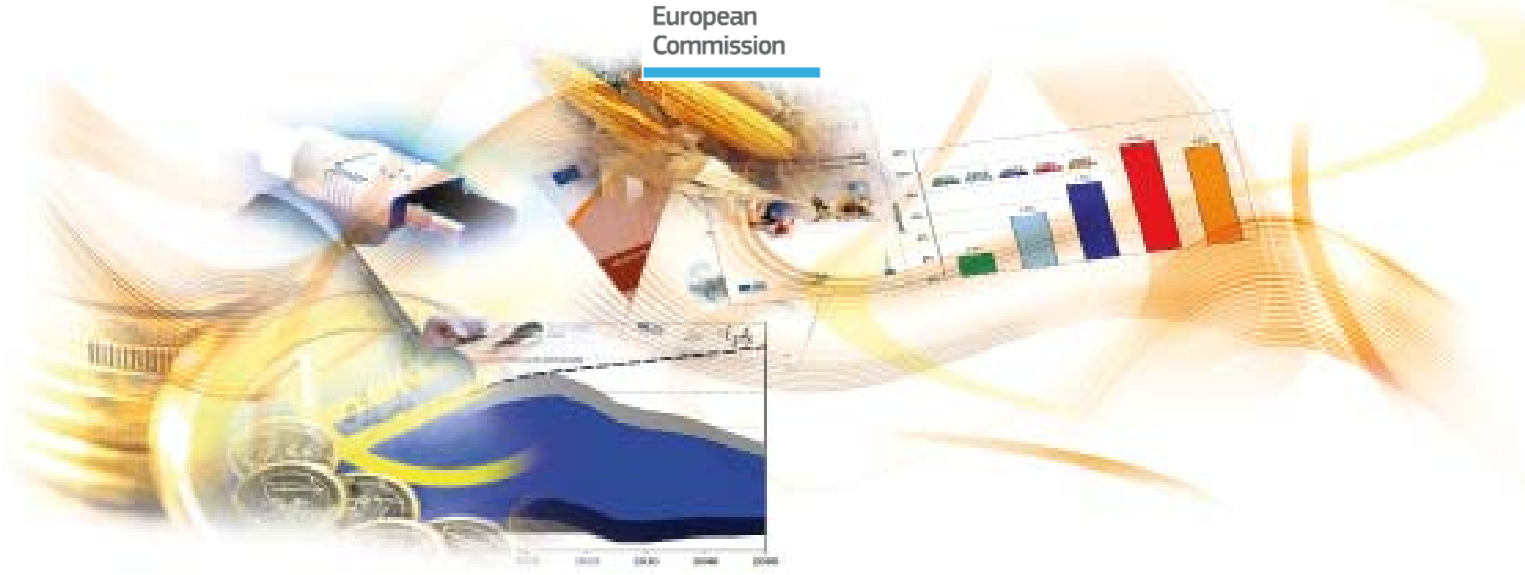
European Commission



JRC TECHNICAL REPORTS

IPTS WORKING PAPERS ON CORPORATE R&D AND INNOVATION – NO. 01/2012

Projection of R&D Intensive Enterprises' Growth to the year 2020: Implications for EU policy?

Peter Voigt and Pietro Moncada-Paternó-Castello

February 2012

Report EUR 25292 EN

Joint Research Centre

European Commission
Joint Research Centre
Institute for Prospective Technological Studies

The *IPTS WORKING PAPERS ON CORPORATE R&D AND INNOVATION* address economic and policy questions related to industrial research and innovation and their contribution to European competitiveness. Mainly aimed at policy analysts and the academic community, these are scientific papers (relevant to and highlighting possible policy implications) and proper scientific publications which are typically issued when submitted to peer-reviewed scientific journals. The working papers are useful for communicating preliminary research findings to a wide audience to promote discussion and feedback.

The *IPTS WORKING PAPERS ON CORPORATE R&D AND INNOVATION* are published under the editorial responsibility of Fernando Hervás, Pietro Moncada-Paternò-Castello and Andries Brandsma at the Knowledge for Growth Unit – Economics of Industrial Research and Innovation Action of IPTS / Joint Research Centre of the European Commission, Michele Cincera of the Solvay Brussels School of Economics and Management, Université Libre de Bruxelles, and Enrico Santarelli of the University of Bologna.

Contact information
Fernando Hervás Soriano
Address: European Commission, Joint Research Centre - Institute for Prospective Technological Studies
Edificio Expo. C/ Inca Garcilaso, 3 E-41092 Seville (Spain)
E-mail: jrc-ipts-kfg-secretariat@ec.europa.eu
Tel.: +34 95 448 84 63
Fax: +34 95 448 83 26
IPTS website: http://ipts.jrc.ec.europa.eu/; JRC website: http://www.jrc.ec.europa.eu

JRC69761

EUR 25292 EN

ISBN 978-92-79-21274-1

ISSN 1831-9424

doi:10.2791/81696

Luxembourg: Publications Office of the European Union, 2012

Printed in Spain

Abstract

The paper investigates how sector composition and the magnitude of R&D investment in the EU may differ in 2020 in comparison to the past, if a selection of top R&D-investing SMEs were assumed to be on a fast growth track while the top R&D-investing large-scale companies continue to grow as before. The background of this research objective is the emerging focus on SMEs – and in particular the fast-growing among them – with regard to the "Europe 2020" policy strategy. The study relies on the sample of top R&D-investing firms as given by the latest available "EU Industrial R&D Investment Scoreboard" editions, building there from an unbalanced panel. Scenarios were developed by distinguishing SMEs' assumed growth paths vs. that of large scale companies. A linear prediction model has been used to calculate the scenario simulations.

Overall, the study indicates that if one expects the (R&D-intensive) small firms to be a driving force for a substantial structural change in the EU economy, from being driven by medium-tech sectors towards a high-tech based economy, it requires either a significant longer-term horizon of the assumed fast growth track than the simulated 10 years, or small firms' growth figures which even exceed the assumed annual 30% (as in the most optimistic scenario). Neither case appears to be particularly realistic. Hence, we need more top R&D investors in Europe to further intensify their engagement in R&D (increasing volume and R&D intensity) as well as numerous small firms that start and/or significantly increase their existing R&D activities and thus seek to become large firms and (global) leading R&D investors. Accordingly, a broad R&D and innovation (policy) strategy is needed with policy interventions which also target well all these options; i.e. stimulating firm growth and R&D and innovation-intensity across firm-sized classes.

JEL Classification: 031, L11, L25, R38

Keywords: SME, company growth, industrial dynamics, structural change, R&D/innovation policy, Barcelona target, Europe 2020

Executive summary

Problem: What specific problem does the study focus on?

The paper seeks to investigate how sector composition and the magnitude of R&D investment in the EU may differ in 2020 in comparison to the past/present, if the top R&D-investing SMEs were assumed to be on a fast growth track while the top large-scale R&D-investing companies continue to grow as before. The background of this research is the emerging focus on the growth of innovative firms (thus especially SMEs) in terms of the "Europe 2020" policy strategy.

Current understanding: What is known about this problem?

The current understanding of small firms' growth and what policy can contribute in this regard relies widely on incomplete information, focusing mostly on the national and/or industry level or certain variables only assumed to determine growth (e.g. R&D, tax regimes, constraints in terms of factor endowments). In fact, a review of the recent economic and policy literature on the growth of innovative SMEs indicates that the EU shows – compared to the US – a higher share of absolute R&D expenditure made by SMEs, but on average SMEs in the EU are individually far less R&D intensive since they tend to engage in less R&D intensive sectors (medium- and low-tech). Further relevant findings from the literature are as follows: a) smaller firms tend to grow faster, are more R&D intensive and produce higher quality innovations, b) the optimal size-dependent type of R&D subsidy policy generally performs better than size-independent policies; c) supporting small firms' investment in R&D is often more growth-enhancing than subsidising large firms (e.g., Symeonidis, 1996; Akcigit, 2009; Coad and Hölzl, 2010; Moncada-Paternò-Castello, 2011).

Research question: What is the study's goal?

The study's goal is to assess whether a substantial increase in spending on business R&D in the EU economy, and thus implicitly reducing the gap of private R&D investment between Europe and its competing economies (e.g. the US), may appear to be achievable within one decade (which is set out as a policy objective by the EU) if it is assumed to be driven by fast-growing SMEs. In this regard, the paper will address the following specific question: How would the sector composition and the overall volume of R&D investment in Europe differ in 2020 compared to the past/present if the (currently) top R&D-investing SMEs were assumed to be on a fast growth track while the top R&D-investing large scale companies may continue to grow as before?

Design/methodology/approach: How was the study carried out?

Empirically, this study relies on the sample of top R&D-investing firms as provided by the EU Industrial R&D Investment Scoreboard [SB] in the 2010 edition; i.e. the most recent firm level data referring to the accounting year 2009, which is taken as the starting point for individual firm level projections of steady growth paths over a period of 10 years, thus simulating the SB for 2020 [SB-2020]. Scenarios are distinguished for SMEs vs. large scale companies (assumed growth path) and with regard to high-, medium- and low-tech industries. Several SB waves have been merged in order to amplify the empirical base, resulting in pooled data of 2,000 companies (1,000 from EU and 1,000 from the rest of the world) over the period 2002 - 2009. A linear prediction model (according to e.g. Makhoul, 1975; Markham and Palocsay, 2006) has been applied to simulate three main future scenarios (and two alternative reference scenarios meant to benchmark the empirical results).

The limitations of this study (see Section 4.3) appear to be centred in the non-trivial assumptions with regard to the growth scenarios and a rather simplistic (linear) projection method, which is due to neglect of a number of other factors which are in truth relevant for firm and sector dynamics.

Findings: What are the main outcomes?

The main results of the scenario analyses are as follows:

The simulated scenarios – distinguished according to the assumed growth of small R&D intensive companies – suggest that corporate R&D spending of the EU's SB companies will rise by a total of 70 - 90% until 2020 in comparison to the figures from SB-2010 (depending on the assumed scenario and subject to a series of assumptions; see chapter IV).

The ratio of Business Enterprise Expenditure on R&D [BERD]/GDP in EU-27 is expected to increase up to 1.6 - 2.0% in 2020 and may thus be about to reach the Europe 2020 target in this regard (3% GERD, of which 2/3 should come from the business sector), if both the most optimistic firm growth scenario and in parallel the lowest scenario concerning GDP growth come true.

The share of high-R&D-intensive sectors in terms of total expenditure on R&D in Europe is assumed to be increasing from 34% in SB-2010 up to at least 37% (low-growth scenario) and even 43% given the highest growth scenario. In turn, the shares of low- and medium-low-R&D intensive sectors are expected to remain virtually unchanged. Accordingly, and depending on the corresponding scenario assumptions, a gradual shift from medium-high towards high-R&D-intensive sectors should be expected for business expenditure on R&D in Europe. However, the structural gap of R&D investment between Europe and the US is not expected to close until 2020; at least not if assumed to be driven mainly/only by the growth of small firms.

Contribution: What does the study add to current understanding?

The study presented, by using a unique micro-data set and covering a representative sample of top-R&D-performing firms for the EU as a whole, presents an ex ante appraisal of the order of magnitude of anticipated changes in terms of overall EU spending on business R&D and sector composition given several growth scenarios, distinguished according to company size. The results are expected to contribute to a better understanding of the potential impact which may arise from policy support targeted at company growth (sensitivity at macro-level/structural effects).

Practical implications: Who will gain from the findings, why and how?

As the simulated scenarios vary according to the assumptions concerning small firms' growth, the magnitude of the differences in the results provides a good grasp of the importance of small vs. large firms for certain sectors. Overall, the projection indicates that if one expects small R&D-intensive firms to be an engine for a substantial structural change in the European economy, from being driven by medium-tech sectors towards a high-tech based economy, it requires either a significant longer time horizon for the assumed fast growth track than the 10 years simulated or small firms' growth figures which even exceed the assumed annual 30% (as in the most optimistic scenario). Neither case appears to be particularly realistic.

