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Doing R&D or not, that is the question (in a crisis…)

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Abstract

This study investigates how corporate R&D evolves in the light of the contemporary economic crisis. We investigate what empirical evidence from past downturns suggests, discuss the relevant literature and perform an empirical analysis of recent business survey data (collected during 2009). We question whether companies tend to spend more or less on R&D and innovation activities during periods of recession and analyse empirically what general patterns can be distinguished in this regard, given the particular circumstances of the most recent crisis.

Our findings suggest that company behaviour varies: some companies have reduced their innovation activities significantly, while others maintained them and a third group even increased their activities to reap the benefits in the expected upswing afterwards. Overall, we observe a deceleration of R&D and innovation activities in the light of the crisis, but the trend figures remain positive. Driven by the companies that reinforce their R&D and innovation efforts to thrive through the downturn and thus seek to gather the benefits in the upswing to come, the R&D and innovation landscape is likely to look different in the aftermath of the crisis.

These changes will inevitably affect policy intervention in the field of innovation and are a unique chance for the reorientation of policy measures. More profoundly, they could be at the roots of a new paradigm, departing from a transition from an industrial to a knowledge-based society.

JEL Classification: F01, G01, O33

Keywords: Corporate R&D investments, innovation activities, company strategy, economic crisis, R&D globalization

"European businesses are more reluctant to spend money on R&D activities in the financial crisis, while US businesses see this type of spending as crucial to maintain their competitiveness. European policy makers must improve spending conditions for businesses if they want Europe to retain its competitiveness. "

Source: Research Day: Europe issue 3226

1 Introduction

The turmoil in the global financial markets of 2008 and 2009 and the following economic crisis hit companies in all sectors around the globe like a tsunami. Billions of money got burnt almost overnight in the threat of a collapsing banking sector. The resulting shock waves on the 'real economy' led to substantial drops in production and trade worldwide, producing the most significant economic crisis the world has faced since World War II (European Commission, 2009a).

Although the recovery of some leading economic indicators and business figures for some is already the light at the end of the tunnel, the crisis is likely to persist for some time. Companies facing economic pressure often choose cost-reduction strategies and re-examine their R&D commitments and innovation strategies (Barrett et al, 2009). In the shorter term, lack of finance may cause stretched or reduced R&D budgets, leading to delays in new product development, slimmed down processes and activities and even stopped or cancelled R&D and innovation projects. These shifts of R&D strategies and innovation may also lead to substantial re-orientations with longer-term effects on the capacity for technological development for businesses as a whole. An example is when corporate R&D activities are concentrated on fewer core business areas, emerging technological sectors or specific markets only. On a wider scale, these ad hoc changes in the spending and behaviour of companies also affect the whole innovation system through technological clusters and university-industry links, which may suffer longer-term damage and may 'dry out' in terms of its financial and R&D-capacity. The crisis may even have an enduring impact on the way businesses R&D is performed in the future and therefore also on the perception of the importance of innovation and corporate R&D activities. Thus, the current financial and economic crisis may well be a fault line in the transition from an industrial to a knowledge-based society (Etzkowitz and Ranga, 2009). In addition, with the crisis placing important financial constraints to companies, it may have an impact on the internationalisation of R&D as cost competition becomes more important.

The present paper investigates the adjustments in corporate R&D and innovation strategies as a result of the current economic crisis using recent official statistics and survey data. We discuss how the crisis has affected corporate R&D and innovation activities in general, which adjustments of corporate strategies have already been made or are planned to be made. This approach is similar to Archibugi and Filippetti (2009), who analysed the impact of the crisis on innovation in Europe using data from the European Innovation Scoreboard (2009). However, it goes beyond that using much more recent and complete data from the biggest R&D investors and builds upon our earlier study on the impact of the global economic and financial downturn and on companies' R&D strategies (Voigt and Moncada-Paternò-Castello, 2009).

We look at corporate innovation activities by assessing their R&D investments. The underlying assumption is that – among a large variety of determinants of innovative performance – intramural R&D is key (Nelson, 2000; OECD, 2005). Empirically, we rely on the results of a recent survey on business R&D investment (hereinafter named the R&D Outlook survey), which represents about 18% of the R&D investment of the largest R&D corporations in the EU. That survey gathered information on company level R&D investment for the period 2005 to 2012, with 2009 to 2012 being expectations. Thus, our empirical analyses are based on a unique set of the most comprehensive data available to date. By assessing the impact of the crisis on the behaviour and innovation strategy of companies, we also intend to shed light on the longer-term techno-economic impact of the crisis, which may determine the R&D and innovation landscape afterwards.

We examine not only the impact of the crisis on R&D investment levels, but also the more general distinguishable patterns of company characteristics like company size, technology intensity, headquarter location or company age. The analysis also covers the impact on R&D investment levels in different world regions and produces new insight on geographic shifts in terms of R&D Investment, which is an important aspect as the effects on the different world regions are not homogeneous due to differences in local innovation systems and policies (Archibugi and Filippetti, 2009). Where there is evidence that the companies changed their technological emphasis or the way to achieve innovation, e.g. via shifts towards more collaborative R&D, this is indicated in the paper.

Methodologically, our empirical analysis relies on a quantitative assessment of companies' past, current and future planned innovation activities, which are approximated by the amount of past, present, and expected future R&D investment. Apart from descriptive statistics, we ran an econometric regression to control for non-response bias for the survey sample data and arising and examined certain company characteristics that may explain the observed R&D patterns over time, for instance company size, R&D intensity, the sector of activity and headquarter location.

The paper is structured as follows: section 2 provides a review of the relevant literature and focuses on the patterns and underlying mechanisms of corporate R&D and innovation activities in times of economic crisis. In section 3, we formulate the hypothesis and in section 4 describe the characteristics of the empirical data used. Section 5 provides descriptive statistics to illustrate how individual companies have adjusted their R&D activity during the crisis in order to provide the context for the results of our econometric analysis, which is presented in section 6. The paper finishes with conclusions in section 7.

2 Literature review: How is corporate R&D evolving in times of crisis and what are the driving mechanisms?

It is not a trivial matter for any company to cope with an economic crisis. The challenge is particularly relevant to those companies heavily relying on corporate R&D and innovation as engagement in these activities means longer-term commitments with uncertain results. In addition, the present economic crisis goes together with financial turmoil. The International Monetary Fund (IMF) pointed out that those crisis accompanied by financial crises tend to be "two to three times deeper and two to four times longer" than those that are not and lead to "negative GDP growth of 4.5%" (Rhodes and Stelter, 2008). This may suggest that the effect of GDP drops on R&D spending may be similarly severe and long-lasting. According to (Sainsbury, 2007; thus relying on OECD figures), spending on R&D and innovation is often one of the first things to be cut. In fact, Business Expenditure on R&D (BERD) across industrialised countries was scaled back in the recession of the 1990s in terms of decreasing as a proportion of GDP from 1990 to 1995. This rather dim picture at the macro-level is the result of changes in company behaviour due to the crisis. In the next two subsections, we summarise the literature concerning companies' adjustments in their R&D activities in times of crisis and what, in this regard, the general impact for R&D internationalisation may be.

2.1 What do companies do with their R&D in times of crisis?

At the company level, the economic literature shows the impact of an economic downturn on the dynamics of R&D investment to as a matter of dispute. Traditionally, investing in R&D has been seen as a typical anti-cyclical measure for companies, because the negative impact of a crisis on profitability forces them to search for higher productivity. Thus, in accordance with the Schumpeterian concept of 'creative destruction', a crisis provides opportunities, and many of these can be reaped by re-organising and up-skilling R&D activities. For example, R&D personnel in times of downturn tends to be subject to "labour hoarding", the best qualified scientists and engineers are kept on at the expense of lower skilled personnel (Soete, 2009). Further, opportunity costs in terms of foregone profits of reorganising manufacturing to R&D activities are lower in recessions than in expansions because the demand for directly productive activities (manufacturing) is lower (Stiglitz, 1993; Aghion and Saint-Paul, 1998). Even the likelihood of bankruptcy for firms that do not undertake a necessary reorganisation of their investments increases in recessions (Aghion and Saint-Paul, 1998). The same argument – that opportunity costs of achieving productivity growth are lower in recessions – also provides incentives for undertaking (additional) research during downturns (Aghion and Saint-Paul, 1998; Canton and Uhlig, 1999).

Despite many good arguments for R&D being anti-cyclical, the more common view in economic literature is that companies do not treat R&D differently compared to other activities, which means that R&D would be cyclical. In fact, implementing new ideas, particularly in case of seminal innovations, tends to be postponed in a recession, with companies waiting for the next upswing (Shleiffer, 1986; Francois and Lloyd-Ellis, 2003). However, there is as yet no consensus on Gerhard Mensch's so-called 'innovation acceleration hypothesis' (1975), whereby radical innovation is favoured in depressions out of a sense of despair (Clark, Freeman and Soete, 1981).

