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CROSS-COUNTRY DIFFERENCES IN INNOVATION BEHAVIOR OF GERMAN MNEs – DOES LOCATION MATTER?

DRAFT

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CORPORATE R&D: AN ENGINE FOR GROWTH, A CHALLENGE FOR EUROPEAN POLICY

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Abstract

This paper analyzes cross-country differences in the innovation behavior of subsidiaries of German multinational enterprises. We find considerable differences in innovation input intensity as well as in innovation output intensity between German subsidiaries located in various European countries.

Multivariate analysis reveals that these differences are mainly related to firm characteristics, in particular to firm size, intramural R&D activity, public funding and international market orientation. From our analysis, we see a significant relationship between innovation performance and the host country only for innovation output: the share of products new to the firm on turnover is highest in the country group with the lowest income and R&D intensity levels.

From a policy perspective, our results imply that policy should focus on improving the innovative capabilities of foreign-owned firms, rather than offer benefits to attract foreign-owned firms.

Key words: Internationalisation of innovation, German multinational firms, innovation performance

JEL classification: O320; O330; F230

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1 - Introduction

In recent decades firms increasingly decentralized their innovation activities. Affiliates of multinational enterprises already account for up to 20% of total manufacturing R&D in France, Germany and the United States; between 30% and 50% in Portugal, the Netherlands, Canada, Sweden and the United Kingdom; and more than 50% in Belgium, the Czech Republic, Hungary and Ireland (OECD 2008, p. 27).

This internationalization of innovation has been examined by a considerable number of studies in recent years (Dunning and Narula 1995; Kuemmerle 1999; von Zedtwitz and Gassmann 2002; Ambos 2005; Cantwell and Mudambi 2005; Narula and Zanfei 2005; UNCTAD 2005; Veugelers 2005). This literature has followed a number of different approaches. Two of them are important for this paper:

First, various authors relate foreign-located R&D and innovation activities to market- and knowledge-related strategies of multinational firms (examples include Patel and Vega 1999; Cantwell and Piscitello 2002; Edler 2004; Ambos 2005; Cantwell and Piscitello 2005). Their main question is how **location** shapes innovation activities of foreign-owned firms in various countries. This approach assumes that firms plan innovation efforts abroad in response to the locational advantages of potential home countries; a potential host country with high market growth will pose a considerable incentive for a MNE to increase innovation efforts in this country. A second stream of the literature investigates the role of foreign ownership in explaining innovation performance of firms (Ebersberger and Lööf 2005; Sadowski and Sadowski-Rasters 2006; Frenz and Ietto-Gillies 2007). Here, foreign ownership is typically one of many variables describing **firm characteristics** shaping innovation behavior.

The literature has examined the drivers and strategies of internationalization in detail, and developed differences between foreign-owned and domestic-owned enterprises as well as possible consequences of internationalization for national innovation policy. Despite the large number of publications on this topic in recent years, there are still some blind spots in the literature which, nevertheless, have a high relevance for policy. For example, we know only little about how the innovative performance of foreign-owned enterprises differs between countries and how these differences can be explained from the interplay of locational advantages and firm characteristics.

The vast majority of studies that look at firm characteristics include only observations from one country. Hence, they implicitly assume that there are no differences with respect to the analyzed home countries and results gained from one country can be generalized. Dunning and Narula (1995) point out that there is considerable variance in the innovative activities of foreign-owned enterprises across borders even within Europe.

Studies that explain the variation across countries, in contrast, rarely correct for a large number of firm characteristics. Many of these studies employ patent data which is difficult to combine with information on innovation expenditure, employment or financial information, or they use datasets that provide information only on a small sample of firms. Only a small number of studies try to capture both, locational advantages and firm

characteristics. Two examples are the papers by Ito and Wakasugi (2007) and Schmiele (2009).

The aim of this paper is to analyze cross-country differences in the innovation behavior of foreign-owned enterprises in various host countries. We focus on subsidiaries of German multinational enterprises (MNEs). Innovative activities of firms abroad depend to a considerable degree on their technological strengths and capabilities build up at home (Patel and Pavitt 1999; le Bas and Sierra 2002). By including only German-owned subsidiaries, we eliminate possible effects from home country specialization on the innovative performance of the subsidiary.

We test the cross-country variance using data from the Community Innovation Survey 4 (CIS4), which is based on the reference year 2004. The data covers 16 European countries. The CIS4 provides information on the characteristics of innovation activity at enterprise level. We analyze the relationship between two dependent left-hand variables, Innovation input intensity and innovation output intensity, describing innovative behavior and various right-hand variables. The independent variables capture both firm-specific characteristics, as size, market orientation, sectoral affiliation, etc. and country-specific characteristics that describe the innovation system of the host country.

The paper is structured in the following way. In the next chapter we will discuss our research questions and the hypotheses to be proofed. Section 3 describes the data employed in this paper. The empirical analysis includes two phases: first, in Chapter 4 the results of the descriptive analysis are presented. We mainly focus on innovation activity, innovative input and innovation output intensity used as dependent variables in the multivariate analysis. Second, determinants of innovation behavior are shown in Section 6, after specifying the econometric model employed in our analysis in chapter 5. Finally, the main conclusions and policy implications derived from the analysis are given in Section 7.

2 - Research questions

The main questions of this paper are:

(i) *Are there significant differences in innovation behavior of German-owned enterprises in different countries?*

And, if yes,

(ii) *How can these differences be explained?*

We assume that a considerable degree of these variations are associated with firm level characteristics such as size, industrial sector, R&D orientation, export orientation or co-operations. Indications for the importance of these factors can be found in the literature that analyzes the determinants of innovativeness at the firm level (Dogson and Rothwell 1994; Cohen 1995; Kleinknecht and Mohnen 2002; OECD 2009).

Hypothesis 1:
Innovation performance is associated with size, sector, export intensity and other firm-level determinants specified in our model.

Moreover, we assume a relationship between various characteristics of the host country and innovativeness of the firm. Competitive pressure from other firms may force German subsidiaries to increase innovative inputs to the level of other enterprises in the country. Potential spillovers may be richer in innovation-intensive environments, which in turn may be an incentive for German subsidiaries to spend more on innovation. We may therefore assume that:

Hypothesis 2:
German subsidiaries spend more on innovation in countries with high average innovation input intensities.

Germany is among the most R&D intensive countries in the world. In the context of multinational enterprises, this indicates that German MNEs may possess considerable intangible assets which can be commercialized by their overseas subsidiaries and give them an advantage over domestic competitors and other foreign-owned firms in the country. The advantage German subsidiaries can generate from these assets may be largest in countries which have the largest gap to Germany in terms of R&D expenditure.

Hypothesis 3:
German subsidiaries gain more turnover from innovations in low income countries.

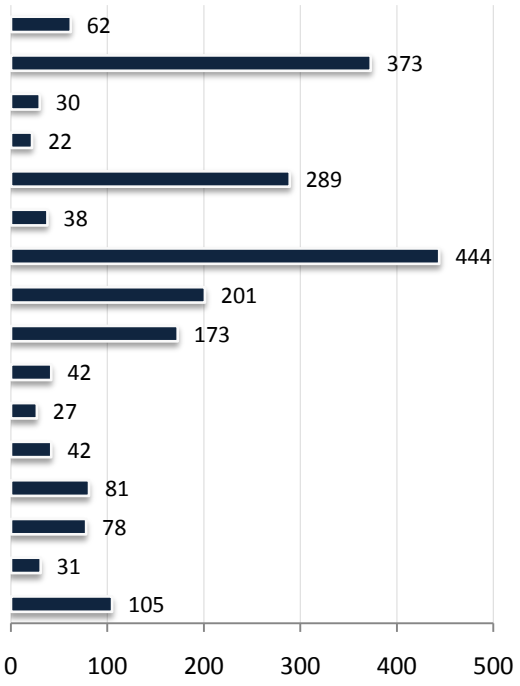
We will test these three assumptions in the subsequent chapters of this paper. A descriptive analysis will follow in section 4; we will estimate the multivariate analysis in section 6.

3 - Data

We draw on data from the fourth wave of the Community Innovation Survey (CIS 4). CIS 4 is a survey based on a harmonized questionnaire administered by Eurostat[1] and national statistical offices or research institutes in all EU member states, Iceland and Norway. CIS aims at assessing various aspects of the innovative behavior and performance of enterprises and follows the definitions laid down in the OECD Oslo Manual (OECD 2005). The CIS 4 covers the period 2002-2004. The data set employed in this paper consists of more than 2,000 German subsidiaries from 16 European countries. Figure 1 below gives an overview of the allocation of the subsidiaries.

Figure 1: Observed enterprises with innovation activity per country

Host Country	(1) %	(2) Number of Observations
Bulgaria (BG)	3.04	62
Czech Republic (CZ)	18.30	373
Denmark (DK)	1.47	30
Estonia (EE)	1.08	22
Spain (ES)	14.18	289
Finland (FI)	1.86	38
France (FR)	21.79	444
Hungary (HU)	9.86	201
Italy (IT)	8.49	173
Luxembourg (LU)	2.06	42
Latvia (LV)	1.32	27
Norway (NO)	2.06	42
Portugal (PT)	3.97	81
Romania (RO)	3.83	78
Slovenia (SI)	1.52	31
Slovakia (SK)	5.15	105
Total	100	2038



(1) Share of enterprises per country
(2) Observed enterprises in absolute numbers

Source: EUROSTAT, own calculations

[1] We thank Sergiu Parvan from EUROSTAT for data access and his support.

