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Drivers and policies for increasing and internationalising R&D activities of EU MNEs

Michele Cincera, Claudio Cozza and Alexander Tübke

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Contact information - P. Moncada-Paternò-Castello
European Commission, Joint Research Centre - Institute for Prospective Technological Studies
Edificio Expo
C/ Inca Garcilaso, 3
E-41092 Seville (Spain)
Fax: +34 95 448 83 26; E-mail: jrc-ipts-kfg-secretariat@ec.europa.eu
IPTS website: http://ipts.jrc.ec.europa.eu/; JRC website: http://www.jrc.ec.europa.eu
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Abstract

Based on an original and recent sample representative of the largest R&D corporations in the EU, this paper aims at investigating in a quantitative way the main factors explaining: (i) the decision of firms to increase their R&D investment effort in the near future; (ii) the main drivers explaining the favourite international location choice for R&D; and (iii) the impact of direct and indirect policies to support R&D activities in the EU. The main findings suggest that competitive pressures from the US are the main determinants for increasing R&D investments. Public support to R&D and proximity to other activities of the company influence the decision to locate R&D in the home country. Considerations on the cost of employing researchers become one factor among others only for firms preferring a location outside their home country, in particular in the rest of the world (countries other than the EU or the US).

JEL Classification: F 23; O 32

Keywords: Drivers of R&D internationalisation; R&D policies; EU large R&D corporations

1 Introduction

Research and Development (R&D) investments by private companies have since long attracted considerable attention due to their role for growth, productivity, employment and competitiveness. Ever since Solow (1957), R&D has been perceived as a fundamental engine for productivity growth, both at the macro and microeconomic level (for an overview of the findings as to the original approach by Griliches, 1979, see e.g. Mairesse and Mohnen, 2001, and for more recent additions: Baumol, 2002; Jones, 2002; Lööf and Heshmati, 2003; Rogers, 2006) and has therefore been widely analyzed. Many studies have found a significant contribution of R&D to firm productivity, in the range of estimated overall average elasticity between 0 and 0.25, depending on the methods of measurement and the data used. Recent findings from Ortega-Argilés et al. (2009) confirmed R&D as a fundamental determinant of possible competitive advantage and revealed that companies in high-tech sectors not only invest more in R&D, but also achieve more in terms of efficiency gains connected with research activities.

Attracting and retaining companies with significant R&D investment thus has the potential of considerable economic benefit. As a consequence, governments have increasingly seen R&D policies as an instrument for achieving their wider objectives related to growth, productivity and competitiveness. One effect of this is that many governments, as well as the EU as a whole, have established R&D intensity targets[1].

The Lisbon strategy[2] includes the commitment to higher levels of R&D intensity as well as to changes in organizational R&D and framework conditions. The objectives rest partly on proposals to increase publicly-funded R&D, but also emphasize the need for significant increases in business-funded R&D. The EU aim was to approach and possibly surpass the effort made by competing economies, especially Japan and the US. In fact, the EU has failed to convince the private sector and its citizens to invest in knowledge, the key to its own long term future (Soete, 2006). Building on the Lisbon objective, the 2002 Barcelona European Council set a target for EU R&D of 3% of EU GDP, of which 2/3 should be financed by the private sector (European Commission, 2003). These targets are appealing and enticingly easy to grasp. However, they are even more easily misunderstood because aggregate R&D numbers for countries or regions are not simply an effect of R&D 'effort': they are a combined outcome of firm strategies, company demographics, industrial structures, and macroeconomic dynamics (Soete, 2005).

[1] For a comprehensive overview, see Sheehan and Wyckoff (2003).

Falk (2004) and Jaumotte and Pain addressed a range of top-down determinants of R&D expenditure, e.g. in the form of shares of BERD financed by government, high-tech export shares, or patenting activity, from a country level point of view. These determinants constitute an important background for R&D investment location. While R&D internationalization has been observed as a trend since decades (for a first comprehensive review, see Granstrand et al., 1992), there are very few studies addressing location decisions from a bottom-up company viewpoint. Among them, von Zedtwitz and Gassmann (2002) showed the concentration of R&D sites in the US, Europe, Japan and Asia, often around major regional centres in South Korea, Singapore, and other emerging economies along the Pacific Rim. Furthermore, a trend of the past years – and often a matter of concern for policy-makers – is the increasing attractiveness of China and India as R&D locations with these countries being the two biggest "net-importers" of R&D (Jaruzelski and Dehoff, 2008).

Within its Industrial Research Monitoring and Analysis (IRMA[3]) activities, the European Commission since 2004 collects annual data on companies investing the most in R&D (the EU Industrial R&D Investment Scoreboards[4]) as well as R&D investment expectations, trends and motivations (the EU Surveys on R&D Investment Business Trends[5]). While the analyses of these data are mostly qualitative, the present paper aims at investigating in a quantitative way the main factors explaining R&D investment effort and location in the world by the largest EU R&D spenders together with the main determinants from both the supply and the demand side for increasing these activities. For the first time, it also applies a methodology to the dataset which allows controlling for sample selection bias.

The data used here come from the last edition of the 2008 Survey (European Commission, 2009), which addressed the 1000 European companies of the 2008 Scoreboard (European Commission, 2008). According to the dataset of 130 responding companies, roughly half of EU Multi-National Enterprises (MNEs) consider their home country as the most attractive location for R&D. For the other ones, Germany, the US and India are the most often cited as being the most attractive economies for expanding R&D investment. The availability of researchers and the access to specialized R&D knowledge emerge as the main drivers of R&D location decisions of firms. Though of less importance, considerations on the cost of employing researchers appear also to matter for firms preferring a location outside their home country. Then, in line with the findings in the literature, market pull and exploiting technological

[2] http://ec.europa.eu/growthandjobs/index_en.htm
[3] See: http://iri.jrc.ec.europa.eu/
[4] See: http://iri.jrc.ec.europa.eu/research/scoreboard.htm
[5] See: http://iri.jrc.ec.europa.eu/research/survey.htm

opportunities appear to be the most important drivers for increasing the overall R&D investment.

With the quantitative methodology applied to the Survey dataset, we investigate three main questions:

(i) What are the main factors both on the demand and supply sides explaining the decisions of companies to increase the budget they allocate to R&D activities on the three coming years;

(ii) What are the main reasons explaining why a given country is considered by a firm as the most favourite destination for performing R&D; and

(iii) Which are the most important policies for supporting R&D activities of MNEs in the EU.

The structure of the paper is as follows. Section 2 presents a brief state of the art of the literature dealing with the determinants of R&D investments and localization decisions of the largest European MNEs. Section 3 reports the main qualitative results of the Survey dataset, data specificities and descriptive statistics. Section 4 presents the results of the econometric analysis and section 5 the main conclusions.

2 Theoretical and empirical background

In the last two decades, theoretical (Dunning and Narula, 1995; Kuemmerle, 1997) and empirical studies (among others see: Kuemmerle, 1999; Kumar, 2001; Von Zedwitz and Gassmann, 2002) on the internationalization of R&D have highlighted a shift from the so-called home-base exploiting to the home-base augmenting R&D strategies. Within such framework, MNEs set R&D laboratories abroad not only for adapting technologies and products developed at home to local market conditions; but even with the aim of tapping into knowledge and technological sources in centres of scientific excellence located worldwide.

Such location strategies refer to multiple dimensions, comprising the technological strengths of the countries with respect to those of the company (Patel and Vega, 1999; Le Bas and Sierra, 2002), institutional factors – such as public support to R&D, IPR systems, quality of technological infrastructures – and lowering costs of qualified research, especially in emerging countries (UNCTAD, 2005).

From the company point of view, R&D location decisions are however complex and subject to a number of underlying factors. Thursby and Thursby (2006) found four outstanding factors: output market potential, quality of R&D personnel, university collaboration and intellectual property protection. Further, for companies locating in emerging economies, the growth potential in the market and the quality of R&D personnel were the most important factors. For companies locating in developed countries (at home or in another country), the quality of R&D personnel and intellectual property protection were the most important factors. In addition, for more than 75 percent of the respondents, the R&D location decision was part of an expansion and in less than 30 percent a relocation.

As regards the more specific topic of the drivers for the internationalisation of MNEs R&D activities, a well established literature (Dunning and Narula, 1995, and Kuemmerle, 1997) has led to the distinction between two sets of forces:

- Demand-pull forces or Home based exploiting (HBE) activities: Foreign R&D laboratories adapt technologies and products developed at home to local market conditions (regulations, standards, consumer tastes), eventually providing technological support to local subsidiaries.
- Technology-push forces or Home based augmenting (HBA) activities: Foreign R&D laboratories are needed in order to tap into knowledge and technology sources in centres of scientific excellence located worldwide.

