried out alone (Schmiedeberg, 2008). Therefore, domestic and foreign R&D although both are firm internal but at different locations are complements if they increase innovation performance. A variety of complementarities in R&D have been proved to influence innovation success positively. Internal R&D have been found to be complementary to contracted R&D (Schmiedeberg, 2008), external technology acquisition (Cassiman and Veugelers, 2006) and R&D cooperation for different industries and partners (Schmiedeberg, 2008; Cassiman and Veugelers, 2002, 2005; Schmidt, 2005; Arora and Gambardella, 1990). Some of the advantages apply to truly external firm innovation partners such as risk and cost sharing (Love and Roper, 2004) and do not count for international corporate research centers. Nevertheless, the access to additional sources of knowledge abroad is consistent with the complementarity concept.

The Innovation Output of Firms with International R&D

The existing literature is providing only a scarce evidence of whether international R&D is beneficial to firms' innovation performance. The to-date studies only use patent data to analyze the impact of foreign knowledge sources on firms' innovations. Following this strategy, Iwasa and Odagiri (2004) have analyzed the contribution of R&D at home and R&D abroad to the number of granted patents for a sample of 137 Japanese MNE. Their results confirms the existence of technology sourcing as they find innovative (not adaptive) R&D carried out abroad in the US and EU to have a positive impact on the patent output. Penner-Hahn and Shaver(2005) use a panel study of 65 Japanese pharmaceutical firms and also employ the number of patents as performance measure. They show that international R&D activities exert a positive effect on patenting. Almeida and Phene (2008) confirm these findings by using the number of firm patents of US semiconductor firms and find that patents which originate from foreign subsidiary R&D labs increase the patent portfolio of the firm significantly. More important, they find via patent citation analysis that knowledge

from other firms of the host country affect the scale of patented firm innovations positively. By using the number of patent citations, Singh (2008) has analyzed the quality of the patents to observe the outcome of international R&D activities. In contrast, he finds a negative influence of R&D activities abroad. It has been argued before that patents might not always be the appropriate way to capture the innovation success of R&D activities. Patents proof the result of inventive activities and display the location of inventors. However, not all innovations result in patents (Griliches, 1990) and therefore patents cover only a threshold of the results from innovation activities abroad (Levin et al., 1987; Arundel and Kabla, 1998). Some underlying reasons are time and costs which are involved in the patent application process, as well as the aspect of knowledge disclosure by patents and only new inventions can be patented, new to the firm innovations are not patentable. Therefore this paper aims to contribute firm level evidence about innovation activities abroad to the analysis of innovative outcomes of foreign R&D activities and corporate growth.

The direct impact of performing R&D at numerous locations vs. centralized R&D activities on innovative outcome has been analyzed for the number of national R&D locations within Finland (Helfat and Leiponen, 2006). The results confirm that R&D decentralization fosters the extent and breadth of innovation outcomes So far there is no evidence whether these results hold also for international R&D decentralization.

This paper follows the rational of the knowledge-based view that a higher number of R&D locations will give firms the opportunity to interact with a number of international actors and a wider range of knowledge sources. No assumptions about the internal organization and capabilities to transfer knowledge within the firm efficiently are made. Assumptions on these matters based on results are drawn. The hypotheses are simply based on the rational that firms' international R&D activities represent an advantage and results in a higher level of innovation output.

When the firm can enlarge its knowledge base by adding foreign knowledge it is likely to build competitive advantages by enlarging the base of knowledge and therefore the corporate resources. This resource base provides firms with the necessary platform to

decide which resources or capabilities to exploit, develop or discard as their environment changes (Ndofor and Levitas, 2004) This perspective is typically summarized as the knowledge based view of the firm (Grant, 1996).

Hypotheses

Overall, firms that perform R&D intensive innovation activities abroad enrich their existing corporate knowledge base by adding new sources of know-how. In this vein it is argued that firms accumulate more knowledge by decentralizing their innovativeness and therefore gain access to foreign knowledge pools which leads to the first hypotheses:

H1*: Firms with international R&D activities are more innovative than firms that undertake R&D solely in their home country.*

H2: *Firms with international R&D activities will have higher sales growth with new products than firms that only have domestic R&D capacities.*

H3: *The higher the degree of R&D internationalization, the more innovative the firms are.*

H4: *Firms with a high degree of R&D internationalization achieve higher sales growth due to new products than firms with a lower degree of R&D decentralization and firms with domestic R&D only*.