Hence, from the empirical results of the study can be concluded that we need more top R&D investors in Europe to further intensify their engagement in R&D (increase volume and R&D intensity) as well as numerous small firms that start and/or significantly increase their existing R&D activities and thus become large firms and (global) leading R&D investors. Accordingly, we need policy interventions targeting

all these different options and therefore a broad R&D and innovation (policy) strategy; i.e. stimulating firms' growth and R&D and innovation-intensity regardless of firm size with appropriate/differentiated policy instruments.

1 Introduction

Enterprises' competitiveness and individual growth is largely recognised as playing a pivotal role in terms of EU's economic prosperity. There is a conviction that (public and private) R&D represents one of the key elements that can push the EU towards a more knowledge-based, competitive economy; an argument which has been fully endorsed in the EU policy agenda where there is a revamping focus on private sector investment in R&D. This is, for instance, the case with regard to the "Europe 2020" policy strategy, which among other elements (i) confirms the Lisbon policy target (i.e. 3% of European GDP should be spent on R&D by 2010, and that two-thirds of this spending should come from the private sector), (ii) supports the design, implementation and assessment of targeted policy measures aiming at supporting the growth of European innovative firms, and (iii) aims to help (in particular) small firms to succeed through research and innovation.

The objective of this study is to assess whether a substantial increase in spending on business R&D in the EU economy, thereby implicitly reducing the gap of private R&D investments between Europe and its competing economies1, may appear to be achievable within one decade (which is set out as a policy objective by the EU), if it is assumed to be driven by fast growing SMEs. In this regard, the following specific question will be addressed: How would the sector composition and the overall volume of R&D investment in Europe differ in year 2020 compared to the past/present, if the (currently) top R&D-investing SMEs were assumed to be on a fast growth track while the top R&D-investing large scale companies continue to grow as before?

After a brief overview of the literature (chapter II), in chapters III and IV the data base is discussed, several growth scenarios are developed, and the corresponding results of a linear projection model are presented. Chapter V summarises possible implications for EU policy making.

2 Literature review

There is ample literature on firm growth, the role R&D and innovation play in this respect and the link between company size and corresponding growth paths (see, for example, Acs (1990) and Audretsch (2006)). There is also evidence suggesting significant differences in firms' growth distribution in different countries (see e.g. Junge and Kaiser, 2004; Bartelsman et al, 2005).

In general, economists have long been studying the link between technological innovation and economic growth. This research has been driven by Schumpeter's (1934) description of technological innovation as the source of economic growth. But what is the relative contribution to growth made by small compared to large high-tech firms?

Reviewing the existing literature concerning the contribution of firms (distinguished by their size) to global innovation and public policy uncovers three relevant facts: a) smaller firms tend to grow faster, are more R&D intensive and produce higher quality innovations, b) the optimal size-dependent type of R&D subsidy policy generally performs better than size-independent policy, c) supporting small firms' investment in

1 According to European Commission & EUROSTAT (2011), the US in 2008 had business sector expenditure on R&D [BERD] of 2% GDP compared to 1.2% in the EU-27.

R&D is often more growth-enhancing than subsidising large firms (e.g., Symeonidis, 1996; Akcigit, 2009; Coad and Hölzl, 2010).

Numerous empirical studies analysing firms' growth patterns show that emerging firms seem to grow much faster in the US than in Europe. In addition, firms in the EU, especially smaller companies, exhibit a reduced ability for growing beyond certain size thresholds, especially when entering into new, knowledge-intensive sectors and sustaining growth (Hoffmann and Junge, 2006). Nonetheless, according to a recent study by Bravo-Biosca (2010), unsuccessful US firms also shrink much faster than corresponding EU firms, and yet the EU has a much larger share of stable firms for which employment has not varied too much (upwards or downwards) in recent years.

In fact, reviewing the recent economic and policy literature on the growth of innovative SMEs indicates that the EU shows – compared to the US – a higher share of absolute R&D expenditure carried out by SMEs, but on average the EU SMEs are far less R&D intensive as they tend to engage in less R&D intensive sectors (medium- and low-tech). Further literature (e.g. Acs et al., 2008) indicates that although the EU group of SMEs is larger (in terms of the number of enterprises and the overall number of employees), in terms of absolute new job creation a smaller group of large high-growth enterprises is at least equally important as the high-growth SMEs.2

With regard to the possible cause of the EU vs. US R&D intensity gap, divergent findings arose from the literature. For instance, Moncada-Paternò-Castello et al., 2010 found that the lower overall corporate R&D intensity for the EU is the result of sector specialisation (structural effect). Indeed, the US has a stronger sectoral specialisation in the high R&D intensity sectors (especially ICT-related) compared to the EU. Moreover, the US seems to have a much larger population of smaller (also younger)3 firms in these high R&D-intensive sectors, which leads to higher overall investment in R&D as well as certain differences in terms of common company characteristics. The aforementioned study thus confirms the finding by other authors (Mathieu and Van Pottelsberge de la Potterie, 2008, Van Ark et al., 2003). However, such results contradict other studies (e.g. Erken and van Es, 2007; Pianta, 2005; van Reenen, 1997), which conclude that the R&D intensity gap is rather due to firms' underinvestment in R&D (intrinsic effect).

The literature also offers the results of several exercises to simulate R&D expenditure growth by both the private and public sector. For example, Brécard et al. (2004) used the Nemesis European macro-econometric model to determine the various economic mechanisms involved in the effects of innovations in competitiveness, employment (total and in research), growth and public authority budget, in relation to the 3% GDP target for research in Europe. In another study, Gardiner (2010) simulated R&D investment scenarios and thus calibrated the impact on a set of multi-country models, also considering the R&D investment targets set by the Lisbon Strategy. Data was collected from the available input-output, sectoral, R&D, and macro data. The model simulations provided the likely impacts of targeted R&D increases on GDP growth, employment, unemployment, sectoral production, trade, prices, public finance, etc. in different Member States and the EU25.

However, to our knowledge there are no future-oriented scenario analyses using simulation/projection techniques – which are based on micro-data at EU level – aimed at researching whether the faster growth of R&D-intensive enterprises (SMEs vs. large companies) reduce the EU R&D intensity gap within this decade(s), thus shedding light ex ante on the possible outcome of policies targeting fast growth in SMEs. An overview about corresponding policy measures is given in Lilischkis (2011): Policies in support of high-

2 For an extended literature review in this regard, see for example Vinnova (2008) or Moncada-Paternò-Castello et al., (2010). For literature on firms' dynamics and economic competitiveness see for instance Bosma and Levie, 2010 and Teruel and de Wit, 2011.

3 In fact, Cincera and Veugelers (2010) found that younger companies (i.e. those created from 1975 onwards) show higher R&D intensity than the older ones and are more numerous in the US than in the EU. Moreover, the younger companies based in the EU are less R&D intensive than their US counterparts. Altogether these factors explain to a large extent the overall lower R&D intensity of EU companies.

growth innovative SMEs. An inventory of R&D and innovation policies (in the EU and elsewhere) is provided in http://erawatch.jrc.ec.europa.eu/.

3 Data

3.1 The EU Industrial R&D Investment Scoreboard database

In general, the EU Industrial R&D Investment Scoreboards [SB] collect data from the latest audited company reports and accounts published up to 1 August in the previous year. It also encompasses data for the three previous reporting years. The SB's list companies whose registered offices are located within the EU (in total 1,000) and the same number with registered offices outside the EU. These companies are considered to be the top R&D investors for each of their respective EU and non-EU groups and account for a significant share of overall Business Expenditure on R&D [BERD]. For instance, the total investment in R&D of the 1,000 EU companies listed in the SB-2010 corresponds to 88.4% of total BERD in EU-27 (statistical year 2009).

Admittedly, the concepts of capturing investment in R&D in BERD and SB are different, which makes the direct comparison of the two figures difficult.4 However, comparing the volumes of R&D investment as represented by SB firms may help us to understand the order of magnitude. In fact, as BERD is mainly driven by domestic firms (in Europe SB companies account for ~80% of BERD)5, by projecting the growth paths of the leading R&D investors in Europe and simulating the SB-2020 we may get a fair grasp of the anticipated changes in terms of BERD too (although neglecting structural changes in terms of territorial in- and outflows of R&D investment, i.e. the impact of a possibly increasing globalisation of corporate R&D and innovation activities, ceteris paribus).

3.1.1 R&D-intensive SMEs within the R&D Investment Scoreboard

In general, the majority of SMEs in Europe do not carry out their own R&D activities.6 Of those few firms which actually do, only the very top investors make it into the SB (due to the very nature of the Scoreboard of crowding out smaller firms; see above). Hence, the SMEs in the sample are somehow 'exotic' within a sample of fairly specific firms. By no means can the overall sample (and especially not the SMEs within) be seen as representative of the entire population of companies in Europe. This should always be kept in mind when interpreting results and possibly generalising from empirical findings resulting from this data.

The latter holds in particular if – like in this study – small firms' growth is a matter of interest. In order to distinguish firms as 'small' and 'large' for the simulation of growth scenarios, the pooled SB-2010 sample has been scanned for companies which at any year had to be classified as SME; no matter whether they have grown later beyond the size of an SME (see Appendix I for a discussion of 'fast growing companies in SB' and Appendix II for 'SMEs in SB'). This means that in the base year of the projections (2009) – among the companies considered as SME – there might be some companies which already had grown well

4 While the SB provides figures at consolidated firm level (regardless of where the investment in R&D is taking place), BERD is a territorial concept providing the sum of R&D invested within a certain area (thus also taking into account in- and outflows).

5 See Azagra Caro and Grablowitz (2008). More recent data on this has been just published together with SB-2011.

6 Spielkamp and Rammer (2006), analysing a sample mostly consisting of SMEs, concluded that across Europe about one out of four manufacturing firms and about one out of three firms in knowledge-intensive business services (KIBS) are engaged in R&D activities (with significant regional differences).

beyond SME size. Nevertheless, they are 'stigmatised' as small and medium sized companies in order to distinguish their growth paths from those of the large/mature companies.

Recall the definition of SME: >250 employees and net sales <50 mill Euros within a given year.[7] Companies which are hereinafter considered as an SME have to fulfil these two joint criteria in at least one year from 2002 to 2009 (coverage of the SB waves until SB 2010).

3.1.2 Representativeness & sample selection bias

As outlined above, there is a general bias in SB towards larger companies (more relevant for the 'rest-of-the-world-sample' than for the European one, but still notable in the EU, too)[8] due to the very nature of a scoreboard including companies according to an absolute number (in the given case volume of R&D investment). Moreover, as the scenarios distinguish between the growth of large and smaller companies – which takes the focus onto SMEs – certain problems with representativeness arise since only very few and to some extent rather specific SMEs are listed in the SB (for a discussion of SMEs in the SB see Appendix II and e.g. Ortega et al., 2009).

Taking exemplary data from SB-2010, complemented by data from SB-2006 (i.e. pooled SB data, hereinafter named Sample 2; details described in Appendix II), altogether 160 'small firms' were found, i.e. 160 firms were classified as SMEs at any point in time from 2002 to 2009. Among these 160 firms, 133 belong to the top 1,000 EU Scoreboard companies and just 27 are from the 'non-EU' top R&D investors.[9] In fact, smaller firms tend to be crowded out with rising geographical coverage and, accordingly, any direct comparison of sectoral distribution between the EU and the 'rest-of-the-world' [RoW] sample in terms of SMEs may appear misleading, due to the sample size and coverage bias, and is therefore generally disregarded hereinafter.

3.2 Data processing

As mentioned above, the data set this study relies on was obtained from different SB editions from 2004 to 2010. In order to create this sample, starting with the 2,000 companies listed in the SB-2010 and going backwards in time to observations for 2002, the initial data set has been complemented by including data from earlier SB waves, thus accepting that the resulting panel will be unbalanced (increasingly lacking observations for earlier years). The projections of SB-2020 are restricted to EU companies' growth scenarios only.