Besides these, other institutional factors have been identified. These include public support of R&D activities; the strength and scope of the IPR system; the quality of the technological infrastructure; the macro economic and political stability and other framework conditions. Furthermore, reasons to choose a particular location vary by the type of activity or unit. Locating an activity with stronger “Research” focus is usually based on other reasons than locating one with a stronger “Development” component (Table 1).

Table 1: Reasons to locate 'Research' and 'Development' in a particular location

Reasons to locate 'Research'	Reasons to locate 'Development'
Proximity to local universities and research parks	Local market requirements
Tapping informal networks	Global customers request local support
Proximity to centres-of-innovation	Customer proximity and lead users
Limited domestic science base	Cooperation with local partners
Access to local specialists/recruiting	Market access

Source: von Zedtwitz and Gassmann (2002)

In a similar vein, the function or typology of R&D units to be located is subject to a different set of determinants (Table 2).

Table 2: Determinants for the location of R&D by type of R&D unit

	Scientific and technological supply	Demand
Production support unit	Quality of formation (engineers, technicians)	Important local market (size, purchasing power)
Global unit	Centres of excellence Quality of science-industry relations	Lead market

Rationalisation unit	Cost/efficiency of R&D activities	

Source: Sachwald (2004)

Many of these location aspects can also be found in the qualitative results of the Survey dataset, presented in the next section.

3 Data: the IRMA 2008 EU Survey on R&D Investment Business Trends

As mentioned above, this paper uses the data of the 2008 Survey of R&D Investment Business Trends (European Commission, 2009) and analyses them with a set of quantitative methods in order to see if these methods can deliver results, are robust for the relatively small sample size, and allow controlling for sample selection. In order to shed light from a company perspective, the IRMA Surveys of R&D Investment Business Trends[6] have gathered information from across Europe on the factors and issues which influence R&D investment by companies. The 2008 Survey is part of the Industrial Research Monitoring and Analysis (IRMA) project and accompanies the 2007 EU Industrial R&D Investment Scoreboard (European Commission, 2008)[7]. The survey explicitly avoids duplication with other R&D investment related surveys and data collection exercises (e.g. Innobarometer[8], the results from the Knowledge Economy Indicators project[9], EUROSTAT data collection of structural indicators or other ongoing surveys).

The questionnaire was sent to the 1000 European companies which appear in the 2007 EU Industrial R&D Investment Scoreboard. The 130 responses received from these companies yielded a response rate of 13%. These respondents are responsible for a total global R&D investment of almost €40 billion, which corresponds to 30% of the total R&D investment by the

[6] See: http://iri.jrc.ec.europa.eu/research/survey.htm.
[7] These activities are jointly carried out by the European Commission's Joint Research Centre (JRC) - Institute for Prospective Technological Studies (IPTS) and Directorate General Research - Directorate C, European Research Area: Knowledge-based economy. Their aim is to improve the understanding of industrial R&D and Innovation in the EU and to identify medium and long-term policy implications.
[8] http://cordis.europa.eu/innovation/en/policy/innobarometer.htm
[9] http://kei.publicstatistics.net

European Scoreboard companies and a similar share of the R&D spent and performed by the business sector in the EU[10].

When grouping[11] the number of responses of the 2008 Survey by R&D intensity[12], most of these came from the medium R&D intensity sectors (Table 3).

Table 3: Responses to the 2008 Survey by sector group

Sector group	ICB Sector	Number of responses
High R&D intensity	Biotechnology, health care equipment & services, leisure goods, pharmaceuticals, software, and technology hardware & equipment	35
Medium R&D intensity	Aerospace & defence, automobiles & parts, chemicals, commercial vehicles & trucks, electrical components & equipment, electronic equipment, fixed line telecommunications, food producers, general industrials, industrial machinery, personal goods, and support services	68
Low R&D intensity	Banks, construction & materials, electricity, food & drug retailers, food producers, general retailers, industrial metals, industrial transportation, and oil & gas producers	27
	total	130

Source: European Commission JRC-IPTS (2009)

Whereas the largest number of responses came from the medium R&D intensity sector group (table 3), the biggest share of R&D investment in the sample is from the high R&D intensity sectors (figure 1). Also compared to the Scoreboard, the sample contains a bigger share of companies with higher-than-average R&D investments[13].

In terms of employees and turnover, the average size of the responding companies is very large. The average figures for the responding companies were a turnover of €9.3 billion, and a workforce of 28 000 employees, of whom 1 700 employees work in R&D. Among the 130 respondents there are eight medium-sized companies according to the European Commission's SME definition[14]. In this regard, the 2008 Survey differs from other surveys in

[10] The Scoreboard and BERD data address industrial R&D in the EU through different concepts and are therefore not directly comparable, but their latest figures were of similar magnitude. According to the latest available data for 2006: Scoreboard €121 bn and BERD (Eurostat) €116 bn.

[11] The sectors were combined into three groups according to their average R&D intensities in the 2007 Scoreboard: High (more than 5% R&D intensity: biotechnology, health care equipment & services, leisure goods, pharmaceuticals, software, support services, technology hardware & equipment), medium (between 2 and 5% R&D intensity: aerospace & defence, automobiles & parts, chemicals, commercial vehicles & trucks, computer services, electrical components & equipment, electronic equipment, food producers, general industrials, industrial machinery, personal goods) and low (less than 2% R&D intensity: banks, construction & materials, electricity, fixed-line telecommunications, food & drug retailers, food producers, forestry & paper, gas, water & multiutilities, general retailers, industrial metals, industrial transportation, oil & gas producers, oil equipment, services & distribution). This grouping has been used in the different EU Scoreboard analyses since 2004, similar to the OECD high-technology classification (see: Hatzichronoglou, 1997, "Revision of the High-Technology Sector and Product Classification" in: OECD Science, Technology and Industry Working Papers, 1997/2).

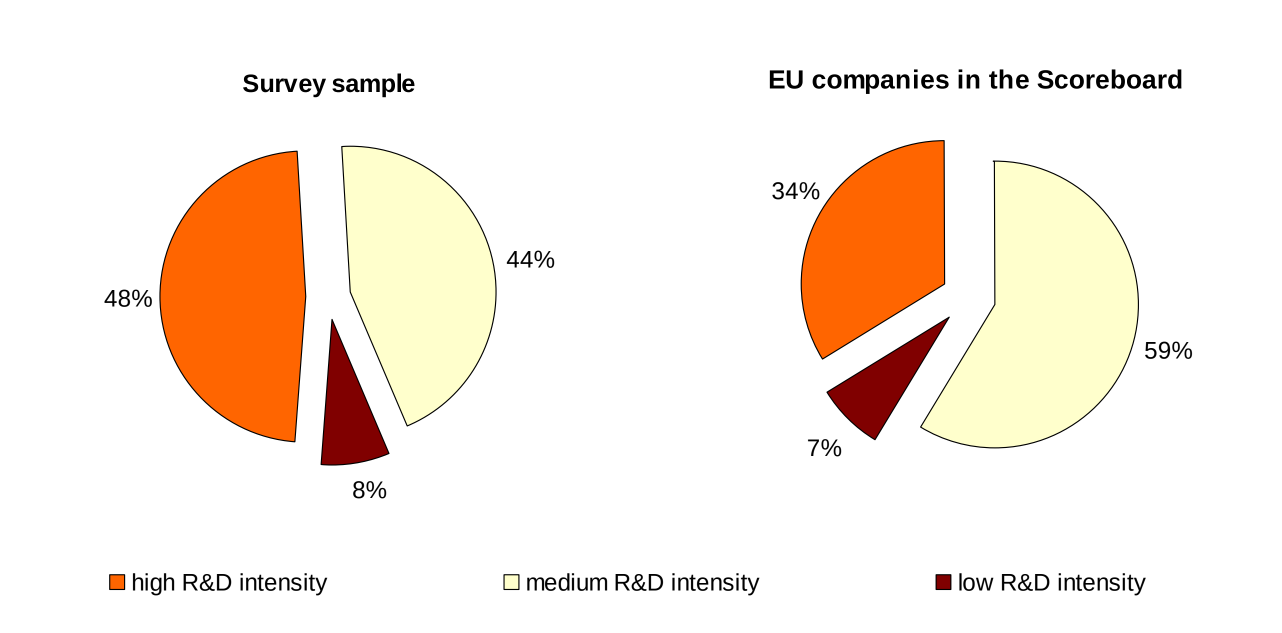
[12] R&D intensity is the ratio between R&D investment and net sales. An individual company may invest a large overall amount in R&D but have a low R&D intensity if net sales are high (as is the case of many oil & gas producers, for example).