Empirical Analysis

Data Set

For the empirical analysis, data from the Mannheim Innovation Panel (MIP), which incorporates the German corporate innovation data used for the European wide Community Innovation Survey (CIS) since 1993 is used.[2] The MIP survey is carried out

[2] The MIP is based on annual innovation surveys which are conducted by the Centre for European Economic Research (ZEW), Fraunhofer Institute for Systems and Innovation Research (ISI) and infas Institute for Applied

annually and targets legally independent firms with headquarters located in Germany and with at least five employees in manufacturing, mining, energy and in selected service sectors. The survey is drawn as a stratified random sample and is representative of the corresponding target population. Usually, the MIP goes beyond the design and extent of the core CIS surveys and offers additional information on innovation-related topics. The survey 2006 collects data about foreign innovation activities of firms. Firms were asked what type of innovation activity they perform abroad, distinguishing into different categories (R&D, conception/design/construction of new products, implementation of new processes, and manufacturing of new products).

Firms were requested to state whether they performed these activities in 2005. In a free text field firms were asked to state in which countries they predominantly performed the different types of innovation activities.

The MIP is designed as a panel which allows the analysis of R&D activities abroad in one period and the innovation performance in subsequent periods by merging different waves. Usage of the to-date latest available data survey results from the year 2009 and is merged with the survey from 2006 This creates a time lack of 3 years between existing corporate R&D activities abroad in 2005 (survey 2006) and the measurement of innovation performance in the period 2006-2008 (survey 20009). This approach reduces potential endogeneity problems between R&D activities and innovation output which usually arise in cross-sectional analyses. Endogeneity might occur because the most innovative firms may have the prerequisites to perform R&D abroad, i.e. self-select into the sample of international R&D at foreign locations is believed as realistic to capture the observed performance and innovativeness effects in a two-years time period.

The samples in 2006 and 2009 consist of 5563 and 7662 firms, respectively. Though the surveys are designed as a panel, merging the two cross-sections leads to a reduction of about 50% in the amount of observations since participation is voluntary. For estimation purposes it further excludes firms with incomplete date for any of the relevant variables. 2118 firms remain for the empirical analysis.

Adalikwu, C. (2011). impact of international and home-based research and development (R&D) on innovation performance. *International Journal of Human Sciences* [Online]. 8:2. Available: **http://www.insanbilimleri.com/en**

Dependent Variables

Given that many studies have analyzed the outcomes of domestic R&D activities and their market success (see e.g. Griffith et al., 2006; Parisi, 2006), these studies are followed by defining the measurement of out two sets of dependent variables for the innovation performance of international R&D activities. The first setoff dependent variables defined whether firms had introduced new products in the period 2006 to 2008. According to the Oslo Manual (OECD and Eurostat 2005) which provides the guidelines for the CIS, these new products could be either new to the firm only (Firm novelties) or to the market (Market novelties). This leads to distinguish between three kinds of innovations (new products/ market novelties/ firm novelties) that are used as our three innovation outcome measures.

The second set of dependent variables will capture the sales growth due to these innovations in the same manner as it has been done by many studies before (Criscuolo and Haskel, 2003; Mairesse and Mohnen, 2005; Jefferson et al., 2006). That is, measurement is made of the market success with innovation outcomes as the growth rate with sales due to new products, market novelties and firm novelties. The growth rate describes the growth of sales due to the different kinds of innovations between the year 2006 and 2008. It is computed as the share of sales due to new products in year 2008 times sales in 2008 divided by sales in 2006 (see Harrison et al. 2008), Table 1 summarized the 6 different dependent variables.