3.2.1 Exchange rate adjustments

In each SB all monetary values are provided in Euros. Exchange rates to be applied for those firms not reporting in Euros are assumed to be the end of the year exchange rate into Euros of the currency the company is reporting in. This conversion rate then is applied to each reported year. In order to be able to join the annual SB waves together, each monetary value of companies not reporting in Euros had to be

7 According to the definition (see: http://ec.europa.eu/enterprise/policies/sme/facts-figures-analysis/sme-definition/index_en.htm), an "SME", moreover, has to have a total balance sheet of ≤ €43 mill Euros. However, the latter is not taken into account here due to lack of information on Scoreboard company balance sheets.

8 The underlying reason relates to the differences in sample coverage when focusing on the main R&D investors globally rather than EU-wide only.

9 All from the USA; belonging to the Pharmaceutical & Biotech (25), Health (1), and Telecom (1) sectors.

converted into the 'original values' (reported currency) and then – by applying the exchange rate reported in SB-2010 – back into Euros, thus resulting in values equivalent to 2010 Euros. By using this procedure a further price adjustment of the monetary values of non-Euro companies was no longer necessary.

3.2.2 Price adjustments (companies reporting in Euros)

All monetary values of companies reporting in Euros were given in current Euros, and therefore had to be price adjusted (correction for inflation). In order to do this, the Industry Producer Price Index (PPI) for the EU, as provided by EUROSTAT (2011), was used (resulting in constant 2010 Euros). For a discussion of possible bias introduced due to the selection of conversion/exchange rate/price adjustments, see the technical annex to the analytical SB reports.

3.3 Descriptive statistics

As a result of pooling several annual editions of the EU Industrial R&D Investment Scoreboard, several different longitudinal sample(s) of R&D-intensive companies were obtained (different in terms of their in-/exclusion of observations with missing values/blanks for certain years). For details, see the description of samples S-1, S-2, and S-3, provided in Appendix II.

For this study, the S-2 sample will be used,[10] as it constitutes an unbalanced panel of a total of 160 small firms out of the 2,000 companies listed in SB-2010 (133 SMEs from the EU). Tables 1 and 2, Appendix II, provide descriptive statistics, broken down according to firm classes and sample selection procedure. Recall: For the scenario projections only EU firms are considered!

Evidence from Table 1 suggests that large-scale R&D-intensive companies can basically be found in any sector of economic activity, whereas R&D-intensive SMEs are mainly linked to five emerging sectors only (frequency >3%), namely Electronic & Electrical Equipment, Healthcare Equipment & Services, Technology Hardware & Equipment, Software & Computer Services, and Pharmaceuticals & Biotechnology. From Table 2, Appendix II, it can be seen that firm characteristics are quite different when comparing R&D-intensive SMEs and large-scale R&D-intensive companies, which suggests significant firm/size effects. For instance, the operating profits of R&D-intensive SMEs – in contrast with large companies – appear on average to be even negative. This gives reason to generally distinguish SMEs from other companies for the growth projection scenarios.

Apart from differences attributable purely to company size (such as the number of employees, net sales, capital expenditures, R&D investment, etc.) some common patterns stand out from the descriptive statistics. For example, R&D intensity tends to be higher in small firms (this is not surprising given the underlying sample selection of the largest nominal investors in R&D), while profits in average across all SMEs even appear negative (see Table 2, Appendix II).

10 Given the three alternative sample options (see Appendix), S-2 corresponds to the least strict assumptions. In fact, relying on S-1 (balanced panel) would mean reducing the number of firms to be considered (to a total of 1375) and in particular the number of SMEs (to 4% only). In turn, S-3 may provide additional information concerning small firms in earlier years but would not widen the sample of firms used for the projections (base year 2009). S-2 instead has a clearly defined cut-off point in terms of R&D investment (SB threshold for 2009); data for 2009 – the starting point for projections – is available for all companies, and there are in total exactly 1,000 companies in Europe. NB: For SME survival and growth path analyses, S-3 could appear to be more appropriate (unbalanced panel). S-1, since it is a balanced panel, may serve rather, for instance, for calibrating growth models and/or researching the impact of environmental variables in terms of SME trajectories.

In general, the descriptive statistics already allow some important conclusions to be reached: Firstly, R&D-intensive SME's are fairly special. In fact, they differ from 'normal' SMEs and from other R&D-intensive companies not only in terms of R&D investment but also in growth patterns and possibly even in terms of their underlying business model, as, for instance, outlined by Ortega-Argilés et al (2009). Secondly, sector specifics appear to be prominent among R&D-intensive firms, which is all the more reason for a more detailed analysis of particular firm groups (e.g. along certain R&D intensity groups such as high-tech industries, medium high/low, low-techs) and – at the same time – points towards the need for support measures tailored to sector-specifics.

The sector-wise consideration of descriptive statistics, as presented in Table 3, Appendix II, proves the heterogeneity of SMEs and the above-mentioned significant sector specifics, which both together may imply analysing business concepts, company growth patterns, survival rates, etc. sector-wise too. However, for the envisaged projection of company growth paths – first of all – sector-independent scenarios are assumed. This will possibly be changed in future studies, when going into more detailed analyses, but it is generally limited by the given sample due to the comparably low number of SMEs assigned to each of the individual sectors.

4 Methodological approach

4.1. Scenario building

In order to provide an outlook on potential growth paths of R&D intensive firms in the EU and on the corresponding tentative impact on the sector composition of the EU economy (high-, medium-, and low-R&D intensity sectors), individual firm level projections of steady growth paths over a period of 10 years are computed by applying a linear projection model (see below for details).

This study therefore relies empirically on the sample of top-R&D-investing firms as given by the SB-2010 edition (i.e. the most recent firm level data referring to the accounting year 2009, which is the starting point of the projections). Several SB waves have been merged in order to amplify the empirical base (pooled data, see above for a description of the data base).

As a result of the projections – distinguished according to several scenarios (defined below) – the Scoreboard for year 2020 is simulated (target year); hereinafter called SB-2020. In this regard we shall look at how sector composition and the magnitude of R&D investments in Europe may differ in 2020 – compared to the image provided by the SB-2010 – if the SMEs within the SB are assumed to be on a fast growth track while the remaining (larger) companies continue to grow as before (extrapolation of their past growth paths).

The projections envisaged for firm development (EU firms only!) are subject to a number of non-trivial assumptions. For instance:

- All companies may grow at the same rate in terms of employment and sales.

  This assumption is non-trivial as one might argue that a company could grow faster in terms of sales than employment (or the other way round). Although this is certainly possible in the short run, it is assumed that in the mid to long run the growth paths of sales and employment of a certain company may appear virtually the same (thus implicitly assuming constant returns to scale and full technical efficiency at any time). However, the admittedly fairly strict assumption of equivalent growth rates in terms of sales and employment had to be made since simulating fast growth in terms of sales only

was assumed to provide a biased picture, as a number of SMEs report sales figures close/equal to zero[11] and projecting a growth scenario (only) based on these figures likely would have provided meaningless results.

- The company level R&D intensity (R&D/sales ratio) is assumed to remain constant.

  This assumption tends to introduce a bias towards overestimating R&D intensities in the projected scenario. In fact, small firms in SB have higher R&D intensities than the large firms (see e.g. R&D intensities in different samples of SMEs in SB vs. all SB firms as reported in Table 2, Appendix II) and – given this evidence – there is reason to believe that R&D intensity decreases over a firms' growth history (asymptotically rather than linear). Hence, by assuming constant R&D intensities in small firms – even in case of rapid growth – the simulated volume of R&D investments in the target year tends to be overestimated. However, assuming firm specific paths of R&D intensities based on the comparably short time series of observations available – particularly with regard to smaller SB firms – appeared to be impossible (this could possibly be the subject of a future refinement of the study). Hence, we had to rely on the assumption of constant intensities (i.e. R&D/sales ratios). Furthermore, in order to avoid a bias resulting from an impact of the financial crisis on R&D intensities, instead of the most recent available year the projections are based on the firm-specific R&D intensity of 2007 (pre-crisis).[12]

- A company is considered to be 'small' (and – with regard to the projections – therefore implicitly on a fast growth track) if it had to be classified as an SME in any year between 2002 and 2009. In other words: A firm that was an SME in the base year of the projection (2009) and another which has already grown well beyond the corresponding threshold from being an SME at any time from 2002 to 2009 would both be assumed to be on a fast growth path.

  This assumption relies on an empirical investigation of 'fast growth' among the SB firms (presented in Appendix I). In fact, the fastest growing firms in Europe appear to be the smaller companies whilst in the US and even more evidently in the Rest of the World sample the fast growing companies are rather the large ones. Hence, in order to simulate the growth path of R&D intensive firms in Europe up to 2020 more appropriately, we have pooled the potentially fast growing firms (the current SMEs) and also those which are already growing fast in Europe (companies which recently grew beyond SME thresholds) and – by that means – form a sample which actually comprises firms of different sizes (see descriptive statistics below and Tables 2 & 3, Appendix II).

- SMEs and large scale companies are growing at a different speed.

  All European companies not classified as 'small firms' (i.e. which were not an SME at any point between 2002 and 2009, see point above and chapter III concerning details of the dataset) are assumed to be growing at an **annual growth rate of 5.8%**, which is the average employment growth rate across all large EU companies in SB-2010 (CAGR employment 8yrs).[13]

- For the growth of small firms the following growth scenarios were computed:[14]

11 See Appendix II for SMEs in SB or the related discussion in e.g. Ortega-Arquiles et al (2009).

12 In case of reported zero sales or missing values for 2007, the average for the corresponding sector group has been assumed (thus distinguishing high, medium-high, medium-low and low-tech). Moreover, for high-tech firms R&D/sale ratios above 10 (i.e. 1000%) were considered as outliers and set to 10 by default (NB: all corresponding 'outlier' companies are SMEs from the Pharma & Biotech sector).

13 Employment CAGR 8yrs across all 2,000 SB firms: 6.1% (EU only: 7.1%); large scale firms in EU: 5.8%, in RoW: 4.8% (all large firms together: 5.3%); SMEs in EU: 15.0%, SMEs in RoW: 12.6% (all together: 14.6%).

14 NB: Computing a scenario of 5% annual growth for small companies was skipped as it would be much lower, given their current growth path (and even lower than the reference scenario R-II, assuming an equal growth rate of 7.1% employment CAGR 8yrs across all EU companies; thus disregarding firm size).

Scenario (A): R&D intensive small firms in the SB will grow at **10% per year** until 2020;

NB: the average annual employment growth rate calculated for the corresponding sample of firms for the period 2002 – 2009 was 15%! Hence, assuming 10% annual growth for the projection of 2020 – i.e. Scenario S-A – implicitly represents an under-proportional growth, given the empirical evidence from the past (and to this extent not really a 'fast growth track').

Scenario (B): **20% annual growth** rate;

Implicitly this scenario corresponds to the definition of a fast-growing firm as agreed by OECD & EUROSTAT: A company is classified as being 'fast-growing' if in a consecutive three year period in each of these years a minimum of 20% increase in either sales or employment is achieved.[15]

Scenario (C): **30% annual growth** rate;

Reference scenario R-I:
In order to assess the empirical results of each scenario a reference scenario R-I is computed, assuming an annual employment growth of **5.8%** (8yrs CAGR) for large SB companies and **15%** annual employment growth for small firms (8 yrs CAGR). Given these assumptions, the reference scenario has to be seen between the scenario A and B as set out above.

Reference scenario R-II:
All companies may grow at the same growth rate of **7.1%** (un-weighted average 8 yrs. employment CAGR across all EU SB firms) regardless of the corresponding company size.

4.2 Projection model

A linear prediction model has been applied to simulate each of the three main future scenarios (thus following, for instance, Makhoul, 1975; Strobach, 1990):

$$\hat{x}(n) = \sum_{i=1}^{p} a_i x(n-i)$$

Where $\hat{x}(n)$ is the predicted value, and $x(n-i)$ the previous observed values, and a_i the growth coefficients.

