Globalisation, industrial diversification and productivity growth in large European R&D companies[∇]

Michele Cincera[‡], Julien Ravet[*]
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Abstract:

This paper aims to assess the impact of both geographic and industrial diversification of economic activities on the productivity performance of large European R&D Multinational Enterprises (MNEs). Based on the worldwide subsidiaries of these firms, we measure the performance of the firms according to their level of industrial diversification and globalisation that we proxy with the presence and importance of subsidiaries in the EU, North America and Asia-Pacific regions. The sample consists of large R&D firms that represent about 80% of total European R&D. In general, the results indicate a positive impact from globalisation on firms' R&D productivity, especially in the US, while a negative impact for industrial diversification is found.

Key words: R&D; European MNEs; productivity; globalisation; industrial diversification.

JEL codes: O33

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[‡] Michele Cincera is a Professor at the Solvay Brussels School of Economics and Management, Université Libre de Bruxelles; Address: DULBEA-CP.140, 50 Av. F.D. Roosevelt, 1050 Brussels, Belgium; Email: mcincera@ulb.ac.be; Tel: 00 32 (0) 650 4151. He is currently a research fellow (senior grant holder) at the Institute for Prospective Technical Studies, a Joint Research Centre for the European Commission based in Seville, Spain.

[*] Julien Ravet is a PhD student at the Solvay Brussels School of Economics and Management, ULB.

1. Introduction

According to Schumpeter's view (1942) on the role played by the size of firms on Research and Development (R&D) activities, large R&D firms can be expected to benefit from economies of scope by diversifying their research portfolio and the intrinsic technological risk of R&D activities. Nakamura (1999) finds evidence of a positive relationship between R&D diversification and knowledge spillovers both among research programmes within a firm and across firms. Industrial diversification can however increase the agency costs between shareholders and managers (Denis et al. 2002) through personal risk reduction, increased power and prestige or compensation arrangements for the latter.

Geographic or global diversification is another source for enhancing R&D productivity. Firms delocalising research facilities abroad can benefit from the availability of the local knowledge base and supply of a skilled workforce (Kuemmerle, 1997). Outsourcing R&D outside the home country allows firms to exploit existing innovations in local market conditions. On the other hand, the diversification of activities can also be detrimental to the R&D productivity of firms. Diversified economic and research activities prevent firms from exploiting economies of scale and can also increase managerial costs (Asakawa, 2001).

Using consolidated data for R&D, labour, sales and physical capital, we estimate firm-level production functions augmented with R&D capital stocks (Griliches, 1979), and we pay particular attention to the partial elasticities of sales to R&D capital. Several model specifications are tested in order to measure the impact of both sources of diversification, i.e. industrial and global diversification on the productivity performance of firms. In doing so, we are also interested in comparing the productivity growth according to the three main regions where large EU MNEs delocalise their research and production activities, i.e. the EU, North America and the Asia Pacific region.

We use two sources of information to construct the database for the empirical study: the last edition of the EU industrial R&D scoreboard released in 2009 by the JRC-IPTS and the Amadeus database (Bureau van Dijk). The sample consists of the top 1,000 R&D-active MNEs in the EU over the 2005-2008 period. The empirical analysis is based on 43,966 subsidiaries of these MNEs. We compute different globalisation indicators, such as Herfindahl-Hirschman indexes based on the number of countries covered by firms and their subsidiaries, their number of employees and net sales. Indicators for industrial diversification are constructed on the basis of firms' industrial classifications and subsidiaries.

The results of the econometric analysis show a positive impact for globalisation on R&D productivity but a negative impact for industrial diversification. European MNEs with a higher share of subsidiaries in the US and Canada and in the Asia-Pacific region globally exhibit a higher R&D intensity and productivity performance.

The paper is arranged as follows: the second section briefly reviews theoretical aspects of the literature on the geographic and industrial diversification of firms. The third section documents the data and the empirical framework. The estimated results are presented in section four. Finally, conclusions are drawn, and suggestions for future work are made in the last section.

2. Review of the literature

Nowadays, a significant portion of companies diversify their productive activities, either across multiple lines of business, i.e. industrial diversification, across different geographic markets, i.e. international diversification or globalisation, or both (Denis et al., 2002). The purpose of this section is to review some of the main theoretical arguments as well as empirical findings on the effect of industrial diversification and globalisation on R&D activities and firms' economic performance.

Studies in the literature report potential benefits as well as costs for R&D and the economic performance of both types of diversification strategies. On the one hand, industrial diversification positively affects productivity performance through economies of scope (Kamien and Schwartz, 1982; Porter, 1985) and an excess of technological resources. These new technological opportunities are in turn deployed in new directions and industries. A classical example to illustrate this concept is the DuPont de Nemours company (Penrose, 1959; Chandler, 1962), which was created at the beginning of the 19th century as a gunpowder mill, it invented nylon in 1935 and is now one of the largest worldwide chemical companies.

According to Williamson (1975, 1985), multi-product firms increase the willingness of managers to engage in riskier activities such as R&D and innovation, which enhance the firm's productivity. Within a multidivisional firm, "corporate managers usually evaluate division managers' performance on the basis of both financial performance and other relevant information. Top managers generally have access to information that is both more abundant and superior to that available in the external capital market. Thus, although the number of investment opportunities available within multidivisional firms is limited, at least in comparison to the number of opportunities in the external capital market, top management's knowledge with respect to each is 'incredibly deep' " (Williamson, 1970: 177).

However, other authors in the strategy literature (Burgelman, 1983; Hayes and Abernathy, 1980 and Hill et al. 1988) have suggested a negative impact for industrial diversification on the propensity of firms to engage in R&D. Division managers operating in this type of M-form companies have a tendency to avoid risky strategies, such as R&D, and invest in projects with a more immediate financial performance. For instance, Baysinger and Hoskisson (1989) put forward the argument that "in large diversified firms, corporate managers tend to use a return-on-investment (ROI) criterion for evaluating division managers' performance (Dundas & Richardson, 1982), causing division managers to meet short-term ROI objectives by reducing expenditures that are not essential for the attainment of short-run returns but are critical to the maximisation of organisational efficiency in the long run". A second argument is that when the M-firm is too diversified it becomes difficult for the corporate manager to know precisely all the businesses in the firm's portfolio. "Even for firms engaged in related diversification, top-level managers' ability to gather, process, and interpret the information needed to evaluate divisional performance accurately and allocate resources and rewards may be highly limited" (Williamson, 1975). Therefore, industrial diversification can potentially benefit corporate managers through increased power and prestige, compensation arrangements, or personal risk reduction. In this case, industrial diversification is more likely to represent a cost for the agency relationship between the managers and shareholders.

As regards the determinants and the impact of globalisation on firms' R&D activities and productivity performance, theoretical studies (Dunning and Narula, 1995; Kuemmerle, 1997) and empirical studies (Kuemmerle, 1999; Kumar, 2001; Von Zedwitz and Gassmann, 2002) on the internationalisation of R&D over the last two decades have highlighted a shift from the so-called home-base exploiting to home-base augmenting R&D strategies[1]. Within such a framework, MNEs set up R&D laboratories abroad not only for adapting technologies and products developed at home to local market conditions, but also to tap into the knowledge and technological resources in centres of scientific excellence located worldwide. Such location strategies have multiple dimensions: 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 for R&D, IPR systems, quality of technological infrastructures; and lowering the costs of qualified research, especially in emerging countries (UNCTAD, 2005).