Table 1: Definition of dependent variables

Dependent Variables	Definition
Firms with Product innovations	1 if firm had new products (market or firm novelties) in 2006-2008
Firms with Market novelties	1 if firm had market novelties in 2006-2008
Firms with Firm novelties	1 if firm had firm novelties in 2006-2008
Sales growth due to new products	Growth rate of turnover betw. 2006-2008 due to new products in that period
Sales growth due to market novelties	Growth rate of turnover betw. 2006-2008 due to market novelties in that period
Sales growth due to firm novelties	Growth rate of turnover tetw. 2006-2008 due to firm novelties in that period

Adalikwu, C. (2011). impact of international and home-based research and development (R&D) on innovation performance. *International Journal of Human Sciences* [Online]. 8:2. Available: **http://www.insanbilimleri.com/en**

Explanatory Variables

One aims to compare the effects of national and international R&D performers on their innovation outcome and their market success with innovations. Therefore one's prominent explanatory variables in this study are domestic innovating firms, which only innovate in Germany and international innovating firms which have both R&D labs in Germany and abroad. One further distinguished the international R&D performers according to their degree of R&D internationalization. Thus, one creates three variables for the intensity of firms' international R&D decentralization. Thus, one uses the number of countries in which the firms have R&D activities (A detailed list of variable definitions is provided in Table 2).

Note that not all firms, not even all innovators, are performing R&D activities in 2005 at all. Among the non-R&D performing firms one further distinguishes between non-innovative firms and firms which have introduced innovations but without any R&D activities. The reference category in this analysis comprises innovators without R&D activities in 2005.

In the literature of innovation performance (for overview see Peters (2006), Hall and Mairesse (2006)) the main factors that have been examined to influence innovation output are firms' internal knowledge, R&D efforts and external knowledge. The success with innovations in terms of sales growth based on new product developments is supposed to be related to innovation input, absorptive capacity (Cohen and Levinthal, 1989; Becker and Peters, 2000; Lanz et al., 2004), technological capabilities and opportunities, market demand, knowledge capital (Lööf and Heshmati, 2002), ownership (Jefferson et al., 2006) among other factors.

The importance of internal firm R&D activities in this sense is emphasized by many scholars. Becker and Peters (2000) have shown that firms with pronounced absorptive capacities are more likely to have higher sales with new products. Therefore one includes variables that indicate the absorptive capabilities such as R&D intensity and the share skilled employees. Since absorptive capacities are generated with internal R&D the

Adalikwu, C. (2011). impact of international and home-based research and development (R&D) on innovation performance. *International Journal of Human Sciences* [Online]. 8:2. Available: **http://www.insanbilimleri.com/en**

innovation efforts are reflected in the absorptive capacities as well. One adds innovation activities without R&D as another variable to complement the R&D efforts. Since the level of firm knowledge and skills is also indicated by the degree of product diversification (Vermeulen and Barkema, 2002) and can have an impact on the firm performance (Chatterjee and Wernerfelt, 1991) one includes the product diversity in estimations. The access to external knowledge is captured by innovating abroad variables in this study. One includes variables to characterize the competitive environment of firms by their industries, whether the competition is rather price of technology driven and if the firm also serves international markets. Control variables include firm size, the location of the firm within Germany as well as the organization and ownership structure of the firms.

Table2: Definition of explanatory variables

Explanatory Variables	Definition (Note: Data year of all explanatory variables is 2005)
Non-Innovator	1 if firms is innovative but has no R&D
Innov. With domestic R&D only	1 if the firm has R&D labs in Germany only
Innov. With foreign R&D	1 if the firm has R&D labs in Germany and at least one R&D lab abroad (outside Germany)
Innov. With centralized foreign R&D	1 if the firm has an R&D lab in only 1 country abroad
Innov. With medium centralized foreign R&D	1 if the firm has R&D labs in 2 or 3 countries abroad
Innov. With decentralized foreign R&D	1 if the firm has R&D labs in 4 or more countries abroad
R&D intensity	R&D expenditure per sales
Non- R&D - intensity	Innovation expenditure (except R&D) per sales
High-Skilled Employees	No. of graduated employees per total number of employees
Degree of product diversification	1 divided by the share of sales with the most important product
National group	1 if firm is a national group
Intern. Group with German HQ	1 if firm is an international group headquartered in Germany
Intern. Group with HQ abroad	1 if firm is an international group headquartered abroad
Exporter	1 if Firm is having exports
Firm size	No. of employees (in log)
Firm in East Germany	1 if firm is located in Eastern Germany
Competition: Price	Average importance of price as indicator of competition (at NACE 3 industry level)
Competition: Technology	Average importance of technological advantage as indicator of competition (at NACE 3 industry level)