That the question whether R&D is cyclical or not has not been finally cleared may as well have to do with the different ways of reacting to a crisis at the company level. Companies may decide to cut R&D investment to reduce costs, but this implies the future risk of falling behind those competitors who continue innovating. They may also stick to their R&D and innovation investments or even increase them hoping to gain competitive advantage later-on. However, there are not only decisions about the level of R&D investment, it is also the way companies manage their R&D processes and interact with others, e.g. via collaboration or outsourcing. This is why there is a wide range of literature on the company-specific impact of a crisis on R&D. Saint Paul (1993), for example, found very little evidence of any pro- or counter-cyclical behaviour in R&D as the cash-intensive nature of R&D eventually offsets the opportunity cost effect. Figures for larger companies by Stephen (2004) suggest a counter-cyclical pattern of R&D as a share of total investment. The author also found R&D investment of SMEs to be sometimes anti-cyclical. For example, in times of low capacity utilisation, engineers devoted more time to product improvements instead of extending production capacity, which was the case in times of high capacity utilisation.

The access of companies to finance is a factor which became more difficult in the current crisis, given that it originated from a financial crisis. If companies can choose between shorter-term capital investment and longer-term R&D investment, innovation requires a company being able to rely on their shorter-term earnings plus borrowing alone to cover liquidity needs. Whenever the firm is hit by an adverse (idiosyncratic or aggregate) shock, its current earnings are reduced, and so is its ability to borrow for R&D. A shortening of supply due to capital markets in crisis further tightens companies' credit lines. In fact, even fast-growing companies operating in emerging markets currently have limited access to finance. In this regard, Aghion et al (2005, 2008) analysed the role of credit constraints on R&D investment and the findings suggest that R&D tends to be more pro-cyclical for companies facing tighter constraints on capital supply (i.e. many SMEs). In particular, R&D investment as a share of total investment was countercyclical in the absence of credit constraints, became more pro-cyclical as companies faced tighter credit constraints and these effects were only observed during downturns and in the presence of financial constraints. In other words: relative R&D investments plummeted during a recession, but did not increase proportionally during upturns. Furthermore, the level of R&D investment was lower in more credit-constrained companies and decrease further during crisis. Hence, the credit crunch caused by the financial crisis and the subsequent credit constraints may prevent R&D from being countercyclical, and thus amplify the business cycle, increase productivity growth volatility and hold back average productivity growth.

The crisis therefore adds to an already important risk for innovative and R&D performing firms of facing financial constraints and one may tend to expect significant R&D investment cuts across many sectors and countries. However, most R&D and innovation activities have a strategic and longer-term nature, making them a rather fixed factor of production (Arrow, 1962). And there is evidence that R&D investments are less subject to financial constraints than investments in physical capital (Harhoff, 1988; Bond, Harhoff and Van Reenen, 1999; Audretsch and Weigand, 1999; Mulkay et al., 2001; Audretsch and Weigand, 1999; Cincera, 2003). Due to the longer-term nature of running R&D projects and high adjustment costs for changing these, financial constraints tend to affect rather the decision to start new R&D activities rather than the year-to-year level of spending on ongoing R&D projects (Bond et al., 1999; Cincera, 2003). In other words, high adjustment costs for running R&D and innovation projects tend to make them robust against increasing financial constraints. However, this is less the case for firms in sectors that depend more heavily upon external finance, or that are characterized by a low degree of asset tangibility (Aghion et al. 2008). Despite financial constraints, recessions might offer opportunities for newcomers as they weaken the position of firms already present in the market and may thereby stimulate research by outside firms (Canton and Uhlig, 1999). And recessions do not affect companies and sectors alike. High-technology manufacturing, for instance, is far better-positioned compared to low-technology

manufacturing, which may be expected to fare particularly badly (NESTA, 2008, p. 13). In this regard, Stephan (2004) stressed that high-tech firms usually adjust their R&D expenditures less to the business cycle than do low- and medium-tech ones. This might explain why R&D expenditures are in fact less cyclical than those of tangible investments or sales and why R&D expenditure figures in the face of the current crisis.

The above observations point to a somewhat mixed picture of the relationship between the business cycle and R&D investment. While there are many arguments for pro-cyclical behaviour, anti-cyclical behaviour directs the attention to the fact that different companies react differently to an economic crisis. Overall it looks as if, at the firm level, there is a relation between R&D investment and company growth: R&D seems to be a good predictor of future growth especially in terms of profit and employment, but also sales, value added and cash flows, while no R&D or moderate R&D intensity predicts growing debt (Heshmati and Lööf, 2006).

Summing up, a more or less significant contraction of R&D activities in the light of the economic downturn is one way the crisis may affect R&D activities at the company level. Investment in R&D is increasingly seen as risk taking, and will not be for the timid (EurActive.com, 2008). When the perception of R&D changes and companies slow down their R&D activities, the appearance of new technologies, products, and services including new medicines could be at least delayed, and companies could turn their attention toward business innovations rather than technological ones. The downturn may reward companies that can find more effective ways to innovate, are more agile, incremental, customer-focused, and willing and able to adjust their strategies at the expense of technological innovation, which in turn can have a large cumulative impact on technological advancement and collaboration with the public sector (Mohandas, 2008). This may cause the financial crisis to have a knock-on effect on the public sector (especially higher education, universities, or public research infrastructures). One may however argue that these effects may take some time to come and are difficult to capture analytically due to the time lag in the corresponding empirical evidence. More pressing concerns may arise from the impact of the crisis on R&D internationalisation. The literature on this is summarised in the next section.

2.2 What may be the impact of the crisis for R&D internationalisation?

The internationalisation of R&D has been widely examined in the past two decades (see for example Dunning and Narula 1995, Brockhoff 1998, OECD 1998, Hatzichronoglou 2008, OECD 2010). Until the 1980ies, R&D internationalisation was rather uncommon as companies tended to centralise R&D in their home country. Afterwards, however, R&D internationalisation gained momentum and became an important driver of globalisation, with R&D expenditures of foreign affiliates growing many times faster than those of domestic companies (OECD 2008 and UNCTAD 2005).

As regards the more specific topic of the drivers for the internationalisation of MNEs R&D activities, two sets of forces are commonly distinguished (Dunning and Narula, 1995, and Kuemmerle, 1997):

- ⇨ 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.

There seems to be a shift from the home-base exploiting to the home-base augmenting R&D strategies as companies increasingly tap into knowledge and technological sources in centres of scientific excellence located worldwide in order to become more competitive at the global stage. The underlying location strategies combine multiple dimensions, comprising e.g. technological strengths of the countries with respect to those of the company (Patel and Vega, 1999; Le Bas and Sierra, 2002), institutional factors (e.g. public support to R&D, IPR systems, quality of technological infrastructures), or lowering costs of qualified research, especially in emerging countries (UNCTAD, 2005). 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)

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 ones. In addition, for more than 75 percent of the respondents, the R&D location decision was due to an expansion and in less than 30 percent relocation.

It is interesting to note that costs of R&D seem to play little role up to now in the R&D internationalisation business. This is supported by recent surveys showing that low labour costs of researchers were the least important of 12 location factors for R&D investment (European Commission (2009b), although they were more important for companies referring to a location which is not their home country. This may point to increasing importance of costs in R&D internationalisation, especially as emerging economies become more important

as host countries for R&D and producers of original R&D results. Emerging countries start to show up on the international patenting scene, and doing R&D in these countries may offer companies not only cost reduction, but also faster access to research talent and fast growing markets (UNCTAD 2005; OECD 2008). Especially China and India become bigger players on the international R&D stage (The Economist Intelligence Unit (2004), UNCTAD 2005, Cincera et al. 2010). As these countries develop, we may even see increased on-shoring, triggered by companies from China or India, which may step into the gap Western companies are opening up by cutting back their R&D and innovation activities[1].
Our analysis of the impact of the crisis on R&D investment also addresses whether the behaviour of companies in terms of location of R&D in these countries has changed.

3 Hypothesis and variables

The literature review on the impact of the crisis on firms' R&D strategy decisions and their adjustments in the light of a crisis, as presented in chapter 2, revealed a number of related hypotheses that shall be tested in the empirical part of this study. These hypotheses are listed in Table 1.

[1] Argument put forward by W. Gehrisch, Deputy Secretary General of the European Industrial Research Management Association [EIRMA], in Research Europe (11/12/2008).