The empirical evidence on the effects of industrial and global diversification is somewhat limited and has produced mixed findings. A study by Denis et al. (2002), based on 44,288 firm-year observations over the period 1984-1997, showed that an increase in industrial diversification negatively affects the excess values of the firms[2]. A positive impact, however, was found for globalisation, which can be explained by an increase in flexibility to address changes in local environments, such as relative prices, differences in tax codes, and other institutional differences[3]. Global diversification tends also to positively affect firms' market capitalisation by exploiting firm-specific assets, e.g. intangible assets such as R&D, marketing skills, and management quality, increasing operating flexibility, and satisfying investor preferences for holding globally diversified portfolios. Morck and Yeung (1998) also found a positive effect for internalisation of foreign markets on productivity performance.

Conversely, because of its higher complexity in terms of management, coordination costs and information asymmetries between corporate headquarters and divisional managers, more globalised corporations are less efficient and exhibit lower performance. Thus, global diversification can also lead to the inefficient cross-subsidisation of less profitable business units (Meyer et al., 1992), and divisional managers may have incentives to adopt and maintain value-reducing diversification strategies, which in turn reduce shareholder wealth (Jensen and Murphy, 1990).

3. Data and empirical framework

3.1. Constructed data set and variables

We use two sources of information for the empirical study. The first one is the 2009 edition of the EU industrial R&D scoreboard, released annually by the JRC-IPTS of the European Commission. The second data source is the Amadeus database published by the Bureau van Dijk. The R&D scoreboard has been issued every year since 2004 and provides data at the

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[1] See Cincera et al. (2010) for a discussion.
[2] This excess value is defined by the authors as the “log of the ratio of the firm’s total market value to the sum of the imputed market values of its segments”. The authors use three measures of industrial diversification: the reporting of more than one business segment, the average number of business segments, and a sales-based Herfindahl index across business segments. Due to limitations in their data, the authors cannot use the number of countries as a measure of global diversification. Instead, they use the fraction of firms that are globally diversified and the fraction of total sales that come from foreign subsidiaries.
[3] Descriptive statistics reported in this study show that the average R&D intensity is higher for multinational firms and lower for industrially diversified firms.

firm level for the top 1,000 R&D-active firms in the EU-27 and the top 1,000 outside the EU-27.

Our analysis focuses on the EU firms in the scoreboard. The information available in the R&D scoreboards is consolidated at the group level and includes, among others, R&D investments[4], net sales, number of employees, capital expenditures, the country where the MNE has its registered headquarters and the main business sector, based on the Industry Classification Benchmark (ICB) at the two digits level, i.e. 45 industry and services sectors[5]. The period covered by the 2009 R&D scoreboard is 2005-2008, but previous R&D scoreboards allowed us to extend the observed period for the firms from 2000 to 2008. Each monetary observation was converted into a constant currency (in euros) and prices.

The Amadeus database[6] contains financial information from 14 million companies in Europe. We extracted the following data from Amadeus about the subsidiaries of the EU-27 firms available in the 2009 R&D scoreboard: the number of subsidiaries and, for each subsidiary, its turnover, number of employees, ownership, location and business sector. The data for these subsidiaries are observed once between 2005 and 2007, and therefore time series for these variables are not available. Table 1 summarises the main variables and data sources used in this study.

Table 1. Variables and data sources

2009 R&D scoreboard	Amadeus
R&D, net sales, employees, capital expenditures, country, industry (ICB)	# subsidiaries, turnover of subsidiaries, # employees of subsidiaries, localization of subsidiaries, industry of subsidiaries (ICB)

The matching between the 1,000 European firms in the R&D scoreboard and their counterpart in Amadeus is not straightforward and involves a manual matching procedure considering several criteria. Following our criteria, each firm in the scoreboard is matched manually with one firm in Amadeus with the same or slightly different name (e.g. Philips Electronics and Koninklijke Philips Electronics), located in the same country, with the same status (e.g. Ltd, SA, OY) and with consolidated financial data in Amadeus.

[4] The definition of "R&D" is that used by companies, following accepted international accounting standards (IAS38), in accordance with the definitions used in official statistics (as defined in the OECD's Frascati Manual). The term "R&D Investment" is used in the Scoreboard.
[5] See http://www.icbenchmark.com/.
[6] Amadeus, September 2009 version.

Table 2. Sample of EU R&D companies

Industry	# firms	R&D 2008 in mio EUR	R&D intensity 2008
High tech	**385**	**81173**	**7.2%**
Biotechnology	52	1296	21.3%
Semiconductors	19	3270	16.9%
Pharmaceuticals	50	14433	15.8%
Telecommunications equipment	26	12013	13.1%
Software	71	3798	13.1%
Electronic office equipment	2	303	7.9%
Electronic equipment	33	974	7.1%
Leisure goods	9	1892	6.2%
Aerospace & defence	25	7482	5.9%
Computer hardware	6	123	5.9%
Automobiles & parts	40	29564	5.3%
Electrical components & equipment	26	5239	4.0%
Computer services	26	786	3.2%
Medium tech	**243**	**20589**	**2.7%**
Health care equipment & services	29	1671	4.7%
Commercial vehicles & trucks	15	2356	3.7%
Chemicals	42	7075	3.2%
Alternative energy	4	286	3.0%
Industrial machinery	69	3289	2.7%
General industrials	20	1318	2.4%
Household goods & home construction	22	1352	2.3%
Media	12	1292	2.2%
Food producers	30	1951	1.5%
Low tech	**207**	**14828**	**0.5%**
Banks	2	70	1.9%
Personal goods	16	963	1.7%
Life insurance	1	29	1.7%
Fixed line telecommunications	13	4321	1.6%
Support services	25	449	1.1%
Tobacco	2	151	1.1%
Internet	4	31	0.9%
Other financials	11	269	0.8%
Mobile telecommunications	4	334	0.8%
Oil equipment, services & distribution	4	91	0.7%
Electricity	15	1449	0.6%
Construction & materials	26	671	0.5%
Forestry & paper	6	235	0.5%
Mining	5	485	0.5%
Industrial metals & mining	12	859	0.4%
Industrial transportation	12	432	0.3%
Nonlife insurance	1	5	0.3%
General retailers	13	406	0.3%
Oil & gas producers	9	2458	0.3%
Gas, water & multiutilities	8	584	0.2%
Travel & leisure	9	167	0.2%
Beverages	4	88	0.2%
Food & drug retailers	5	282	0.2%
All	**835**	**116590**	**2.4%**

We also made use of the information provided in the contact list used by the European Commission to contact the firms when assembling the R&D scoreboard[7]. This allows us to

[7] This information is confidential.

compare the city of the firm in the contact list with the city disclosed in Amadeus as a further criterion for validating the match. We also compare information as regards sales and employees in both databases[8].

Out of the 1,000 EU scoreboards firms in 2008, 55 could not be found in Amadeus[9] and 110 were found but not kept because of unconsolidated accounts or doubts about the matching procedure. Our final sample consists of the 835 remaining firms in the R&D scoreboard.

Table 2 presents an overview of the sample and some aggregate sector figures. We use the same classification as Ortega-Argiles et al. (2008) to assign the ICB industry and service sectors into high-, medium- or low-tech sectors.

3.2. Subsidiaries and diversification

The Amadeus database records 43,966 subsidiaries affiliated with the 835 EU MNEs in our sample. The R&D scoreboard firms hold at least 50% of the ownership of about 93% of these subsidiaries and at least 90% of the ownership of 84% of them.