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Descriptive Statistic

After merging the two German innovations survey (MIP) waves from the survey year 2006 and 2009 via the identification number of firms one retrieves a sample of 2118 innovation active firms in Germany. About 39% of the sample firms had product innovations in the period between 2006 and 2008, of which 21% had market novelties and 34% had firm novelties. The innovation activities of 28% of the sample firms were concentrated in the national innovation environment, 11% had innovation activities in both Germany and foreign countries. Most of the international innovating firms prefer to focus their R&D work in one foreign country (5%). Two or three foreign countries as sources in their innovation network are used by 3% of our sample firms and 2% had R&D labs in more than three countries. The average sales growth due to new products (growth between the data years 2006 and 2008) is about 13%, while the growth of sales only due to market novelties is on average 3% and for firm novelties the average growth rate is 10% in our sample.

Table 3: Descriptive statistics of model variables

Dependent and Explanatory Variables	**Mean**	**Std. Dev.**	**Min**	**Max**
Firms with Product innovations	0.385	0.487	0	1
Sales growth due to new products	0.127	0.338	0	7.292
Firms with Market novelties	0.213	0.410	0	1
Sales growth due to market novelties	0.026	0.125	0	4.228
Firms with Firm novelties	0.339	0.473	0	1
Sales growth due to firm novelties	0.101	0.288	0	6.946
Non-Innovator	0.427	0.495	0	1
Innov. With domestic R&D only	0.276	0.447	0	1
Innov. With foreign R&D	0.111	0.314	0	1
Innov. With centralized foreign R&D	0.051	0.221	0	1
Innov. With medium centralized foreign R&D	0.030	0.171	0	1
Innov. With decentralized foreign R&D	0.016	0.125	0	1
Exporter	0.492	0.500	0	1
Firm size	4.278	2.220	0	12.121
High-Skilled employees	0.196	0.232	0	1
Degree of product diversification	1.668	1.495	0	50
National group	0.179	0.384	0	1
International Group with German HQ	0.132	0.338	0	1
International Group with HQ abroad	0.068	0.251	0	1
R&D intensity	0.027	0.116	0	2.667
Non-R&D intensity	0.026	0.086	0	1.534
Firm in East Germany	0.349	0.477	0	1
Competition: Price	5.122	0.400	3	6
Competition: Technology	3.283	0.710	1	5

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Estimation Method

To test the hypotheses one carries out two step heckman estimations. The selection equation is designed to estimate the effects of the explanatory variables on the likelihood to generate innovation outcomes (Product innovations, Market novelties, Firm novelties). The second step of the heckman estimation is designed to observe the impact of the explanatory variables on the growth of sales due to the innovation outcomes (from the selection equation). For the second step we do not include three variables since they are only significant in the selection equation but contribute no significance in the second equation (see Table 4 for results of coefficients). Therefore one uses firm size, the share of high skilled employees and the degree of product diversification as identifying/instrument variables for the heckman model (see Wooldridge 2002).

Table 4: Result of Heckman estimation: Coefficients

	Product Innovation		**Market novelties**		**Firm Novelties**	
	Yes/No	Sales growth	Yes/No	Sales growth	Yes/No	Sales growth
Prior innovation activities (ref. group: innovator without R&D)						
Non-Innovator	-0.831***	-0.181	-0.717***	0.067	-0.778***	-0.375**
Innov. With domestic R&D only	0.514***	0.143*	0.499***	-0.030	0.550***	0.225*
Innov. With foreign R&D	0.743***	0.205***	0.832***	-0.058	0.809***	0.308**
Firm size	0.138***	0.004	0.173***	-0.028*	0.127***	0.024
High-Skilled	0.336**	0.095	0.529***	-0.072	0.254	0.167
Degree of deversification	0.099***	0.001	0.046	-0.004	0.015	0.009
Exporter	0.296***	0.019	0.436***	-0.078	0.238***	0.074
National group	-0.008	0.066	-0.088	0.060*	-0.020	0.051
Intern. Group with German HQ	0.245*	0.077	0.174	0.042	0.232*	0.083
Intern. Group with HQ abroad	-0.173	0.060	-0.236	0.141***	-0.325**	-0.023
R&D intensity	2.244**	0.638***	2.043**	0.472***	1.378	0.348*
R&D intensity^2	-2.024**	-	-1.746**	-	-1.601*	-
Non-R&D intensity	-0.365	0.466	0.621	0.844***	-0.178	-0.167
Non-R&D intensity^2	0.328	-0.622*	-0.138	-0.647***	0.350	-0.244