4.3 Acknowledgment of limitations

The outlined methodology appears to suffer from two main threats, namely strong (and somewhat unrealistic) assumptions with regard to the growth scenarios and a rather simplistic (linear) projection method which is due to the neglect of a number of impact factors that are relevant for firm and sector dynamics. We are fully aware of these shortcomings and acknowledge them briefly below.

15 See: OECD-EUROSTAT (2005).

- Macro-economic cycles and possible external market shocks are not reflected in the scenarios outlined, although they would certainly affect the growth paths of companies and, given the time span of 10 years, are quite likely to play a role.
- Assuming constant growth rates at a firm level for both small and large firms neglects the existence of business cycles and individual firm specifics in terms of growth paths. In fact, empirical evidence of individual firm growth paths suggests non-linear trajectories; i.e. after a period of fast growth, lower or even flat/negative growth figures might be seen.
- Likewise, the assumption of constant growth rates and/or constant R&D intensities somehow collides with the idea of industrial dynamics driven by creative destruction. In fact, fundamental innovations may cause a certain technology/industry to become obsolete while another is created/rising. Whether overall spending on R&D in such a case in-/decreases or remains constant cannot be answered in general. Hence, any implementation of these aspects in the scenarios is non-trivial and was therefore skipped here for the purpose of simplification. For the same reason, a possible impact due to increasing internationalisation of corporate R&D has been left out, and no sector differences have been assumed for the growth scenarios (this could be the subject of further refinement in the study).
- With regard to assuming constant growth rates, moreover, the time span of 10 years under consideration appears to be problematic. In fact, a persistent growth differential between small and large firms would encourage the management of larger (presumably slower growing) companies to react, which tends to stimulate mergers and acquisitions [M&A][16]; i.e. the composition and size distribution of the sample analysed would dynamically change.
- The assumptions on GDP growth rates until 2020 (relevant for calculating the BERD/GDP ratio) have not been endogenised. In fact, there is no distinction according to the 3 scenarios, although it appears likely that – if e.g. the most optimistic growth scenario turns out to be true – the corresponding GDP figures would be at the upper end of the anticipated corridor (2 – 3% annual growth) or eventually even go beyond it.
- As no simulations for the sector composition of the Rest-of-the-World sample have been made, the comparison of structural change (sector composition) of the simulated SB-2020 has to be made with a historical image (SB-2010). However, non-EU economies are likely to develop further too and the economic structure may change accordingly. Hence, the benchmark is not static.
- Finally, given that there is a significant population of fast-growing R&D-intensive companies (as assumed in the scenarios), it appears likely that numerous spillover/spin-off effects may occur, leveraging overall spending on R&D and innovation. However, given the nature of the data set such an effect would not be captured (due to the entry threshold of SB).[17]

Given all the mentioned limitations, it should be recalled that the aim of the projection exercise presented is – rather than providing the most accurate forecast possible – to illustrate the order of magnitude of a potential rapid growth of R&D intensive SMEs and how the aggregate sector composition in the EU's economy may change accordingly. For the study presented the crucial question is how the empirical results might be affected by the above-mentioned methodological threats.

16 Although empirical evidence suggests a significant growth differential between large and smaller (R&D intensive) companies (see Appendix I), in fact, large R&D-intensive companies would probably not stay aside and observe smaller companies growing rapidly over such a long period, thus challenging the larger companies in their markets/market positions. A series of M&A would likely occur (larger firms taking over smaller companies).

17 Amplifying the empirical scope (e.g. using S-3 instead of S-2) would likely not result in significant changes concerning the projections of overall spending on R&D (order of magnitude) or the sector composition because the additional companies are simply too small and invest too little in R&D (individually as well as aggregate).

Taking the most optimistic S-C scenario as a benchmark, and addressing all the above-mentioned limitations by implementing more realistic assumptions and a distinctive methodology – with the exception of the last point (significant spillovers due to many fast-growing R&D intensive firms which may cause positive multiplier effects) – would rather tend to lower the expectations concerning an overall increase of corporate R&D spending in the EU and an accelerated structural change towards high-tech/knowledge-intensive sectors. In other words, if taking all points mentioned above on board (which would likely make the projection non-operational), the order of magnitude of the corresponding results should be expected to be lower than the projection of the S-3 scenario, but likely still above S-A, i.e. the order of magnitude has to be expected anyway within the bandwidth rendered by the empirical results due to the scenarios outlined (S-A <> S-C).

5 Results

Table 1 below presents the main results of the simulation of SB-2020; i.e. the projections of R&D investment by sector groups given the specific scenario assumptions (S-A: 10% p.a. growth of small companies; S-B: 20%, and S-C: 30%). Moreover, the two reference scenarios presented, R-I (growth p.a.: small firms 15%; large: 5.8%) and R-II (all firms grow at 7.1% p.a.) may help in assessing the S-A, S-B, and S-C scenario results.

Table 1: Results of scenario projections

	SB 2010		**R-I** SB 2020 reference scenario		**R-II** SB 2020 reference scenario		SB 2020 **Scenario A** (+10% p.a.)		SB 2020 **Scenario B** (+20% p.a.)		SB 2020 **Scenario C** (+30% p.a.)	
R&D investment by SB companies from EU (million/billion Euro)	128bn	%	224bn	%	219bn	%	220bn	%	228bn	%	244bn	%
Pharma & Biotech	20397	15.9	43123	19.3	36308	16.0	41086	18.6	46133	20.2	56785	23.3
ICT related	19070	14.9	33274	14.9	33488	14.8	32485	14.7	34441	15.1	38571	15.8
Other high	3970	3.1	8195	3.7	6987	3.1	8100	3.7	8337	3.7	8839	3.6
Automobile & parts	27408	21.4	41035	18.3	55185	24.3	41030	18.6	41043	18.0	41070	16.8
Electronic & Electricals	6994	5.5	10002	4.5	12528	5.5	9960	4.5	10064	4.4	10283	4.2
Chemicals	7473	5.8	11537	5.2	13595	6.0	11532	5.2	11544	5.1	11569	4.7
Aerospace & Defence	7998	6.2	16018	7.2	14668	6.5	16000	7.2	16044	7.0	16136	6.6
Other medium-high	12073	9.4	19147	8.5	19671	8.7	19093	8.6	19226	8.4	19508	8.0
Medium-low-tech	9487	7.4	14336	6.4	14689	6.5	14328	6.5	14349	6.3	14396	5.9
Low-tech	13106	10.2	26922	12.0	20274	8.9	26918	12.2	26927	11.8	26946	11.0
BERD/GDP [%] subject to assumed GDP growth#												
2% annual GDP growth	*ESTAT*	*1.25*		1.8		1.8		1.8		1.8		2.0
2.5% annual GDP growth				1.7		1.7		1.7		1.7		1.9
3% annual GDP growth				1.6		1.6		1.6		1.7		1.8

NB: Sectors are split into four groups according to the worldwide R&D intensity of the corresponding sector:

High R&D intensity sectors (intensity above 5%) include e.g. Pharmaceuticals & biotechnology, Health care equipment & services, Technology hardware & equipment and Software & computer services.

Medium-high R&D intensity sectors (between 2% and 5%) include e.g. Electronics & electrical equipment, Automobiles & parts, Aerospace & defence, Industrial engineering & machinery, Chemicals, Personal goods, Household goods, General industrials, Support services.

Medium-low R&D intensity sectors (between 1% and 2%) include e.g. Food producers, Beverages, Travel & leisure, Media, Oil equipment, Electricity and land line telecommunications.

Low R&D intensity sectors (less than 1%) include e.g. Oil & gas producers, Industrial metals, Construction & materials, Food & drug retailers, Transportation, Mining, Tobacco and Multi-utilities.

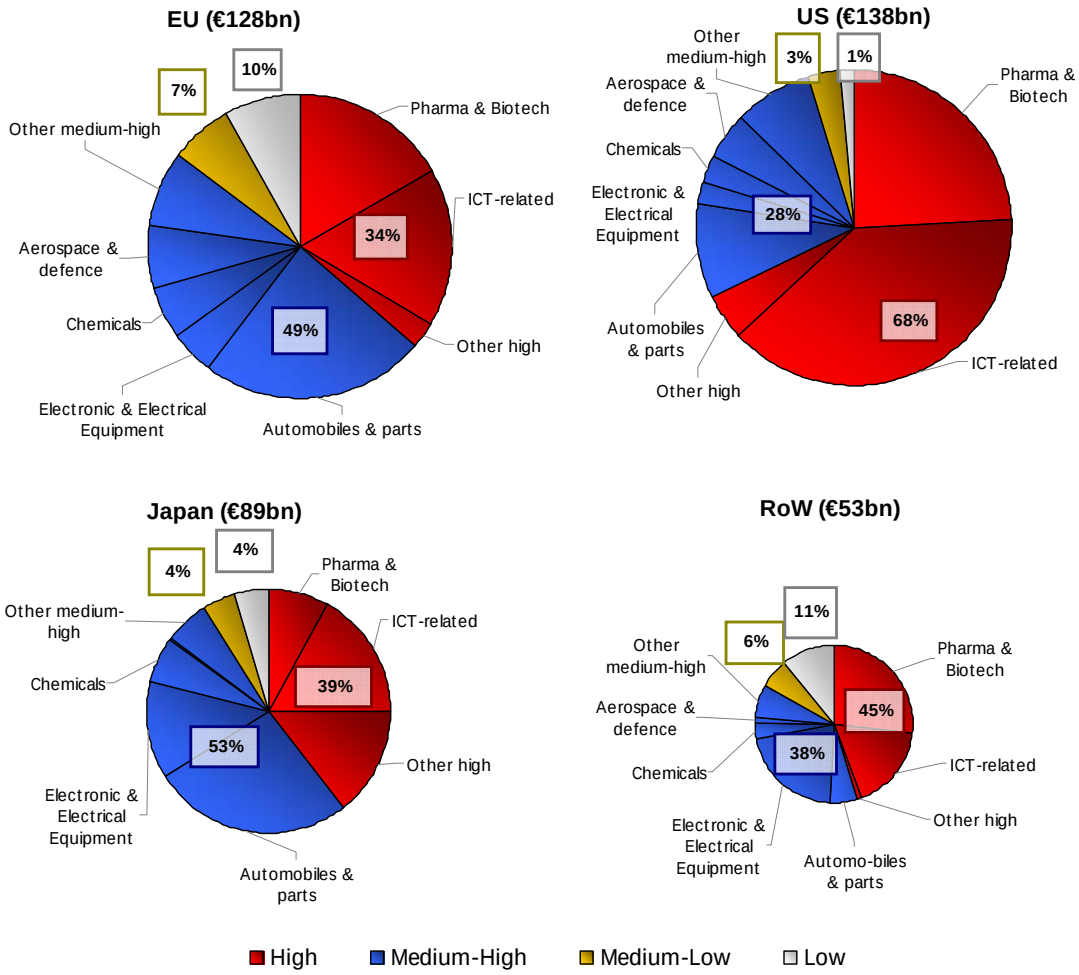
For details see European Commission: The 2010 EU Industrial R&D Investment Scoreboard

Relying on the empirical results of the scenario projections, Table 1 also illustrates what the presented growth scenarios may imply for Business Expenditure on R&D [BERD] figures in the EU-27 related to the corresponding GDP (see: 'Europe 2020 Indicator').[18] Thus, the estimation of BERD/GDP relies on the non-trivial assumption of a time-invariant multiplier for SB firms' R&D investments in relation to the overall BERD of the EU-27. This assumption implies that over the period of the scenario projections no significant changes in terms of representativeness of SB firms for overall corporate R&D investment in the EU-27 will occur and, moreover, that there will be no changes in terms of relative volumes of in-and outflows of R&D investment regarding the EU territory (e.g. due to increasing globalisation of corporate R&D and innovation activities). Both assumptions are far from being trivial and might be the subject of further discussion and refinement. Nevertheless, when testing the sensitivity of the simulated BERD/GDP shares for all scenarios (empirically tested for various SB multipliers) the results calculated appear to be robust (which is most likely due to the overwhelming importance of the top R&D investors in Europe for the overall business expenditure on R&D in the EU).