Table 1: Hypotheses as regards firms R&D responses to the current crisis

	Hypotheses	Expected impact on R&D	Variable / proxy
H1	According to the literature it is controversially whether, in a given crisis, firms tend to increase or decrease their spending on R&D (counter-/pro-cyclical behaviour). Therefore we formulate two hypotheses in this regard:		Observed change of R&D investment
	H1a: firms spend in general more on R&D in a downturn.	+	
	H1b: firms spend in general less on R&D in a downturn.	–	
H2	Moreover, with regard to H1, we assume that there are some general patterns based on certain company characteristics, which can be distinguished. Hence, we formulate and test a set of H2x:		
H2A	Company size is positively linked to flat or increased investment in R&D in times of a crisis (counter-cyclical behaviour).[2]	0 / +	No. of employees
H2B	Firms with higher R&D intensity preserve their R&D activities also in a crisis (possibly increase it even further).	+	R&D/ net sales
H2C	Firms operating in a high tech sector (vs. medium & low tech) keep their spending on R&D at a high level (no decrease).[3]	+	Sector of activity
H2D	Firm age is linked directly to persistence of high R&D spending (i.e. young firms tend to decrease while mature firms keep their levels of R&D spending constant or even increase).[4]	+	Years of firm foundation
H2E	Profitability and high R&D spending remains positively linked also in times of a crisis		
H3	Finally we test, in geographic terms, where are the R&D budgets cut down and where are they expanded? In fact, is there a geographic shift observable? Firms located in the Euro-area preserve higher R&D spending in a crisis compared to those outside[5]	+ / 0	Firm headquarter location

Hypotheses H1a/b refer to the central question we would like to address in this study, i.e. do companies generally tend to spend more or less on R&D and innovation activities in the current economic crisis, (R&D and innovation activities approximated here with their R&D expenditures). This (as well as all other hypotheses) will be empirically tested based on the results of the R&D Outlook survey.

[2] In fact, firms of a certain size, however, have more financial resources at their disposal and are presumably better placed to deal with a liquidity squeeze that is likely to arise in a crisis. Company size is therefore assumed to be positively linked to the persistence of R&D activities in response to the current crisis (spending continued and/or increased). However there are examples of very large firms in some sectors that experienced notable difficulties due to the crisis. The banking as well as the automotive sector are two striking examples.

[3] In general, firms with a higher R&D intensity and/or those operating in high tech sectors are assumed to naturally face higher incentives to maintain or even expand their R&D activities during a crisis due to both the opportunity and adjustment cost arguments as discussed in section 2 (to be tested in terms of H2B and H2C).

[4] Hypothesis H2D will test whether older companies (proxy: years since formation) may take advantage of their reputation and therefore may face lower borrowing costs (Diamond, 1989); as it is likely to be the case for firms that benefit from high profitability rates (hypothesis H2E).

[5] According to the theory of optimal currency areas (Mundell, 1961), firms in the Euro area are assumed to be affected in a similar way (positively or negatively) in case of an exogenous shock (hypothesis H2F). In fact, access to the capital market for these firms should be easier and less costly due to lower transaction costs. Hence, we assume a positive link.

Given the answer to this question and given the fact that some firms will react in a counter-cyclical way as argued above, while others will inevitably reduce their R&D activities, it is moreover interesting to check a series of firm characteristics assumed to affect the individual company responses to the shock induced by the crisis. In this regard, the hypothesis H2A-E will be tested.

Another block of testing will be performed with regard to the observed trajectories of the geographic location of corporate R&D and innovation activities. We are thus interested in figuring out whether there are characteristic trend patterns and – if so – where R&D and innovation activities tend to be cut and where to be expanded. In this regard, for instance, we assumed that firms in Euro-countries prevail better as those based in non-Euro countries (H3). Yet, given the available data, we will perform further empirical investigations in order to outline spatial trend patterns in terms of R&D activities. The main characteristics of the data used for our empirical investigations are outlined in the following section.

4 Data

According to the fourth *Community Innovation Survey*[6], around one fifth of companies perform in-house R&D (EUROSTAT, 2008). The distribution of R&D investment between these companies is very concentrated. Indeed, the 2000 companies listed each year in the *EU Industrial R&D Investment Scoreboard* (hereafter referred as to the 'Scoreboard')[7], constitute around 80% of global business expenditures on R&D. Since 2005, the 1000 EU companies listed in the Scoreboard are asked in an annual survey[8] to state their expectations with respect to their R&D activities for the years to come (volume, structural changes, location, etc.). The response rate is between 10% and 15% (between 95 and 130 companies per year). However, there is little overlap among the samples from one year to the other, which is an obstacle for the construction of consistent time series.

In order to address the issue of past and expected future R&D investment trends and distributions in the light of the crisis, the R&D Outlook survey was conducted between April and August 2009. For that purpose, the 1000 EU companies of the 2008 Scoreboard were contacted via email and phone and asked to fill-in a short questionnaire (see Appendix C). For each participating company, the questionnaire contained the past data of the Scoreboards and eventual responses to previous surveys. In total, 90 firms have answered to at least one question, namely the one on the 2007/2008 investment in R&D. These 90 responding companies from the EU represent about one fifth of EU R&D investment of the 2008 Scoreboard, a considerable share (see Table 3). For a subsample of firms, the time series comprise past and prospective data. The longest series go from year of reference 2005 to 2012. This time series concerns 51 firms that are representative of 10.8% of the total R&D carried out by the 1000 EU companies of the 2008 Scoreboard.

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[6] The Community Innovation Survey (CIS) is a survey of innovation activity in enterprises covering EU Member States, candidate countries, Iceland and Norway. The data are collected on a two-yearly basis (from 2004 onwards). The CIS is based on the Oslo Manual (2nd edition, 1997), which gives methodological guidelines and defines the concept of innovation, and on Commission Regulation No 1450/2004, see: http://epp.eurostat.ec.europa.eu/portal/page/portal/microdata/cis.

[7] Since its first edition, released in 2004, the Scoreboard includes data on R&D investments along with other economic and financial data from the last four financial years. Such data are taken from companies' publicly available audited accounts. For every year, the Scoreboard reports these figures for top R&D investors in the world (1,000 EU and 1,000 non-EU companies), whose R&D investment accounts for about 80% of global business expenditures on R&D. For further information, see: http://iri.jrc.ec.europa.eu/research/scoreboard.htm.

[8] The EU annual Survey on R&D Investment Business Trends is part of the Industrial Research Investment Monitoring (IRIM) initiative and accompanies the EU Industrial R&D Investment Scoreboard. The activity is jointly carried out by DG RTD C and JRC-IPTS. The questionnaire is sent to the 1,000 EU companies which have appeared in the Scoreboard of the previous year and to the respondents of past surveys. For further information, see: http://iri.jrc.ec.europa.eu/research/survey.htm

5 Findings: Descriptive analyses

Preliminary findings on the three hypotheses addressed in Section 3 can be found through descriptive analyses. Referring to the first one – hypothesis H1: whether companies spend more or less on R&D in a downturn – table 2 below illustrates a sharp drop of R&D investment from 2008 to 2009 (negative annual growth rate of 3.7%), which contrasts with the high increase of the previous period (i.e. annual growth rate of 10.2% from 2007 to 2008). Moreover, this drop in R&D investments appears to be limited in time as the forecasts based on a subsample of 51 firms for the years 2009 to 2012 indicate increasing R&D investment (annual growth rates of 4% from 2009 to 2010 to 6.3% in 2011-2012).

In fact, evidence from the survey results suggests that, in average, firms tend to cut down their R&D and innovation activities in a crisis, but – after having complied with the first shock – increase their R&D expenditures again (i.e. support to the 'somewhat mixed picture of the relationship between business cycle and R&D investment' as outlined above in Section 2). Hence, the first impact of the crisis manifested by a cut in R&D and innovation spending is not assumed to be long lasting; but is expected to be reversed in the years thereafter. Actually, there even seems to be an expectation of an over-proportional increase in terms of R&D for the years to come (after 2009), which supports the hypothesis of a counter-cyclical relation of R&D as argued before. If so, there is also good reason to believe in the outlined relation between R&D investment and company growth with R&D being a good predictor of future profit and employment growth.

The above outlined general patterns in terms of the R&D trend are confirmed by the 2009 Scoreboard (for the largest EU companies), which shows a lower R&D investment growth than in the past. In addition, a further contraction of R&D investment is anticipated according to the latest EU annual survey on R&D investment business trends[9].