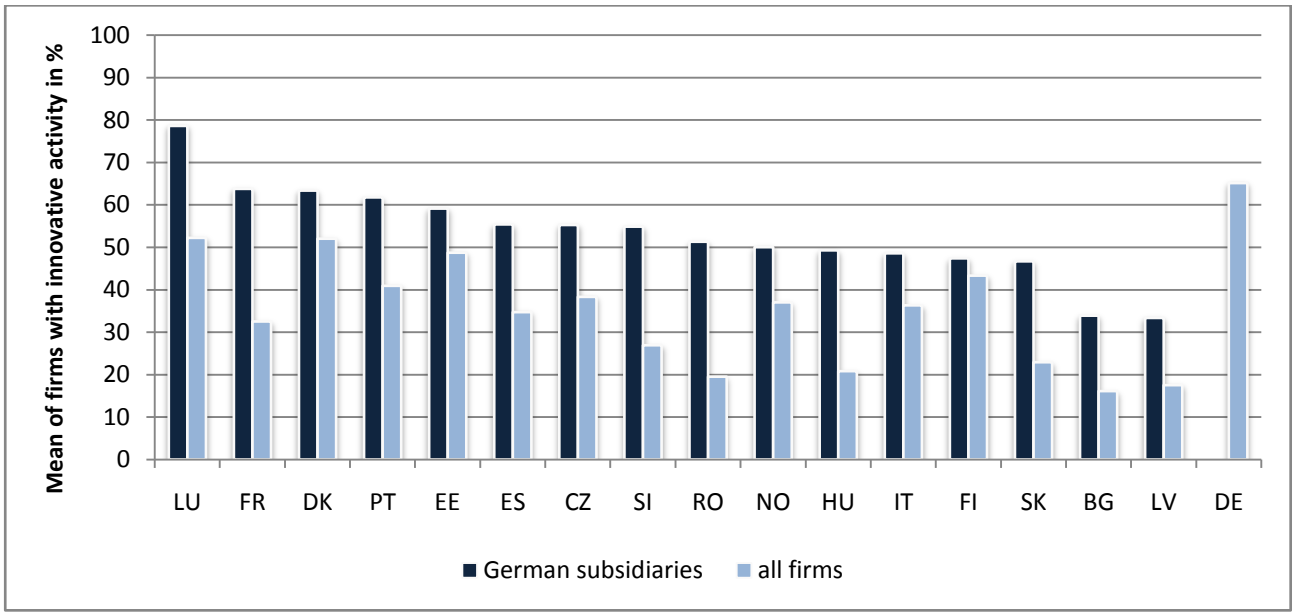
4 - Descriptive Results

In this chapter we will discuss the descriptive results from our analysis. Variables described here, besides hampering factors, we use as dependent variables for the multivariate analysis in the following chapter. In the first sub-section we will have a closer look on innovative activity of German subsidiaries in various host countries and test for differences between these. Afterwards we examine the allocation of occurrence of factors hampering innovation per country. The sub-sections 3 and 4 present descriptive results of innovative input and output regarding the differences between host countries.

4.1 Innovative activity

To analyze cross-country differences in innovation behavior in this section we will look at the allocation of innovation activities of German subsidiaries and enterprises' innovatory activities performed in one country. In the figure below (Figure 2), we illustrate the means of German subsidiaries' innovation activity per host country. Additionally, as a reference value, the figure includes means of enterprises carrying out innovation in the particular countries. In each country, the share of innovators among German subsidiaries is higher than the mean for all enterprises in the country (population mean). The biggest differences between German subsidiaries and the population can be found in Romania. If the enterprise is part of a German MNE, the mean of an enterprise's innovation activity turns out 32 percentage points higher. Likewise, for German subsidiaries in France a difference of 31 percentage points arises (regarding the mean of being active in innovation) compared to all enterprises' innovation activities in France. The smallest difference in innovation activity concerning the home country of the parent enterprise results for Finland.

Figure 2: Mean of enterprises' innovatory activities of German subsidiaries and the population of all enterprises surveyed in the CIS4 per country



Source: own calculations, EUROSTAT

In addition, we can see from the figure (Figure 2) that there are considerable differences in innovation activity between the observed host countries of German MNEs. In Luxembourg 78% of all German subsidiaries are active in innovation, unlike Bulgaria and Latvia, where only 34% and 33% of the German subsidiaries have innovatory activities. Admittedly, we can see as well from the above-mentioned figure that there are barely marginal differences between most of the observed countries: in France 63.7% of German subsidiaries are active in innovation, in Denmark this is the case for 63.3% of German subsidiaries.

To sum up, we can find great differences between the performance of German subsidiaries and the performance of enterprises located in the various host countries. In the host countries German subsidiaries are more innovative than the total country sample. This could indicate that the performance of foreign-owned firms is influenced by home country's conditions.

Furthermore, we test for differences in innovation activity of German subsidiaries between the host countries with ANOVA (Figure 3). The results indicate that there are significant differences between countries. The variance between the 16 national economies is 0.86, with an F-Value of 3.55 and, hence, a level of significance of below 1%. It should be noted that within the countries there is a greater heterogeneity, than between the countries.

Figure 3: ANOVA of innovation activity

	SS	df	MS	F	Prob > F
Between the countries	12.9223	15	0.8615	3.55	0.0000
Within the countries	491.3721	2022	0.2430		
Total	504.2944	2037	0.2476		

Source: own calculations, EUROSTAT

Using the Bonferroni multiple comparison test[2] we test for significant differences between country pairs. Bearing the above in mind, the ANOVA has shown that there are differences between the countries in innovation activity; the Bonferroni test reveals only 9 out of 120 pair wise comparisons of host countries being significantly different from each other. Significant differences on the 1%-level result for Luxembourg respectively France and Bulgaria. On a significance level of 5% there are differences between Luxembourg and Italy, Latvia or Slovakia. Differences with a probability of error of 10% exist between Portugal and Bulgaria, France and Hungary respectively Italy, and Luxembourg and Hungary. Still, within the countries, differences are higher than between the countries.

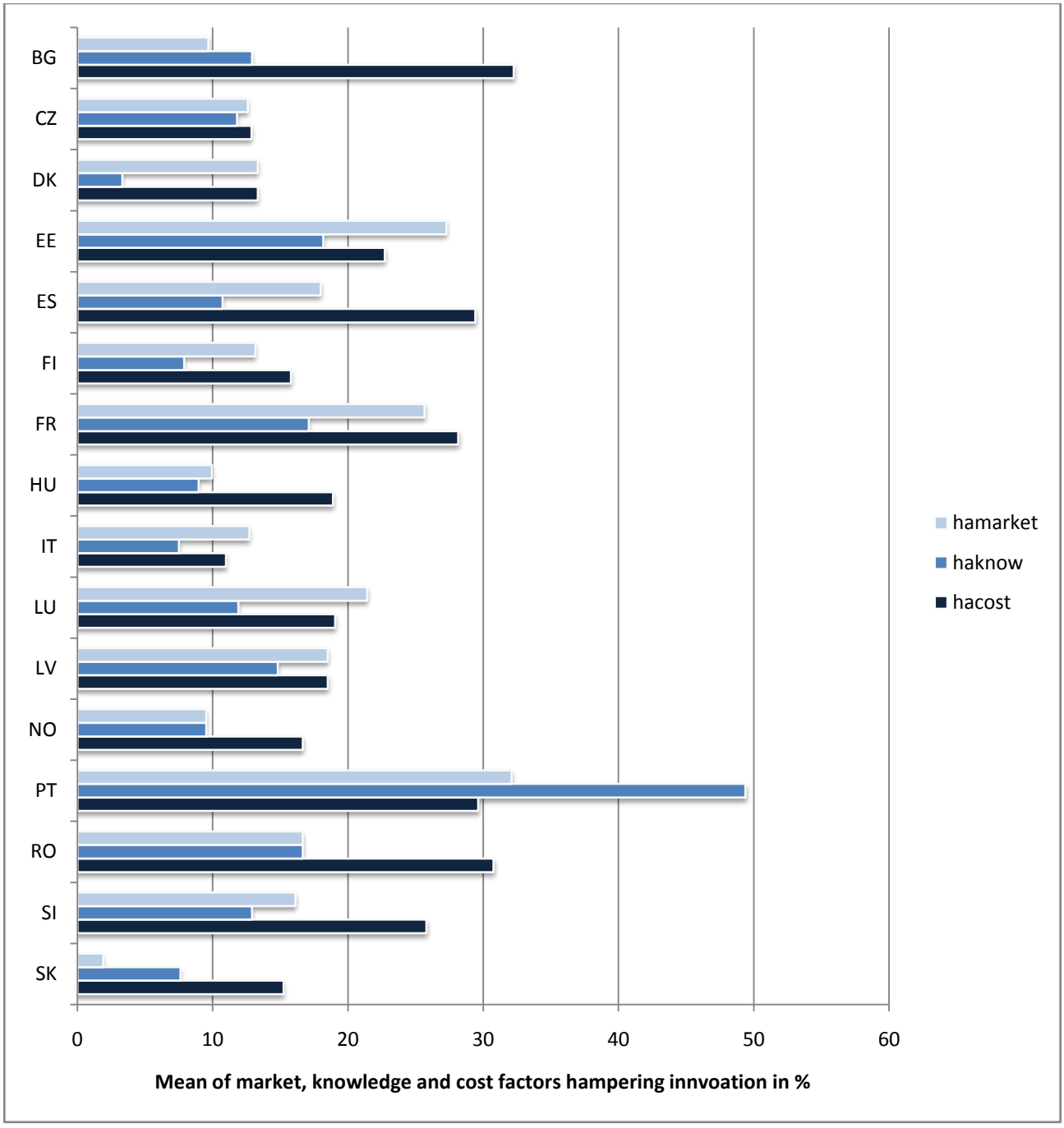
These findings could indicate strong differences in firm's characteristics within one country. Hence, impacts of host country characteristics seem to be weak compared to impacts of firm characteristics on innovative activity.