The reference point for shifts in terms of the sector composition of R&D investment volumes (as suggested by the projection results) is presented in Graph 1 below, which illustrates the current R&D investment shares by sector groups in the EU and other world regions as given by SB-2010.

18 Note: the BERD/GDP share for EU-27 was calculated for 2009 and related to the corresponding share of SB firms' R&D investment in terms of EU-27 GDP, which provides an estimator of overall BERD in the EU-27 on the base of the SB-2010 firms' R&D investments (EU-27 BERD volumes = 115% of SB-2010 EU firms' R&D investments, i.e. SB R&D volumes refer to c. 86% of BERD in Europe).

Figure 1: R&D investment shares by sector group and world region (acc. to SB-2010)

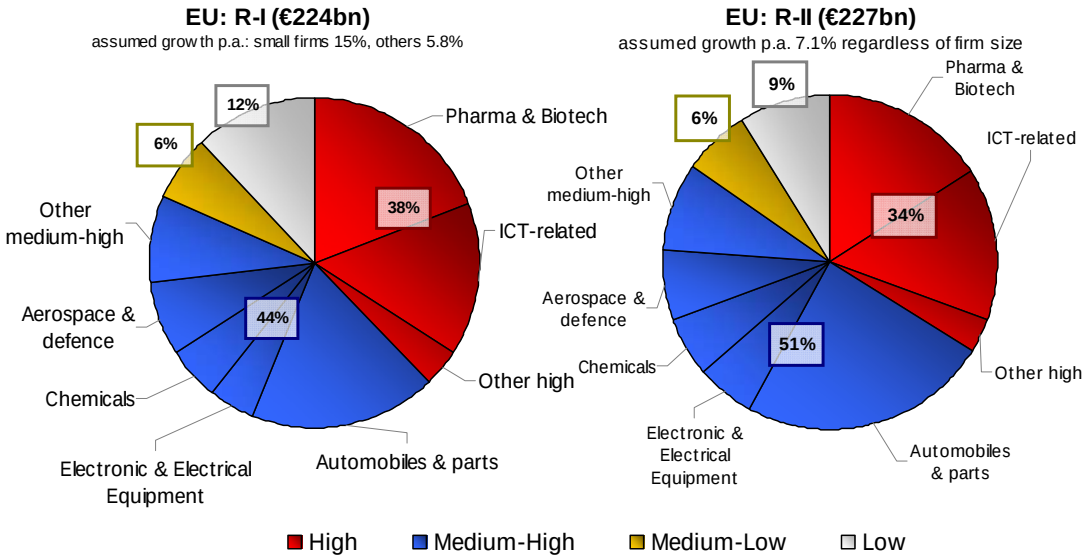


Source: The 2010 EU Industrial R&D Investment Scoreboard; European Commission, JRC/DG RTD

NB: The sector compositions as illustrated in Figure 1 (as well as all the scenarios outlined above) include all 1,000 EU SB companies. However, for an exact comparison of R&D investment shares by sector groups between the EU and those of other world regions (implicitly comparing the 1,000 EU firms to the 1,000 SB firms belonging to the RoW sample) one should ensure that 'similar firms' are being compared, i.e. the threshold for inclusion into the SB should be the same for both samples. It is in fact lower for the EU sample due to the sample size bias, as discussed above in chapter III. Figure 4 in the SB-2010 Report illustrates the corresponding figures under the assumption of identical R&D investment thresholds (in which case the EU sample constitutes only c. 400 firms). Nevertheless, comparing the aggregate sector shares as presented above with those in Figure 4 SB-2010 suggests no significant differences (the numbers are virtually the same), which indicates overall fairly robust results in this regard and presumably also with respect to the corresponding results of the scenario analyses.

Figure 2 illustrates the simulated Reference Scenarios R-I and R-II in order to allow benchmarking for individual scenario results (presented in Figure 3) and especially assessing their differences.

Figure 2: Reference Scenarios



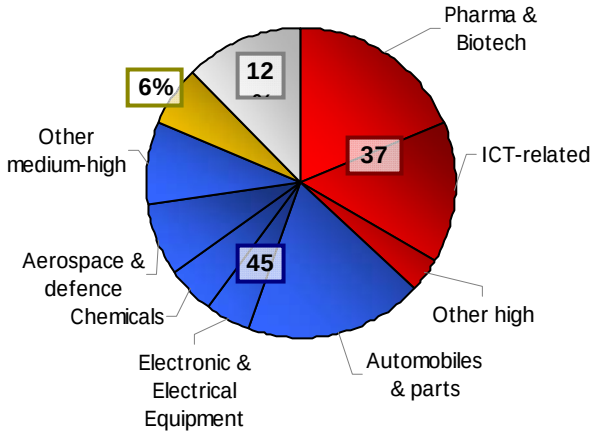
Source: Own calculations

The two reference scenarios demonstrate the relevance of large vs. small firms for the growth of R&D investment volumes per sector group. While the assumption of the growth rate of small firms seems to be sensitive for the simulation results obtained for high R&D intensity sectors (and to some extent for firms belonging to low R&D intensive sectors too), the medium R&D-intensive sectors appear to be driven more by large firms. The latter can be seen from the increasing share of medium R&D-intensive sectors (particularly medium-high) as expected in case of R-II (see Figure 3 above), which is due to the assumed growth rate of 7.1% in R-II (the same for all companies regardless of firm size) compared to 5.8% for large firms in R-I.[19] The same can be seen from the figures for the low R&D intensity sector: The expected volume of R&D investment depends on the assumed growth rate of small companies rather than the one for large firms.

19 For instance, compared to the figures given by SB-2010, Automotive and Parts sector is either expected to increase its R&D investment share by 3% in case of R-II or to decrease by the same amount in case of R-I, both indicating the relevance of large firms in the sector.

Figure 3: Simulated EU Industrial R&D Scoreboard for 2020 – Scenario results

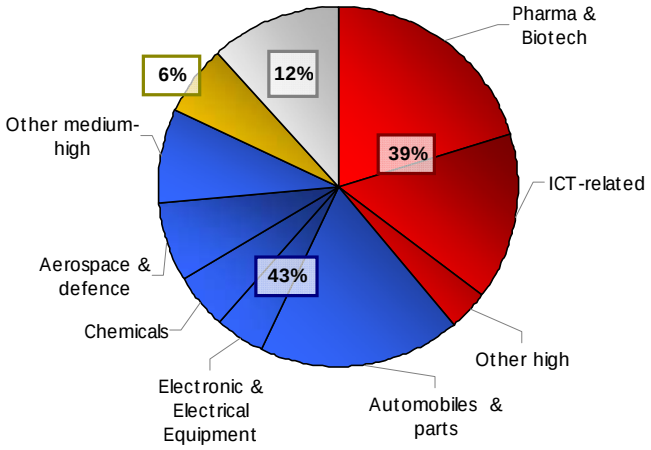
EU: Scenario A (€221bn)
grow th p.a.: small firms 10%; other 5.8%



S-A results appear similar to Reference Scenario R-I (see above)

Compared to SB 2010:
S-A suggests that high-tech sectors (especially Pharmaceuticals & Biotech) as well as low-tech industries may increase their sectoral shares on overall R&D investment in the EU-27; medium-tech sectors (esp. Automotive & Parts) tend to decrease

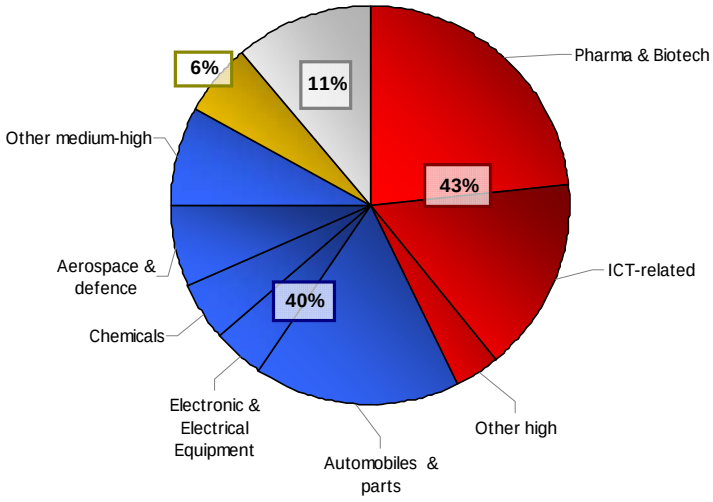
EU: Scenario B (€228bn)
grow th p.a.: small firms 20%; other 5.8%



S-B: SMEs on fast growth track until 2020…

Compared to SB 2010:
According to S-B, the assumed fast growth track of small firms is expected to lead to a moderate shift in terms of shares on overall R&D investments in EU-27 from medium towards high-tech sectors (thus underlining the importance of small firms, particularly for Pharmaceuticals & Biotech sector). Nevertheless, the magnitude of the increase in R&D investments remains relatively small given the assumed fast growth scenario of 20% p.a. (R&D growth +3% compared to S-A and only +2% compared to R-I). Moreover, the distance in terms of sectoral composition of R&D investments compared to the US remains virtually the same.

EU: Scenario C (€244bn)
grow th p.a.: small firms 30%; other 5.8%



S-C: 30% p.a. growth for SMEs until 2020…

Compared to SB 2010:
S-C represents the most optimistic growth scenario. In fact, the simulated R&D investments for year 2020 are 90% above the figures of SB 2010 with the most significant increase expected for the high-tech sectors (+140%). In parallel, the importance of medium-tech sectors for corporate R&D in Europe seems to be decreasing.

Nevertheless, the scenario illustrates that even under the assumption of extreme growth in small R&D-intensive companies over a comparably long period (as assumed in S-C) the sector composition of business R&D in Europe is not changing fundamentally. In this regard, large firms seem to matter more (small firms' growth appears relevant only in some high-tech sectors).

Source: Own calculations

When further disaggregating the sector groups, the underlying company characteristics become more evident and, however, it seems that – across all simulated scenarios – corporate R&D in the EU appears to be driven by both small and large firms in a more or less balanced way (see in this regard the almost negligible differences among the projection results for R-I and R-II for the majority of sectors). Exceptions only seem to be given by some high R&D intensive sectors (esp. Pharmaceuticals & Biotechnology) as well as by the low R&D intensive sectors[20] (both more driven by small firms) and the Automotive & Parts sector (mainly driven by large firms).

6 Conclusions

The bullet points below summarize the main conclusions, some stylised facts, and policy implications arising from the analysis of the empirical results illustrated above.

- The projected scenarios – distinguished according to the assumed growth of small R&D intensive companies – suggest that corporate R&D spending by the EU Scoreboard companies will be rising by a total of 70 – 90% until 2020, compared to the figures from SB-2010 (see scenarios S-A and S-C, respectively).
- The ratio of Business sector Expenditure on R&D [BERD]/GDP in the EU-27 – as empirically resulting from the scenario analysis & subject to further assumptions concerning the SB~BERD R&D investment multiplier and the growth of the EU-27 GDP – is expected to increase up to 1.6 – 2.0% in 2020 and may be about to reach the Europe 2020 target,[21] if the most optimistic firm growth scenario and the lowest scenario concerning GDP growth both turn out to be true at the same time. One should note, however, that these two conditions somewhat contradict each other (see discussion in chapter 4.3). In this regard, recalling the underlying assumptions of the corresponding scenarios may give reason to believe that a BERD/GDP ratio in the middle or even at the lower end of the anticipated bandwidth would be more realistic.[22] This message would be further reinforced if the scenario analysis had been technically refined by addressing some methodological threats outlined in chapter 4.3, which in sum have the tendency to expect empirical results as low as the most optimistic scenario S-3.
- The share of high R&D- intensive sectors in terms of total expenditure on R&D in Europe (as far as captured by the SB) is assumed to be increasing from 34% in SB-2010 up to at least 37% (S-A) and possibly even 43% given the highest growth scenario (S-C). In turn, the shares of low- and medium-low R&D-intensive sectors are expected to remain virtually unchanged (i.e. they are independent of the assumed firm growth scenarios). Accordingly, depending on the corresponding scenario assumptions, a gradual shift from medium-high towards high R&D intensive sectors should be expected for business expenditure on R&D in the EU.[23]

20 The statement concerning the 'driving forces of low R&D-intensive sectors' should be treated with caution since those firms belonging to low R&D-intensive sectors which are listed in the R&D Scoreboard – due to the very nature of this scoreboard including the top R&D investors only – could well be seen as fairly exotic and therefore not representative of the entire low R&D-intensive sector. Hence, generalizing from the findings concerning these (few) firms to the sector characteristics seems to be questionable and the corresponding empirical evidence will therefore not be further stressed hereinafter.