Table 3. Subsidiary characteristics

Industry	average #subsidiaries	average subs. Turnover (mil. USD[a])	average subs. employees
High tech	38	199	436
Medium tech	47	237	597
Low tech	86	1005	2583
All	52	410	1015

Note: a) Amadeus provides data for subsidiaries only in US Dollars and not Euros. This will not affect the empirical analysis, as we are only interested in the share of the sales across countries and industries.

We use two types of indicators to identify the level of geographic diversification of firms. The first is the number of countries covered by the subsidiaries and the main firm. If all subsidiaries are located in the same country as the parent company, it implies no country diversification and a value of 1 is given for this indicator. Higher values are related to a stronger level of internationalisation. The second indicator is a Herfindahl-Hirschman Index (HHI) based on the sales and employee shares for the subsidiaries across countries. We calculate a HHI based on sales and another based on employees, given that for some subsidiaries we have information on the number of employees but not on sales[10]. The sales-based HHI for a firm present in *C* countries is defined as:

[8] Comparison is made for 2007 as it is the most recent year available in our version of Amadeus. Correlation between employees or sales in both databases is 0.99. The mean sales ratio for scoreboard/sales in Amadeus is 1.04, with a median of 1. The mean employees ratio in scoreboard/employees in Amadeus is 1.05, with a median of 1.

[9] 34 of them belong to the financial sector (bank, insurance and other financials) which is not covered in Amadeus.

[10] Employees are only available for some subsidiaries, while sales are only available for other subsidiaries. We do not have information on sales or employees for 48% of the subsidiaries. However, 63% of these subsidiaries do not have any BvD ID in the Amadeus Database. A reason for this could be that these subsidiaries are not large.

$$HHI^{S}{}_{country} = \sum_{c=1}^{C} \left(\frac{sales_c}{S} \right)^2$$

where $sales_c$ represents the sum of the sales of the subsidiaries in country c and S is the sum of the sales of all subsidiaries. The employees-based HHI is given by:

$$HHI^{E}{}_{country} = \sum_{c=1}^{C} \left(\frac{emp_c}{E} \right)^2$$

Where emp_c represents the sum of the employees of the subsidiaries in country c and E is the sum of the employees of all subsidiaries. An increase in the HHI implies a more concentrated distribution of sales or employees across countries.

Table 4. Average geographic diversification measurements

Firms	#countries	HHI sales	HHI emp
High tech	11	0.61	0.62
Medium tech	14	0.56	0.58
Low tech	16	0.65	0.64
All	13	0.61	0.61

The average measurements for these indicators are presented in Table 4. The firms in our sample are located on average in 13 countries. Firms in high-tech industries cover fewer countries. This may reflect a size effect, as these firms are also smaller on average. HHI indicators are close to 0.6.

Table 5 reports the shares of the subsidiaries in the main geographic areas represented in our sample: Europe[11], US-Canada, Asia-Pacific[12] and the rest of the world. While most of the subsidiaries are located in Europe, it appears that the share of European subsidiaries is even higher for low-tech industries, with a share that is 10 points higher for the low-tech firms (78%) than for the high-tech firms (68%). Higher-tech firms seem to favour US-Canada and Asia-Pacific regions when they want to locate their subsidiaries out of Europe.

Table 5. Share of subsidiaries (in %) by regions

Industry	**EU27**	**US-CA**	**Asia-Pacific**	**RoW**
High tech	68	13	9	9
Medium tech	71	11	8	10
Low tech	78	7	5	10
All	72	11	7	10

[11] European Union (27 Member States).
[12] American Samoa, Australia, Brunei, People's Republic of China, Fiji, Federated States of Micronesia, Guam, Hong Kong, Indonesia, Japan, Cambodia, Kiribati, North Korea, South Korea, Laos, Marshall Islands, Myanmar, Macau, Northern Mariana Islands, Malaysia, Nauru, New Zealand, Papua New Guinea, Philippines, Palau, Solomon Islands, Singapore, Thailand, Timor-Leste, Tonga, Tuvalu, Taiwan, Vietnam, Vanuatu and Samoa.

As a first measure of industrial diversification, we count the number of industries in which the MNE and its subsidiaries are active. We use the information available in the Amadeus database only: the NACE code that corresponds to the main industry sector for the subsidiaries. The number of sectors is measured according to the 4-digit Nace industry of the subsidiaries but we also calculate a more aggregate indicator based on the 2-digit Nace level. We also consider two other measures of industrial diversification: the sales-based and employee-based HHI across industries. These indicators are calculated at the 2 digit Nace level. The sales-based HHI for a firm present in *K* industries is defined as:

$$HHI^{S}{}_{nace} = \sum_{k=1}^{K} \left(\frac{sales_k}{S} \right)^2$$

where $sales_k$ represents the sum of the sales of the subsidiaries in industry k and S is the sum of the sales of all subsidiaries. The employees-based HHI is given by:

$$HHI^{E}{}_{nace} = \sum_{k=1}^{K} \left(\frac{emp_k}{E} \right)^2$$

where emp_k represents the sum of the employees of the subsidiaries in industry k and E is the sum of the employees of all subsidiaries. An increase in the HHI implies a more concentrated distribution of sales or employees across industries.

Table 6. Industrial diversification measurements

Industry	#Nace 4 digit	#Nace 2 digit	HHI sales	HHI emp
High tech	10	6	0.67	0.68
Medium tech	14	7	0.59	0.58
Low tech	18	9	0.62	0.58
All	13	7	0.61	0.61

The average measurements of industrial diversification are reported in Table 6. On average, the firms in our sample are active in 13 4-digit Nace industries. Firms in low-tech industries are active in more industries, and, as in Table 4, a reason for this may be the large size of these firms.

3.3. Empirical framework

Assuming a standard Cobb-Douglas production function,

$$Y = AL^{\alpha} C^{\beta} K^{\gamma} e^{u} \quad (1)$$

with *L, C* and *K* being factors of production, i.e. respectively labour, physical capital and R&D capital. Equation 1 taken in logarithm form is:

$$\log(Y_{it}) = \lambda + \alpha \log(L_{it}) + \beta \log(C_{it}) + \gamma \log(K_{it}) + u_{it} \qquad (2)$$

In order to test the relationship between a diversification indicator I and the productivity of R&D, we implement an interaction term between I and K, which may reflect a potential complementarity between both variables. When controlling for country, industry and time effects, equation 2 becomes:

$$\log(Y_{it}) = \lambda + \alpha \log(L_{it}) + \beta \log(C_{it}) + \gamma \log(K_{it})$$
$$+ \gamma_0 \log(K_{it}) + \gamma_1 \log(K_{it}) I_i + I_i + country_i + industry_i + \delta_t + u_{it} \qquad (3)$$

The elasticity of output to R&D capital is:

$$d \log Y / d \log K = \gamma_0 + \gamma_1 I \qquad (4)$$

The stocks of R&D and of physical capital were constructed by using the perpetual inventory method (Griliches, 1979). For each firm, the stock of capital at time t is defined by:

$$ST_t = (1-\delta) ST_{t-1} + Inv_t \qquad (5)$$

where δ is the depreciation rate of the capital and Inv is the amount of investment (R&D expenditure for R&D stock, or capital expenditures for physical capital stock). The depreciation rates were set to 0.15 for R&D and 0.08 for physical capital, which are the rates that are usually assumed in the literature[13]. The initial value of the stock can be computed by using the following expression:

$$ST_0 = \frac{Inv_0}{g + \delta} \qquad (6)$$

where g is the growth rate of investment and is assumed to be constant. The growth rate used for R&D stock is the average sample growth rate for R&D expenditure, i.e. 7.5%. The growth rate for physical capital is the average sample growth rate for capital expenditure, i.e. 11.5%.