[13] For more details see European Commission (2009), Annex A.

[14] See: http://ec.europa.eu/enterprise/enterprise_policy/sme_definition/index_en.htm

Europe such as the Community Innovation Survey (CIS), as the latter not only uses a different sampling technique but also includes Small and Medium-sized Enterprises (SMEs) with 10 employees or more[15].

Figure 1: Responses to the 2008 Survey by sector group (in %)



Source: European Commission (2009)

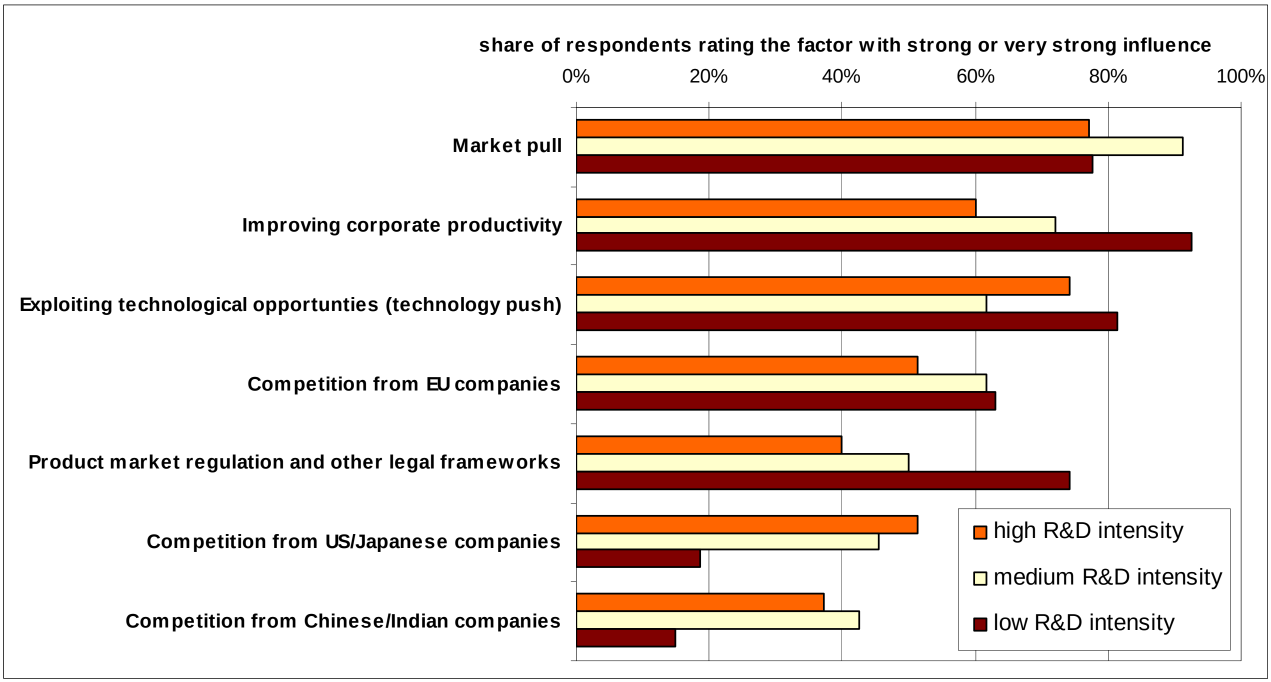
The following sections recall the main qualitative findings of the 2008 Survey before examining them later-on in the quantitative analyses.

3.1 Motivations for increasing R&D investment

More than two thirds of respondents still consider market pull, improving corporate productivity and technological push as the main incentives for increasing the overall level of R&D investment. As shown in Figure 2, there are differences in the relative importance of these factors according to whether the company belongs to the high, medium or low R&D intensive sector group.

[15] The CIS uses a stratified sampling for at least three size classes (small, medium and large enterprises) across all EU Member States.

Figure 2: Importance of factors for increasing R&D investment, by sector group



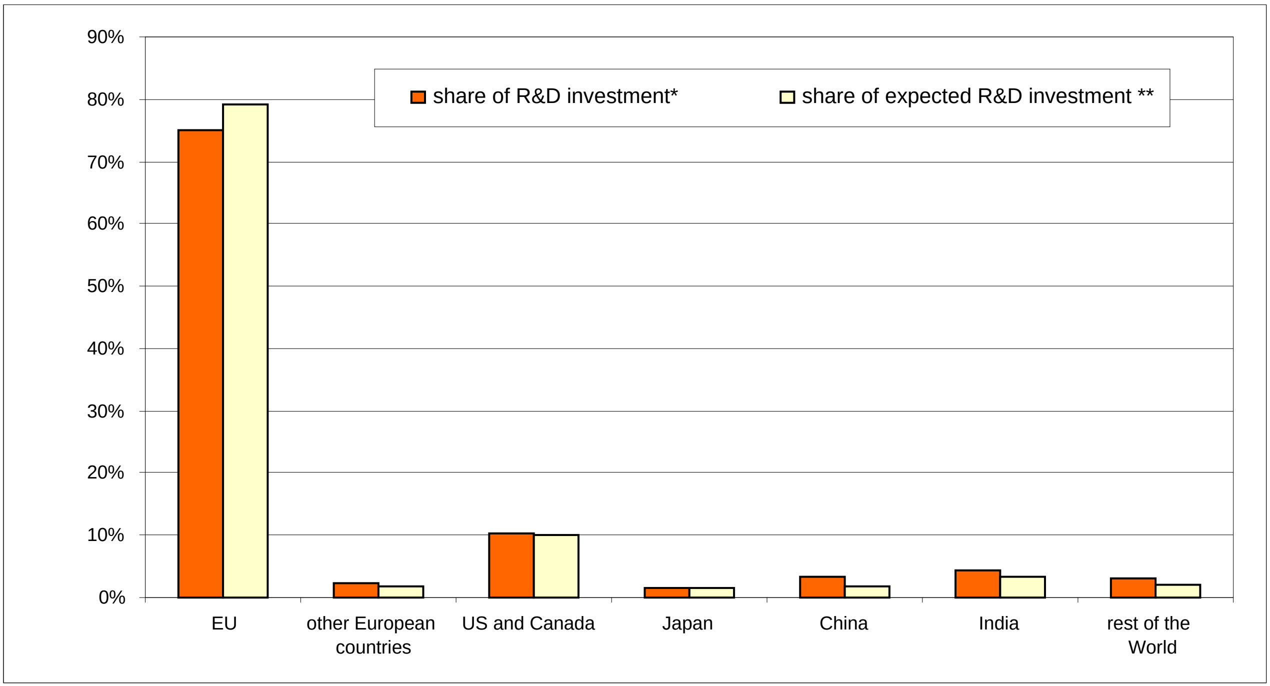
Source: European Commission (2009)

While market pull is generically rated as the most important driver, low tech companies seem to be more interested in expanding R&D activities for productivity and technological reasons and consider regulation as an important motivation. For these companies, competition from other EU companies seems to be more relevant whereas, for high tech companies, the US/Japanese competitors are relevant as well. In general, it seems that the classical motivations for technological development remain the most important. Such conclusion is consistent with the findings of previous editions of the survey.

3.2 Country factors for R&D investment

On average, the EU-based companies in the sample carry out just over 25% of their R&D outside the EU. This magnitude is consistent with the literature, especially with findings stating that shifts of R&D between the home-country and abroad are rather smooth than abrupt (von Zedwitz and Gassmann, 2002). Furthermore, Northern America is still the main recipient for R&D carried out by EU companies outside EU (figure 3). Emerging countries such as China and India are increasing their attractiveness with high growth rates, but based on a rather small level. Apparently, the EU is going to be even more relevant in terms of expected changes.

