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Structural Change and the Development of Business Expenditure on R&D in Austria

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Kurzfassung

Ausgaben für Forschung und Entwicklung (F&E) im Verhältnis zur Wirtschaftsleistung (F&E-Intensität) werden häufig als Indikator für wirtschaftliche und technologische Leistungsfähigkeit einer Volkswirtschaft gesehen. Im internationalen Vergleich ist Österreich dabei eines der wenigen entwickelten Länder mit einem deutlichen Anstieg sowohl bei den F&E-Ausgaben als auch bei der Intensität in den letzten 20 Jahren. Die theoretische Grundlage für diese Arbeit bilden Literatur zu Innovation und F&E sowie aktuelle Studien über die Entwicklung auf nationaler und internationaler Ebene. Technische Innovation und F&E beeinflussen das Unternehmenswachstum im Allgemeinen positiv und gelten als eine der wichtigsten Faktoren für Wirtschaftswachstum und Wohlstand einer Volkswirtschaft.

Die vorliegende Arbeit untersucht den Anstieg der F&E-Ausgaben des österreichischen Unternehmenssektors basierend auf Daten der F&E-Erhebung von 2002 und 2013. In einem ersten Schritt werden die F&E treibenden Firmen in Gruppen auf Basis von Unternehmensgröße, Technologie- bzw. Wissensintensivität sowie relativer als auch absoluter Höhe der F&E-Ausgaben zusammengefasst und die Entwicklung in diesen Gruppen analysiert. In einem zweiten Schritt identifizieren wir darauf aufbauend Unternehmen, die F&E über einen längeren Zeitraum betreiben, und untersuchen deren Wachstum sowie Mobilität. Die Rolle des Strukturwandels wird durch eine Shift-Share-Analyse ermittelt, indem die Auswirkungen verschiedener Strukturwandelseffekte vom Intensitätseffekt getrennt werden.

Unsere Ergebnisse zeigen, dass der Anstieg der F&E-Ausgaben hauptsächlich von großen, F&E-starken Firmen kommt und das Ergebnis einer Intensivierung von F&E in allen Sektoren ist. In dem betrachteten Zeitraum konnten wir nur geringe Mobilität feststellen: Es gibt fast keine kleinen Unternehmen, die zu bedeutenden, forschungsintensiven Akteuren aufgestiegen sind.

Abstract

The relation of expenditure on research and development (R&D) to economic output (R&D intensity) is often considered as an indicator of the economic and technological capability of an economy. In this context, Austria is one of the few developed countries with a significant increase in both R&D expenditure and intensity over the last 20 years. The theoretical basis for this work is literature on innovation and R&D as well as current studies on the development at national and international level. Technical innovation and R&D generally influence firm growth positively and are one of the most important drivers for economic growth and the long-term prosperity of an economy.

This work examines the growth of the R&D expenditure of the Austrian business enterprise sector based on data from the *F&E Erhebung* of 2002 and 2013. In a first step, the R&D performing companies are divided into groups on the basis of firm size, technology or knowledge intensity as well as relative and absolute R&D expenditure. The development is then analyzed in these groups. In a second step, we identify companies that perform R&D over a longer period of time and analyze their growth and mobility. The role of structural change is examined by a shift-share analysis, which decomposes the change in R&D intensity into a structural, interaction, and diffusion effect.

Our results show that the increase in R&D expenditure mainly comes from large, R&D-intensive companies and that it is due to an intensification of R&D across all sectors. We found only low mobility among the R&D performing companies in the considered period: there are almost no small companies that have risen to large, research-intensive actors.

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CHAPTER 1

Introduction

1.1 Motivation

Research and experimental Development (R&D) aims at deriving new knowledge and at finding new applications for that knowledge (OECD, 2015b). In case of businesses, these applications often result in new product and service innovations. It is well agreed in literature, that R&D has an overall positive effect on firm performance. Technical innovation is even considered as one of the most important drivers for economic growth (Rosenberg, 2004). Innovation and R&D are not only important for individual companies, but the overall development and prosperity of an economy. Investments in R&D are especially important for rich, highly developed economies such as Austria, in order to maintain and further improve their economic level (Ecker et al., 2015).

In the last years, there was a very positive development in the R&D expenditure of the business enterprise sector in Austria: Between 2002 and 2013, the investments of Austrian firms in R&D doubled to EUR 6.8 billion. On the one hand his development was the result of an increase in R&D intensity across all sectors. On the other hand, the structure of the corporate sector in these ten years has changed: New companies have entered and left the market, while existing companies have grown or shrunk. What is more, the importance of foreign owned businesses has increased significantly in Austria in terms of R&D spendings during this time. However, it is largely unknown which industries were mainly responsible for this development and whether new players or established, already R&D performing companies primarily contributed to this growth.