21 3% of GDP will be spent on R&D, 2/3 of which is expected to come from the business sector.

22 In the drafting of the scenarios a number of strong assumptions have been made, which in sum tend to overestimate the increase of R&D spending rather than underestimate it. For instance, sector belongings have been neglected, thus assuming that growth rates as evident in emerging sectors may also apply to others, and moreover, R&D intensities have been assumed to remain constant, which appears somewhat implausible, particularly with regard to SMEs that report high R&D spending while having sales close to zero (which together results in very high R&D intensities). In fact, such companies are more likely to either be absorbed or go bankrupt during the period under investigation rather than enter a sustainable fast growth track. See Ortega-Arquiles et al (2009) in this regard.

23 Admittedly, the high R&D-intensive sectors are expected to top the medium-high sectors in terms of total R&D spending only if the most optimistic growth scenario (S-C) is assumed to come true. With growth scenarios below the S-C assumptions, the shift from medium to high-techs may take even longer.

- As the scenarios considered vary according to the underlying assumptions concerning small firms' growth, the magnitude of the differences in the results gives a good grasp of the importance of small vs. large firms for certain sectors. The results suggest that supporting the growth of SMEs may help to significantly leverage spending on corporate R&D in high R&D-intensive sectors like Pharmaceuticals & Biotech (and in some low R&D intensive industries too). Other sectors are apparently more driven by large firms (e.g. Automotive & Parts) and the assumed growth of smaller firms does not really affect the overall sector figures (at least not concerning the simulated SB-2020). In a third group of sectors the corporate R&D in the EU obviously depends on both small and large firms to more or less the same extent.

The results presented above imply that the importance of high-tech sectors in Europe (evident from investment in corporate R&D) is assumed to be rising towards the figures known from the US economy; although it does not reach the corresponding US level.[24] Therefore, the structural gap in terms of R&D investment between Europe and the US is not expected to close until 2020; at least not if it is assumed to be driven by small firms' growth.

We can conclude that, if one expects (R&D-intensive) small firms to be a driving force for a substantial structural change in the European economy, from being driven by medium-tech sectors towards a high-tech based economy, it requires either a significant longer time horizon for the assumed fast growth track than the simulated 10 years, or small firms' growth figures even exceeding the annual 30% assumed (as in Scenario-C). Neither case appears to be particularly realistic.

In short, Europe needs more top R&D investors to further intensify their engagement in R&D (increasing volume and R&D intensity) as well as numerous small firms that start and/or significantly increase their existing R&D activities and seek to become larger and (global) leading R&D investors. Accordingly, a broad R&D and innovation (policy) strategy is needed with policy interventions targeting all these options; i.e. stimulating firm growth and R&D and innovation intensity across firm size classes with individually differentiated policy instruments.

This study confirms the importance of the growth of smaller and large companies for revitalising the EU economy (towards being more knowledge intensive) through *organic and sustainable growth*; i.e. the coexistence of competitive firms which enjoy either a high or a moderate level of growth achieved in a shorter or longer time-frame, and ignoring different firm size classes. In this light we could recall that in a highly dynamic growth scenario the allocation of resources and the distribution of growth rates are dynamic too, which implies that the best performing firms expand while those under-performing shrink, with a contemporaneous creative destruction (growth and decay) process. Policy meant to support firm growth in general should take this into account and allow such kinds of creative destruction phenomena to happen.[25]

24 According to the SB-2010 figures, the high R&D-intensive sectors in the US stand for c. 68% of total R&D spending in the US (see Figure 1, above) and – even if the most optimistic scenario for SB-2020 comes true – the share foreseen for high R&D-intensive sectors in Europe only goes up to 43%.

25 See for instance Caballero and Hammour 2000, Bravo-Biosca, 2010 for corresponding cost adjustments, particularly with regard to poorly functioning labour markets with high unemployment rates.

7 Aknowledgments

The authors would like to thanks Fernando Hervás, Sandro Montresor, Joerg Zimmermann (European Commission, IPTS /Joint Research Centre) and Michele Cincera (Solvay Brussels School of Economics and Management, Université Libre de Bruxelles) for their detailed and useful review comments.

The paper has been accepted for presentation at " The XXIII ISPIM (International Symposium for Product Innovation Management) Conference – Action for Innovation: Innovating from Experience " – Barcelona, Spain 17-20 June 2012 (www.ispim.org) and the present version has benefitted from the related review process. The authors are grateful to Dr Steffen Conn (ISPIM Board Member) and to two anonymous referees for their suggestions and support.

References

Acs, Z. J., (1990): Innovation and Small Firms. MIT Press.

Acs, Z. J., (2008): Employment effects of business dynamics: Mice, Gazelles and Elephants - Discussion Papers on Entrepreneurship, Growth and Public Policy - # 2306 - Max Planck Institute of Economics, – ISSN 1613-8333, Jena 2008

Azagra Caro, J. M., Grablowitz, A. (2008): Data on Business R&D: Comparing BERD and the Scoreboard. European Comission (ed.): JRC – Scientific and Technical Reports. EUR Number: 23364 EN. http://ftp.jrc.es/EURdoc/JRC44585.pdf

Akcigit, U. (2009): Firm size, innovation dynamics and growth: A reduced form analysis. Chapter 2 in *Essays on Growth and Innovation Policies*, MIT doctoral dissertation available at http://dspace.mit.edu/handle/1721.1/49708.

Audretsch, D. B. (2006): Entrepreneurship, innovation and economic growth, Edward Elgar.

Bartelsman, E., Haltiwanger J., and Scarpetta S. (2005): Measuring and analyzing cross-country differences in firm dynamics. NBER Conference on Research in Income and Wealth. Produce Dynamics: New Evidence from Micro Data. 2005.

Brécard, D., Chevallier, C., Fougeyrollas, A., Le Mouël, P., Lemiale, L., and Zagamé, P., (2004): A 3 % R&D effort in Europe in 2010: An analysis of the consequences, using the Nemesis model – Implemented for the European Commission, DGRTD (ed.), Paris, 2004.

Bogliacino, F. (2010): Innovation and Employment: A firm level analysis with European R&D Scoreboard data. In: IPTS Working Papers on Corporate R&D and Innovation, No. 08/2010. European Commission (ed.), Seville / Spain.

Bosma, N., and Levie, J. (2010): Global entrepreneurship monitor - 2009 Global Report. Wellesley: Babson College.

Bravo-Biosca, A. (2010): Exploring firm growth across countries. NESTA. 04/05/2010 https://workspace.imperial.ac.uk/business-school/Public/CAED/B-Bravo-Biasco_Growth.pdf

Caballero, R. J, and Hammour M. L. (2000): Creative Destruction and Development: Institutions, Crises, and Restructuring. NBER Working Paper no. 7849, 2000.

Cincera, M., Veugelers, R. (2010): Young Leading Innovators and EU's R&D intensity gap. IPTS - Working Papers on Corporate R&D and Innovation, No. 07/2010-EUR 24325 EN / 7. European Commission (ed.), Seville / Spain.

Coad, A. and Hölzl, W. (2010): Firm growth: Empirical analysis. In: Papers on Economics and Evolution 2010-02, Max Planck Institute of Economics.

Erken, H. and van Es, F. (2007): Disentangling the R&D shortfall of the EU vis-á-vis the US, No 2007-107, Jena Economic Research Papers from Friedrich-Schiller-University Jena, Max-Planck-Institute of Economics, Germany.

European Commission (2006): SMEs in STREPs under FP6. DG RTD (ed.), Brussels

European Commission, (2011): Online Database on Science, Technology & Innovation. European Commission - EUROSTAT http://epp.eurostat.ec.europa.eu/portal/page/portal/science_technology_innovation/data/database

European Commission (2010): The EU industrial R&D investment scoreboard. JRC Scientific and Technical Research Series – JRC-IPTS. Editions 2004 – 2010 available at http://iri.jrc.ec.europa.eu/reports.htm

Gardiner, B. (2010): Evidence on R&D Impact Using Macroeconomic and General Equilibrium Models. Done by Université Libre de Brixelles and Cambridge Econometrics for the European Commission, DG JRC – IPTS, and presented at the 2nd European Conference on Corporate R&D (CONCORD, 2010): http://iri.jrc.ec.europa.eu/concord-2010/papers/gardiner.pdf - Seville, 3 March 2010.

Hoffmann A.N. and Junge M., (2006): Documenting data on high-growth firms and entrepreneurs across 17 countries. ICE http://ice.foranet.dk/upload/documentation_of_high_growth_firms_oct_2006.pdf

Junge, M. and Ulrich K. (2004), "Benchmarking of Small and Medium Size Firms for Twenty Selected Countries – Construction of Growth Indicators", EBST and FORA Working Paper, www.foranet.dk.

Lilischkis, S. (2011): Policies in support of high-growth innovative SMEs. An INNO-Grips Policy Brief by *Empirica* Communication and Technology Research. European Commission (ed.), Bonn / Germany.

Makhoul J. (1975): Linear prediction: A tutorial review". Proc. IEEE, 63(4):561–580.

Mathieu, A., Van Pottelsberghe de la Potterie, B. (2008): A Note on the drivers of R&D intensity. Centre for Economic and Policy Research, Working Paper No. DP6684, February 2008. Available at www.cepr.org/pubs/dps/DP6684.asp.asp.

Markham Ina S. and I.S., Palocsay, S.W. (2006): Scenario Analysis in Spreadsheets with Excel's Scenario Tool. *INFORMS Transactions on Education*, Vol. 6, No 2, http://ite.pubs.informs.org/Vol6No2/MarkhamPalocsay/

Moncada-Paterno-Castello, P, C Ciupagea, K Smith, A Tübke and M Tubbs (2010): Does Europe perform too little corporate R&D? A comparison of EU and non-EU corporate R&D performance. *Research Policy*, 39(4), 523–536.

Moncada-Paternò-Castello, P. (2011): Companies' growth in the EU: What is research and innovation policy's role? – IPTS Working Papers on Corporate R&D and Innovation, No. 03/2011-EUR 24747 EN/3. European Commission (ed.), Seville / Spain.

OECD-EUROSTAT (2005): Oslo Manual - Guidelines for Collecting and Interpreting Innovation Data. OECD, Paris, 3rd edition.

Ortega-Argilés, R.; Potters, L., Voigt, P. (2009): R&D-intensive SMEs in Europe: What do we know about them? European Commission (ed.), IPTS Working Paper on Corporate R&D and Innovation, No.

15/2009. European Commission (ed.), Seville / Spain.
http://iri.jrc.es/papers/15_IPTS_WP_JRC52424.pdf

Pianta, M. (2005): Innovation and employment. In: Fagerberg, J., Mowery, D., Nelson, R. (eds.): The Oxford Handbook of Innovation. Oxford University Press, Oxford, pp. 568–598.

Schumpeter, J.A. (1934): The theory of economic development. Cambridge, MA: Harvard University Press.

Spielkamp, A., Rammer, C. (2006): R&D - Strategic elements for innovation and market success. In: Management & Marketing, Economic Publishing House, Vol. 1(4); pp. 1 -12. ISSN 1842-0206

Strobach, P. (1990) Linear prediction theory: A mathematical basis for adaptive systems; Springer-Verlag, Berlin and New York. ISBN 0387518711

Symeonidis, G. (1996): "Innovation, Firm Size and Market Structure: Schumpeterian hypotheses and some new themes," OECD Economics Dept. Working Paper, 161.