Table 2: Annual growth rate of R&D investments (90 respondents)

			Annual growth rate of R&D investments (ΔR)						
Period[a]	# obs	representativeness in 2008[b]	ΔR06[c]	ΔR07	ΔR08	ΔR09	ΔR10	ΔR11	ΔR12
2005-2012	51	10.80	0.019	0.002	0.102	-0.037	0.040	0.057	0.063
2005-2009	75	12.03	0.029	0.002	0.098	-0.029			
2007-2009	81	12.24			0.093	-0.029			
2007-2008	90	18.22			0.107				

Notes: a) Period over which R&D investments are available for each year;
b) Representativeness of subsamples of firms with respect to the 1000 EU companies of the 2008 Scoreboard.

As regards hypothesis H2: general patterns in terms of company characteristics, some peculiarities of the sample companies have to be outlined. In terms of size, while the companies in the sample are bigger than the average company in the 2008 Scoreboard,[10] the statistical test in Table B3 in Appendix B indicates that their R&D investment growth in the past has been similar and highly correlated to the rates observed in past Scoreboards. Furthermore, we observe many similarities with respect to the trends in past R&D investment distributions of the sample based on the R&D Outlook survey compared to those of the

[9] This survey was conducted at the end of 2009 / beginning of 2010 (see the 2009 EU Survey on R&D investment business trends for more details).

[10] The statistical tests reported in Tables B1 to B2 in Appendix B show that, in terms of R&D in 2007 and 2008, the average firm in the sample is larger than the average firm in the Scoreboard. In other words, larger firms in terms of their R&D investment volumes show a higher propensity to participate to the R&D Outlook survey.

annual survey.[11] In addition, simulations with different overlaps of years among different subsets of the sample and scenarios for those companies, which revealed above average variations in the figures stated, showed the sample to be robust. Overall, this suggests that the responses to the R&D Outlook survey provide a good indication of the trends in R&D investment and R&D investment distribution.

In terms of sectoral distribution, as it can be seen in Table 3, the sample is representative of the 10 biggest sectors in the Scoreboard, but with a significantly higher share of automobiles & parts, aerospace & defence and industrial engineering companies. On the other hand, R&D investments in the pharmaceuticals & biotechnology, technology hardware & equipment, electronic & electrical equipment, and software & computer services are under-represented compared to the 2008 Scoreboard.

Table 3: R&D investment sectoral distribution in the *2008 Scoreboard* and in the *R&D Outlook survey*

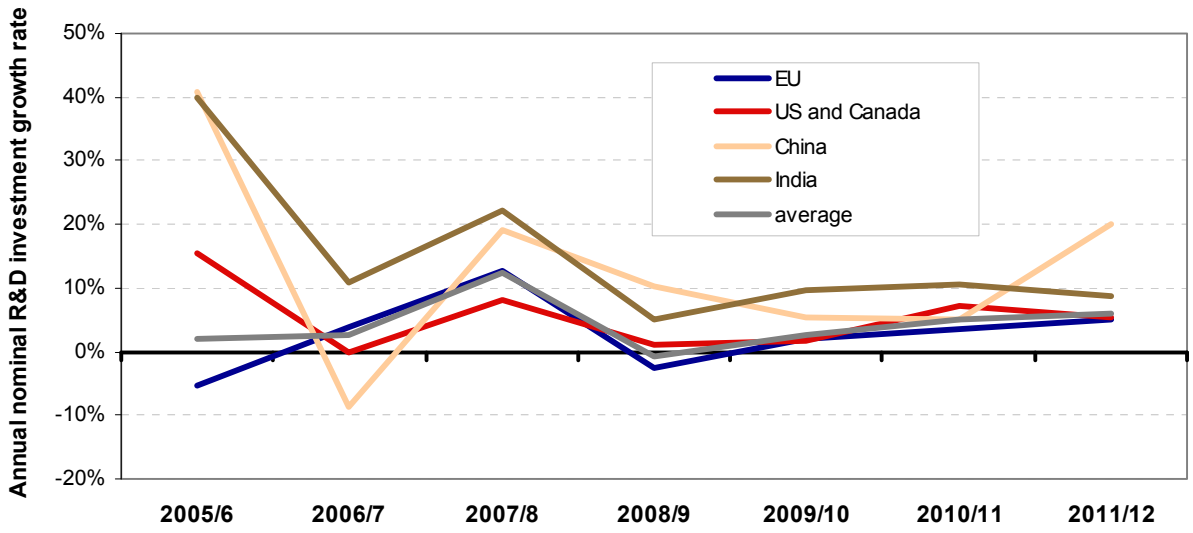
Sectors	R&D investment share of the total Scoreboard R&D	R&D investment share of the total Survey R&D
Automobiles & parts	22.8%	38.8%
Pharmaceuticals & Biotechnology	16.6%	10.7%
Technology Hardware & Equipment	13.4%	0.9%
Aerospace & defence	6.4%	9.3%
Chemicals	5.6%	7.3%
Electronic & Electrical Equipment	4.8%	1.8%
Industrial Engineering	4.7%	9.3%
Software & Computer Services	3.7%	0.7%
Fixed line telecommunications	3.4%	2.7%
Banks	2.2%	2.0%
Main 10 sectors	83.6%	83.5%
Other 29 sectors	16.4%	16.5%
Total 39 sectors	100.0%	100.0%

Descriptive statistics can then serve to tackle hypothesis H3 and thus help illustrating potential geographic trend patterns. In this regard, Figures 1 and 2 illustrate the annual growth rate of R&D investments for each year over the period 2005 – 2012 across four macro regions in the world: the EU, Northern America[12], China, and India. With respect to the largest R&D investors in the EU, there is indeed some evidence suggesting a geographic shift in terms of the distribution of R&D.

[11] The EU annual Survey on R&D Investment Business Trends. See European Commission (2009b).

[12] Canada and US.

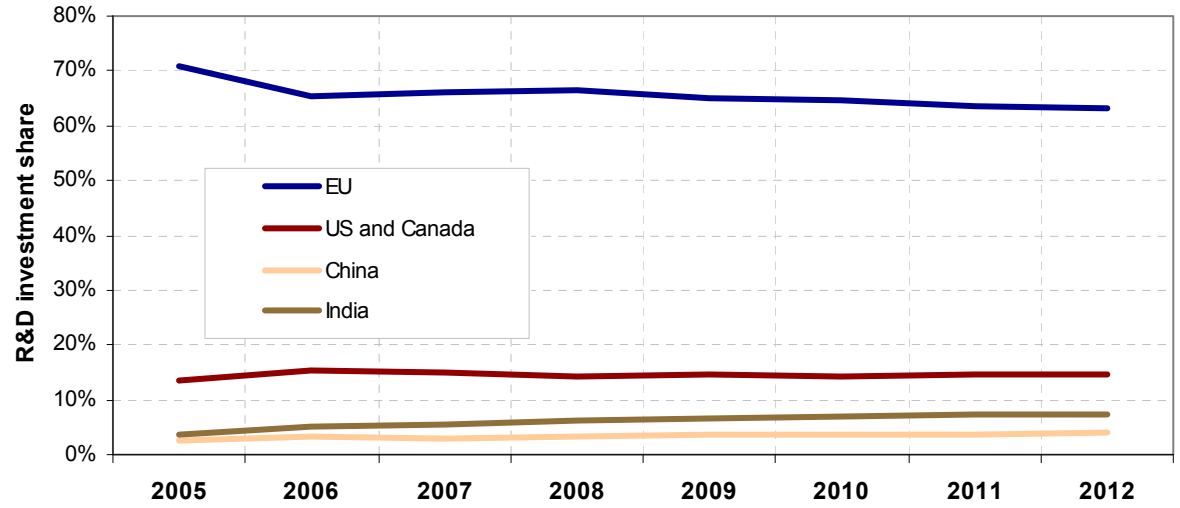
Figure 1: Annual growth rate of R&D investments in the main regions in the world



Source: Based on the R&D Outlook survey for 51 companies with complete time series for 2005-12.

Figure 1 shows that annual growth rates of corporate R&D in China and India are in a much less spectacular range than in the past; i.e. firms are expecting rates more similar to the EU or US in the future. Nevertheless, the respondents to the R&D Outlook survey however expect a growth differential to remain. Although this growth differential (with higher R&D investment growth outside the EU than inside) appears to decrease as it can be seen in Figure 2, the share of R&D investment in the EU is further eroding, although less quickly than in the China/India boom years.