[2] Differences between the countries are calculated with the Bonferroni multiple-comparison test. This test neutralizes the accumulation of α errors doing multiple pair wise comparisons. A detailed schedule with significance levels can be found in the Annex.

4.2 Hampering factors

We assume that innovation activity is affected by various hampering factors which can be classified in market, knowledge and cost factors. The following figure (Figure 4) displays the means of the hampering factors per host country. In the CIS4, the question concerning hampering factors had to be answered by all enterprises, no matter if they had innovation activities or not.

Figure 4: Mean of market, knowledge and cost factors hampering innovation of German subsidiaries in the host country



Source: own calculations, EUROSTAT

Over all countries **cost factors** are the most severe hampering factors. 21.26% of all enterprises consider a lack of funds within the enterprise or enterprise group, lack of finance from sources outside the enterprise or overspends in innovation to be very important. Regarding host countries individually, cost factors hampering innovation activities seem to be most important for German subsidiaries in Bulgaria (32.36% of all surveyed enterprises in Bulgaria), followed by Romania (30.77%), Portugal (29.63%), Spain (29.41%) and France (28.15%). The lowest importance of cost factors can be found in Italy (10.98%), the Czech Republic (12.87%), Denmark (13.33%), Slovakia (15.24%) and Finland (15.59%). Considerable discrepancy in the valuation of cost factors can be found between Bulgaria and Italy. From the point of view of Bulgarian enterprises this factor is rated three times as important as from the Italian's point of view.

From the enterprise's point of view **market factors** hampering innovation activity play the second most important role. On average, 16.67% of the observed enterprises consider very important market domination by established enterprises or uncertain demand for innovative goods or services. Portuguese enterprises assess market factors hampering innovation activities with 32.10% higher than any other country of the sample. Likewise, enterprises from Estonia (27.27%), France (25.68%), Luxembourg (21.43%), and Spain (17.99%) rank this factor above average. For Slovakian enterprises, market factors barely seem to hamper innovation activities with a percentage of 1.9%. Norwegian enterprises in contrast, penultimate enterprises in this ranking, consider this factor notably more important, also Bulgarian (9.68%), and Hungarian (9.95%) enterprises.

Knowledge factors hampering innovation activities from the enterprise's point of view are the least crucial factors in comparison to cost and market factors. By contrast, there is no other factor which is considered important from so many enterprises in one single country. Nearly 50% of all subsidiaries resident in Portugal regard lacks of qualified personnel, lacks of information on technology, lacks of information on markets or difficulties in finding co-operation partners for innovation very important. In addition, with no other hampering factor, opinions are so different between two countries. Portuguese subsidiaries of German MNEs consider this factor for about 30 percentage points higher than Estonian (18.18%), French (17.12%) or Romanian (16.67%) subsidiaries having an impact on innovation activity.

4.3 Innovation Input Intensity

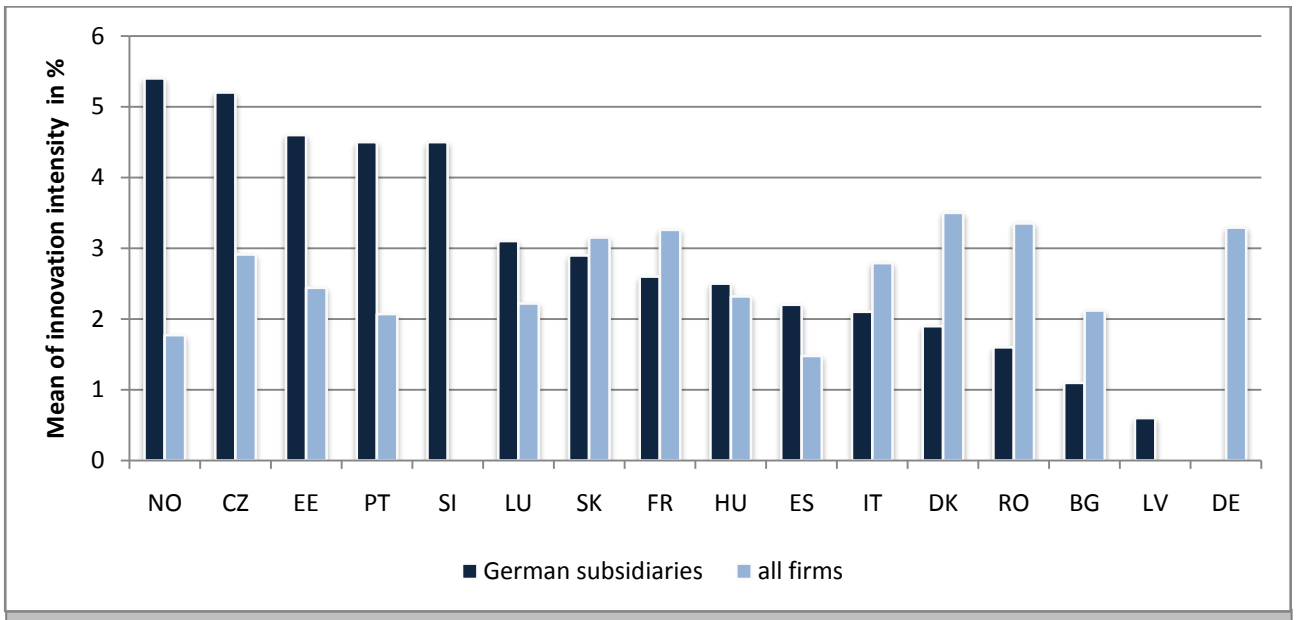
We measure innovative input intensity by innovation expenditures of the enterprise as a share of turnover from the reference year 2004. Innovation expenditures include internal and external R&D expenditures, expenditures for machinery, equipment, and software, other external knowledge and training related to innovation. The figure stated below (Figure 5) shows the innovation input intensity of German subsidiaries in various countries. We display mean innovation input intensity for both, German subsidiaries and all enterprises resident in a country.

Differences between countries range between 5.4% in Norway and 0.6% in Latvia. Subsidiaries of German MNEs with highest innovation intensities are located in Norway (5.4%), Czech Republic (5.2%), Estonia (4.6%), Portugal (4.5%), and Slovenia (4.5%).

Low innovation intensities of German subsidiaries can be found in Latvia (0.6%), Bulgaria (1.1%), Romania (1.6%), Denmark (1.9%), Italy (2.1%), and Spain (2.2%).

If we compare innovation input intensity of German subsidiaries with the innovation input intensity of all enterprises in a country, it seems that there is no correlation between the two variables. German subsidiaries in Norway for example exhibit the highest innovation intensities, while innovation input intensity for all enterprises in Norway is one of the lowest. A similar case turns out for Portuguese enterprises. In Denmark, in contrary, German subsidiaries reach relatively low innovation intensities of 1.9%, in the national average in comparison to the enterprises surveyed in Denmark, which are on top of all observed countries.

Figure 5: Mean of innovation input intensity for German subsidiaries and the population of all enterprises surveyed in the CIS4 per country



Methodology:

(a) Innovation input intensity is measured as share of innovative expenditure on turnover

(b) Innovation input intensity of Finland (FI) cannot be calculated on grounds of the non-authorized value of innovation expenditure. Hence Finland is not included in this analysis.

(c) There are no national population means for Slovenia (SI) and Latvia (LV).

Source: own calculations, EUROSTAT

Innovation intensities of German subsidiaries are dispersed in a broader way than the means of innovation input intensity of enterprises located in a nation state. Enterprises residents in Denmark on average reach an innovation input intensity of 3.5%; Spanish enterprises, the country with lowest innovation intensities, reach 1.48%. Over all countries, there is an absolute discrepancy of about 2 percentage points. Highest innovation intensities, besides Denmark, can be found in Romania (3.35%), France (2.36%), Slovakia (3.15%), and Czech Republic (2.91%). Lowest national averages of innovation intensities can be detected, as mentioned before in Spain, and furthermore in Norway (1.77%), Portugal (2.07%), Bulgaria (2.12%), Luxembourg (2.22%), and Hungary (2.32%).

The ANOVA of innovation input intensity (Figure 6) confirms the results described above. Between the countries, we do not get any significant differences ($p = 0.1515$). As the

Bonferroni multiple comparison test shows, there do not exist any significant differences between the host countries out of 120 pair wise comparisons. In addition, differences within the countries are considerably higher, than between the observed countries.