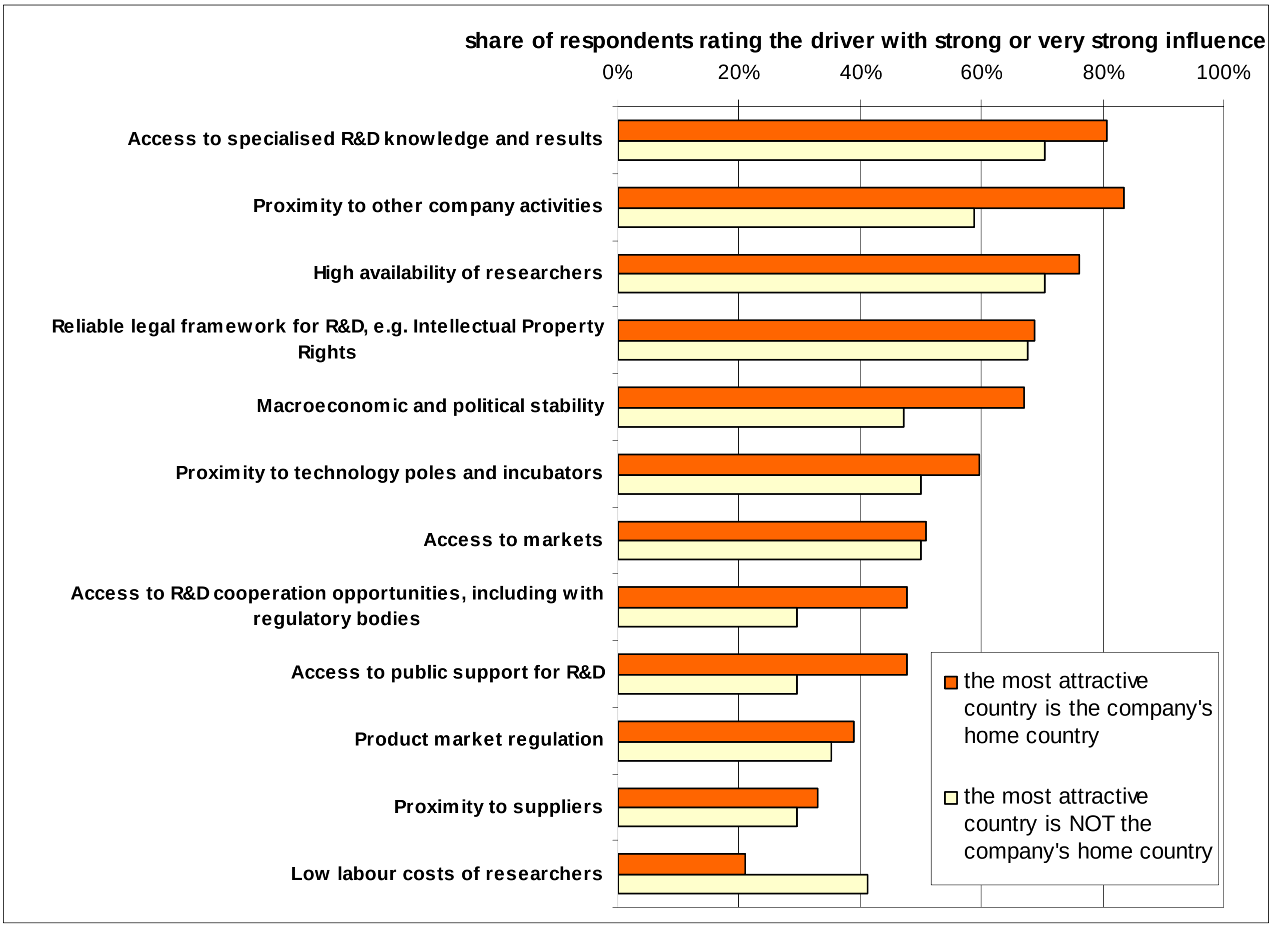
Figure 3: Shares of R&D investment and expected R&D investment by world region



Note: * The share of R&D investment is the amount accounted for by the world region as a share of the total R&D investment in the world. ** The share of expected R&D investment is the share of R&D investment in the next 3 years.

In order to verify the most important factors for the R&D international location, the dichotomy within/outside the home country is useful for detecting shifts and clarifying trends. One of the main results of the survey is that for all but one location drivers (ranked in figure 4), the home country is still generically considered as the most attractive country. The only factor for which that is not true, is the "low labour costs of researchers". For “access to markets” and “reliability of the legal framework”, the relative attraction of home and outside location is very similar.

Figure 4: Location factors for companies according to whether or not they choose their home country as the most attractive place for R&D



Note: The factors are sorted by average importance.
Source: European Commission (2009)

The size of the country where a company is headquartered may influence the factors for location decisions. Companies from smaller countries of the EU might be more likely to answer that the most attractive country for their R&D investment is NOT the home country and vice versa for companies resident in bigger countries[16]. This turns to be true only for some variables: access to specialised R&D, proximity to other company activities, macroeconomic and political stability, access to R&D cooperation and public support for R&D. For such variables, the home country as most favourable location is in fact due to the 'staying at home' effect of companies from big countries which are usually in line with the overall average; while the companies from small countries tend to answer that these variables are more effective if related to a foreign location (their average is around 20% higher than the overall one).

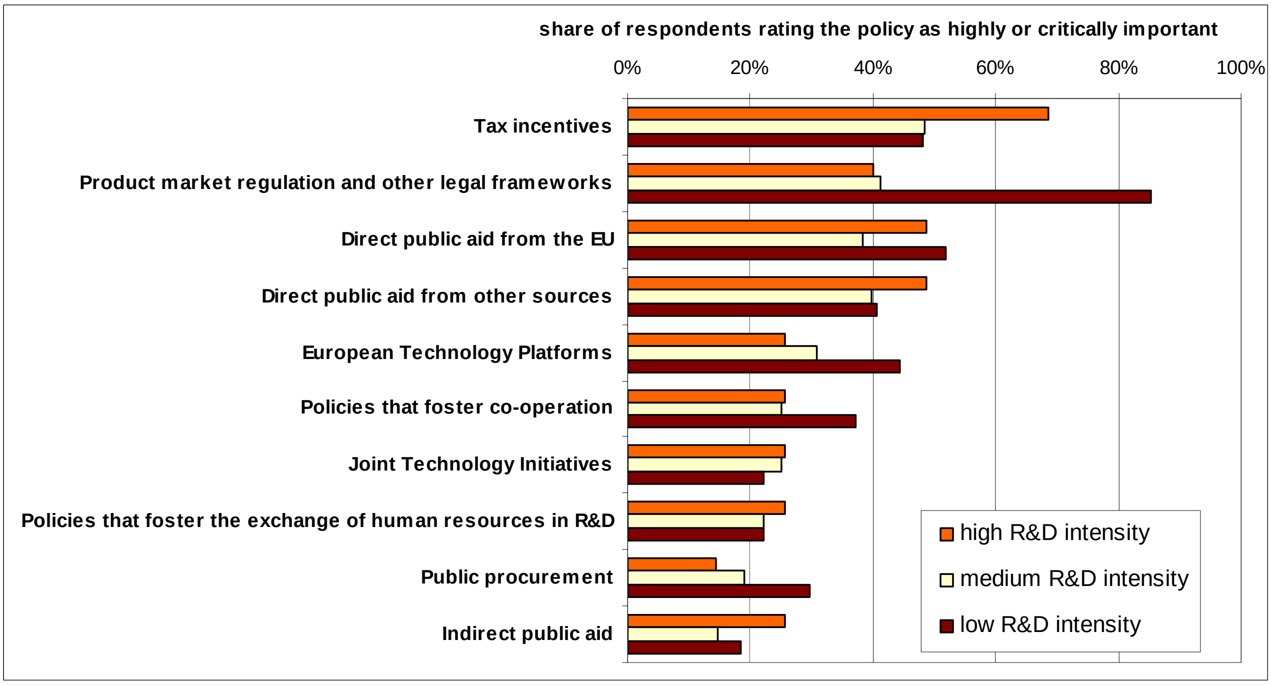
[16] With regard to this, we consider as 'big countries': Germany, France, Italy, Spain and the UK.

The opposite phenomenon appears for the variable: low labour cost of researchers. In this case, companies from big countries are more likely to answer that the foreign location is important, and vice versa for companies from small countries. Therefore, the net result in figure 3 is that the two trends are compensating each other and reducing the importance of this variable. As we will see in the econometric part, the search for low cost researchers is actually a key reason for locating R&D abroad.

3.3 Public policies supporting R&D activities

Companies were also asked to rate the importance of some public policies for supporting their R&D activities (see Figure 5). Among these, the most notable observation is the difference in perception according to the degree of R&D intensity: companies in high R&D intensity sectors consider tax incentives as the most important policy; companies in low R&D intensity sectors report as first priority the product market regulation and other legal frameworks.