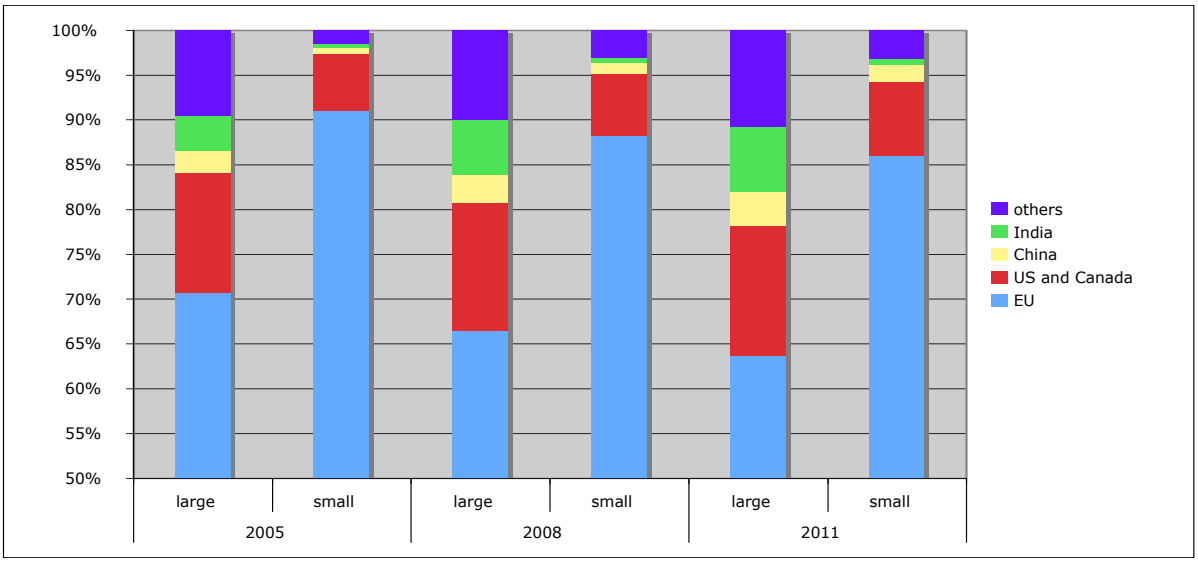
Figure 2: R&D investment shares across main regions in the world



Source: Based on the R&D Outlook survey for 51 companies with complete time series for 2005-12.

Figure 3 illustrates some differences in terms of internationalisation of small vs. large companies. In fact, larger companies, with more than € 50 million R&D investment, appear to distribute their R&D activities geographically to a much higher degree than the smaller firms in the sample. For the former, the share of R&D investment in the EU is 20% lower than with regard to the smaller firms. Yet for both subsamples (larger and smaller firms), the share of R&D investment in the EU is expected to decrease.

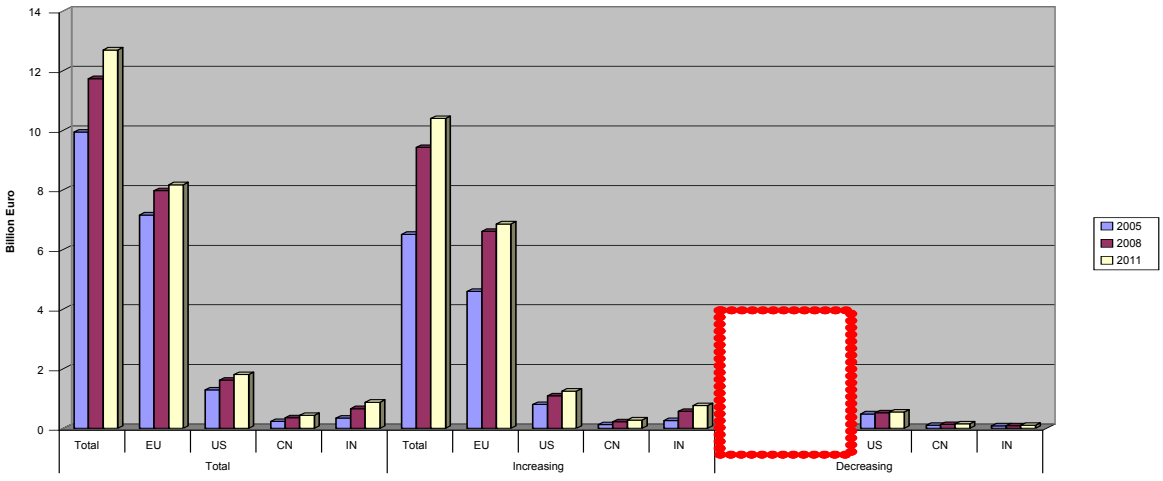
Figure 3: R&D investment shares across world macro regions – large vs. 'small' corporations



Source: Own calculations based on the quantitative survey for 19 companies with R&D above € 50 million with complete time series for 2005-12 (large corporations) vs. 32 companies with R&D below € 50 million with complete time series for 2005-12 ('small' corporations).

Examining the patterns of internationalisation of R&D further, Figure 4 illustrates both the absolute R&D value and its geographical distribution for the years 2005, 2008 and 2011. Thus, Figure 4 is based on an alternative sub-sample of 57 responding firms (representing two thirds of total observations and half of the R&D investment of all respondents in the R&D Outlook survey in 2008). Firms in this subsample show an overall increase of R&D in the past as well as in their predictions for 2011. This is true for all geographical areas, with India being apparently more attractive than China. Among these firms, however, we observe two general patterns: those increasing their R&D over the period 2005 – 2011 have done so predominantly within the EU and, in relative terms, also in India. Rising figures are confirmed for these companies also with regard to the US and China, though they appear less significant.

Figure 4: R&D investment in macro regions – firms with increasing / decreasing R&D spending

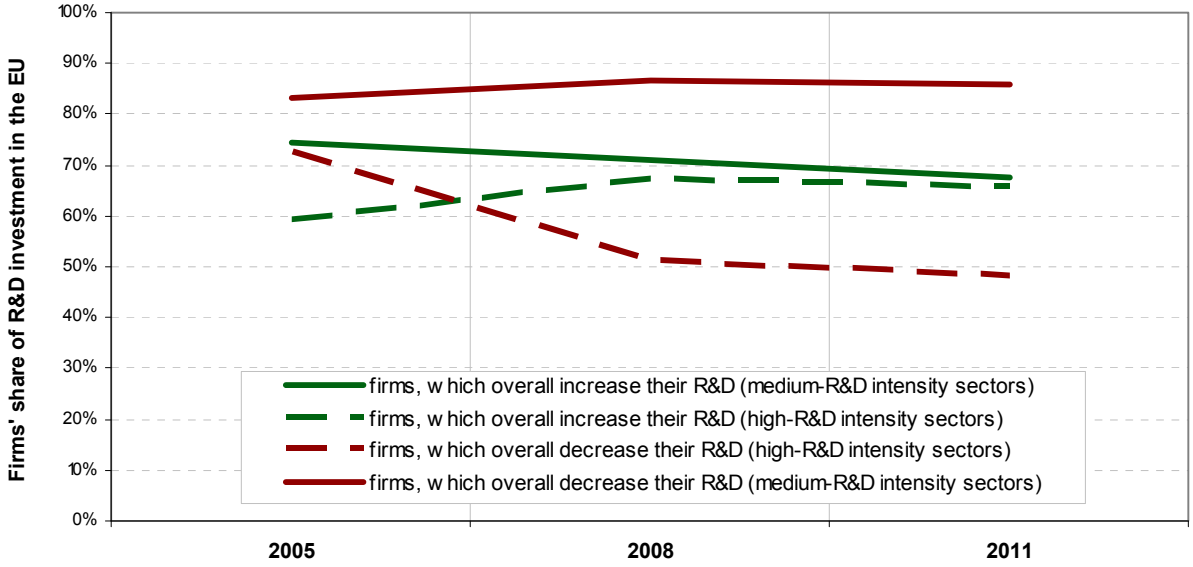


Source: Based on the R&D Outlook survey for 51 companies with complete time series for 2005-12.

On the other side, those firms decreasing their R&D investment between 2005 and 2008 have done so exclusively in the EU, while their actual and predicted R&D investment in the other three areas remains stable or is even slightly increasing. In other words, if a European company is about to expand its overall R&D activities, it is likely to increase its R&D investment within the EU, too. If with regard to a certain company a general tendency of decreasing R&D investments is prevailing, the investments in the EU are likely to be cut first. The underlying reasons for this may lie in the way the companies respond to the crisis. In fact, the outlined company strategy of relocating R&D from the EU to other areas might be a reduction of R&D activities in general (overall contraction) or subject to cost reduction in the light of a crisis. Given the latter, firms would tend to keep their R&D commitment outside the EU in order to exploit advantages there (access to technology and key markets, outsourcing / cost reduction, especially in China and India). Therefore, these advantages might be considered as more important in a "defensive" competitive strategy leading to R&D cuts in Europe. In turn, if firms wish to expand their overall R&D activities they tend to do that especially where they are already strong. And since all companies in the sample are EU companies, it is not surprising to see in the data that the majority of such an increase stays in the EU.