Figure 6: ANOVA of innovation input intensity

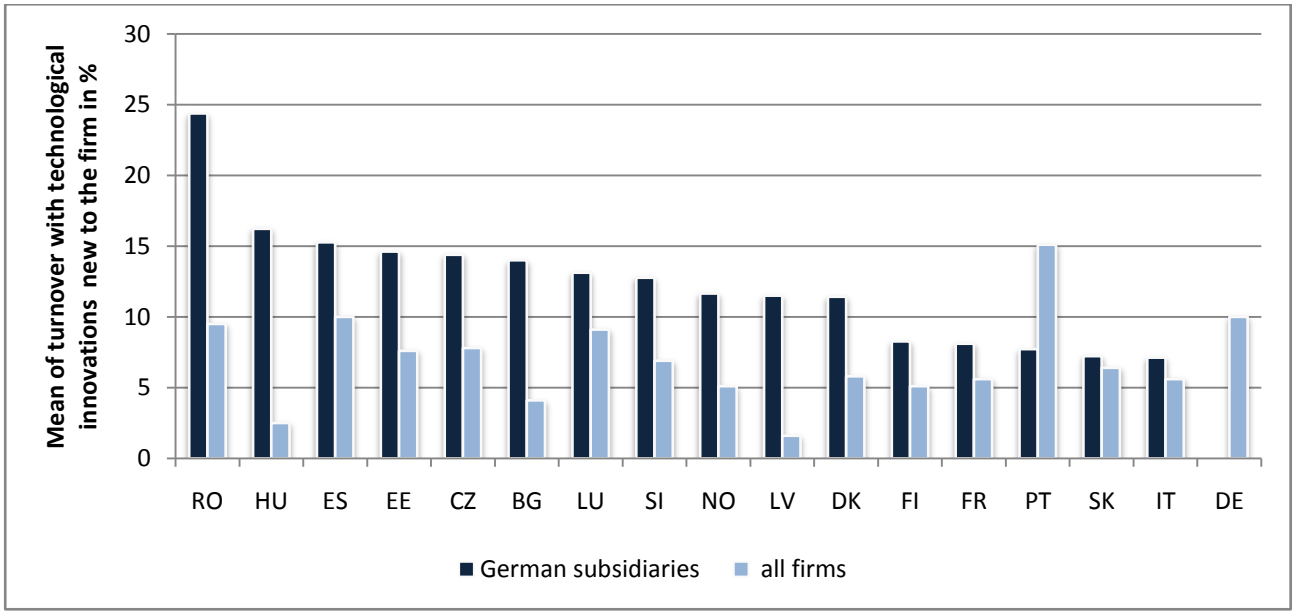
	SS	df	MS	F	Prob > F
Between the countries	0.3584	15	0.0246	1.37	0.1515
Within the countries	36.1662	2022	0.0179		
total	36.5346	2037	0.0179		

Source: own calculations, EUROSTAT

4.4 Innovation Output Intensity

Our second dependent variable used in the regression equation is innovation output intensity. It is measured by the share of products new to the enterprise introduced between 2002 and 2004 on turnover. A comparison between German subsidiaries and all enterprises in the host country is given by Figure 7 below.

Figure 7: Mean of share of turnover from goods or services innovations new to the enterprise for German subsidiaries and the population of all enterprises surveyed in the CIS4 per country



Source: own calculations, EUROSTAT

In contrary to the input indicator innovation input intensity, we can see that in all countries, except Portugal, German subsidiaries achieve higher innovation output intensity than the enterprises located in a particular country. Turnovers are even higher for German subsidiaries in most host countries than for enterprises located in Germany.

Highest turnovers from innovations result for German subsidiaries located in Romania (24.38%), followed by Hungary (16.22%), Spain (15.27%), Estonia (14.62%), the Czech

Republic (14.39%), and Bulgaria (14.0%). In contrary lowest turnovers are generated in Italy (7.12%), Slovakia (7.22%), Portugal (7.72%), France (8.10%), and Finland (8.27%).
It is striking that the highest turnovers with new products are achieved mainly in Eastern European host countries (14.39%), besides Spain, whereas lowest turnovers are gained mainly in Western European host countries (10.33%). Regarding in contrast all firms surveyed in the CIS4, innovation output intensity in Eastern European countries is marginally lower (5.8%) than in Western European countries (7.68%).

Big differences in turnovers from goods and services innovations new to the enterprise as a share of total turnover can be found for Romania (14.88 percentage points) and Hungary (13.72 percentage points). In Romania, the average turnover of a German subsidiary is more than twice as high as if the enterprise is not affiliate to a German MNE. The case is even stronger for Hungary as a host country: the average turnover of a German subsidiary is more than six times higher, as if all enterprises located in Hungary are taken into consideration. For Portugal, a converse result is achieved: the average turnover of an enterprise is nearly twice as high regarding all enterprises located in Portugal.

Figure 8: ANOVA of innovation output intenisty

	SS	df	MS	F	Prob > F
Between the countries	1.9582	15	0.1305	3.00	0.0001
Within the countries	47.6739	1097	0.0435		
total	49.6320	1112	0.0446		

Source: own calculations

The ANOVA of the turnover from goods or services new to the enterprise shows that differences between the countries are significant at the 1%-level. Similar to the ANOVA of innovation activity, heterogeneity is bigger within the countries (Sum of Squares 47.67). As the ANOVA has shown there are significant differences between the countries; the Bonferroni multiple comparison test reveals that only 5 out of 120 pair wise country comparisons result significant. On a significance level of 1% there are differences for Romania and France and Romania and Italy. Differences with a probability of error of 5% result for Romania and Portugal and Romania and Slovakia. Differences significant at the 10%-level ensue for France and Spain.

To sum up, descriptive statistics already reveals that German subsidiaries behave differently in different countries; in general, they are more innovative than the total enterprise population. In about half of the countries, they spend less on innovation than the average enterprise, measured by innovative expenditure as a percentage of turnover. Innovation output intensity, measured as the share of new products on turnover of German subsidiaries, in contrast, is in all countries but one higher than the innovation output intensity of the average enterprise.

These results may be caused by two factors: first, the firm characteristics of German subsidiaries in these countries which, in many ways, affect innovative performance; second, the characteristics of the host countries which may lead to a higher or lower innovative performance of German subsidiaries. In the next chapter, we will explain the econometric model used for the multivariate analysis, to disentangle these two factors with multivariate analysis in chapter 5.

5 - Estimation

This section develops the methodical framework of the analysis. We first focus on the specification of the econometric model. Subsequently we continue with a short description of the variables employed in the analysis.

5.1 Econometric Model

The econometric analysis employs a two equation sample selection model, i.e. the Heckman Selection Model, to test the assumptions stated above. This model is a standard tool in various evaluation studies, for example in the evaluation of labor market programs. The bias that arises from using least squares in a model with nonrandom sample selection is characterized as an estimator applicable to such models. This estimator amounts to estimating the omitted variable and using least squares including the estimated omitted variable as a regressor (Heckman 1976, 1979).

The Heckman Selection Model (Greene 2002; Wooldridge 2002; Kennedy 2003) is appropriate because data is incidentally truncated due to the questionnaire design. We observe some variables such as size, main market or sectoral affiliation for all enterprises. A number of other variables such as innovative expenditure, however, can only be observed for innovative enterprises. Thus, the availability of most dependent variables – and therefore the composition of the sample - depends on whether or not the enterprises have introduced an innovation. The group of enterprises for which we have data on innovative behavior constitute a non-random, self-selected sub-sample of the whole population (Blundell and Costa Dias 2000). The selection equation (1) identifies the determinants of being innovative (z_i^*) while the function equations [(4) and (5)] relate various independent variables to innovative behavior, i.e. to innovation input intensity ($y_{i,input}$) and share of new products on turnover ($y_{i,output}$). Let z_i^* be our latent variable. The firm's probability of being active in innovation (z_i^*) is not observable. We only know whether an enterprise introduced new or significantly improved goods, services or processes (z_i) during 2002 to 2004. Let w be a variable containing firm characteristics (as e.g. size of the enterprise, market-orientation, etc.) and dummies for a sectoral taxonomy. In the regression equations (4) and (5) x contains firm characteristics only for innovation active firms (e.g. innovation co-operation, public funding of innovation, etc.), again dummies for a sectoral taxonomy as well as dummies for the host countries. Let the equation that determines the sample selection be

$$z_i^* = w_i\gamma_i + u_i,\ z_i = 1 \text{ if } z_i^* > 0 \text{ and } 0 \text{ otherwise} \qquad \text{for } i = 1,...,n \tag{1}$$

$$\text{Prob}(z_i = 1 \mid w_i) = \Phi(w_i\gamma_i) \tag{2}$$

$$\text{Prob}(z_i = 0 \mid w_i) = 1 - \Phi(w_i\gamma_i) \tag{3}$$

and let the equations of primary interest be

$$y_{i,input} = x_i\beta_i + \varepsilon_i \text{ observed only if } z_i = 1 \tag{4}$$

$$y_{i,output} = x_i\beta_i + \varepsilon_i \text{ observed only if } z_i = 1 \tag{5}$$

y_i is only observed, when $z_i^* > 0$. For the general case of $z > a$ we define

$$\alpha_z = \frac{(a-\mu_z)}{\sigma_z} \tag{6}$$

$$\lambda(\alpha_z) = \frac{\phi(\alpha_z)}{[1-\Phi(\alpha_z)]} \tag{7}$$

$$\delta(\alpha_z) = \lambda(\alpha_z)[\lambda(\alpha_z) - \alpha_z] \tag{8}$$

If y and z have a bivariate normal distribution with means μ_y and μ_z, standard deviations σ_y and σ_z and correlation ρ then

$$E[y \mid z > a] = \mu_y + \rho\sigma_y\lambda(\alpha_z) \tag{9}$$

$$Var[y \mid z > a] = \sigma_y^2[1-\rho^2\delta(\alpha_z)] \tag{10}$$

It is assumed, that ε_i and u_i have a bivariate normal distribution with zero means and correlation ρ. It is supposed that z_i and w_i are observed for a random sample but $y_{i,input}$ and $y_{i,output}$ are observed only when $z_i^* > 0$. In the following the Model is described only for y_i as it is the same for both cases.