3.4. Descriptive statistics

The 835 firms are observed during the 2000-2008 period, with data missing for some firms. To remove outliers, the sample was trimmed by dropping observations in the first and last centile of sales, labour, physical capital and R&D capital variables. The sample is also restricted to observations with no abnormally high R&D intensity, i.e. above the 95th centile, which is 1 (100%). The panel is unbalanced with an average observed period of 5 years per firm and a total of 4,230 observations. Because of missing observations for some subsidiaries,

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[13] See for instance Hall and Mairesse (1995) or Capron and Cincera (1998).

there are less than 4,230 observations for variables related to the subsidiary country and industry. Table 7 shows some descriptive statistics for the sample[14].

Table 7: Descriptive statistics

Variable	Obs	Mean	Med	Std dev	Min	Max
ln(sales)	4230	6.65	6.64	1.94	.45	11.16
ln(labour)	4230	8.28	8.34	1.81	3.47	12.46
ln(physical capital)	4230	5.61	5.56	2.24	.17	11.12
ln(R&D capital)	4230	4.75	4.48	1.57	1.52	9.68
R&D/sales	4230	0.08	0.04	0.12	0	.99
#subsidiaries	4230	52	24	83	1	534
#countries	4207	13.65	9	14.17	1	126
HHI countries - sales	3773	0.59	0.56	0.29	0.11	1
HHI countries - emp	3783	0.59	0.54	0.29	0.08	1
#nace 4 digit	4190	13.45	9	12.80	1	119
#nace 2 digit	4190	7.32	6	5.36	1	42
HHI nace - sales	3821	0.63	0.59	0.25	0.14	1
HHI nace – emp	3892	0.61	0.55	0.25	0.18	1

Table 8 lists the 20 firms in our sample with the highest share of subsidiaries in Asia-Pacific for R&D. High-tech industries related to electronic equipment, semiconductors, software and telecommunications equipment are the main industries present in this ranking.

Table 8. Top 20 EU firms with subsidiaries in Asia-Pacific

Firm	%AP	ICB
James Hardie Industries	76%	Construction & materials
Micronic Laser Systems	60%	Semiconductors
Ilog	50%	Software
FRIWO (ex CEAG)	50%	Telecommunications equipment
BE Semiconductor Industries	41%	Semiconductors
Anoto	40%	Computer hardware
AVEVA	40%	Software
EPCOS	39%	Electronic equipment
ASM International	39%	Semiconductors
Rio Tinto	38%	Mining
Aixtron	38%	Semiconductors
ASML	36%	Semiconductors
SAES Getters	36%	Electronic equipment
Oberthur Technologies	36%	Electronic equipment
Novozymes	35%	Biotechnology
Option	33%	Telecommunications equipment
Manz Automation	33%	Industrial machinery
Wavecom	33%	Telecommunications equipment
ARM	33%	Semiconductors
Tekla	33%	Software

[14] See Appendix A for more detailed statistics.

Interestingly, Table 9 shows a different industrial specialisation pattern for the subsidiaries present in North America. The most represented industries in the top 20 ranking of firms with subsidiaries in US-Canada are the biotechnology and pharmaceuticals industries.

Table 9. Top 20 EU firms with subsidiaries in US-Canada

Firm	%US	ICB
Transgene	100%	Biotechnology
Flamel Technologies	100%	Biotechnology
Clipper Windpower	100%	Electricity
Basler	100%	Electrical components & equipment
ExonHit Therapeutics	100%	Biotechnology
Exiqon	100%	Biotechnology
Reed Elsevier	69%	Media
Gas Turbine Efficiency	67%	Industrial machinery
ARC International	65%	Semiconductors
Glunz & Jensen	60%	Computer hardware
Sophos	57%	Software
nCipher	57%	Software
Merial	50%	Biotechnology
Reckitt Benckiser	50%	Household goods & home construction
NicOx	50%	Pharmaceuticals
Boliden	50%	Mining
MediGene	50%	Biotechnology
Antisoma	50%	Biotechnology
AGI Therapeutics	50%	Pharmaceuticals
Plethora Solutions	50%	Pharmaceuticals

4. Empirical findings

Table 10 gives the estimates from equation 3 when using the number of EU MNE subsidiaries as diversification indicators, as well as the number of countries and the number of industries where the firm is active. We use a logarithmic specification for these indicators[15]. Because the diversification indicators are not observed over time, but only for one year, a within or first difference transformation would drop one of the variables included in the interaction term. The following results are based on pooled-OLS estimates and we try to control for individual heterogeneity with sets of industry dummies and country dummies[16]. Time dummies are also included in the estimates. We do not correct variables for the double-counting of R&D in other inputs (i.e. labour and capital used for R&D activities) because of data limitation.

In order to control for the possible endogeneity of regressors, estimates including factors of production at time t- rather than factors at time t are reported in Appendix B. Note that since the information about the subsidiaries is only available in the cross-sectional dimension, it is not possible to use lagged periods as instruments for this variable. Rather, we considered as an additional robustness endogeneity test a regression with the output and the inputs dated in periods 2006-2008 (see Appendix C) and 2007-2008 (i.e., periods before the subsidiaries are

[15] A non-logarithmic specification does not affect the significance or signs of the diversification measurements.
[16] When the model in column 1 of Table 10 is estimated with fixed-effects, the elasticities of labour, physical capital and R&D capital are 0.72, 0.15 and 0.12, respectively.

observed are excluded). It follows that these additional results are not substantially different from the ones reported in Table 10.