Figure 5: Importance of public policies for supporting R&D activities inside the EU



Note: The factors are sorted by average importance.
Source: European Commission (2009)

4. Empirical findings

The qualitative analysis has served to describe and explain the main aspects of R&D behaviour by companies. In this section, we report the empirical findings of the econometric analysis according to the three subthemes: motivations for increasing the overall R&D engagement, geographical preferences and importance of EU public policies supporting R&D activities in the EU.

With respect to the pure descriptive analysis presented in the previous section, the econometric investigation has several advantages that we now briefly discuss.

First, as it is inevitably the case with survey datasets, care is needed in the interpretation of subjective responses in that they may be dependent upon the experience and the characteristics of the respondent such as for instance the firm's size, the industry sector or the country of the firm. A company investing outside the EU, for instance, may consider political stability a more important factor because of its experience. In a similar vein, people who answered to the survey may not have the same knowledge about EU and Member states policies and initiatives to support R&D. Yet, thanks to the econometric methodology implemented, it is possible to address or at least to mitigate such limitations by including in the model to be estimated some variables that allow one to control for the characteristics of the responding unit. In this study, we consider as control variables the size of the company, its R&D intensity, the share of R&D outsourced as well as two sets of industry sectors and country dummies.

Second, the econometric analysis is a tool for testing the significance of the answers of the firms. In the questionnaire, companies are asked to evaluate the importance of each variable (on an increasing scale from 1 to 5, see Appendix B). While averages and means reflect the overall importance of the variables, they are not related to a specific R&D behaviour (i.e. R&D growth or country location). In other words, the sample may contain additional information which cannot be detected via averages and means. Some variables might be important for all companies in all situations, thus implying that they are not crucial, but others might only show up when examining them in relation to a specific situation, e.g. the location decision. The econometric model establishes these relations via regressions and tests their significance.

A third advantage rests in the possibility to control for some possible sample selection biases arising from the firms that did not respond to the survey. Indeed, as we have seen in the descriptive part, the 130 firms that did answer to the survey do not have the same average characteristics (non random sample), i.e. size, industry, than the ones that did not answer, i.e.

the 1000 R&D EU companies form the Scoreboard. As a result, the answers as regards the importance of the different questions may differ – or in statistical terms the results may be biased - compared to the ones of the non-respondents. Thanks to the econometric model proposed by Heckman (1979) it is possible to correct for these biases.

4.1. Drivers for increasing R&D investment

The first research question addressed in the IRMA Survey regards the drivers for increasing the overall R&D investment regardless of location. The dependent variable, according to the survey, is the increase of overall R&D investment over the next three years. Table 4 reports the main findings as regards the main factors explaining such decision by EU firms.

Table 4: Most relevant drivers for increasing the overall R&D investment of the company (over the next three years, i.e. 2009-2011)

	OLS			Heckman					
				Outcome equation			Selection equation		
Constant	8.735		(7.657)	9.203		(5.968)	-0.015		(0.563)
Market pull	0.405		(1.058)	0.233		(0.729)			
Technology push	-0.169		(0.803)	-0.234		(0.568)			
Competition from firms located in:									
European Union	-0.508		(0.777)	-0.455		(0.569)			
Other developed countries, e.g. Japan or US	1.406	*	(0.777)	1.441	**	(0.571)			
Emerging countries, e.g. China or India	-1.119		(0.728)	-1.241	**	(0.521)			
Meeting product market regulation and other legal frameworks	-0.519		(0.950)						
Improving the company's productivity	0.353		(0.774)	0.150		(0.467)			
Other drivers	-0.432		(0.512)	-0.536	*	(0.380)			
R&D intensity in 2007	0.055		(0.072)	0.051		(0.054)	-0.001		(0.001)
Size of the firm	-0.001		(0.002)	-0.001		(0.001)	0.001	***	(0.000)
% of R&D performed in the EU in 2008	-0.001		(0.001)						
Firm is listed on the stock market							-0.358	**	(0.167)
Number of observations	113			113			967		
R^2	0.435								
Log likelihood				-608.2					
Rho				-0.151		(0.227)			
Wald test of independent equations				0.43		[0.5127]			

Notes: Robust standard errors in brackets; P-value in square brackets; * (**, ***) statistically significant at the 1% (5%, 10%) level; country and industry sector dummies included.

The left hand side of Table 4 reports the results of an Ordinary Least Square (OLS) regression while the right hand side reports the results of a Heckman Maximum Likelihood regression model which allows controlling for sample selection. The equations also include country and industry and services sector dummies which are not reported here for the sake of space. The

Wald test for the independence between the selection equation, i.e. the fact that the EU firms from the R&D scoreboard answered to the survey, and the drivers one, i.e. the factors explaining the decision to increase R&D, is not statistically different from zero. Thus we can conclude that there is no sample selection bias in the estimates and the firms that responded to the survey can be considered as a representative sample of the full EU 1000 ones from the R&D Scoreboard although they had a larger size on average. The results from the selection equation confirm that the largest companies in terms of size are indeed more likely to answer to the survey. An opposite conclusion emerges for the firms listed on the stock market.

The control variables in the outcome equation, i.e. the R&D intensity, the size of the firm and the share of R&D performed in the EU turn out not to be significant. The only factor that is statistically significant at the 1% and 5% levels in both regression models and hence is likely to positively influence the decision of the firms to increase the R&D investment level in the near future is the competition arising from companies located in other developed countries. For the Heckman selection model, two other explanatory variables turn out to be significant, namely the competition arising from emerging countries such as China or India and a second variable 'other drivers'. These two variables negatively affect the firm's decision to augment its R&D activities in the near future, i.e. would lead to a reduction of R&D.

The main explanation for the difference between this result and the descriptive statistics (where competition with non-EU countries were the least important drivers in the ranking) resides in the different standard deviations associated with the explanatory variables[17]. For instance, for the "classical drivers" such as market pull, improving productivity and technology push, the standard deviations are by far the lowest. In other words, these drivers are considered in the same way by all companies, do they increase or not their R&D investment in the near future. In the present case, all the firms consider them as very important. This lack of variability in the answers to the questions corresponding to these factors explains why these variables are not statistically significant in the regressions explaining the variations in the level of R&D. For the "market pull" factor for instance, Figure A1 in Appendix A provides additional evidence to explain this fact. Indeed, whatever the level of changes in firms' R&D investment, this determinant appears as being a very important one for almost all companies.

As far as competition with firms resident in advanced countries (namely the US[18]) is concerned, this factor is more likely to be considered as a critical driver. This is consistent with the literature on the EU-US technology gap (O' Sullivan, 2007). Competition with China and India is, instead, characterised by a significant negative value in the regression. One possible

[17] This information is reported in Table A1 in the Appendix A together with other basic descriptive statistics of main variables.

explanation rests in the fact that firms for which this factor is (critically) important for increasing their R&D activities are in fact the ones increasing to a lesser extent their R&D in the future. Conversely this factor may not be very important (or not important at all) for firms that expect to increase at most their R&D in the next three years to come. Figure A2 in the Appendix seems to validate this second explanation. Finally the 'other drivers' have also a negative impact of firms R&D future increases. Having a closer look at the types of answers for this variable, they appear to be quite general: creating international networks, environmental issues, corporate strategies (this answer appeared two times), meeting consumer needs etc. This suggests that these companies do not have really clear R&D strategies for which devoting clear resources and therefore their investments in R&D are less important.

4.2. Determinants for R&D localisation

The second question in the IRMA Survey concerns the most important factors determining the "most attractive" country to carry out R&D activities. To explore this, we first distinguish whether this favourite country is or not the home country of the company. It should be noted that more than 50% of survey respondents reported their home country as the most favourite location for investing in R&D. Table 5 summarizes the main findings as regards this question.

Again, in order to control for possible biases arising from the firms that did respond to the survey, Heckman models with sample selection are estimated. The left hand side of Table 5 presents the results of a Heckman Maximum Likelihood probit model while the right hand side the results of a Heckman Maximum Likelihood regression model. The reason for implementing a probit Heckman model rests in the binary nature of the dependent variable, i.e. the most favourite location for doing R&D, in this case the firms' home country. Hence the dependent variable takes the value one when a firm reports its home country as its most favourite location for doing R&D and zero otherwise.

As it can be seen in Table 5, the results do not differ a lot from one regression model to the other. The estimated coefficients in the first model seem to be less precise, i.e. their associated standard errors are somewhat higher, as compared to the corresponding results in the second model. Finally, we can notice that in terms of selection bias, the Wald tests reject

[18] See the questionnaire in Annex B.

the null hypothesis of no independence between the equation of interest and the selection one[19].