$$\begin{aligned} E[y_i \mid y_i \text{ is observed}] &= E[y_i \mid z_i^* > 0] \\ &= E[y_i \mid u_i > -w_i\gamma_i] \\ &= x_i\beta_i + E[\varepsilon_i \mid u_i > -w_i\gamma_i] \\ &= x_i\beta_i + \rho\sigma_\varepsilon\lambda_i(\alpha_u) \\ &= x_i\beta_i + \beta_\lambda\lambda_i(\alpha_u) \end{aligned} \tag{11}$$

where

$$\alpha_u = \frac{-w_i\gamma_i}{\sigma_u} \tag{12}$$

and

$$\lambda(\alpha_u) = \frac{\phi\left(\frac{w_i\gamma_i}{\sigma_u}\right)}{\Phi\left(\frac{w_i\gamma_i}{\sigma_u}\right)} \tag{13}$$

Estimating the probit equation (selection equation) by maximum likelihood, we obtain estimates of γ_i and thus the nonselection hazard – what Heckman (1979) referred to as the inverse of the Mill's ratio, $\hat{\lambda}_i$

$$\hat{\lambda}_i = \frac{\phi(w_i\hat{\gamma}_i)}{\Phi(w_i\hat{\gamma}_i)} \tag{14}$$

and

$$\hat{\delta}_i = \hat{\lambda}_i(\hat{\lambda}_i - w_i\hat{\gamma}_i) \tag{15}$$

We obtain $\hat{\beta}$ by augmenting the regression equation with the nonselection hazard $\hat{\lambda}_i$. Hence, regressors become $[X\ \lambda]$ with the additional parameter estimate β_λ on the variable containing the nonselection hazard. We can then obtain a consistent estimate of the regression disturbance variance using the residuals from the augmented regression and the parameter estimate on the nonselection hazard,

$$\sigma^2 = \frac{e'e + \beta_\lambda^2 \sum_{i=1}^{n} \delta_i}{n} \tag{16}$$

Thus, the estimator of ρ is

$$\hat{\rho} = \frac{\beta_\lambda}{\hat{\sigma}} \tag{17}$$

5.2 Dependent and Independent Variables

Our model includes innovation input and output intensity as dependent variables. Both variables have been described above (chapter 4).

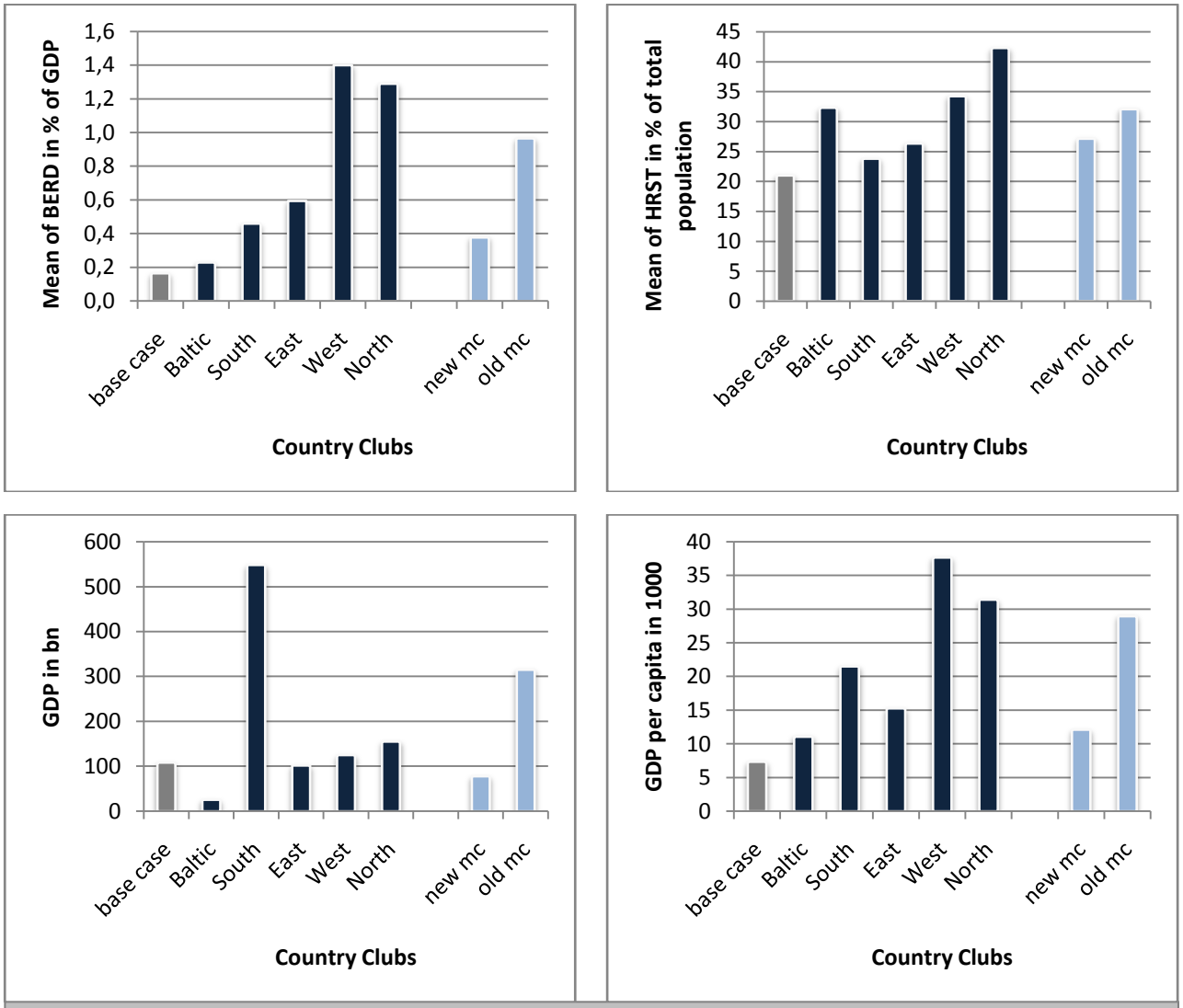
Independent variables include at first firm-level variables which have been identified by various studies to be related to the propensity of enterprises to innovate. The size of the enterprise is measured by the number of employees and the number of employees squared (*lemp* and *lemp2*) to allow non-linear relationship between size and innovative behavior. *Mar_int* identifies enterprises which are mainly engaged at international markets. The dummy variable *finsup* indicates that the enterprises have received financial support for innovation. The selection equation also includes three variables that indicate that the enterprise has faced obstacles to innovation: *haknow* is one if the enterprises has faced obstacles related to the availability of knowledge; *hacost* is one if the enterprise has faced obstacles related to unexpected high innovation costs and the availability of funding; *hamarket* is one if the enterprise has faced obstacles related to market acceptance of the innovation. We also include the measure of innovation input intensity and a measure for absorptive capacity. Innovation input intensity (*lintens*) is the share of innovative expenditure on turnover. *Rrdin* is 1 if the enterprise has internal R&D activity, which can be seen as an indication for absorptive capacity.

To account for influences from the sectoral level, we employ a new taxonomy of economic sectors according to their innovation intensity proposed by Peneder (2010). We feel that this taxonomy is better suited to reflect sectoral characteristics than other taxonomies, because it has been constructed with firm-level data and includes both, manufacturing and service industries.

Peneder classifies sectors according to cumulativeness of the knowledge base, appropriability conditions, technological opportunity and creative vs. adaptive strategies. This results in six groups of sectors with rising innovativeness. *None, Low*, *med_low*, *med*, *med_high* and *high* are sectoral dummies which refer to different levels of innovativeness according to this taxonomy. The reference category is none, which indicates sectors with very little of no innovative activity. Differences between host countries will be captured with country dummies.

We include three types of country dummies. The country dummies are representing metric variables from which w assume that they are influencing innovation behavior of foreign-owned firms. These metric variables are illustrated in the figures stated below (figure 9). First, we construct a dummy for each country with Bulgaria as the base case in order to find some impacts from the various host countries on innovative behavior of German subsidiaries. Second, we aggregated countries in six groups, Northern Europe, Southern Europe, Eastern Europe, Baltic States, Western Europe and Bulgaria/Romania as reference category. We differentiated between these six country clubs, as the country characteristics are distinctive for each region. Bearing in mind primarily R&D expenditure from the business enterprise sector and GDP per capita, we can find considerable differences between the old (the EU15) and the new member countries. Thus, third, we just differentiate between old member countries and new member countries with new member countries as the base case.