Teruel, M. and de Wit, G. (2011). Determinants of high-growth firms: Why have some countries more high-growth firms than others? - EIM Research Reports, No. H201107. Zoetermeer, The Netherlands. January 2011

Van Ark, B., Inklaar, R., McGuckin, R.H., (2003): ICT and productivity in Europe and the United States where do the differences come from? CESifo GroupCESifo Economic Studies 49 (3), 295–318, doi:10.1093/cesifo/49.3.295.

Van Reenen, J. (1997): Why has Britain had slower R&D growth? *Research Policy* 26, 493–507.

Vinnova, (2008): Growth through research and development - What does the research literature say? By R. Svensson - VINNOVA, Swedish Governmental Agency for Innovation Systems. VINNOVA Report VR 2008:19. ISBN: 978-91-85959-33-4 ISSN: 1650-3104. Published: December 2008.
http://www.vinnova.se/upload/EPiStorePDF/vr-08-19.pdf

Annexes

APPENDIX I: Fast growing companies in SB

APPENDIX II: SMEs in Scoreboard

APPENDIX I: Fast growing companies in SB

Definition of 'fast growing' companies

Following the definition by OECD-EUROSTAT (2005), a company is classified as being a 'fast-growing' if in each year in a consecutive three-year period a minimum of 20% increase in either sales or employment is achieved.

Descriptive Statistics

Pooling several annual editions of the Scoreboard provides longitudinal samples of R&D-intensive companies. See Tables A1 and A2 below for some descriptive statistics of 'fast-growing' firms in SB (polled SB sample SB 2010 + SB 2006, namely S-2, see Appendix II for details).

The sample – due to a sample selection bias towards large firms – tends to crowd out many small firms engaged in corporate R&D, which are just under the minimum R&D investment threshold although they are highly R&D-intensive given their R&D ~ sales ratios.[26] This very nature of a Scoreboard (i.e. comprising companies being selected according to an absolute number) also has a potential impact on considerations of firm growth/firm histories. In fact, small companies are more often associated with the term 'fast-growing companies', about to become large companies. In other words, capturing this type of companies in an SB is a matter of picking them in the right moment (once they have grown above the minimum entry threshold and before they reach major limiting barriers to their growth, such as e.g. market saturation). On the other hand, large/mature companies are usually assumed to grow at slower rates (but steadily), which altogether may lead to the belief that among the companies listed in the SB only a limited number might be classified as 'fast-growing'.

In fact, descriptive statistics can demonstrate the opposite (at least with regard to Europe, where the fast growth companies tend to be the smaller firms, while remaining above the threshold of being classified as SME) while in the RoW fast-growing companies appear to be at the upper end of the firm size distribution). These findings support the assumption of differences in growth paths between small and large firms and the assumption of a significantly higher (average) annual growth rate for the SMEs (in this light, see the SME growth scenarios developed above).

The evidence from Table 1 below suggests that fast-growing companies are mainly linked to only three sectors, whereas companies belonging to the remaining sectors tend to follow a rather smooth growth path (i.e. few/no fast-growing firms). Hence, further (add-on) considerations of fast-growing companies may concentrate on these three sectors, namely Pharmaceuticals & Biotechnology, Software & Computer Services, and Technology Hardware & Equipment.

Moreover, given the number of fast-growing companies compared to the total number of companies in the corresponding sector as presented in Table 1, Healthcare Equipment & Services stands out and therefore deserves a closer look. Interestingly enough, a number of fast-growing companies (in terms of sales and to some extent with regard to R&D investment too) were found among the Oil & Gas Producers in the SB. However, the evidence suggests that EU firms miss this emerging trend.

In contrast, in the Electronic & Electrical Equipment Sector as well as in Industrial Engineering, only comparably few companies were identified as fast-growing although the overall population of companies in these two sectors accounts for about 15% of all SB companies. This is quite surprising since both sectors are commonly assumed to develop rather dynamically. Nevertheless, there are at least some companies in both sectors characterised by notable R&D investment growth, and among them – in both sectors – the EU companies outnumber those from US and RoW together.

26 Moreover, there is also a geographical bias due to differences in the sample coverage when focusing on the main R&D investors globally rather than EU-wide only. This tends to result in smaller companies being crowded out with rising geographical coverage.

There are almost no fast-growing companies at all in Automobiles & Parts (if anything at all appears notable it might be the fact that there are some companies in this sector characterised by fast-growing R&D investment and – with only one exception – they are all from Asia).

Table A1: Frequency and sector alignment of companies identified as fast-growing
[pooled Scoreboard sample; growth criteria: sales, employment, and R&D]

	SB 2010 (reference)		*Fast-growing companies* [acc. to sales]*			*Fast-growing* [employment growth]*			*Fast-growing* [R&D investment]*		
Sector of activity	**Freq**	**%**	**EU**	**US**	**RoW**	**EU**	**US**	**RoW**	**EU**	**US**	**RoW**
Aerospace & Defence	55	2.75	3	1		2			1	3	
Alternative energy	15	0.75	2	1		5	1		4	1	1
Automobiles & Parts	104	5.20	1		2				1		5
Banks	35	1.75							3		1
Beverages	6	0.30							2		1
Chemicals	114	5.70						1	2		1
Construction & Materials	62	3.10	1		1	1					
Electricity	29	1.45							2		
Electronic & Electrical Equipment	149	7.45	4		7	3	2	1	7	2	4
Fixed Line Telecommunications	21	1.05									1
Food & Drugs Retailers	8	0.40									
Food Producers	54	2.70									
Forestry & Paper	9	0.45									
Gas, Water & Multi-utilities	13	0.65	1								
General Industrials	52	2.60				1	1	1			1
General Retailers	18	0.90		3						2	
Healthcare Equipment & Services	67	3.35	4	8	1	2	2		1	6	1
Household Goods	37	1.85	1		1				2		
Industrial Engineering	157	7.85	1	1	1	1			8	2	3
Industrial Metals	28	1.40	1						1		1
Industrial Transportation	14	0.70									
Leisure Goods	35	1.75			1		1	1		1	2
Life Insurance	5	0.25	1								
Media	20	1.00							2		
Mining	9	0.45	1		1				1		1
Mobile Telecommunications	8	0.40									
Nonlife Insurance	9	0.45	1			1			1		
Oil & Gas Producers	27	1.35	1	3	5					1	2
Oil Equipment, Services & Distribu-	17	0.85	1		1						
Other financials	25	1.25	1	1					3		
Personal Goods	30	1.50	1			1					
Pharmaceuticals & Biotechnology	243	12.15	14	20	2	14	6	1	14	7	3
Software & Computer Services	188	9.40	12	10	4	8	10	2	11	9	6
Support Services	44	2.20	2						3	1	
Technology Hardware & Equipment	255	12.75	8	7	10	4	10	4	5	18	8
Tobacco	6	0.30									
Travel & Leisure	32	1.60	2								
total			64	55	37	43	33	11	74	53	42
Total	**2000**	**100**	**156**			**87**			**169**		

* Number of companies classified according to the 'fast-growing' criterion as defined above (in three consecutive years a minimum of 20% annual growth).

NB: Sectors with frequency above 5% in the SB are highlighted in grey.

In general it can be stated that fast growth in terms of R&D investment was detected in those sectors where fast-growing sales/employment figures were also found. However, the Alternative Energy sector,

together with Banks and Other Financials, seems to be an exception in this regard as there are several firms characterised by fast (and steady) R&D investment growth while they are not growing as fast in terms of sales and/or employment. Presumably the latter is still to come when the companies reap the benefits of their strongly increased engagement in corporate R&D.

Table A2: Descriptive statistics of fast-growing firms' characteristics
[EU vs. US and the rest of the world]

Table A2.1: according to sales growth criterion

	all firms		*Fast-growing firms in EU*		*Fast-growing firms in US*		*Fast-growing firms in RoW*	
Variable	Median	Std. dev.	Median	Std. dev.	Median	Std. dev.	Median	Std. dev.
R&D (abs.)	35.1	171.9	12.9	26.0	53.6	239.7	73.8	151.5
Employees	1251.0	54353.0	608.0	19935.1	1328.0	19027.9	9452.0	112537.8
Net Sales	357.0	26782.6	138.1	6498.7	338.9	39903.1	2465.5	23325.0
Operating Profits	33.4	4449.0	8.5	683.6	31.7	6567.9	228.9	4381.2
Capital Expenditure	16.0	2511.0	4.0	665.1	19.3	2485.8	113.0	3927.2
R&D intensity (% sales)	0.09	3.5	0.09	3.6	0.15	3.6	0.03	0.1
No of individuals	**2000**		**64**		**55**		**37**	

Note: *Median* is reported instead of *Mean* since the companies appear to be very heterogeneous (technically, the distribution is fat tailed) and providing an average across all firms could lead to meaningless numbers due to the weight of the 'outliers'.

When looking at SB companies characterised as 'fast-growing' according to their sales figures, the evidence from Table A2.1 suggests that in the RoW large firms are growing the most, thus being characterised by a comparably low R&D intensity. In the EU this is vice versa; i.e. fast-growing firms tend to be much smaller, but highly R&D-intensive. In the US the fast-growing companies tend to be highly R&D-intensive too (with 15% vs. 9% of sales invested in R&D, more than in the EU), but compared to European firms they appear to be larger in terms of staff, net sales and profits (by factors 2, 2.5 and 4, respectively) and on average they also invest much more in R&D in absolute terms compared to European firms (4 times more).

In general, there are less fast-growing companies in terms of employment compared to the number of firms found with fast-growing sales (this applies in particular to the RoW region).

Table A2.2: according to employment growth criterion

	all firms		*Fast-growing firms in EU*		*Fast-growing firms in US*		*Fast-growing firms in RoW*	
Variable	Median	Std. dev.	Median	Std. dev.	Median	Std. dev.	Median	Std. dev.
R&D (abs.)	33.4	208.0	12.6	22.6	80.1	286.3	113.6	138.3
Employees	1332.0	20873.5	340.0	2907.7	2064.0	8823.2	8196.0	52388.9
Net Sales	352.4	2860.2	103.0	616.5	616.2	3213.1	1969.9	4509.1
Operating Profits	24.6	586.6	7.0	112.8	43.0	867.9	257.1	427.5
Capital Expenditure	13.1	251.6	3.0	114.9	35.0	208.8	79.6	506.2
R&D intensity (% sales)	0.12	23.0	0.10	34.5	0.15	0.5	0.08	0.08
No of individuals	**2000**		**43**		**33**		**11**	

Note: *Median* is reported instead of *Mean* since the companies appear to be very heterogeneous (technically, the distribution is fat tailed) and providing an average across all firms could lead to meaningless numbers due to the weight of the 'outliers'.

The differences between fast-growing firms in the EU compared to those in the US and in the RoW as described above in relation to Table A2.1 become even clearer when looking at companies characterised by significant employment growth (see Table A2.2). Fast-growing firms from the EU appear to be even smaller in terms of staff and net sales than outlined above. The median fast-growing EU firm is just above the size of an SME (~ 340 employees)[27] while the median US firm has six times more staff and companies in the RoW, sometimes even 24 times more. Similar figures result for all other company characteristics.

Finally, the reported R&D intensity of fast-growing companies in the EU and the US are virtually the same in Table A2.1 and A2.2 regardless of whether fast growth in terms of sales or employment is the matter of interest. In fact, fast-growing companies from US appear to be extremely R&D intense, while those from the EU still have a fairly high R&D intensity – although already much less compared to those in the US – and the lowest R&D intensity is found with regard to the RoW companies. However, the differences in R&D/sales ratio of the RoW firms compared to those in EU and US appear smaller in Table A2.2 than above in Table A2.1 which might indicate that significant employment growth (in contrast to significant sales growth) in the RoW is also linked to R&D intensity. A more detailed discussion of the impact of R&D on employment can be found in Acs (2008) or related to Scoreboard data in Bogliacino (2010).