Table 5: Most important factors explaining the most attractive location for R&D – Home country

	Heckman ML probit model				Heckman ML regression model			
	Outcome equation		Selection equation		Outcome equation		Selection equation	
Constant	4.346	(10.128)	0.489	(0.598)	0.349	(0.370)	0.496	(0.596)
Access to markets	-0.094	(0.159)			-0.021	(0.037)		
Access to public support for R&D	0.469 **	(0.227)			0.105 *	(0.041)		
Proximity to other activities of your company	0.494 **	(0.212)			0.118 *	(0.035)		
Proximity to suppliers	-0.107	(0.210)			-0.026	(0.044)		
Proximity to technology poles and incubators	0.109	(0.174)			0.028	(0.040)		
Access to specialised R&D knowledge and results	0.257	(0.242)			0.037	(0.042)		
High availability of researchers	-0.078	(0.233)			-0.023	(0.045)		
Low labour costs of researchers	-0.303 ***	(0.173)			-0.075 **	(0.032)		
Access to R&D cooperation opportunities, including with regulatory bodies	-0.534	(0.328)			-0.088 ***	(0.053)		
Reliable framework for R&D, e.g. IPR	0.076	(0.247)			0.017	(0.051)		
Regulation of your product markets	0.239	(0.191)			0.058	(0.038)		
Macroeconomic and political stability	-0.212	(0.236)			-0.052	(0.044)		
Size of the firm			0.001 *	(0.000)			0.001 *	(0.000)
Firm is listed on the stock market			-0.244	(0.169)			-0.245	(0.163)
Log likelihood	-343.059				-345.988			
Number of observations	125		999		125		999	
Rho	0.242		(0.799)		0.177		(0.288)	
Wald test of independent equations (rho = 0): $\chi^2(1)$	0.100		[0.7542]		0.690		[0.5348]	

Notes: ML = Maximum Likelihood; robust standard errors in brackets; P-value in square brackets; * (**, ***) statistically significant at the 1% (5%, 10%) level; country and industry sector dummies included.

Three factors that explain the firms' home country as the favourite destination for carrying out R&D appear to be statistically significant in both models. The access to public support for R&D and the proximity to other activities of the company positively influence this choice while low labour costs of the R&D workforce negatively affect this choice. These results confirm the ones based on the descriptive statistics as well as those reported in the literature. For

[19] It should also be noted that the maximum likelihood functions of these two regression models did not converge when the control variables are included (R&D intensity, size of the firm and share of R&D performed in the EU).

Instance Kuemmerle (1999) found that HBE sites (as compared to HBA ones) are more likely to be located in proximity to an existing factory. Davies and Meyer (2004) found that government support has a positive effect on the incidence of subsidiary R&D, but not its level. The estimated coefficient associated with the costs of the R&D personnel has a negative sign. This implies that firms for which this factor is important will tend to delocalize more their R&D activities outside the EU.

Table 6 reports the results concerning the main factors determining the overall favourite location of firms R&D investments for two other destinations, i.e. the US and the Rest of the world[20] besides the home country whose results are reported once again.

It should be noted that these results are based on a Heckman maximum likelihood regression model. Indeed, with the Heckman Maximum Likelihood probit model no convergence could be achieved after more than 2000 iterations due to the non concavity of the log-likelihood function.

Table 6: Most important factors explaining the most attractive location for the company's R&D – Home country vs. US and Rest of the world

Favourite location Factors	Home country		US		Rest of the World	
Constant	0.349	(0.372)	-0.095	(0.178)	-0.097	(0.204)
Access to markets	-0.021	(0.034)	0.019	(0.016)	-0.002	(0.019)
Access to public support for R&D	0.105 *	(0.038)	-0.004	(0.018)	-0.053 **	(0.021)
Proximity to other activities of your company	0.118 *	(0.035)	0.014	(0.016)	-0.065 *	(0.020)
Proximity to suppliers	-0.026	(0.041)	0.016	(0.019)	0.016	(0.023)
Proximity to technology poles and incubators	0.028	(0.037)	0.003	(0.017)	-0.014	(0.021)
to specialised R&D knowledge and results	0.037	(0.044)	-0.016	(0.021)	0.026	(0.025)
High availability of researchers	-0.023	(0.046)	0.012	(0.021)	-0.024	(0.026)
Low labour costs of researchers	-0.075 **	(0.034)	-0.038 **	(0.016)	0.114 *	(0.019)
Access to R&D cooperation opportunities, including with regulatory bodies	-0.088 ***	(0.052)	0.003	(0.024)	-0.032	(0.029)
Reliable framework for R&D, e.g. IPR	0.017	(0.049)	0.007	(0.022)	-0.025	(0.027)
Regulation of your product markets	0.058	(0.037)	0.027	(0.017)	0.007	(0.021)
Macroeconomic and political stability	-0.052	(0.044)	-0.036 ***	(0.020)	0.067 *	(0.025)
Log likelihood	-345.988		-248.893		-273.122	
Number of observations	125		125		125	
Rho	0.177	(0.288)	0.179	(0.482)	-0.217	(0.281)
Wald test of independent equations	0.690	[0.5348]	0.000	[0.9698]	0.530	[0.4648]

Estimating a Heckman two-step model addresses this issue and leads to results that are similar to the ones obtained with the maximum likelihood method.

[20] The countries concerned are China (2 responses); India (5 responses) and Korea; Philippines; Russia and Tunisia (one response).

(rho = 0): $\chi^2(1)$			

Notes: Heckman Maximum Likelihood regression models with sample selection, robust standard errors in brackets; P-value in square brackets; * (**, ***) statistically significant at the 1% (5%, 10%) level; country and industry sector dummies included.

For the US, the coefficient on the choice of this destination for performing R&D is negative for two factors: low labour costs of R&D personnel as well as macroeconomic and political stability. Taking into account the formulation of this question and its scale categories (see the questionnaire in Appendix B), this suggests that these factors do not matter for the location decision, i.e. they are considered in a way as boundary conditions.

For those respondents that prefer another country (Rest of the World), the results obtained for the factors 'low labour costs of R&D personnel' and 'macroeconomic and political stability' is the opposite to that described above for the US: low labour costs of R&D personnel and macroeconomic and political stability do play an important role in the location decision of EU R&D MNEs. Gassman and Han (2004) found that the low wage structure in China is an important factor for attracting R&D foreign MNEs[21] while Reddy (2000) and von Zedtwitz and Gassmann (2002) emphasise the role of adequate systems of IPR protection among other determinants as an important driver to attract foreign R&D in host developing countries. On the other hand, the access to public support for R&D and the proximity to other activities of the company have a negative impact. In terms of selection bias, the Wald tests once again reject the null hypothesis of no independence between the equation of interest and the selection one.

4.3. Public policies supporting R&D investment in the EU

Finally, we are interested in quantifying the most important EU public policies for keeping the R&D activities of European MNEs within the EU itself. Table 7 reports the main findings about this question. The dependent variable considered is the growth rate between 2006 and 2009 of the R&D investment carried out in the EU.

Two public policies turn out to positively affect the increase of R&D activities inside the EU: indirect public aid, e.g. publicly supported loan and guarantee schemes and meeting product market regulation and other legal framework. This last policy measure was also reported as among the most important ones in the descriptive analysis (cfr. Figure 4). More surprisingly, the Joint Technology Initiative[22] (JTI) appears to have a negative impact on R&D investments in the EU. One possible reason to explain this result rests in the fact that this initiative is very recent and therefore may be rated as not being a very important policy measure for supporting the firms R&D in the EU. There might even exist a difference between the experience of companies that are involved in JTI and those that are not. Therefore, increasing the factual data about companies' participation in JTI can be seen as an important factor for further analysis.

Table 7: Most important public policies for supporting R&D within the EU

	Growth rate (2009 and 2011) of R&D carried out in the EU		
	Outcome equation		
Constant	16.450		(17.286)
Direct public aid from the EU	-3.308		(6.689)
Direct public aid from other sources	-2.979		(6.367)
Indirect public aid	28.233	**	(13.496)
Tax incentives	6.071		(5.847)
Public procurement	9.874		(7.615)
European technology platforms	7.683		(9.164)
Joint Technology Initiatives	-25.870	**	(10.390)
Meeting products market regulation	12.983	**	(5.311)
Policies that foster cooperation	-22.013		(16.001)
Policies that support the exchange of human resources in R&D	-5.896		(15.914)
Number of observations	125		
Rho	0.506		(0.310)
Mills ratio	0.9854		(7.327)

Notes: Heckman Maximum Likelihood regression models with sample selection, standard errors in brackets; P-value in square brackets; * (**, ***) statistically significant at the 1% (5%, 10%) level; country and industry sector dummies included.