A further look at the R&D investment trends and expectations in the different regions is provides insights concerning underlying sectoral dynamics. Figure 5 reveals that those companies operating in high R&D intensity sectors and planning to increase their R&D between 2005 and 2011 expect the share of R&D investment in the EU to increase slightly, mainly through reducing the share of their R&D investments in the US. Those companies with decreasing R&D spending expect their EU share to drop considerably, doubling their share in the US, and tripling it in China and India.

Figure 5: Corporate R&D investment trajectories and its geographical emphasis
(firms grouped per R&D intensity / industries)



Source: Based on the R&D Outlook survey for 51 companies with complete time series for 2005-12.

In turn, with regard to companies in the medium R&D intensity sectors, for those increasing R&D investment, the EU share drops a little, basically due to a shift towards China and India. For those with decreasing overall R&D spending, the EU share is expected to increase slightly through a shift away from the US towards the EU (with some increases also in China and India). In fact, this is the exact opposite trend pattern as outlined above in terms of high R&D-intensity companies. Moreover, although these observations are based on a relatively

small sample, they illustrate that the sectoral dimension of the geographical shifts of R&D investment should not be under-estimated and therefore deserve further analytical attention.

6 Econometric analysis

The qualitative analysis presented in the previous section has served to illustrate how individual companies have adjusted their R&D activities in times of crises. In this section, we report the result of the econometric analysis. With respect to the pure descriptive analysis, a main advantage of the econometric one[13] rests in the possibility to control for the potential selection biases arising from the firms that did not answer to the survey[14]. This will occur when some characteristics of the firms that responded to the survey, for instance company size, are different then the corresponding ones of the full sample surveyed, i.e. in our case the EU 1000 companies of the R&D Scoreboard. The next sub-section analyses the characteristics which explain why firms are more likely to answer to the R&D outlook survey.

6.1. Sample selection tests

Table 4 reports the results of a probit regression model that examines the determinants affecting the probability to answer to the R&D Outlook survey. In fact, firms with a higher R&D intensity tend to have a higher probability to participate in the survey. This relationship is however not linear. Indeed, the positive and significant estimated coefficient associated with the square of the R&D intensity variable rather indicates a 'U-shaped' relation in this regard, suggesting that the firms that responded most to the survey are the ones characterised by a small or a high R&D intensity (not in-between).

In terms of company size (number of employees), a non linear inverted 'U-shape' relationship was observed. It appeared that the smallest and largest Scoreboard companies are less likely to participate in the survey, with a general tendency of having more of the bigger than of the smaller companies in the sample[15].

[13] Thanks to the method developed by Heckman (1979).
[14] See Cincera et al. (2010) for a more detailed discussion.
[15] Note that this finding confirms the results of the statistical tests reported in Tables B1 and B2 in appendix B which we discussed in Section 3.

Table 4: Probability to answer to the R&D Outlook survey

Explanatory variable	Estimated coefficient	s.e.			Estimated coefficient	s.e.	
Constant	-5.280	(1.738)	*				
R&D intensity 2008	0.010	(0.005)	**	Chemicals	0.078	(0.397)	
R&D intensity 2008 (square)	0.000	(0.000)	**	Construction	-1.036	(0.551)	***
Size in 2008	0.787	(0.367)	**	Electrical equipment	-0.316	(0.485)	
Size in 2008 (square)	-0.035	(0.020)	***	Electricity, Gas & water	-0.448	(0.507)	
Belgium	0.406	(0.425)		Electronic equipment	-0.200	(0.437)	
Denmark	-0.280	(0.469)		Financials	-0.954	(0.445)	**
Finland	0.373	(0.394)		Food	-0.302	(0.441)	
France	-0.321	(0.400)		General industrials	-0.300	(0.458)	
Germany	-0.005	(0.356)		Health	-0.609	(0.572)	
Italy	0.628	(0.390)		Household goods	-0.887	(0.463)	**
Slovenia	1.340	(0.823)		Industrial machinery	-0.508	(0.397)	
Spain	0.801	(0.460)	***	Media	-0.608	(0.443)	
Sweden	-0.383	(0.467)		Oil & gas	-0.081	(0.493)	
The Netherlands	0.406	(0.417)		Pharmaceuticals	-0.011	(0.405)	
UK	-0.115	(0.365)		Semiconductors	-0.212	(0.525)	
Automobiles & parts	-0.546	(0.403)		Software	-0.124	(0.419)	
Basic resources	0.146	(0.439)		Telecommunication	-0.584	(0.503)	
Biotechnology	-0.737	(0.455)		Transport	-0.210	(0.532)	
Number of observation	863						
Log-likelihood	-210.898						
LR-Chi²	75.660						
Pseudo R²	0.140						
Models' predictive power	91.87%						

Notes: s.e. = robust standard errors ; * (respectively **, ***) statistically significant at the 1% (respectively 5 and 10%) levels; Control groups: Austria and aerospace and defence.

This is also supported by the finding that firms operating in industry sectors that are more severely hit by the crisis were found to be less likely to participate in the survey, namely companies belonging to biotechnology sector, construction, financial and household goods.

6.2 Determinants of corporate R&D growth for the period 2005-2012

Table 5 illustrates the main determinants explaining the R&D growth rate of firms over the period considered, i.e. average growth rate of R&D expenditures over the 2005-2008 sub-period to average expected R&D expenditures over the 2009-2012 one. It is thus referring to the block of hypotheses H2 as outlined above.

Evidence suggests that firms with a large volume of R&D activity (cfr. hypothesis H2A) and (at the margin from a statistical point of view) firms with a high R&D intensity (cfr. hypothesis H2B) tend to decrease their R&D investments over the period considered. This negative impact of R&D intensity on the expected R&D growth contradicts the a priori expected positive relationship between these two variables due the opportunity and adjustment cost arguments discussed in Section 2.

More fundamentally, in terms of the EU R&D intensity gap vis-à-vis the US; these results are daunting for the EU for two reasons. First, the R&D gap is not likely to reduce over the period investigated, i.e. 2005-2012, as the two types of companies that decrease the most their R&D investments in the EU are the largest and the most R&D intensive ones. In addition, as we discussed in the previous section, companies operating in high R&D intensity sectors and which decrease R&D are the ones that anticipate their EU share to drop considerably, doubling their share in the US, and tripling it in China and India.

However, the conclusion as regards the relationship between firms' size and R&D investment needs to be qualified. Indeed, a 'U-shaped' relationship between size and R&D is detected. Hence, given the sample of companies, in the current economic crisis, both the largest and even more so the smallest firms are increasing the resources allocated to research.

This finding confirms previous studies that found a U-shaped relationship between innovation and firm size (e.g. Gellman Research Associates, 1976; Acs and Audretsch, 1981; Veugelers, 1995, the 'Pilot Study of the Belgian Innovation System' by Capron et al. (1998). Our analysis shows that this U-shaped relationship remains in times of crisis.

Table 5: Factors explaining R&D growth rate (average 2005 – 2008 to average 2009 – 2012)

Explanatory variable	Estimated coefficient	s.e.			Estimated coefficient	s.e.	
Constant	21.202	7.271	*				
R&D intensity 2008	-0.128	0.074	***	Biotechnology	-30.229	64.057	
R&D intensity 2008 (square)	0.001	0.001		Chemicals	-2.079	0.348	*
Size in 2008	-3.482	1.471	**	Construction	-2.545	0.625	*
Size in 2008 (square)	0.166	0.075	**	Electrical equip	-1.886	0.582	*
Belgium	0.150	0.851		Electronic equip	-2.338	0.466	*
Denmark	-0.571	0.760		Financials	-0.987	0.278	*
Finland	-0.356	0.399		Gen. industrials	-1.908	0.495	*
France	-3.141	0.853	*	Health	-2.177	0.465	*
Germany	-0.289	0.409		Household goods	0.198	0.594	
Italy	-1.100	0.930		Ind. machinery	-2.331	0.489	*
Slovenia	-0.834	0.870		Media	-1.556	0.460	*
Spain	-0.156	0.543		Oil & gas	-2.357	0.533	*
Sweden	-0.393	0.411		Pharmaceuticals	-0.633	0.818	
The Netherlands	-1.143	0.606	***	Semiconductors	-0.874	0.755	
UK	-0.686	0.564		Software	0.164	1.230	
Automobiles & parts	-2.200	0.826	**	Telecom.	-2.985	0.788	*
Basic resources	-2.365	0.635	*	Transport	-2.144	0.720	*
Number of observations	49						
R^2	0.856						

Notes: s.e. = robust standard errors; * (respectively **, ***) statistically significant at the 1% (respectively 5 and 10%) levels; Control groups: Austria and aerospace and defence.