Figure 9: Means of metric variables as the basis of the country clubs used in the multivariate analysis



Methodology:

(a) new/old mc: new / old (EU15) member countries

(b) BERD: R&D expenditure from the business enterprise sector as a percentage of GDP, 2004

(c) HRST: Human resources in science and technology as a percentage of total population, 25-64 years old.

(d) GDP in bn: GDP in billion Euros

(e) GDP per capita in 1000: GDP per capita per 1000 inhabitants

Source: own calculations, EUROSTAT

6 - Results of the Multivariate Analysis

The presentation of the results below focuses on the determinants of the innovative behaviour of German subsidiaries. We first report results from the selection equation on innovative activity, and look afterwards at the association between innovative input or output, firm characteristics and the host country of the subsidiary.

6.1 Innovative Activity

The likelihood of an enterprise being active in innovation increases significantly with the size (measured in the total number of employees), and with international market orientation of an enterprise. The small influence of firm size could suggest a decreasing marginal effect of this variable. Moreover we find a positive, but quite usual coherence between the possibility of an enterprise being active in innovation and the presence of hampering factors such as the lack of knowledge, too high cost and too little market acceptance. This can be attributed to the subjective rating of the aforementioned hampering factors. An enterprise might not be able to appraise an obstacle in a realistic way until it had not been confronted with factors hampering innovation. It is assumed that enterprises not engaged in innovation underestimate these hampering factors. With respect to innovation input intensity, only cost factors and knowledge factors result significant, to innovation output intensity (turnover from innovations new to the enterprise) additionally market factors result significant.

The likelihood of enterprises to be innovative increases with sectoral innovation intensity measured by the sectoral taxonomy of Peneder (2010). Significant results are obtained for medium to high innovation intensities. For enterprises acting in industries with low innovation intensity results a negative insignificant correlation with the possibility of being innovation active.

6.2 Innovation Input and Output Intensity

Innovation input intensity is measured by the fraction of innovation expenditures over total turnover. Innovation expenditure includes expenditures for ongoing, completed and abandoned projects during one year. They incorporate ongoing expenditure (personnel and material expenses etc.) and investments.

The results show a highly significant, U-shaped relationship between innovation input and size. This means that innovation input intensity first decreases with size and, at a certain number of employees, rises with size. The literature explains this phenomenon by the specific advantages and disadvantages of small and large firms in the innovation process (Cohen and Levin 1989). Larger firms have considerable higher management capabilities, whereas small firms have a high degree of flexibility to enter market niches which may be too small for large companies.

International market orientation, in contrast, has no significant association with innovation input intensity that goes beyond the effects in the selection equation. There is also a significant association between innovation input intensity and public funding, which points to the importance of incentives set by policy to stimulate innovation. With respect to received funding, the results show that German MNEs are well integrated into their host country innovation systems and responding to policy incentives. Higher innovation input intensity is also associated with the decision of the firm to engage in internal R&D activities. There is, however, no significant influence of innovation co-operation on innovation input intensity.

Enterprise size is marginally less important for innovation output intensity compared to innovation input intensity. The U-shaped relationship between size and innovativeness however is also confirmed for innovation output intensity. The explanations for this relationship are the same as in the case of innovation input intensity. Additionally, large multidivisional firms also enjoy a much broader range of possible applications for new knowledge, which may further increase their advantages in the commercialisation of new products (Rosenberg 1990).

There is a significant and positive relationship between innovation output intensity and co-operation agreements of the firm which could not be found for innovation input. We conclude that German subsidiaries use co-operation mainly as a tool to gain knowledge that helps them to adjust their products to the host market, rather than as a tool to create new knowledge.

Public funding has no significant impact on the turnover from innovations new to the enterprise, which can be seen as a sign for the uncertainty associated with the market introduction of new products. It may also indicate that most innovation policy schemes support innovation input (in particular R&D funding), but not commercialisation and innovation output of firms.

An interesting finding results from the variable indicating that the firm engages in intramural R&D activity. The coefficient is significant in both cases, but has a positive sign for innovation input intensity and a negative sign for innovation output intensity. This may be a result of different strategies pursued by foreign-owned firms. The literature (Kuemmerle 1999; Cantwell and Mudambi 2005; Narula and Zanfei 2005) broadly differs between overseas innovation activities that aim at adapting existing technologies to new markets (market-seeking) and innovation that aims at creating new knowledge (knowledge-seeking).

Firms that follow knowledge-seeking strategies may also have internal R&D activities, which is not necessary for firms which mainly follow market-seeking strategies. As a result, internal R&D is positively associated with innovation input intensity, but negatively related to innovation output intensity, because firms that follow market-seeking strategies mainly commercialize existing technologies of the company.

6.3 Firm Characteristics and Country Variables

Variables describing firm characteristics are significant in many cases. In contrast to firm characteristics, the association between innovation input or output intensity of the subsidiary and the host country indicated by country dummies is not significant in almost all cases. This means that the host country has no influence on the innovative performance of German subsidiaries after correcting for firm characteristics and sectoral affiliation.

The picture changes if we use country groups instead of country dummies. Here, we see a significant effect of the host country on innovation output intensity. Compared to the base case (Romania and Bulgaria) the share of turnover from new products is significantly lower in all other regions except Southern Europe, holding all other factors constant. The coefficient is smallest Northern Europe, indicating that this is the region where German subsidiaries find it hardest to produce novelties. We can interpret this as an indication that German subsidiaries find it easier to transfer their intangible assets and technologies into new products in low-income countries than in high-income countries. In contrast to innovation output intensity, we could find no effect of the host country on input intensity.

To sum up, our results clearly show the importance of firm characteristics for innovative behaviour of German subsidiaries and do not refute hypothesis 1. The development of technological capabilities of subsidiaries is an evolutionary process and R&D and design activities are an extension of existing production and marketing activities in most cases (Birkinshaw and Hood 1998; Birkinshaw et al. 1998; Archibugi and Iammarino 1999).

The importance of location, in contrast, could only be confirmed for innovation output intensity and, on a very general level, when we distinguish between Eastern and Western European locations. We therefore accept hypothesis 3 and refute hypothesis 2. We cannot rule out that this result is due to the econometric set-up and the use of dummy variables. A more elaborated approach using variables that address particular locational advantages such as R&D intensity of the host country or the availability of skilled personnel will be employed in a later version of the paper.

7 - Conclusions

This paper analyzed the innovative activities of subsidiaries of German multinational firms in 16 European countries. Special emphasis was laid on innovation input intensity (innovation expenditure as percentage of turnover) and innovation output intensity (share of products new to the firm on turnover).

The analysis revealed that innovation output intensity of the average German subsidiary is higher than innovation output intensity of the average firm in all but one country. This result indicates that subsidiaries of German MNEs are highly innovative and contribute with the introduction of new products and processes to growth and employment of their host countries.

Innovation input intensity, in contrast, is more heterogeneous; German subsidiaries spent more on innovation than the average firm in half of the countries. A comparison of the host countries where input intensity of German subsidiaries is highest suggests that these differences are unrelated to host country characteristics such as GDP per capita or R&D intensity.

We further investigated the relationship between innovation input and output intensity, firm characteristics and host countries with multivariate analysis. Regression analysis revealed that firm characteristics such as size, intramural R&D activity, international market orientation, or sectoral affiliation are significantly associated with innovation input and output intensity of German subsidiaries.

The assumption that the host country plays a decisive role for innovative performance of German subsidiaries is only partly supported by the regression results. Country variables are significant only when we aggregate countries into country clubs. We can find an effect of the host country on innovation input intensity only when we distinguish between Western and Eastern Europe.

Innovation output intensity of German subsidiaries decreases when we move from locations in Bulgaria or Romania to locations in other Eastern European countries and is further reduced when we move to Western and Northern European countries. We interpret this as an indication that German subsidiaries find it easier to transfer their intangible assets and technologies into new products in low-income countries than in high-income countries. In other words, the economic advantages German subsidiaries can generate from intangible assets of their parent companies are largest in countries which have the largest gap to Germany in terms of R&D expenditure.

This seems, at a first sight, a contradiction to the assumption that innovative efforts may be higher in high-income countries due to richer potential spillovers and stronger pressure from competitors that force firms to keep innovative efforts at par with their business environment. The finding is also somewhat at odds with other studies (for example Belderbos et al. 2009) which demonstrate that scientific excellence or market size matter for innovative efforts of foreign-owned firms. It is, however, important to consider that we are talking about innovation output, not input. Multinational firms do not necessarily develop and commercialize new products in one and the same country.

In a policy perspective, this country hierarchy stated above indicates that foreign-owned firms are a valuable source of international technology diffusion. Low-income countries can benefit in particular from the presence of German subsidiaries; first, because new products introduced by these firms may be used as inputs in the production processes of domestic firms and raise their productivity. A second channel for spillovers is the imitation of new products by domestic firms. Additional spillover effects may arise from the mobility of personnel between foreign and domestic firms.