Table 10. Estimates – Diversification indicators

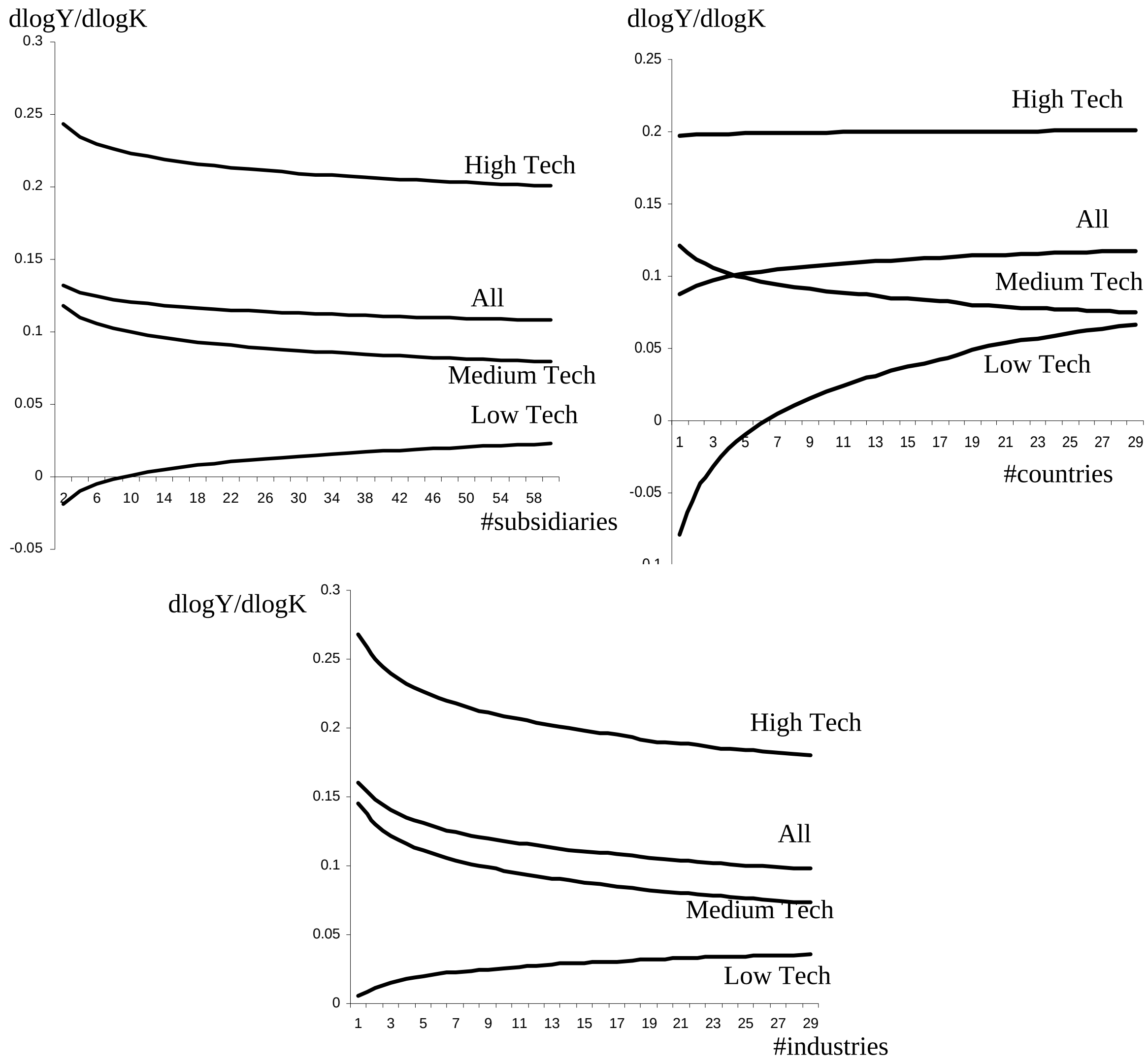
	(1)	(2)	(3)	(4)
log(*L*)	.65 (.02)***	.64 (.02)***	.65 (.02)***	.64 (.02)***
log(*C*)	.24 (.01)***	.23 (.01)***	.24 (.01)***	.24 (.01)***
log(*K*)	.11 (.01)***	.14 (.02)***	.09 (.02)***	.16 (.02)***
log(*K*) x log(#subs)		-.01 (.004)*		
log(#subsidiaries)		.04 (.02)**		
log(*K*) x log(#count)			.01 (.004)**	
log(#countries)			-.06 (.02)**	
log(*K*) x log(#indus)				-.02 (.01)***
log(#industries)				.10 (.03)***
R-sq	.95	.95	.95	.95
#obs	4230	4183	4159	4148

Notes: ***, **, * mean statistically significant at the 1%, 5%, 10% levels, respectively. Pooled OLS estimates including sets of industry (ICB classification), country and time dummies. Heteroskedastically-consistent standard errors in brackets. 'Industries' is the number of 4-digit Nace industries where the firm is active. Estimates conducted without observations above 99th percentile of diversification.

According to column 1 in Table 10, the output elasticities of labour, physical capital and R&D capital are respectively 0.65, 0.24 and 0.11. Columns 2 to 4 report estimates of the production function augmented with an interaction term between R&D capital and a diversification indicator. The coefficient of the interaction term is negative and significant when using the number of subsidiaries and the number of 4-digit Nace industries as diversification indicators (columns 2 and 4). However, it appears that the coefficient of the interaction between R&D capital and the number of countries covered by the firms is positive and significant (column 3).

Figure 1 represents the output elasticity of R&D capital with respect to the number of subsidiaries, countries and 4-digit Nace industries based on the results of columns 2 to 4 in Table 10. The pattern by technology level (i.e. sectors classified as High-, Medium- and Low-Tech, based on Table 2) is also reported. The curves are not linear as the coefficients are estimated using a logarithmic specification for the diversification measures. It appears that there is a positive relationship between the elasticity of R&D capital and the number of subsidiaries, countries and industries for firms in low-technology industries. The relationship between this elasticity and the number of subsidiaries and industries is negative for higher technology industries. The number of countries is negatively correlated with the elasticity of R&D capital for firms in medium-tech industries.

Figure 1 – Output elasticity of R&D capital by technology level



Note: logarithmic specification in the model estimated for the number of subsidiaries, countries and industries.

Table 11 reports the interaction term coefficients from Equation 3 when using the Herfindhal-Hirschman indexes given in section 3.2. Results show that a higher concentration of the MNEs across countries is related to lower R&D capital elasticity for firms in low-tech and medium-tech industries, while the effect is positive for firms in high-tech industries. A higher concentration across Nace industries seems to positively affect the R&D capital output elasticity for firms, especially those in high and low tech industries.

Table 11. Concentration index estimates

	Countries		Industries	
Firms	log(*K*) x HHI sales	log(*K*) x HHI emp	log(*K*) x HHI sales	log(*K*) x HHI emp
All	-0.02 (0.02)	-0.03 (0.02)	0.05 (0.02)***	-0.01 (0.02)
High tech	0.04 (0.02)*	0.04 (0.02)	0.1 (0.03)***	0.04 (0.03)
Medium tech	-0.03 (0.02)	-0.06 (0.02)***	-0.05 (0.03)	-0.03 (0.03)
Low tech	-0.15 (0.06)**	-0.11 (0.06)*	0.14 (0.06)**	0.01 (0.06)

Notes: ***, **, * mean statistically significant at the resp. 1%, 5%, 10% levels. Pooled- OLS estimations including sets of industry (ICB classification), country and time dummies. Heteroskedastically-consistent standard errors in brackets.

To analyse the relationship between the output elasticity of R&D capital and the location of the subsidiaries in Europe, US-Canada and Asia-Pacific, estimates of equation 3 are performed using the share of subsidiaries in these regions as diversification indicators, and the results can be seen in Table 12. As shown in column 2, the coefficient of the interaction term with the share of European subsidiaries is negative and significant, which indicates a strong negative correlation between the R&D capital elasticity and the percentage of European MNE subsidiaries located within Europe rather than outside. Column 3 reports a positive and significant coefficient for the interaction terms with the share of subsidiaries in North America, while column 4 indicates a positive but non significant coefficient for the interaction term with the share of subsidiaries in Asia-Pacific.

Table 12. Estimates for Shares of subsidiaries in main regions

	(1)	(2)	(3)	(4)
log(*L*)	.65 (.02)***	.64 (.02)***	.65 (.02)***	.64 (.02)***
log(*C*)	.24 (.01)***	.24 (.01)***	.24 (.01)***	.24 (.01)***
log(*K*)	.11 (.01)***	.20 (.02)***	.09 (.01)***	.11 (.01)***
log(*K*) x %EU subs		-.12 (.03)***		
%EU subs		.85 (.13)***		
log(*K*) x %US subs			.23 (.04)***	
%US subs			-1.4 (.21)***	
log(*K*) x %AP subs				.05 (.06)
%AP subs				-.66 (.28)**
R-sq	.95	.95	.95	.95
#obs	4230	4207	4207	4207

Notes: ***, **, * mean statistically significant at the 1%, 5%, 10% levels, respectively. Pooled OLS estimates including sets of industry (ICB classification), country and time dummies. Heteroskedastically-consistent standard errors in brackets. %EU subs, %US subs and %AP subs mean shares of subsidiaries in the EU27, US-Canada and Asia-Pacific regions, respectively.