5. Conclusions

The objective of this paper was to test, based on the more qualitative results of the IRMA 2008 Survey, whether a quantitative approach would prove robust and show additional results as compared to the descriptive analysis of these data. One important aspect was to see if this would allow for controlling for the sample selection bias compared to the 2007 Scoreboard despite the relatively small sample size of the firms that responded to the survey.

[21] As pointed out by the authors, "Although the wages of highly qualified Chinese R&D staff is higher compared to Chinese domestic level, it is still 25% or 20% of that of R&D staff salary in triad regions".

[22] Joint Technology Initiatives are a major new element of the EU's 7th Research Framework Programme. They provide a way of creating new partnerships between publicly and privately-funded organisations involved in research, focussing on areas where research and technological development can contribute to European competitiveness and quality of life.

In methodological terms, the results obtained show that the implementation of quantitative methods unveils additional characteristics of the dataset. To start with, the results of the statistical tests did not suggest any presence of sample selection biases of the Survey compared to the Scoreboard data. Then, with respect to the individual factors, the regression analysis confirmed the importance of competition with companies in advanced countries (e.g. the US), so this can be considered a critical driver. For competition with Chinese or Indian companies, the quantitative model seems to outline that the respondents that chose these destinations for R&D as a critical issue are already affected and expect lower increases of their R&D investments in the future.

For the determinants of R&D localisation, the quantitative model confirms the significance of three factors already observed in the qualitative analysis (access to public support, proximity to other company activities and low labour costs). Yet, for the factors explaining the most attractive location, the quantitative model provides further details. For the US as preferred location, labour costs and political stability seem to be taken as boundary conditions. For other countries (Rest of the World), labour costs and political stability do seem to play a role for the choice of location.

These findings are in-line with those from the qualitative analysis and the literature. Concerning public policies, the quantitative analysis highlight the importance of indirect public aid and product and market regulation.

In terms of policy conclusions, an integrated analysis of the three aspects addressed in the quantitative analysis (drivers for increasing R&D, determinants of localisation and public policies) suggests that EU companies perceive the need of increasing their technological strength in order to compete with the global leaders (often companies resident in the US). The strategy of lowering research costs is only a part of the story and might be not enough: public support is needed to reinforce the overall home base (represented by the proximity to other activities of the company).

In order to extend the analysis, a further step would be to compare the present results with those coming from previous editions of the IRMA survey. Moreover, an integrated analysis of a panel built on the four surveys, although unbalanced, might provide additional insights with regards to the trends in R&D internationalisation of EU MNEs. This is expected to be especially helpful for distinguishing further sub-samples for larger and smaller companies, different Member States, or high, medium and low R&D intensity companies in future econometric analyses.

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Annex A

Table A1. Descriptive statistics of main variables

Variable	Mean	Standard deviation.	Min	Max
Growth rate (2006 and 2009) of total R&D	4.770	6.502	-10	30
Market pull	4.270	0.898	0	5
Technology push, i.e. exploiting technological opportunities	3.762	1.054	0	5
Competition from firms located in:				
European Union	3.619	1.144	0	5
Other developed countries, e.g. US or Japan	3.087	1.321	0	5
Emerging countries, e.g. China or India	2.754	1.395	0	5
Improving the company's productivity	3.889	1.090	0	5
Meeting product market regulation and other legal frameworks	3.484	1.270	0	5
Most favourite destination = home country	0.540	0.500	0	1
Most favourite destination = US	0.056	0.230	0	1
Most favourite destination = Rest of the World	0.087	0.283	0	1
Access to markets	3.286	1.469	0	5
Access to public support for R&D	3.056	1.405	0	5
Proximity to other activities of your company	3.802	1.302	0	5
Proximity to suppliers	2.794	1.347	0	5
Proximity to technology poles and incubators	3.230	1.404	0	5
to specialised R&D knowledge and results	3.802	1.380	0	5
High availability of researchers	3.810	1.238	0	5
Low labour costs of researchers	2.706	1.357	0	5
Access to R&D cooperation opportunities, including with regulatory bodies	3.159	1.341	0	5
Reliable framework for R&D, e.g. IPR	3.603	1.321	0	5
Regulation of your product markets	2.698	1.466	0	5
Macroeconomic and political stability	3.357	1.249	0	5
Growth rate (2006 and 2009) of R&D carried out in the EU	16.370	24.161	-27.1	119.7
Direct public aid from the EU	0.135	0.343	0	1
Direct public aid from other sources	0.175	0.381	0	1
Indirect public aid	0.032	0.176	0	1
Tax incentives	0.159	0.367	0	1
Public procurement	0.071	0.259	0	1
European technology platforms	0.103	0.305	0	1
Joint Technology Initiatives	0.063	0.245	0	1
Meeting products market regulation	0.222	0.417	0	1
Policies that foster cooperation	0.024	0.153	0	1
Policies that support the exchange of human resources in R&D	0.024	0.153	0	1

Figure A1. Scatterplot between the changes in firms' R&D investment in the three years to come (RD_INC3) and the importance of market pull factor from 1 to 5 (DR_MKT)

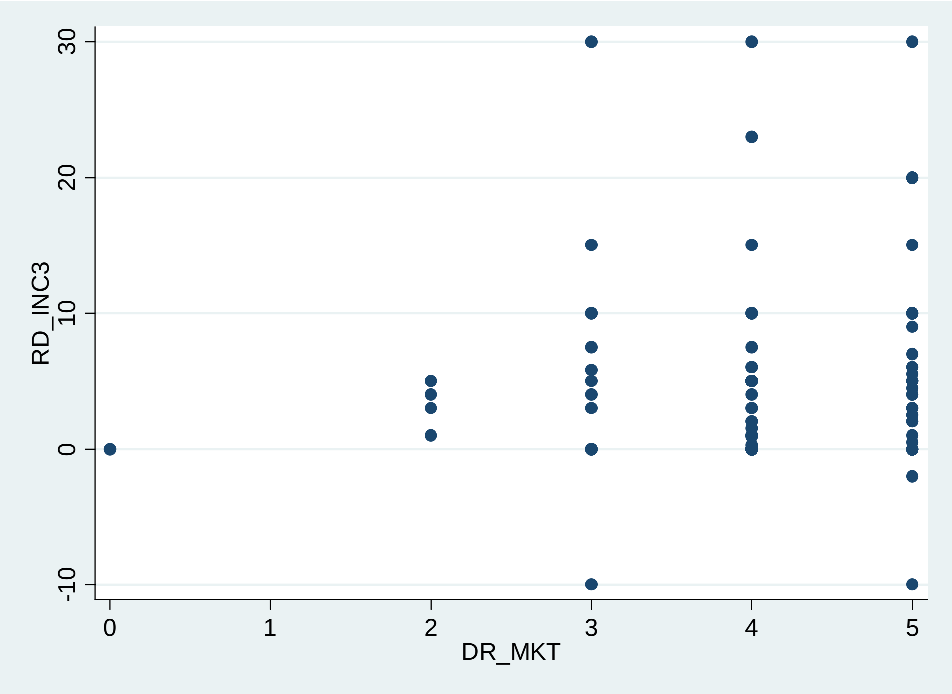
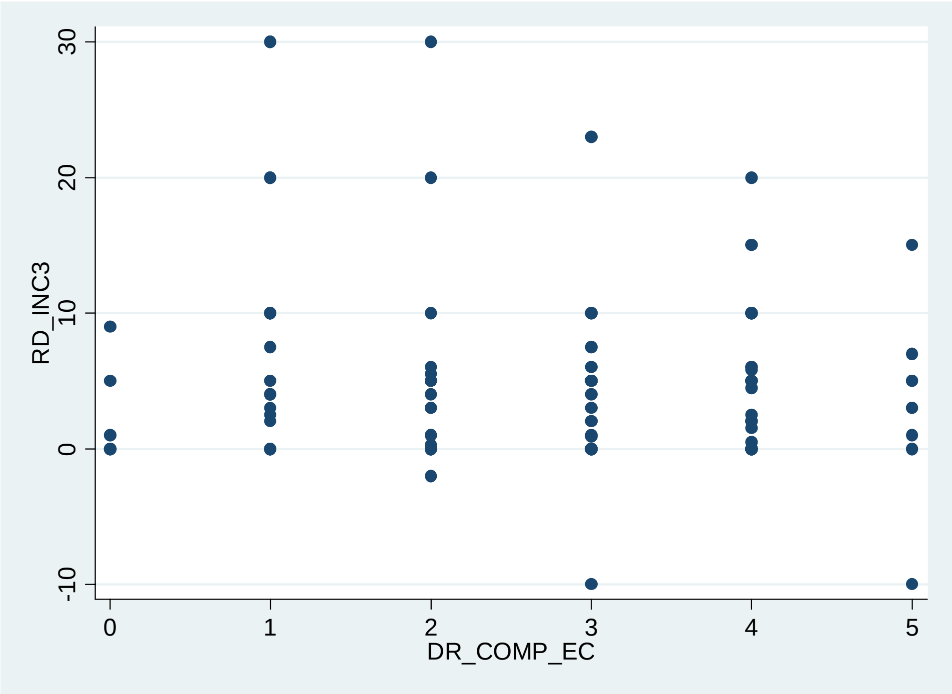