Benefits from the presence of German subsidiaries, however, do not justify a policy of offering special incentives to attract these firms. We cannot see from our results if these benefits are also generated by other foreign-owned firms, or if foreign-owned firms perform better than domestic ones. Our results, however, clearly show the importance of firm characteristics for innovative behavior of German subsidiaries. From a policy perspective, this implies that policy should improve the innovative capabilities of foreign-owned firms, rather than offer benefits to attract foreign-owned firms. This is the consensus approach in the policies towards foreign-owned firms in the of the EU and OECD countries (OECD 2008).

Future research could improve and refine our results by extending the list of host country variables with indicators for the R&D intensity of the business sector of the country, scientific output of universities, the availability of skilled personnel, and market size and growth.

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9 - Annex

Table 1: Explanatory Variables

Model variable	Indicator
Internal capabilities concerning all enterprises surveyed in the CIS4	
Size	ln(Total number of employees) in the reference year 2004
International market-orientation	1 if a firm did sell goods or services during the years 2002-2004 in other EU countries, EFTA, or EU candidate countries; 0 otherwise
Market factors hampering innovation	1 if at least one of the following factors were important to the enterprise: market is dominated by established enterprises or uncertain demand for innovative goods/services; 0 otherwise
Cost factors hampering innovation	1 if at least one of the following factors were important to the enterprise: lack of funds within the enterprise or enterprise group, lack of outside funds or innovation costs too high; 0 otherwise
Knowledge factors hampering innovation	1 if at least one of the following factors were important to the enterprise: lack of qualified personnel, lack of information on technology, lack of information on markets, or difficulty in finding cooperation partners for innovation; 0 otherwise
Internal capabilities concerning enterprises with innovation activities only	
$Size^2$	$ln(Total\ number\ of\ employees)^2$ in the reference year 2004
Co-operation arrangements	1 if an enterprise co-operated on any of the innovation activities with other enterprises or institutions (pure contracting out of work with no active o-operation is excluded); 0 otherwise
Public funding of innovation	1 if the firm got public funding either from local or regional authorities, or from central government, or from the EU, or funding from EU's 5th or 6th RTD; 0 otherwise
Engagement in intramural R&D	1 if the enterprise is engaged in intramural (in-house) R&D; 0 otherwise
Innovation input intensity	Ln(innovation expenditure as a share of the total turnover)

Table 2: Bonferroni multiple comparison test for innovation activity

	BG	CZ	DK	EE	ES	FI	FR	HU	IT	LU	LV	NO	PT	RO	SI
CZ	0.2136														
	(0.193)														
DK	0.2946	0.0811													
	(0.871)	*(1.000)*													
EE	0.2522	0.0386	-0.0424												
	(1.000)	*(1.000)*	*(1.000)*												
ES	0.2149	0.0014	-0.0797	-0.0373											
	(0.224)	*(1.000)*	*(1.000)*	*(1.000)*											
FI	0.1350	-0.0786	-0.1596	-0.1172	-0.0799										
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*										
FR	0.2987 ***	0.0851	0.0041	0.0465	0.0838	0.1637									
	(0.001)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*									
HU	0.1538	-0.0597	-0.1408	-0.0984	-0.0611	0.0189	-0.1449 *								
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(0.067)*								
IT	0.1468	-0.0667	-0.1478	-0.1054	-0.0681	0.0119	-0.1518 *	-0.0070							
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(0.072)*	*(1.000)*							
LU	0.4470 ***	0.2334	0.1524	0.1948	0.2321	0.3120	0.1483	0.2932 *	0.3002 **						
	(0.001)	*(0.439)*	*(1.000)*	*(1.000)*	*(0.528)*	*(0.569)*	*(1.000)*	*(0.056)*	*(0.049)*						
LV	-0.0054	-0.2189	-0.3000	-0.2576	-0.2203	-0.1404	-0.3041	-0.1592	-0.1522	-0.4524 **					
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(0.226)*	*(1.000)*	*(1.000)*	*(0.025)*					
NO	0.1613	-0.0523	-0.1333	-0.0909	-0.0536	0.0263	-0.1374	0.0075	0.0145	-0.2857	0.1667				
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(0.956)*	*(1.000)*				
PT	0.2786 *	0.0650	-0.0160	0.0264	0.0637	0.1436	-0.0201	0.1247	0.1317	-0.1684	0.2840	0.1173			
	(0.099)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*			
RO	0.1741	-0.0395	-0.1205	-0.0781	-0.0408	0.0391	-0.1246	0.0203	0.0273	-0.2729	0.1795	0.0128	-0.1045		
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(0.464)*	*(1.000)*	*(1.000)*	*(1.000)*		
SI	0.2097	-0.0039	-0.0849	-0.0425	-0.0052	0.0747	-0.0890	0.0559	0.0628	-0.2373	0.2151	0.0484	-0.0689	0.0356	
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	
SK	0.1280	-0.0856	-0.1667	-0.1242	-0.0870	-0.0070	-0.1707	-0.0259	-0.0189	-0.3190 **	0.1333	-0.0333	-0.1506	-0.0462	-0.0817
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(0.173)*	*(1.000)*	*(1.000)*	*(0.048)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*

* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

Source: own calculations, EUROSTAT

Table 3: Bonferroni multiple comparison test for innovation input intensity

	BG	CZ	DK	EE	ES	FI	FR	HU	IT	LU	LV	NO	PT	RO	SI
CZ	0.040														
	(1.000)														
DK	0.008	-0.033													
	(1.000)	*(1.000)*													
EE	0.034	-0.006	0.027												
	(1.000)	*(1.000)*	*(1.000)*												
ES	0.011	-0.030	0.003	-0.024											
	(1.000)	*(0.537)*	*(1.000)*	*(1.000)*											
FI	-0.011	-0.052	-0.019	-0.046	-0.022										
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*										
FR	0.014	-0.026	0.007	-0.020	0.004	0.026									
	(1.000)	*(0.669)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*									
HU	0.014	-0.027	0.006	-0.021	0.003	0.025	-0.001								
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*								
IT	0.010	-0.031	0.002	-0.025	-0.001	0.021	-0.005	-0.004							
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*							
LU	0.019	-0.021	0.012	-0.015	0.009	0.031	0.005	0.006	0.010						
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*						
LV	-0.005	-0.046	-0.013	-0.040	-0.016	0.006	-0.020	-0.019	-0.015	-0.025					
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*					
NO	0.042	0.002	0.035	0.008	0.032	0.054	0.028	0.029	0.033	0.023	0.048				
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*				
PT	0.034	-0.006	0.026	0.000	0.024	0.045	0.020	0.020	0.024	0.015	0.040	-0.008			
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*			
RO	0.004	-0.036	-0.003	-0.030	-0.006	0.016	-0.010	-0.009	-0.005	-0.015	0.010	-0.038	-0.030		
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*		
SI	0.033	-0.007	0.026	-0.001	0.023	0.045	0.019	0.019	0.023	0.014	0.039	-0.009	-0.001	0.029	
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	
SK	0.017	-0.023	0.010	-0.017	0.007	0.029	0.003	0.004	0.008	-0.002	0.023	-0.025	-0.017	0.013	-0.016
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*

* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

Source: own calculations, EUROSTAT

Table 4: Bonferroni multiple comparison test for turnover from goods or services innovations new to the enterprise

	BG	CZ	DK	EE	ES	FI	FR	HU	IT	LU	LV	NO	PT	RO	SI
CZ	0.0039														
	(1.000)														
DK	-0.0258	-0.0297													
	(1.000)	*(1.000)*													
EE	0.0062	0.0023	0.0319												
	(1.000)	*(1.000)*	*(1.000)*												
ES	0.0127	0.0088	0.0385	0.0065											
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*											
FI	-0.0573	-0.0612	-0.0315	-0.0635	-0.0700										
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*										
FR	-0.0590	-0.0629	-0.0332	-0.0651	-0.0717 *	-0.0016									
	(1.000)	*(0.123)*	*(1.000)*	*(1.000)*	*(0.064)*	*(1.000)*									
HU	0.0222	0.0183	0.0480	0.0161	0.0095	0.0796	0.0812								
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(0.106)*								
IT	-0.0688	-0.0727	-0.0430	-0.0750	-0.0815	-0.0115	-0.0098	-0.0910							
	(1.000)	*(0.861)*	*(1.000)*	*(1.000)*	*(0.455)*	*(1.000)*	*(1.000)*	*(0.397)*							
LU	-0.0088	-0.0127	0.0170	-0.0149	-0.0215	0.0485	0.0502	-0.0310	0.0600						
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*						
LV	-0.0250	-0.0289	0.0008	-0.0312	-0.0377	0.0323	0.0340	-0.0472	0.0438	-0.0162					
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*					
NO	-0.0235	-0.0274	0.0023	-0.0297	-0.0362	0.0338	0.0355	-0.0457	0.0453	-0.0147	0.0015				
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*				
PT	-0.0628	-0.0667	-0.0370	-0.0690	-0.0755	-0.0055	-0.0038	-0.0850	0.0060	-0.0540	-0.0378	-0.0393			
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*			
RO	0.1038	0.0999	0.1295	0.0976	0.0911	0.1611	0.1627 ***	0.0815	0.1726 ***	0.1125	0.1288	0.1273	0.1666 **		
	(1.000)	*(0.679)*	*(1.000)*	*(1.000)*	*(1.000)*	*(0.79)*	*(0.001)*	*(1.000)*	*(0.002)*	*(1.000)*	*(1.000)*	*(1.000)*	*(0.021)*		
SI	-0.0124	-0.0162	0.0134	-0.0185	-0.0250	0.0450	0.0466	-0.0346	0.0565	-0.0036	0.0126	0.0111	0.0504	-0.1161	
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	
SK	-0.0678	-0.0716	-0.0420	-0.0739	-0.0804	-0.0104	-0.0088	-0.0900	0.0011	-0.0590	-0.0428	-0.0443	-0.0050	-0.1715 **	-0.0554
	(1.000)	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(1.000)*	*(0.014)*	*(1.000)*

* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

Source: own calculations, EUROSTAT

Table 5: (A) Heckman Selection Model: Estimation of Regression equations with countries

	(1) Innovation input intensity		(2) Innovation output intensity	
Internal capabilities				
Size	-1.1304	***	-0.6731	***
	(-4.29)		*(-2.84)*	
$Size^2$	0.0805	***	0.0606	***
	(3.34)		*(2.81)*	
International market orientation	0.1314		0.5298	***
	(0.75)		*(3.31)*	
Co-operation arrangements	-0.0709		0.3471	***
	(-0.61)		*(3.46)*	
Public funding of innovation	0.5031	***	-0.0463	
	(3.32)		*(-0.37)*	
Engagement in intramural R&D	0.3209	**	-0.3262	***
	(2.44)		*(-2.75)*	
Innovation input intensity			0.1103	***
			(3.71)	
Sectoral innovation intensity				
low	0.9260	***	-0.7249	**
	(2.72)		*(-1.97)*	
medium low	0.8221	**	-0.6337	
	(2.13)		*(-1.64)*	
medium	1.4874	***	-0.4165	
	(4.12)		*(-1.13)*	
medium high	1.1569	***	-0.6023	*
	(4.35)		*(-1.68)*	
high	2.0342	***	-0.4018	
	(5.82)		*(-1.10)*	
Countries				
Czech Republic	-0.1358		-0.2695	
	(-0.29)		*(-0.63)*	
Denmark	-0.4403		-0.7738	
	(-0.73)		*(-1.55)*	
Baltic States	0.1222		-0.6767	
	(0.20)		*(-1.19)*	
Spain	-0.7914	*	-0.1322	
	(-1.68)		*(-0.30)*	
France	-0.6188		-0.5514	
	(-1.33)		*(-1.30)*	
Hungary	-0.3838		-0.1712	
	(-0.80)		*(-0.39)*	
Luxembourg	-0.0697		-0.1879	
	(-0.13)		*(-0.39)*	
Norway	-0.4902		-0.5472	
	(-0.73)		*(-0.94)*	
Portugal	-0.3407		0.2281	
	(-0.65)		*(0.44)*	
Italy	1.1696	**	-0.9166	
	(2.03)		*(-1.62)*	
Romania	-0.2571		0.3675	
	(-0.48)		*(0.79)*	
Slovenia	-0.5461		-0.6684	
	(-0.87)		*(-1.11)*	
Slovakia	-0.0136		-0.6476	
	(-0.03)		*(-1.37)*	

* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

Source: own calculations, EUROSTAT

Table 6: (B) Heckman Selection Model: Estimation of regression equations with country clubs

	(1) Innovation Input Intensity	(2) Innovation Output Intensity
Internal capabilities		
Size	-1.1929 ***	-0.7144 ***
	(-4.47)	*(-3.02)*
$Size^2$	0.0837 ***	0.0633 ***
	(3.42)	*(2.93)*
International market orientation	0.1433	0.5008 ***
	(0.82)	*(3.14)*
Co-operation arrangements	-0.0858	0.3252 ***
	(-0.73)	*(3.25)*
Public funding of innovation	0.5416 ***	-0.0267
	(3.59)	*(-0.22)*
Engagement in intramural R&D	0.3145 **	-0.3314 ***
	(2.39)	*(-2.79)*
Innovation intensity		0.1063 ***
		(3.58)
Sectoral innovation intensity		
Reference case: none		
low	-0.1901	-0.0886
	(-0.73)	*(-0.35)*
medium low	-0.3034	-0.0020
	(-0.97)	*(-0.01)*
medium	0.3256	0.1863
	(1.19)	*(0.74)*
medium high	0.2773	0.0115
	(1.13)	*(0.05)*
high	0.8140 ***	0.2000
	(3.26)	*(0.82)*
Country Clubs		
Reference case: BG, RO		
Northern Europe	-0.2870	-0.9756 ***
	(-0.70)	*(-3.13)*
Southern Europe	-0.3293	-0.3882
	(-1.14)	*(-1.62)*
Eastern Europe	-0.0552	-0.5541 **
	(-0.20)	*(-2.53)*
Baltic States	0.2967	-0.9561 **
	(0.59)	*(-2.16)*
Western Europe	-0.4546	-0.7667 ***
	(-1.62)	*(-3.37)*

* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

Source: own calculations, EUROSTAT

Table 7: (C) Heckman Selection Model: Estimation of regression equations with country clubs

	(1) Innovation Input Intensity		(2) Innovation Output Intensity	
Internal capabilities				
Size	-1.1958	***	-0.7277	***
	(-4.49)		*(-3.03)*	
$Size^2$	0.0833	***	0.0644	***
	(3.41)		*(2.94)*	
International market orientation	0.1261		0.5046	***
	(0.72)		*(3.11)*	
Co-operation arrangements	-0.0967		0.2852	***
	(-0.83)		*(2.82)*	
Public funding of innovation	0.5633	***	0.0051	
	(3.81)		*(0.04)*	
Engagement in intramural R&D	0.3026	**	-0.3796	***
	(2.31)		*(-3.18)*	
Innovation intensity			0.1068	***
			(3.54)	
Sectoral innovation intensity				
Reference case: none				
low	-0.2296		-0.2366	
	(-0.93)		*(-1.00)*	
medium low	-0.3561		-0.2863	
	(-1.18)		*(-1.06)*	
medium	0.2911		-0.0728	
	(1.11)		*(-0.30)*	
medium high	0.2473		-0.1847	
	(1.04)		*(-0.79)*	
high	0.7821	***	-0.0062	
	(3.22)		*(-0.03)*	
Country Clubs				
Reference: Western and Northern Europe				
Eastern Europe	0.3589	***	0.1469	
	(2.81)		*(1.37)*	

* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

Source: own calculations, EUROSTAT

Table 8: Heckman Selection Model: Estimation of selection equations

	Selection equations: Innovation input intensity (1)			Selection equations: Innovation output intensity (2)		
	(A1)	**(B1)**	**(C1)**	**(A2)**	**(B2)**	**(C2)**
Internal capabilities						
Size	0.1890 ***	0.1878 ***	0.1877 ***	0.2065 ***	0.2063 ***	0.2063 ***
	(8.37)	*(8.32)*	*(8.32)*	*(7.63)*	*(7.62)*	*(7.62)*
International market orientation	0.2698 ***	0.2733 ***	0.2733 ***	0.3176 ***	0.3188 ***	0.3195 ***
	(3.68)	*(3.73)*	*(3.73)*	*(3.48)*	*(3.50)*	*(3.50)*
Cost factors hampering innovation	0.1832 **	0.1694 **	0.1708 **	0.2394 ***	0.2362 ***	0.2274 **
	(2.46)	*(2.29)*	*(2.32)*	*(2.64)*	*(2.60)*	*(2.49)*
Knowledge factors hampering innovation	0.3336 ***	0.3368 ***	0.3359 ***	0.3708 ***	0.3749 ***	0.3803 ***
	(3.70)	*(3.79)*	*(3.79)*	*(3.40)*	*(3.44)*	*(3.49)*
Market factors hampering innovation	0.0187	0.0776	0.0787	0.2125 **	0.2080 **	0.2063 **
	(1.02)	*(0.98)*	*(1.00)*	*(2.20)*	*(2.15)*	*(2.13)*
Sector Taxonomy						
low	-0.1972 *	-0.2048 *	-0.2057 **	-0.0646	-0.0655	-0.0659
	(-1.88)	*(-1.95)*	*(-1.96)*	*(-0.48)*	*(-0.48)*	*(-0.49)*
medium low	0.0713	0.0643	0.0631	0.2981 *	0.2980 *	0.2983 *
	(0.53)	*(0.48)*	*(0.47)*	*(1.81)*	*(1.80)*	*(1.81)*
medium	0.2714 **	0.2604 **	0.2609 **	0.4661 ***	0.4656 ***	0.4657 ***
	(2.35)	*(2.26)*	*(2.26)*	*(3.23)*	*(3.23)*	*(3.23)*
medium high	0.4329 ***	0.4216 ***	0.4199 ***	0.6998 ***	0.6984 ***	0.6982 ***
	(4.32)	*(4.21)*	*(4.19)*	*(5.61)*	*(5.61)*	*(5.60)*
high	0.3096 ***	0.2986 ***	0.2969 ***	0.5910 ***	0.5910 ***	0.5919 ***
	(2.95)	*(2.84)*	*(2.83)*	*(4.55)*	*(4.55)*	*(4.56)*

* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

Source: own calculations, EUROSTAT