Adalikwu, C. (2011). impact of international and home-based research and development (R&D) on innovation performance. *International Journal of Human Sciences* [Online]. 8:2. Available: **http://www.insanbilimleri.com/en**

East Germany	0.020	0.048	-0.166*	-0.026	0.014	0.093**
Comp: Price	-0.322***	-0.013	-0.151	0.073**	-0.357***	-0.088
Comp: Technology	0.079	0.045*	0.067	0.019	0.093*	0.043
_cons	0.105	-0.141	-1.694***	-0.032	0.279	-0.218
rho	0.403		-0.393		0.860	
sigma	0.480		0.235		0.546	
lambda	0.193		-0.092		0.470*	
W_all	47.61(16)***		87.81(16)***		23.88(16)*	
N° of observations	**2118**		**2118**		**2118**	
censored obs.	1303		1666		1400	
uncensored obs.	815		452		718	

Empirical Results

Table 5 and Table 6 present the results of one's estimations for the innovation outcome and the success with innovations of firms with international or national R&D locations (Table 5) as well as for the different degrees of R&D internationalization (Table 6). The tables report marginal effects for a firms' likelihood to generate product innovations, firm novelties and market novelties. The innovation success is shown by the sales growth due to product innovations, firm novelties and market novelties.

Innovation outcome

The results show that the influence of international innovation locations is significant positive on all innovation output measures. Having said this one's prime intention was to compare national versus international innovating firms. The results show that one's first hypotheses can be confirmed, firms with international R&D activities show stronger marginal effects for their likelihood to have product novelties, market novelties and abroad, of statistical equality show that these effects are significantly different from each other. For market novelties the difference of influence from national and international R&D is the greatest which is also reflected in the test statistics (is significant at the 1% level (0.005)). These results confirm one's assumptions of the knowledge-based view and

that multiple locations are offering firms attractive sources of knowledge. In addition the results suggest that the foreign knowledge is integrated into the innovation process of the whole firm and firms are actually carrying out knowledge sourcing tasks. The degree of R&D internationalization is not showing a linear relationship to innovation outcomes in one's results (Table 6). For market novelties one finds a stronger effect of international R&D centralization (one location abroad) and an even stronger effect of medium internationalized R&D organizations than only domestic R&D activities have. Having said this, the effects of medium decentralized R&D abroad show a stronger impact than a higher degree of R&D internationalization for market novelties. In the case of firm novelties and new product development one can observe that domestic R&D activities have a stronger influence than centralized international R&D but medium decentralized R&D activities abroad have a higher positive influence than purely domestic innovating firms. Due to data constraints one could not retrieve results from the estimation for the effects of high R&D internationalization on the likelihood to promote new product and firm novelties. The underlying reason is that all firms in the sample that have a high degree of R&D internationalization (R&D departments in more than three countries) have product innovations and firm novelties. Therefore the explanatory variable predicts the dependent variable perfectly and the results are dropped. The results reject one's third hypothesis that the effects for innovation outcomes increase with the degree of R&D internationalization. The test of equality between the marginal effects of the domestic R&D and the medium degree of R&D internationalization and between the domestic R&D and the medium degree of R&D internationalization and between the domestic R&D and a high degree of R&D internationalization (for market novelties only) is rejected significantly therefore the marginal effects differ statistically from each other. One's results for market novelties contradict the findings of Silverman and Argyres (1994) that found that high decentralized R&D organizations exceed the positive influence of medium decentralized innovation activities but are in line with Helfat and Leiponen(2006) who find that two R&D locations are most beneficial to product and process innovations as well as to any innovation.