APPENDIX II: SMEs in Scoreboard

Pooled data - general remarks

The amount of information available on European firms, in particular broken down by company size classes and activities, is surprisingly low. Admittedly, some data is available, and EUROSTAT, the OECD and others have recently made notable efforts to improve data availability, especially on SMEs. However, particularly as regards small and micro-enterprises (together they account for about 50% of the EU-25 value added), these databases are rather fragmented and often no more than anecdotal evidence. Unfortunately, this applies even more so where company activities are a point of interest, for instance R&D and innovation in SMEs.

Characteristics of the three SME samples created from Scoreboard data:

(1) A mainly[28] balanced panel has been filtered out from the "1375 SB 09-02" data set, which comprises a merger of the SB's from 2006 and 2010 and contains only those firms (1,375 in total) which happen to appear in both data sets. In total **89 SMEs** could be identified from this sample, hereinafter called **S-1** (10 companies from US, the rest from the EU).

(2) **S-2** constitutes an unbalanced panel of altogether **160 SMEs** out of the 2,000 companies listed in SB-2010. In order to create this sample, starting from the 2,000 companies listed in SB-2010 and going backwards in time to observations for 2002, the initial data set has been complemented by including data from earlier SB waves, thus accepting that the panel created will be unbalanced (increasingly lacking observations for earlier years). 27 of the 160 SMEs are from US/RoW, the remaining **133 from the EU**.

(3) **S-3**: An unbalanced panel of a total of **398 SMEs** has been created, resulting from a merger of all SB waves published so far (SB-2004 until SB-2010). For this exercise, from every single SB, the companies to be classified as an SME in at least one year (see definition below) have been filtered out. By this means a list of companies has been created comprising those SB companies which were an SME in at least one year of there listing in any of the SB. For all these companies the

27 Definition of an SME: >250 employees and net sales <50mill Euros within a given year. See: http://ec.europa.eu/enterprise/policies/sme/facts-figures-analysis/sme-definition/index_en.htm

28 "Mainly balanced" means that there are indeed some blanks in this data set although the panel can be considered as "balanced". In fact, the corresponding blanks do not refer to missing data rather than to the non-existence of the corresponding observation, i.e. a certain company may simply not have existed in an earlier year of a certain SB wave (but was included in a later year of the same wave since it has grown into a leading R&D investor) or the company was included in the SB 2006 and in SB 2010, but had to be dropped due to a merger or acquisition.

data from all SB waves was then merged (in case of overlapping data, coverage priority was always given to the information from the most recent SB). For merging observations from companies not reporting in Euros and taken from different SB waves, monetary values were first transferred into the original currency (using the exchange rate as provided in the corresponding SB) and thereafter – by using the conversation rate from SB-2010 – values were turned into 2010 Euros (see exchange rate adjustments as described above). Overall, there are 84 from rest of the world countries (76 from the US), and **314 from the EU** (among them 155 companies from the UK!).[29]

Please note that for the simulation purposes presented above S-2 was used!
See below for complementary descriptive statistics.

Table A3: Sector alignment of large firms and SMEs in pooled Scoreboard samples

	SB 2010 (reference)		*balanced panel (S1)*		*pooled SB 2010 sample (S2)*		*Pooled SB 04-10 sample (S3)*	
ICY CLASS	*all SB firms*		*SMEs*		*SMEs*		*SMEs*	
Sector of activity	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**
Aerospace & Defence	55	2.75			1	0.63	3	0.75
Alternative energy	15	0.75	1	1.12	2	1.25	3	0.75
Automobiles & Parts	104	5.20	1	1.12	3	1.88	5	1.26
Banks	35	1.75					3	0.75
Beverages	6	0.30						
Chemicals	114	5.70			2	1.25	3	0.75
Construction & Materials	62	3.10						
Electricity	29	1.45					2	0.50
Electronic & Electrical Equipment	149	7.45	5	5.62	8	5.00	21	5.28
Fixed Line Telecommunications	21	1.05						
Food & Drugs Retailers	8	0.40						
Food Producers	54	2.70						
Forestry & Paper	9	0.45						
Gas, Water & Multi-utilities	13	0.65						
General Industrials	52	2.60						
General Retailers	18	0.90					1	0.25
Healthcare Equipment & Services	67	3.35	3	3.37	5	3.13	18	4.52
Household Goods	37	1.85						
Industrial Engineering	157	7.85	2	2.25	4	2.50	9	2.26
Industrial Metals	28	1.40						
Industrial Transportation	14	0.70						
Leisure Goods	35	1.75			1	0.63	5	1.26
Life Insurance	5	0.25						
Media	20	1.00					2	0.50
Mining	9	0.45					1	0.25
Mobile Telecommunications	8	0.40			1	0.63	2	0.50
Nonlife Insurance	9	0.45	1	1.12	1	0.63	1	0.25
Oil & Gas Producers	27	1.35						
Oil Equipment, Services & Distribu-	17	0.85					2	0.50
Other financials	25	1.25						
Personal Goods	30	1.50						
Pharmaceuticals & Biotechnology	243	12.15	46	51.69	91	56.88	194	48.74
Software & Computer Services	188	9.40	21	23.60	27	16.88	80	20.10
Support Services	44	2.20			1	0.63	2	0.50
Technology Hardware & Equipment	255	12.75	9	10.11	12	7.50	34	8.54
Tobacco	6	0.30						
Travel & Leisure	32	1.60			1	0.63	7	1.76

29 There seems to be a certain bias towards SMEs from the UK since about 50% of the firms from the EU are from the UK.

Total	**2000**	**100**	**89**	**100**	**160**	**100**	**398**	**100**

Table A4: Descriptive statistics of firm characteristics

Variable	*All firms in SB 2010#*		*SMEs in S1#*		*SMEs in S2#*		*SMEs in S3#*	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
R&D investment (abs.)	196.1	598.4	20.8	23.0	17.3	19.3	16.7	18.0
Employees	22961.0	51470.1	272.1	395.7	198.3	312.8	201.7	284.8
Net Sales	6446.9	16965.9	59.7	113.0	39.6	88.7	36.6	74.4
Operating Profits	744.4	2479.0	-6.6	32.6	-11.4	29.7	-13.5	31.3
Capital Expenditures	455.2	1554.3	2.9	6.8	3.3	16.4	3.0	12.6
R&D Intensity (% sales)	10.1	404.4	4.7	13.9	11.7	53.2	12.9	66.0
No of individuals	**2000**		**89**		**160**		**398**	

* Figures for 2007!
Note: The choice of a certain year for the descriptive statistics might be arbitrary; but – by choosing 2007 – a potential impact/bias introduced due to the financial and economic crisis should be avoided.

Table 5: Descriptive statistics of SMEs in the SB 2010 sample (S2)
- broken down by R&D intensity groups; non-EU firms NOT included -

		High-tech	Medium-high	Medium-low	Low
R&D investment (abs.)	Media	8.11	4.21	2.64	1.91
	St. dev	16.67	2.66	1.70	
R&D Intensity (% sales)	Median	0.72	0.08	0.02	0.00
	St. dev	3.46	0.09	0.01	
Employees	Median	109.00	152.50	62.50	490.00
	St. dev	365.71	120.65	10.50	
Net Sales	Median	15.88	38.24	15.63	779.07
	St. dev	71.43	30.25	15.52	
Operating Profits	Median	-7.85	1.48	4.01	155.88
	St. dev	19.99	18.49	11.72	
Capital Expenditures	Median	0.60	0.90	0.55	2.03
	St. dev	3.53	1.24	0.19	
	No. of obs.	110	20	2	1

Beyond the differences between small and large companies as illustrated, for instance, in chapter III above and by means of Table A3 and A4, Appendix, there seems to be some dissimilarity among SMEs, particularly with regard to R&D intensity, net profits, and employment. But when taking the magnitude and the corresponding standard deviations of R&D investment, net sales, and capital expenditures of SMEs into account, they appear throughout to be relatively low, which in turn suggests a rather uniform picture in this respect. Nevertheless, there are indeed some notable differences among the three SME samples, most likely resulting from the procedures applied in terms of the sample selection/data process.

In general, S-1 consists of SMEs listed in the Scoreboards over the entire period under consideration, which allows the assumption that these firms are either examples of a successful growth path (growing from small into large scale companies) or of a successful market niche strategy, both relying on high R&D intensity as part of the business concept.[30] In contrast, in S-2 and even more in S-3 there are numerous

30 Following the taxonomy of R&D-intensive SMEs as developed in Ortega-Argilés, Potters and Voigt (2009), IRI WP, 15/2009 <link>, S-1 apparently constitutes a major extent of either steady/growing 'niche market producers' or 'gazelles' relying on R&D intensive businesses rather than the 'corporate laboratory' type of SMEs. This hypothesis is supported by the notable differences between S-1 and S-2/S-3 in terms of the average number of employees and net sales.

SMEs which 'come and go', i.e. they appear in just one of the latest SB waves (growing into it) or are included in one or several early SB waves only, but disappear at a certain point in time, most likely due to M&A, bankruptcy, shrinking R&D intensity, etc. Hence, with a look at the number of these cases (see the difference in absolute numbers of SMEs in S1 and S3), there is good reason for further analysing the corresponding firm paths, which is due to be done in ongoing studies carried out by the JRC-IPTS IRI team (Economics of Industrial Research and Innovation).

European Commission

EUR 25292 EN – Joint Research Centre – Institute for Prospective Technological Studies

Title: Projection of R&D-Intensive Enterprises' Growth to the year 2020: Implications for EU policy?

Authors: Peter Voigt and Pietro Moncada-Paterno-Castello

Luxembourg: Publications Office of the European Union

2012 – 30 pp. – 21.0 x 29.7 cm

EUR 25292 EN
ISSN 1831-9424
ISBN 978-92-79-21274-1
doi:10.2791/81696

Abstract

The paper investigates how sector composition and the magnitude of R&D investment in the EU may differ in 2020 in comparison to the past, if a selection of top R&D-investing SMEs were assumed to be on a fast growth track while the top R&D-investing large-scale companies continue to grow as before. The background of this research objective is the emerging focus on SMEs – and in particular the fast-growing among them – with regard to the "Europe 2020" policy strategy. The study relies on the sample of top R&D-investing firms as given by the latest available "EU Industrial R&D Investment Scoreboard" editions, building there from an unbalanced panel. Scenarios were developed by distinguishing SMEs' assumed growth paths vs. that of large scale companies. A linear prediction model has been used to calculate the scenario simulations.

Overall, the study indicates that if one expects the (R&D-intensive) small firms to be a driving force for a substantial structural change in the EU economy, from being driven by medium-tech sectors towards a high-tech based economy, it requires either a significant longer-term horizon of the assumed fast growth track than the simulated 10 years, or small firms' growth figures which even exceed the assumed annual 30% (as in the most optimistic scenario). Neither case appears to be particularly realistic. Hence, we need more top R&D investors in Europe to further intensify their engagement in R&D (increasing volume and R&D intensity) as well as numerous small firms that start and/or significantly increase their existing R&D activities and thus seek to become large firms and (global) leading R&D investors. Accordingly, a broad R&D and innovation (policy) strategy is needed with policy interventions which also target well all these options; i.e. stimulating firm growth and R&D and innovation-intensity across firm-sized classes.

LF-NA-25292-EN-N

As the Commission's in-house science service, the Joint Research Centre's mission is to provide EU policies with independent, evidence-based scientific and technical support throughout the whole policy cycle.

Working in close cooperation with policy Directorates-General, the JRC addresses key societal challenges while stimulating innovation through developing new standards, methods and tools, and sharing and transferring its know-how to the Member States and international community.

Key policy areas include: environment and climate change; energy and transport; agriculture and food security; health and consumer protection; information society and digital agenda; safety and security including nuclear; all supported through a cross-cutting and multi-disciplinary approach.

Publications Office

ISBN 978-92-79-21274-1