At the macro level, with the exception of France and the Netherlands, no particular trend seems to emerge in any EU Member states. Indeed, except for the two countries, the crisis appears to affect all European economies alike.

In terms of industry and services sectors, for a majority of sectors a decrease of R&D expenditures predominates over 2005-2012, for instance in automobiles & parts, basic resources, chemicals, construction, electrical and electronic equipment, financials, general industrials, health, industrial machinery, media, oil & gas, telecommunication and transport. Interestingly, with the exception of electronic and telecommunication equipments, all these sectors are classified as medium or low tech industries. This result again mitigates the conclusion as regards the EU R&D intensity gap that firms operating in low and medium tech sectors (as compared to high-tech ones) are not necessarily the ones expected to increase at most their R&D budget in the near future (cfr. hypothesis H2C).

Table 6 below reports some further results widely confirming the evidence as discussed with regard to the descriptive statistics; such as firms' R&D intensity affecting negatively R&D growth rates while between firm size and R&D growth rate emerges a 'U-shaped' relationship. From Column 3 and 4 in Table 6 can be seen that the age of the firms does not appear to have any particular influence on the probability to increase (or not) R&D expenditures (cfr. hypothesis H2D).[16] The same conclusion holds for the firms' share of the R&D performed within the EU as well as concerning the expectations of changes of these shares over the period analysed (cfr. hypothesis H3). Yet, this last finding does not confirm the conclusions based on Figure 4, where it was found that firms increasing their R&D over the period 2005 – 2011 were likely to do so predominantly within the EU.

Furthermore, firms located in EU Member States which are not belonging to Euro zone do not appear to increase relatively more their R&D investments over the period considered (benchmarked to those that have headquarter within the Euro zone; cfr. hypothesis H2F). Finally, based on an inclusion of dummy variables controlling for the corresponding level of R&D intensity in industry and services sectors, we can conclude that those firms that operate in medium low R&D intensive sectors systematically have lower increases of their R&D as compared to the high R&D intensive control group (cfr. hypothesis H2C).

[16] The age of the firms is calculated as the difference between the age of the creation of the firm and the current year. See Cincera and Veugelers (2010) for more details about the way this variable is constructed and the sources for collecting this information.

Table 6: Company characteristics determining corporate R&D investment growth rate (average 2005 – 2008 to average 2009 – 2012)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Constant	21.202 **	13.638	20.300 ***	28.951 *	24.691 *	20.781 **	20.516 **	20.339 **	19.763 **
	(7.271)	(14.889)	(9.697)	(4.819)	(5.636)	(6.927)	(7.003)	(7.777)	(7.466)
R&D intensity in 2008	-0.128 ***	-0.141	-0.126	-0.139 **	-0.157	-0.151 ***	-0.128 ***	-0.142 **	-0.167 **
	(0.074)	(0.092)	(0.082)	(0.043)	(0.117)	(0.083)	(0.074)	(0.063)	(0.072)
Square of R&D intensity in 2008	0.001	0.001	0.001	0.001	0.003	0.001	0.001	0.002	0.002
	(0.001)	(0.002)	(0.002)	(0.001)	(0.005)	(0.002)	(0.001)	(0.001)	(0.002)
Size in 2008	-3.482 **	-3.027	-3.311	-4.654 *	-4.144 **	-4.168 **	-3.482 **	-3.450 **	-3.309 **
	(1.471)	(1.789)	(1.920)	(0.918)	(1.054)	(1.511)	(1.471)	(1.591)	(1.510)
Square of size in 2008	0.166 **	0.148	0.158	0.218 *	0.196 **	0.204 **	0.166 **	0.164 ***	0.158 ***
	(0.075)	(0.087)	(0.095)	(0.048)	(0.055)	(0.079)	(0.075)	(0.081)	(0.077)
Year of creation		0.003							
		(0.004)							
Old firms (created before 1900)			0.042						
			(0.444)						
New firms (created after 1975 1900)			0.160						
			(0.557)						
% of R&D performed in the EU in 2008				-0.014					
				(0.013)					
Change in % of R&D performed in the EU (2005-2008 to 2009-2012)					-0.031				
					(0.022)				
Low-tech sectors						1.199			
						(0.855)			
Medium low-tech sectors						-3.132 *			
						(1.044)			
Medium high-tech sectors						0.206			
						(0.535)			
EU Member states in the Euro area							0.686		
							(0.564)		
Profit rate in 2008								2.592 **	
								(1.139)	
Profit rate in 2007									2.786
									(1.699)
Number of observation	49	49	49	44	38	49	49	49	49
R^2	0.856	0.864	0.858	0.968	0.985	0.871	0.856	0.883	0.876

Notes: Robust standard errors in brackets; * (respectively **, ***) statistically significant at the 1% (respectively 5 and 10%) levels; industry and country dummies included.

The last two columns (8 and 9) of Table 6 show the impact of the firms' profitability rate on the forecasted R&D increase (cfr. hypothesis H2E). Accordingly, firms with a relative high profitability in 2008 tend to report higher increases of their R&D between 2005 – 2008 and 2009 – 2012, which supports the thesis of generally counter-cyclical behaviour in this regard (given no/low financial constraints). In turn, those firms with lower profit rates and presumably less internal financial resources at their disposal for increasing and/or maintaining their pre-crisis levels of R&D investments are limited also in their crisis-response strategy; likely resulting in a rather pro-cyclical R&D investment strategy due to existing liquidity constraints.[17] Indeed, before the start of the current crisis in the second part of 2008 this variable does not seem to play any significant role in determining R&D changes of firms over the examined period. Hence, our empirical results provide strong support to the arguments put forward by Aghion et al. (2005, 2008) as outlined in Section 2 above: R&D investment as a share of total investment appears to be countercyclical in the absence of credit constraints, but it becomes more pro-cyclical as firms face tighter credit constraints (e.g. due to the impact of the financial crisis) and this effect is only observed during downturns.

In order to check the robustness of our empirical results a Heckman regression analysis has been performed controlling for non-response bias. The results are reported in the Appendix A. In fact, our results appeared fairly robust and the parameters remained virtually unchanged. The results concerning the selection equation (which are not reported here) are globally in line with those already discussed in terms of 'factors determining the probability to participate in the survey' (see above). Furthermore, the Mill's ratio is not significant, thus indicating that the sample selection bias is negligible.

[17] See Cincera and Ravet (2010) for a discussion.

7 Conclusions

The main objective of the paper has been to analyse the reaction of the largest R&D companies in the EU to the current economic and financial crisis. To that end, we use a specific dataset from the R&D Outlook survey conducted by the European Commission in 2009 which covers the period 2005 – 2012. The sample is unique with respect to its coverage and timeliness. Because the sample is relatively small, we examined it with great care and are convinced that our analysis reflects the information conveyed in the responses well. The main R&D investment trends in the sample are in line with the figures reported in past Scoreboards. Further, the sample has proven robust and without selection bias.

On average, R&D companies appear to have reduced their R&D budget between the period before and after the current economic crisis, i.e. 2007 and 2008. Yet this drop of the resources committed to this type of activities has shown to be quite modest. Furthermore, this relative reduction in R&D investments appears to be confined in time.

In terms of companies' characteristics, the firms least affected by the crisis are both the larger ones and the smaller ones in terms of size. Firms experiencing high profitability in 2008 are the ones increasing at most their R&D activities. Conversely, firms operating in the medium low-tech sectors[18] and firms characterised by the highest R&D intensities are the ones expecting the highest decrease of their R&D investments over the period 2005-2012. If these trends are confirmed with more recent data, this would be likely to increase the R&D intensity (R&D to GDP ratio) deficit[19] of the EU vis-à-vis the US and specific policy measures should be taken in order to support the R&D activities of these companies and reverse this negative trend. This would also increase the importance of new (smaller) innovators, which would need adequate policy support for new firm creation and growth.

In geographic terms, we observed two general patterns: the companies increasing their R&D over the period 2005 – 2011 have done so predominantly within the EU (but also in China, India and the US), while those which decreased their R&D investment between 2005 and 2008 have done so exclusively in the EU (with R&D in the other three areas remaining stable or slightly increasing). Both patterns point to an increasing share of emerging countries and reinforce the evidence that R&D investment follows the globalisation of markets, which is supported by many findings in the literature. In terms of size, the larger companies are much more internationalised than the smaller ones (the formers' EU share is 20 percent lower than the latter).