Adalikwu, C. (2011). impact of international and home-based research and development (R&D) on innovation performance. *International Journal of Human Sciences* [Online]. 8:2. Available: **http://www.insanbilimleri.com/en**

Table 5: Results of three Heckman estimations: Marginal Effects- International vs. Domestic R&D

	Product Innovation		Market novelties		Firm Novelties	
	Yes/ No	Sales growth	Yes/ No	Sales growth	Yes/ No	Sales growth
Prior innovation activities (ref. group: innovator without R&D)						
Non-Innovator	-0.292***	-0.057	-0.13***	-0.019	-0.251***	-0.070**
Innov. With domestic R&D only	0.195***	0.054**	0.109***	0.018	0.196***	0.046*
Innov. With foreign R&D	0.288***	0.083**	0.223***	0.017	0.304***	0.073
Firm size	0.051***	-	0.033***	-	0.043***	-
High-Skilled	0.124*	-	0.101**	-	0.086	-
Degree of diversification	0.037***	-	0.009	-	0.005	-
Exporter	0.109***	0.000	0.084***	-0.003	0.080***	0.007
National group	-0.003	0.027	-0.016	0.014	-0.007	0.021
Intern. Group with German HQ	0.093*	0.031	0.036	0.014	0.082*	0.027
Intern. Group with HQ abroad	-0.062	0.027	-0.04*	0.034**	-0.100***	0.013
R&D intensity	0.827***	0.273***	0.392***	0.161***	0.466	0.143*
R&D intensity^2	-0.746***	-	-0.335***	-	-0.542*	-
Non-R&D intensity	-0.135	0.196	0.119	0.298***	-0.060	-0.088
Non-R&D	0.121	-0.253*	-	-0.240*	0.118	-0.049

Adalikwu, C. (2011). impact of international and home-based research and development (R&D) on innovation performance. *International Journal of Human Sciences* [Online]. 8:2. Available: **http://www.insanbilimleri.com/en**

intensity^2			0.026	**				
East Germany	0.007	0.024	-0.031	*	-0.013		0.005	0.036 *
Comp: Price	-0.119	*** -0.006	-0.029		0.016		-0.121	*** -0.019
Comp: Technology	0.029	0.019 *	0.013		0.009	*	0.031	* 0.012
Rho	0.284		0.503				0.407	
Sigma	0.470		0.244				0.444	
Lambda	0.134		0.123	**			0.180	
W_all	47.63 (13)	***	81.53 (13)	***			24.91 (13)	
dom. R&D = for. R&D	0.088	0.232	0.005		0.931		0.037	0.213
N of observations	**2118**		**2118**				**2118**	
censored obs.	1303		1666				1400	
uncensored obs.	815		452				718	

Innovation success

The results for our measure of innovation success are shown in the sales growth due to new products, market novelties and firm novelties. It becomes obvious that the innovation success follows the results of innovation outcomes. Firms' benefit from sales growth due to new product development and firm novelties receives higher influence from international R&D activities than from domestic innovation activities. Thus, both R&D efforts show positive and significant effects. However, this is not the case for market novelties. By testing the significant effects of domestic and international R&D for equality one achieves no rejection of this assumption which indicates that the results do not differ statistically. The results for the effect of different

Degrees of international R&D decentralization on Innovation success show that firms with medium decentralized R&D abroad have a stronger significant impact on the sales growth with product and firm innovations than firms which have R&D at home only. These results also differ statistically from each other. For market novelties one retains no significant

Adalikwu, C. (2011). impact of international and home-based research and development (R&D) on innovation performance. *International Journal of Human Sciences* [Online]. 8:2. Available: http://www.insanbilimleri.com/en

results fort the innovation success estimations. In this vein one cannot confirm the last hypotheses. However, one's results are in line with Leiponen and Helfat(2006), they also find a positive significant influence from firms with two R&D locations on Sales with innovations.

Table 6: Results of three heckman estimations: International Decentral R&D vs. Domestic R&D

	Product Innovation		**Market novelties**		**Firm Novelties**	
	Yes/ No	Sales growth	Yes/ No	Sales growth	Yes/ No	Sales growth
Prior innovation activities (ref. group: innovator without R&D)						
Non-Innovator	-0.305***	-0.051	-0.128***	-0.018	-0.267***	-0.071**
Innov. With domestic R&D only	0.166***	0.050**	0.106***	0.017	0.156***	0.040*
Innov. With centralized foreign R&D	0.155**	0.060	0.144***	0.016	0.153**	0.050
Innov. With medium central. Foreign R&D	0.526***	0.162***	0.372***	0.031	0.443***	0.132***
Innov. With decentralized foreign R&D	-***	0.044	0.365***	0.006	-	0.032
Firm size	0.052***	-	0.031***	-	0.045***	-
High-Skilled	0.134***	-	0.11***	-	0.093*	-
Degree of diversification	0.035	-	0.009	-	0.005	-
Exporter	0.113	-0.001	0.082***	-0.003	0.086***	0.008
National group	-0.00	0.028	-0.01	0.014	-0.00	0.022