Table 13 gives the coefficients of the interaction term by technology level. The coefficient is positive and significant for the interaction between the R&D capital and the share of subsidiaries in US-Canada for firms in the high, medium and low tech industries. The interaction with the share of EU subsidiaries is associated with a negative and significant coefficient for high and low tech sectors. The coefficient of the interaction term with the share of Asia Pacific subsidiaries appears to be positive and significant only for firms in low tech industries.

Table 13. Estimates for Shares of subsidiaries in main regions by technology level

Firms	log(*K*) x %EU subs	log(*K*) x %US subs	log(*K*) x %AP subs
All	-0.12 (0.03)***	0.23 (0.04)***	0.05 (0.06)
High tech	-0.07 (0.03)***	0.17 (0.04)***	-0.07 (0.08)
Medium tech	-0.001 (0.04)	0.13 (0.07)*	-0.01 (0.08)
Low tech	-0.39 (0.08)***	0.49 (0.15)***	0.63 (0.17)***

Notes: ***, **, * mean statistically significant at the 1%, 5%, 10% levels, respectively. Pooled OLS estimates including sets of industry (ICB classification), country and time dummies. Heteroskedastically-consistent standard errors in brackets.

5. Discussion and conclusions

This paper aims to assess the relationship between both industrial and global diversification of large European R&D MNEs and the productivity of their R&D activities. By estimating production functions including labour, physical capital and R&D capital, we find that the globalisation of EU MNEs is associated with a higher productivity for R&D capital, while industrial diversification appears to hinder R&D productivity. The R&D expenditure considered in this study represents about 80% of total European R&D. We propose an original approach to assess the effects of these two types of diversification based on the subsidiaries of the firms. This paper also provides recent estimates of output elasticities for large EU firms.

Our findings suggest that the benefits for R&D activities from European MNE industrial diversification strategies, i.e. economies of scope and new technological opportunities deployed in new directions, do not compensate for the loss of efficiency, which may be related to the greater complexity of corporate management. Furthermore, it supports the idea that divisional managers may favour less risky investments and may not optimally invest in R&D projects.

On the other hand, although coordination costs and information asymmetries are expected to arise from the globalisation of EU MNEs, we show that the geographic diversification benefits the R&D productivity of large EU firms. This may be explained by the strategic locations of the subsidiaries, whose aim is to make use of the knowledge and technological resources in centres of scientific excellence located worldwide.

This paper also investigates the strategic location of the subsidiaries in Europe, North America and Asia Pacific, which are the three main regions for EU firms to locate their subsidiaries. EU firms with the highest shares of subsidiaries in North America belong mainly to the biotechnology and pharmaceutical industries, while the MNEs mostly present in Asia Pacific are related to the electronic equipment, semiconductors, software and telecommunications equipment sectors. Figures in Appendix D seem to corroborate a positive link between a higher R&D intensity for EU firms and the share of subsidiaries in North

America or Asia-Pacific, while R&D intensity tends to decrease with the share of EU subsidiaries.

Regarding R&D productivity, we find that a higher share of subsidiaries in Europe decreases the R&D capital output elasticity, while the share of subsidiaries in North America positively affects the elasticity. The share of subsidiaries in Asia Pacific seems to increase this elasticity only for firms in low tech industries.

One issue in the empirical framework is the data limitation regarding subsidiaries only observed in a cross-sectional dimension. This prevents the use of within or first difference transformations for the production function to capture unobserved individual heterogeneity other than industry or country effects, which are taken into account in our estimates. Another concern is the causality in the relationship between R&D productivity and diversification. While there are theoretical reasons to explain that diversification may enhance or alter the productivity of R&D activities, one may also expect firms with a higher R&D productivity to adopt a diversification strategy.

These results have potentially important implications for competition policies and the EU 2020 strategy for jobs and smart, sustainable and inclusive growth recently adopted by the European Council[17].

As a main channel for industrial diversification is through mergers and acquisitions (M&A) (Porter, 1987), antitrust authorities may be careful regarding decisions allowing M&A, as these activities, besides increasing the market power of the merged entities, may also reduce their efficiency and economic performance.

While combining different companies (M&A) may allow them to develop new products more efficiently or reduce production or distribution costs, their increased efficiency means the market becomes more competitive and consumers benefit from higher-quality goods at fairer prices. However, some M&A may reduce competition in a market, usually by creating or strengthening a dominant player. This is likely to harm consumers through higher prices, reduced choice or less innovation.

To the extent that industrial diversification is initially mainly pursued through M&A, and that increased industrial diversification reduces the efficiency and economic performance of the merged entities (for instance, due to less innovation because divisional managers have lower incentives to engage in risky activities, and increased power and prestige through compensation arrangements), consumers may be harmed by reduced product choice and/or quality and eventually higher prices (with less efficient firms being forced at some point to increase their prices to compensate for the higher marginal costs resulting from these efficiency losses). Furthermore, as these effects may take some time to appear (dynamic efficiency - in this case - losses), they could affect the immediate decisions of the competitive authorities which would not take them into account, but rather base their decisions on the short term visible static efficiency gains of M&As.

Thus, as increased globalisation appears to have beneficial effects on large European R&D companies, this advocates increasing support for international S&T collaborations and

[17] http://ec.europa.eu/eu2020/pdf/council_conclusion_17_june_en.pdf

partnerships, and supports one of the recommendations proposed in the Innovation Union Communication: "The European Union's scientific cooperation with third countries must become a matter of common concern and contribute to the establishment of a level playing field (removing market access barriers, facilitating standardisation, IPR protection, access to procurement, etc). By 2011, the Commission will propose common EU/Member States S&T priorities as a basis for coordinated positions or joint initiatives vis-à-vis third countries, building on the work of the strategic forum for international cooperation. In the meantime, the EU and Member States should act in a concerted way when engaging in national (regional or local) S&T agreements and activities with third countries. The potential of 'umbrella' agreements between the EU and Member States with third countries will be explored."

An interesting extension of the work regarding industrial diversification may be to investigate the characteristics of the industries the MNEs are active in. We do not have information about the R&D activities conducted by the subsidiaries, but the industrial classification of the subsidiaries may give a clue about their role in the group. This approach would also be helpful in analysing the relationship between the strategies of vertical integration and the productivity of the firms.

To better understand the activities of European MNEs outside Europe, it may be worth having a closer look at the industrial diversification or concentration strategies in North America and Asia Pacific, and their impact on R&D activity productivity. Moreover, one could investigate the efficiency in these regions of the Home-Based Augmenting and Home-Based Exploiting R&D strategies for EU MNEs.