In any case, the absolute amount of R&D investment in the EU still increases by around 40% between 2005 and 2012. This reveals that R&D internationalisation, at least in terms of the companies surveyed, is not a zero-sum game but also a way to enrich the R&D activity in the home-country. According to the conclusions of a recent study (Belderbos et al., 2010), the trend that EU firms are locating R&D activities outside the EU should not be seen as a trend to be reversed by policy. Indeed, as pointed out by the authors, 'EU firms that exploit global technological expertise are also the companies that manage to maintain the strongest production activities in the EU'.

[18] This finding is confirmed for the less R&D intensive firms.
[19] Cincera and Veugelers (2010) showed that this gap was of 46% in 2007.

An additional policy implication of the results comes from the higher responsiveness in terms of R&D of firms facing the tightest financial constraints. Here also specific support measures could be targeted to this specific group of companies.

Other dimensions worth to be further examined in future analysis include:

- ⇨ the distinction of radical versus incremental innovations, i.e. whether the former are favoured in downturns as compared to the latter.

- ⇨ the relationship between the impact of the crisis and the time for execution of the research project, i.e. if longer-term R&D projects behave differently than shorter-term ones in a crisis.

- ⇨ whether companies concentrate more R&D investment on fewer-core-business areas or on emerging technological sectors and markets only in reaction to the crisis. This could be achieved by matching the data set used in this paper with patent data.

Beyond R&D internationalisation examined in the context of the crisis, there is increasing need for further addressing the importance of location factors via the analysis of a combined sample of all the Survey responses and all EU Scoreboards over the past years (Cincera, Cozza and Tübke, 2010). This may lead to a better insight of the relation between the factors addressed in the questionnaires with future expectations, sector groups, or the choice of location.

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Annex A

Table A1. Heckman regression: Companies' characteristics for explaining R&D investment annual changes

Explanatory variable	Estimated coefficient	s.e.		Explanatory variable	Estimated coefficient	s.e.	
Constant	35.151	27.538					
R&D intensity in 2008	-0.106	0.043	**	Biotechnology	18.070	9.333	**
Size in 2008	-5.398	2.866	***	Chemicals	-2.472	1.744	
Square of size in 2008	0.250	0.120	**	Construction & building	-2.280	2.332	
Belgium	-1.248	2.896		Diversified industrials	-2.703	2.533	
Denmark	-0.582	2.452		Electricity	0.277	1.841	
Finland	-1.103	4.422		Electronic & electrical	-2.684	2.848	
France	-3.585	3.028		Electronic equipment	-1.928	2.549	
Germany	-0.471	1.613		Engineering - contractors	-2.896	1.557	***
Italy	-2.666	2.732		Health care equipment & services	-3.082	3.261	
Slovenia	-3.263	7.596		Household goods	0.171	2.881	
Spain	-1.542	6.218		Industrial machinery	-0.968	1.570	
Sweden	0.542	3.464		Insurance	-2.199	2.880	
The Netherlands	-1.977	3.065		Oil & gas producers	-4.604	5.596	
UK	-1.253	1.861		Pharmaceuticals	-0.356	1.994	
Automobiles & parts	-2.369	2.173		Steel & other metals	-4.195	6.225	
Banks	0.006	4.606		Telecommunication services	-2.810	4.232	

Notes: s.e. = robust standard errors ; * (respectively **, ***) statistically significant at the 1% (respectively 5 and 10%) levels; Control groups: Austria and aerospace and defence.

Annex B

Table B1. R&D investments in 2007: Survey vs. scoreboard two-sample t test with equal variances

Variable	# obs	Mean	Std. Err.
R07_2008 Scoreboard	1000	126.36	15.30
R07_R&D Outlook survey	90	245.14	74.31
Combined	1090	136.17	15.34
Diff		-118.79	55.65
diff = mean(rdsb) - mean(rdsu)	t = -2.1347		
Ho: diff = 0	degrees of freedom = 1088		
Ha: diff < 0	Ha: diff ≠ 0	Ha: diff > 0	
Pr(T < t) = 0.0165	Pr(|T| > |t|) = 0.0330	Pr(T > t) = 0.9835	

Table B2. R&D investments in 2008: Survey vs. scoreboard two-sample t test with equal variances

Variable	# obs	Mean	Std. Err.
R07_2008 Scoreboard	1000	130.41	15.67
R07_R&D Outlook survey	90	271.20	85.12
Combined	1090	142.03	16.03
Diff		58.12	58.12
diff = mean(rdsb) - mean(rdsu)	t = -2.1347		
Ho: diff = 0	degrees of freedom = 1088		
Ha: diff < 0	Ha: diff ≠ 0	Ha: diff > 0	
Pr(T < t) = 0.0089	Pr(|T| > |t|) = 0.0156	Pr(T > t) = 0.9922	

Table B3. Annual growth rate (2007-2008) of R&D investments: Survey vs. scoreboard two-sample t test with equal variances

Variable	# obs	Mean	Std. Err.
ΔR07_2008 Scoreboard	983	52.89	28.39
ΔR07_R&D Outlook survey	90	10.01	4.39
Combined	1073	49.30	26.01
Diff		58.12	93.87
diff = mean(rdsb) - mean(rdsu)	t = 0.4567		
Ho: diff = 0	degrees of freedom = 1071		
Ha: diff < 0	Ha: diff ≠ 0	Ha: diff > 0	
Pr(T < t) = 0.6760	Pr(|T| > |t|) = 0.6479	Pr(T > t) = 0.3240	

Annex C

Questionnaire of the **European Commissions 2009 R&D Outlook survey**

The information you provide usually takes less than 30 minutes to compile and will be treated as confidential, following the European Commission's standards of data protection and privacy (disclaimer below). It will be used only within this study and will be aggregated for the analysis. No access will be granted to individual answers.
Data for your company from previous Scoreboards and Surveys is already filled-in the questionnaire. You may want to correct these data where appropriate.
We will inform you of the results of this exercise as soon as they are available.

Thank you very much for your collaboration.

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). It does not include R&D financed from public sources.

1. What was your company's R&D investment in the past? *Please estimate the amounts which should not be directly available.*

	2005	2006	2007	2008
R&D investment (€ million)				

2. Please estimate your company's R&D investment in the future?

Rationale: Periodicity based upon current context and expected trends.

	2009	2010	2011	2012
R&D investment (€ million)				

3. Please estimate the geographic distribution of your company's R&D investment for the following years?

Rationale: company based in country X is doing R&D in country Y.

R&D carried out:	in 2005	in 2006	in 2007	in 2008	in 2009	in 2010	in 2011	In 2012
in the European Union	%	%	%	%	%	%	%	%
in Switzerland	%	%	%	%	%	%	%	%
in other European countries	%	%	%	%	%	%	%	%

in the United States & Canada	%	%	%	%	%	%	%	%
in Japan	%	%	%	%	%	%	%	%
in China	%	%	%	%	%	%	%	%
in India	%	%	%	%	%	%	%	%
in South Korea	%	%	%	%	%	%	%	%
in other countries (please specify those with significant shares): ….	%	%	%	%	%	%	%	%

4. The past R&D data quality is:
low
medium
high

5. The future R&D depends on factors whose uncertainty is:
low
medium
high

6. Any other comments:

Disclaimer

This exercise follows the European Union's standards of data protection and user privacy as defined in Regulation (EC) nº 45/2001. The personal data in this letter, which consist of the addressee's name and e-mail address, have been taken from public sources and survey data. The exclusive purpose of this file is to allow the European Commission, Directorate General Joint Research Centre (JRC), Institute for Prospective Technological Studies (IPTS) to address you, via its subcontractor TNO Innovation Policy Group, and send you the attached information.

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Abstract

This study investigates how corporate R&D evolves in the light of the contemporary economic crisis. We investigate what empirical evidence from past downturns suggests, discuss the relevant literature and perform an empirical analysis of recent business survey data (collected during 2009). We question whether companies tend to spend more or less on R&D and innovation activities during periods of recession and analyse empirically what general patterns can be distinguished in this regard, given the particular circumstances of the most recent crisis.

Our findings suggest that company behaviour varies: some companies have reduced their innovation activities significantly, while others maintained them and a third group even increased their activities to reap the benefits in the expected upswing afterwards. Overall, we observe a deceleration of R&D and innovation activities in the light of the crisis, but the trend figures remain positive. Driven by the companies that reinforce their R&D and innovation efforts to thrive through the downturn and thus seek to gather the benefits in the upswing to come, the R&D and innovation landscape is likely to look different in the aftermath of the crisis.

These changes will inevitably affect policy intervention in the field of innovation and are a unique chance for the reorientation of policy measures. More profoundly, they could be at the roots of a new paradigm, departing from a transition from an industrial to a knowledge-based society.

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