Adalikwu, C. (2011). impact of international and home-based research and development (R&D) on innovation performance. *International Journal of Human Sciences* [Online]. 8:2. Available: **http://www.insanbilimleri.com/en**

Intern. Group with German HQ	2.091	*	0.022		5.026		0.014		5.084	*	0.022	
Intern. Group with HQ abroad	-0.059		0.025		-0.04	*	0.033	*	-0.092	* *	0.022	
R&D intensity	1.071	* * *	0.293	* * *	0.393	*	0.166	* * *	0.714	* *	0.160	* *
R&D intensity^2	-0.917	* * *	-		-0.324	*	-		-0.711		-	
Non-R&D intensity	-0.164		0.197		0.112		0.305	* * *	-0.083		-0.095	
Non-R&D intensity^2	0.176		-0.256	*	-0.016		-0.247	* * *	0.163		-0.050	
East Germany	0.001		0.026		-0.033	*	-0.013		0.000		0.038	* *
Comp: Price	-0.113	* * *	-0.001		-0.023		0.017		-0.112	* * *	-0.015	
Comp: Technology	0.028		0.018		0.011		0.009		0.033	*	0.012	
rho	0.218				0.492				0.407			
sigma	0.470				0.249				0.444			
lambda	0.102				0.123	* *			0.180			
W_all	49.00(15)	* * *	0.759		81.53(13)	* * *			26.75(15)	* * *		
dom. R&D= cent. for. R&D	0.807		0.007		0.569		0.864		0.871		0.749	
dom. R&D= med.cent.for.R&D	0.017		0.861		0.002		0.442		0.012		0.012	
dom. R&D = decent.for. R&D	-				0.037		0.532		-		0.802	
N of observations	**2086**				**2086**				**2086**			
censored obs.	1659				1659				1393			
uncensored obs.	427				427				693			

Adalikwu, C. (2011). impact of international and home-based research and development (R&D) on innovation performance. *International Journal of Human Sciences* [Online]. 8:2. Available: **http://www.insanbilimleri.com/en**

Conclusions

The central theme of this paper is the result of firms' international R&D activities. one investigated whether firms with R&D activities outside their home country benefit from these ventures in terms of a better innovation outcome and higher innovation success. One analyzes how the degree of R&D internationalization moderates firms' innovativeness and innovation success. To show the benefits of international dispersed R&D one compared the estimation outcomes with the results of firms that only innovate within the borders of their home country. Against the background of the trend to expanding R&D facilities increasingly one's results of are useful for firms' decision to internationalize their R&D activities as well as to their decision to extend their existing overseas R&D locations. The literature review of this study has revealed that existing studies answer the question of international R&D benefits insufficiently by using patent data. This paper contributes by adding addition information about innovation outcomes that would be not captured by patent data, such as firm novelties overall product innovations, as well as probably a certain share of market novelties as well. In addition one also related the added value of international R&D activities to the market success with innovations.

One's results show that firms that follow the trends and internationalize R&D activities have a great potential to strengthen their innovation performance. Firms with international R&D have a higher probability to develop products, market and firm novelties in comparison with firms that gather all their innovation efforts at the domestic headquarter. In addition, firms with international R&D centers are also more successful with their innovations on the market. Their sales growth due to new products, market or firm novelties is higher than for firms with only domestic R&D activities. In the analysis one also observed how the number of locations influences the innovation outcome and innovation performance. The results show that a moderate number of locations are most beneficial for generating innovation outcomes (product innovations, market and firm novelties) and for the sales growth due to new products and firm novelties.

To sum up, international R&D seems to ease the access to new knowledge which evidently results with a higher probability in innovations and therefore contributes to the

competitiveness of the firm. However, for the decision to set up R&D facilities at foreign subsidiaries, manager should careful choose the specific locations and limit the number to a moderate extent.

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