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Appendix A. Detailed descriptive statistics

Industry	#firms	#subsidiaries	av. subs. Turnover (mil. USD[18])	av. subs. employees
High tech	**385**	**38**	**199**	**436**
Biotechnology	52	7	28	119
Semiconductors	19	15	88	308
Pharmaceuticals	50	23	153	268
Telecommunications equipment	26	18	112	231
Software	71	21	23	112
Electronic office equipment	2	61	79	435
Electronic equipment	33	24	28	115
Leisure goods	9	59	154	248
Aerospace & defence	25	63	816	1686
Computer hardware	6	20	51	205
Automobiles & parts	40	91	718	1436
Electrical components & equipment	26	119	162	390
Computer services	26	38	193	404
Medium tech	**243**	**47**	**237**	**597**
Health care equipment & services	29	40	55	163
Commercial vehicles & trucks	15	34	291	709
Chemicals	42	70	222	336
Alternative energy	4	16	175	164
Industrial machinery	69	36	81	255
General industrials	20	64	482	1603
Household goods & home construction	22	44	409	994
Media	12	36	686	1022
Food producers	30	53	306	1036
Low tech	**207**	**86**	**1005**	**2583**
Banks	2	26	123	1028
Personal goods	16	82	139	369
Life insurance	1	5	1	0
Fixed line telecommunications	13	101	508	1424
Support services	25	46	179	835
Tobacco	2	383	382	1186
Internet	4	23	47	62
Other financials	11	76	1225	1589
Mobile telecommunications	4	20	1243	943
Oil equipment, services & distribution	4	119	86	164
Electricity	15	103	1725	2354
Construction & materials	26	89	306	910
Forestry & paper	6	64	542	1137
Mining	5	34	1027	2149
Industrial metals & mining	12	55	973	1422
Industrial transportation	12	120	1097	3686
Nonlife insurance	1	22	224	102
General retailers	13	125	764	1950
Oil & gas producers	9	129	2871	3841
Gas, water & multiutilities	8	99	1868	2732
Travel & leisure	9	101	203	1206
Beverages	4	54	1501	3812
Food & drug retailers	5	123	9776	43390
All	**835**	**53**	**410**	**1015**

[18] Amadeus provides data for subsidiaries only in US Dollars and not in Euros. This will not affect our econometric analysis as we are interested in the share of the sales across countries or industries.

Appendix A. Detailed descriptive statistics (continued)

Countries	#firms	#countries	HHI sales	HHI emp
High tech	**385**	**11**	**0.61**	**0.62**
Biotechnology	52	4	0.72	0.75
Semiconductors	19	7	0.71	0.66
Pharmaceuticals	50	10	0.68	0.63
Telecommunications equipment	26	8	0.72	0.74
Software	71	10	0.54	0.57
Electronic office equipment	2	22	0.32	0.30
Electronic equipment	33	11	0.52	0.58
Leisure goods	9	16	0.66	0.63
Aerospace & defence	25	9	0.64	0.63
Computer hardware	6	11	0.57	0.61
Automobiles & parts	40	18	0.54	0.57
Electrical components & equipment	26	18	0.51	0.50
Computer services	26	12	0.65	0.61
Medium tech	**243**	**14**	**0.56**	**0.58**
Health care equipment & services	29	15	0.50	0.53
Commercial vehicles & trucks	15	13	0.52	0.60
Chemicals	42	17	0.61	0.63
Alternative energy	4	5	0.69	0.67
Industrial machinery	69	14	0.53	0.55
General industrials	20	12	0.71	0.70
Household goods & home construction	22	17	0.48	0.52
Media	12	7	0.79	0.77
Food producers	30	16	0.52	0.47
Low tech	**207**	**16**	**0.65**	**0.64**
Banks	2	2	0.81	0.96
Personal goods	16	25	0.54	0.46
Life insurance	1	1	1.00	
Fixed line telecommunications	13	18	0.62	0.62
Support services	25	12	0.65	0.62
Tobacco	2	70	0.67	0.48
Internet	4	10	0.72	0.62
Other financials	11	15	0.69	0.52
Mobile telecommunications	4	10	0.78	0.86
Oil equipment, services & distribution	4	29	0.40	0.38
Electricity	15	10	0.76	0.75
Construction & materials	26	19	0.57	0.60
Forestry & paper	6	20	0.67	0.66
Mining	5	10	0.58	0.67
Industrial metals & mining	12	16	0.54	0.61
Industrial transportation	12	17	0.77	0.80
Nonlife insurance	1	2	1.00	1.00
General retailers	13	9	0.75	0.76
Oil & gas producers	9	23	0.47	0.56
Gas, water & multiutilities	8	12	0.75	0.68
Travel & leisure	9	20	0.81	0.73
Beverages	4	21	0.43	0.56
Food & drug retailers	5	9	0.88	0.85
All	**835**	**13**	**0.61**	**0.61**

Appendix A. Detailed descriptive statistics (continued)

Industry	#firms	#Nace 4 digit	#Nace 2 digit	HHI sales	HHI emp
High tech	**385**	**10**	**6**	**0.67**	**0.68**
Biotechnology	52	4	3	0.72	0.75
Semiconductors	19	7	5	0.71	0.66
Pharmaceuticals	50	7	4	0.68	0.63
Telecommunications equipment	26	8	5	0.72	0.74
Software	71	7	4	0.54	0.57
Electronic office equipment	2	20	10	0.32	0.30
Electronic equipment	33	10	6	0.52	0.58
Leisure goods	9	13	6	0.66	0.63
Aerospace & defence	25	19	11	0.64	0.63
Computer hardware	6	8	4	0.57	0.61
Automobiles & parts	40	19	10	0.54	0.57
Electrical components & equipment	26	19	9	0.51	0.50
Computer services	26	10	5	0.65	0.61
Medium tech	**243**	**14**	**7**	**0.59**	**0.58**
Health care equipment & services	29	11	6	0.50	0.53
Commercial vehicles & trucks	15	12	8	0.52	0.60
Chemicals	42	17	9	0.61	0.63
Alternative energy	4	7	6	0.69	0.67
Industrial machinery	69	13	7	0.53	0.55
General industrials	20	18	10	0.71	0.70
Household goods & home construction	22	13	8	0.48	0.52
Media	12	11	5	0.79	0.77
Food producers	30	17	8	0.52	0.47
Low tech	**207**	**18**	**9**	**0.62**	**0.58**
Banks	2	10	6	0.81	0.96
Personal goods	16	16	8	0.54	0.46
Life insurance	1	2	2	1.00	
Fixed line telecommunications	13	27	13	0.62	0.62
Support services	25	12	6	0.65	0.62
Tobacco	2	25	13	0.67	0.48
Internet	4	10	4	0.72	0.62
Other financials	11	15	9	0.69	0.52
Mobile telecommunications	4	8	6	0.78	0.86
Oil equipment, services & distribution	4	17	10	0.40	0.38
Electricity	15	19	11	0.76	0.75
Construction & materials	26	20	10	0.57	0.60
Forestry & paper	6	20	10	0.67	0.66
Mining	5	11	9	0.58	0.67
Industrial metals & mining	12	20	10	0.54	0.61
Industrial transportation	12	17	9	0.77	0.80
Nonlife insurance	1	9	6	1.00	1.00
General retailers	13	17	7	0.75	0.76
Oil & gas producers	9	35	19	0.47	0.56
Gas, water & multiutilities	8	34	16	0.75	0.68
Travel & leisure	9	20	10	0.81	0.73
Beverages	4	10	6	0.43	0.56
Food & drug retailers	5	17	9	0.88	0.85
All	**835**	**13**	**7**	**0.61**	**0.61**

Appendix A. Detailed descriptive statistics (continued)