Figure A2. Scatterplot between the changes in firms' R&D investment in the three years to come (RD_INC3) and the importance of competition from companies located in emerging countries, e.g. China or India



Annex B: The Questionnaire

The 2008 Questionnaire on R&D Investment Business Trends

We would appreciate your response by deadline, **preferably by using the questionnaire on our website** at: **http://iri-survey.jrc.es/2008/**. Alternatively, you may return this completed form by e-mail (Alexander.Tuebke@ec.europa.eu), fax (+34.95.448.83.26), or post[23].

Your response will be treated as **confidential**. The information will only be used within this study and aggregated for analysis. The European Commission is committed to data protection and privacy.

It will take about **20 minutes** to complete the questionnaire.

We will automatically inform you of the results of the survey when they are available (please ensure that you have provided your e-mail address below).

Thank you very much for your contribution!

Name of the company you are responding for: ______________________

Its primary sectors of activity: ______________________

Your name: ______________________

Job title: ______________________

E-mail: ______________________

Phone number: ______________________

The European Commission plans to clarify trends revealed in the analysis, which may involve short follow-up interviews. Please **tick here** ☐ if you *do not* wish to be approached for this purpose.

Definition of R&D investment

For the purposes of this questionnaire, **'R&D investment' is the total amount of R&D financed by your company** (as typically reported in its accounts, exclusive of R&D from public sources).

[23] European Commission, Institute for Prospective Technological Studies (IPTS), Attn.: Alexander Tübke, Edificio Expo, Calle Inca Garcilaso s/n, E-41092 Seville, Spain, Tel : +34.95.448.83.80

A. Corporate background

1. How many employees in total work in your company?

   About ____________________________.

2. How many employees work on R&D in the company?

   About ____________________________.

3. What was its turnover in the last financial year?

   About € _________________________ million for the financial year ending _______________.

B. R&D investment levels and trends

4. What was your company's R&D investment in the last financial year?

   About € _________________________ million.

5. At what rate do you expect the company to increase its overall R&D investment over the next three years, in real terms?

   About ______________________________ % per annum.

6. How much of your R&D investment is in research[24] and how much is in development[25]?

	research	development
(a) R&D carried out *inside the EU*	________________ %	_______________ %
(b) R&D carried out *outside the EU*	________________ %	_______________ %

7. How relevant are the following drivers for *increasing* the company's overall R&D investment? *Please rate on a scale from 1 (irrelevant) to 5 (highly relevant).*

	Irrelevant 1	2	3	4	Highly relevant 5
(a) Market pull	☐	☐	☐	☐	☐
(b) Exploiting technological opportunities (technology push)	☐	☐	☐	☐	☐
(c) Competition from companies located in:					
(c1) the European Union	☐	☐	☐	☐	☐
(c2) other developed countries, e.g. the US or Japan	☐	☐	☐	☐	☐
(c3) emerging countries, e.g. China or India	☐	☐	☐	☐	☐
(d) Improving the company's productivity	☐	☐	☐	☐	☐
(e) Meeting product market regulation and other legal frameworks	☐	☐	☐	☐	☐
(f) Other:	☐	☐	☐	☐	☐

[24] Research is undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and facts, with or without any particular application or use in view.
[25] Development draws on existing knowledge to produce new, or to improve substantially, products, processes and services.

C. R&D location strategy and management

8. Please estimate the distribution of your company's in-house R&D activity among the following world regions at present and in three years?

Present distribution	R&D carried out:	Expected distribution in three years
%	in the European Union	%
%	in other European countries	%
%	in the US and Canada	%
%	in Japan	%
%	in China	%
%	in India	%
%	in the Rest of the World	%

9. For supporting your R&D activities *inside the European Union*, how important are the following public policies? *Please rate on a scale from 1 (unimportant) to 5 (critically important).*

	Un-important 1	2	3	4	Critically important 5
(a) Direct public aid from the EU, e.g. the Framework Programme or the Structural Funds	☐	☐	☐	☐	☐
(b) Direct public aid from other sources, e.g. R&D grants	☐	☐	☐	☐	☐
(c) Indirect public aid, e.g. publicly supported loan and guarantee schemes	☐	☐	☐	☐	☐
(d) Tax incentives	☐	☐	☐	☐	☐
(e) Public procurement	☐	☐	☐	☐	☐
(f) European Technology Platforms[26]	☐	☐	☐	☐	☐
(g) Joint Technology Initiatives[27]	☐	☐	☐	☐	☐
(h) Meeting product market regulation and other legal frameworks	☐	☐	☐	☐	☐
(i) Policies that foster cooperation	☐	☐	☐	☐	☐
(j) Policies that support the exchange of human resources in R&D	☐	☐	☐	☐	☐
(k) Other:	☐	☐	☐	☐	☐

[26] European Technology Platforms are led by industry and provide a platform to define R&D priorities, timeframes and action plans on a number of strategically important issues where achieving Europe's future growth, competitiveness and sustainability objectives is dependent upon major research and technological advances in the medium to long term (see http://cordis.europa.eu/technology-platforms/home_en.html).

[27] Joint Technology Initiatives are a major new element of the EU's 7th Research Framework Programme. They provide a way of creating new partnerships between publicly and privately-funded organisations involved in research, focussing on areas where research and technological development can contribute to European competitiveness and quality of life (see http://cordis.europa.eu/fp7/jtis/).

10. Which country do you consider the *most attractive* location for the company's R&D?

⇨ ____

How important are the following factors for this consideration? *Please rate on a scale from 1 (unimportant) to 5 (highly important).*

	Un-important 1	2	3	4	Highly important 5
(a) Access to markets	☐	☐	☐	☐	☐
(b) High availability of researchers	☐	☐	☐	☐	☐
(c) Low labour costs of researchers	☐	☐	☐	☐	☐
(d) Access to specialised R&D knowledge and results	☐	☐	☐	☐	☐
(e) Reliable legal framework for R&D, e.g. Intellectual Property Rights	☐	☐	☐	☐	☐
(f) Macroeconomic and political stability	☐	☐	☐	☐	☐
(g) Proximity to technology poles[28] and incubators[29]	☐	☐	☐	☐	☐
(h) Proximity to other activities of your company	☐	☐	☐	☐	☐
(i) Proximity to suppliers	☐	☐	☐	☐	☐
(j) Access to R&D cooperation opportunities, including with regulatory bodies	☐	☐	☐	☐	☐
(k) Access to public support for R&D	☐	☐	☐	☐	☐
(l) Regulation of your product markets	☐	☐	☐	☐	☐
(m) Other:	☐	☐	☐	☐	☐

D. Comments or suggestions

⇨ ____

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Thank you very much for your contribution!

[28] "Technology poles" are areas where R&D active companies, institutions and universitites are concentrated.
[29] "Incubators" are structures that support innovative startup companies in order to increase their survival rates.

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Abstract

Based on an original and recent sample representative of the largest R&D corporations in the EU, this paper aims at investigating in a quantitative way the main factors explaining: (i) the decision of firms to increase their R&D investment effort in the near future; (ii) the main drivers explaining the favourite international location choice for R&D; and (iii) the impact of direct and indirect policies to support R&D activities in the EU. The main findings suggest that competitive pressures from the US are the main determinants for increasing R&D investments. Public support to R&D and proximity to other activities of the company influence the decision to locate R&D in the home country. Considerations on the cost of employing researchers become one factor among others only for firms preferring a location outside their home country, in particular in the rest of the world (countries other than the EU or the US).

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