Correlation[19]	ln(sales)	ln(labour)	ln(physical capital)	ln(R&D capital)	#subsidiari es	ln(#subs)	#countries	ln(#count.)	HHI countries - sales	HHI countries - emp	#nace 4 digit	#nace 2 digit	ln(#nace 4 dig)	ln(#nace 2 dig)	HHI nace - sales	HHI nace - emp
ln(sales)	1															
ln(labour)	0.93	1														
ln(physical capital)	0.92	0.87	1													
ln(R&D capital)	0.56	0.56	0.55	1												
#subsidiaries	0.50	0.53	0.46	0.38	1											
ln(#subs)	0.56	0.61	0.51	0.39	0.75	1										
#countries	0.42	0.47	0.39	0.45	0.75	0.74	1									
ln(#countries)	0.36	0.41	0.32	0.39	0.57	0.79	0.85	1								
HHI countries - sales	-0.13	-0.18	-0.11	-0.21	-0.30	-0.51	-0.56	-0.72	1							
HHI countries - emp	-0.11	-0.15	-0.08	-0.19	-0.30	-0.52	-0.56	-0.72	0.86	1						
#nace 4 digit	0.57	0.59	0.53	0.41	0.84	0.81	0.67	0.60	-0.33	-0.33	1					
#nace 2 digit	0.58	0.60	0.51	0.39	0.69	0.92	0.66	0.70	-0.44	-0.45	0.88	1				
ln(#nace 4 dig)	0.58	0.59	0.56	0.40	0.75	0.77	0.57	0.53	-0.27	-0.26	0.92	0.86	1			
ln(#nace 2 dig)	0.58	0.59	0.55	0.39	0.63	0.82	0.55	0.59	-0.33	-0.33	0.81	0.92	0.91	1		
HHI nace - sales	-0.18	-0.20	-0.16	-0.16	-0.30	-0.50	-0.33	-0.42	0.46	0.37	-0.47	-0.57	-0.52	-0.60	1	
HHI nace - emp	-0.32	-0.34	-0.30	-0.21	-0.36	-0.57	-0.38	-0.46	0.39	0.36	-0.48	-0.60	-0.52	-0.61	0.69	1

[19] Year 2008

Appendix B. Estimates using production factors with one lagged period.

	(1)	(2)	(3)	(4)
log(L_{t-1})	.66 (.02)***	.66 (.02)***	.67 (.02)***	.65 (.02)***
log(C_{t-1})	.24 (.01)***	.23 (.01)***	.24 (.01)***	.24 (.01)***
log(K_{t-1})	.09 (.01)***	.12 (.02)***	.07 (.02)***	.13 (.02)***
log(K_{t-1}) x log(#subs)		-.01 (.004)*		
log(#subsidiaries)		.04 (.02)**		
log(K_{t-1}) x log(#count)			.01 (.005)**	
log(#countries)			-.07 (.03)***	
log(K_{t-1}) x log(#indus)				-.01 (.01)**
log(#industries)				.08 (.03)**
R-sq	.95	.95	.95	.95
#obs	3486	3447	3468	3421

Notes: ***, **, * mean statistically significant at the 1%, 5%, 10% levels, respectively. Pooled OLS estimates including sets of industry (ICB classification), country and time dummies. Heteroskedastically-consistent standard errors in brackets. Industries is the number of 4-digit Nace industries where the firm is active.

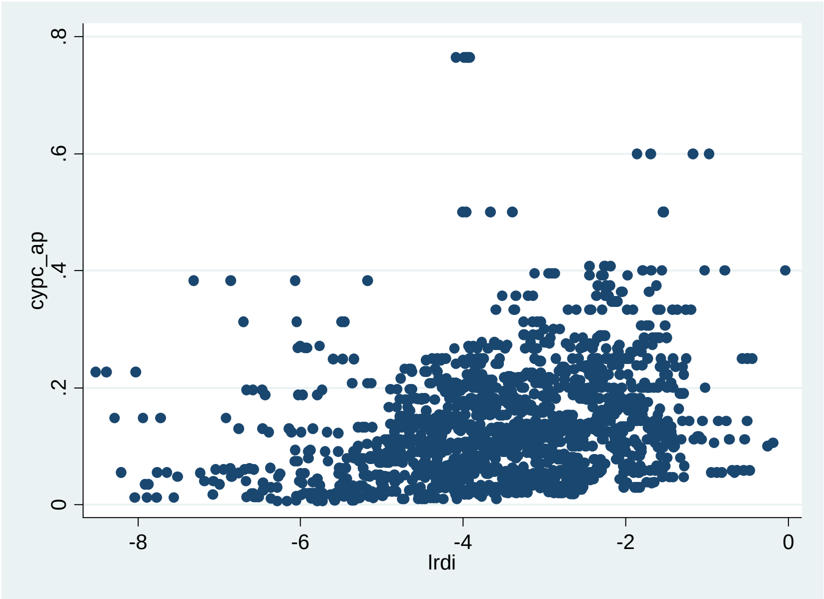
Appendix C. Estimates over 2006-2008.

	(1)	(2)	(3)	(4)
log(L_t)	.63 (.02)***	.63 (.02)***	.63 (.02)***	.61 (.02)***
log(C_t)	.25 (.02)***	.25 (.01)***	.26 (.02)***	.26 (.02)***
log(K_t)	.10 (.01)***	.11 (.02)***	.06 (.02)***	.14 (.03)***
log(K_t) x log(#subs)		-.003 (.004)		
log(#subsidiaries)		.03 (.02)		
log(K_t) x log(#count)			.02 (.01)**	
log(#countries)			-.09 (.04)***	
log(K_t) x log(#indus)				-.02 (.01)**
log(#industries)				.01 (.05)**
R-sq	.95	.95	.95	.94
#obs	2182	2161	2143	2136

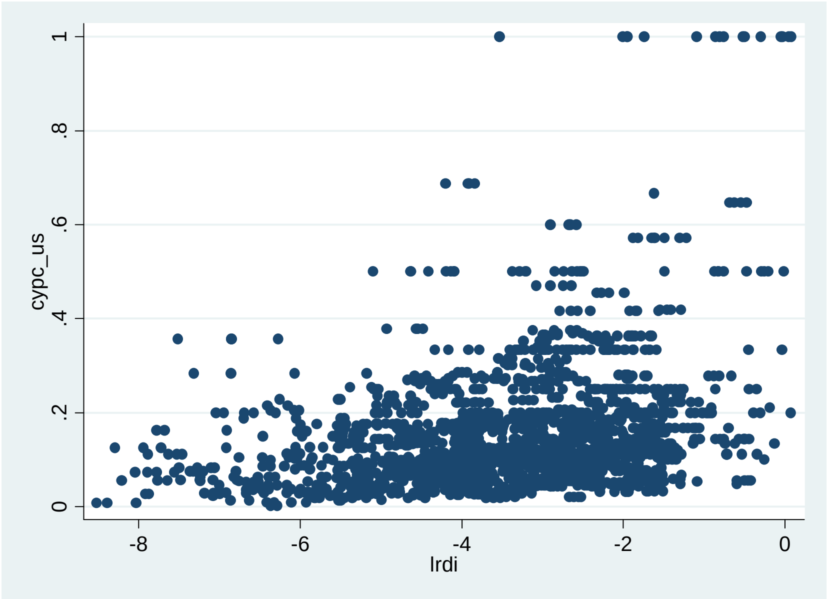
Notes: ***, **, * mean statistically significant at the 1%, 5%, 10% levels, respectively. Pooled OLS estimates including sets of industry (ICB classification), country and time dummies. Heteroskedastically-consistent standard errors in brackets. Industries is the number of 4-digit Nace industries where the firm is active.

Appendix D. R&D intensity and share of subsidiaries in the main geographic regions

%AP versus log(RD/S)



%US versus log(RD/S)



%EU versus log(RD/S)