1.2 Problem Statement

In recent years there has been a lot of research into innovation activities and its impact on firm performance (García-Manjón and Romero-Merino, 2012; Nunes et al., 2012; Star and Wennberg, 2009). Yet there are no current studies examining the structural change of R&D expenditures in Austria and very few for other countries. Austria is particularly interesting, because it is one of the few developed countries with a rapid increase in R&D spendings since 2000 (Falk, 2012).

As for R&D intensity in the corporate sector, Austria ranks in the top third of the OECD countries according to the OECD's latest publication on innovation (OECD, 2015c). However, literature shows that a direct international comparison of the R&D intensity in the corporate sector is only applicable to a limited extent, since the indicator is strongly influenced by the industrial structure. Countries which are specialized in research-intensive sectors tend to have a higher R&D intensity than those with a large proportion of industries with low research volumes (Sandven and Smith, 1998). For example, Moncada-Paternò-Castello et al. (2010) show that the R&D intensity of European companies is low in international comparison due to sector specialization: While the automotive sector (average R&D intensity) is very dominant in the EU, the importance of the IT sector, which is very research-intensive (both hardware and software as well as electronic devices), is relatively low. Consequently, the corporate sector in a country with an R&D quota, which is low in international comparison, can still be quite research-intensive (Reinstaller and Unterlass, 2012).

1.3 Aim of the Work

This work shall examine the role of the structural change in the rise of R&D expenditures in the corporate sector in Austria since 2002. Structural change is measured over time as a shift in the contribution of different groups of firms to the total R&D expenditure. As a first step the thesis will summarize all R&D performing firms in groups on the basis of size, industry or pace of growth. Based on this grouping the proportion of these groups in 2002 is determined and compared to the proportion in 2013. In some cases, also the mobility of actors between the groups will be interesting, for example whether a startup company could develop to a leading R&D company. Building on these results, the following questions will be addressed:

- Did the growth in R&D spendings origin mainly from large, established companies or young innovative startups?
- Could new actors establish themselves in the group of research-intensive companies in Austria during this period?
- What is the role of traditional medium-tech industries in Austria's catching up?

The work concludes with an interpretation of the results.

1.4 Methodological Approach

The methodological approach consists of the following steps:

1. **Literature Review**
   The work starts with a review of relevant literature. It focuses on research related to R&D expenditure and innovation activities of the business enterprise sector. This provides the theoretical basis for the subsequent work.

2. **Exploratory Data Analysis**
   The empirical research of this thesis is of quantitative nature and is based on exploratory data analysis. The analysis is applied on data at firm-level, provided by Statistics Austria. In addition to R&D expenditures, this dataset also contains sales figures and the number of employees for the respective enterprise. The data is available for the years 2002 and 2013, which is the longest period for which this information can be provided. For the data analysis R scripts are written, which are executed remotely by Statistics Austria due to confidentiality requirements.

3. **Shift-share Analysis**
   The shift-share analysis is used for investigating whether the increase in the R&D intensity is the result of a structural change towards more R&D intensive industries, or whether it is due to more R&D intensive production at otherwise similar economic structures. The data therefor is based on results from the exploratory data analysis as well as official publications from Statistics Austria.

4. **Interpretation**
   Finally, the results obtained in the previous steps are interpreted and findings are derived.

1.5 Structure

Chapter 1 introduces the reader to the domain of this thesis. It lays out the motivation for this topic, states the problem by addressing the research questions, briefly explains the methodological approach, and includes the structure of the following work.

Chapter 2 includes the literature review. It covers definitions of innovation and R&D in the business enterprise sector as well as different types of each. This also includes a discussion of innovation and R&D as drivers for economic growth, international competitiveness and the long-term prosperity of an economy. The chapter further presents innovation and R&D related patterns and trends that are derived from a number of national and international publications.

Chapter 3 focuses on the methodology, i.e. on the dataset and the data analysis process. This includes an overview of the variables in the dataset as well as different classifications, e.g. to distinguish between high-tech, medium-high tech, medium-low tech, and low-tech manufacturing industries and their equivalents in the service sector. It further includes the mathematical approach and definition of the shift-share analysis.

Chapter 4 presents the empirical results from the data analysis on three different levels: First, a summary of all R&D performing companies for a broad overview. Second, a classification based on R&D intensity and absolute R&D expenditure. Third, only firms with an R&D expenditure in both 2002 and 2013 are taken into account. These firms are referred to as *long-term R&D performers* in this work. The results from the shift-share analysis are also shown in this chapter. It concludes with a critical reflection by discussing the validity of the results and limitations of the analysis.

Chapter 5 summarizes the work by referring to the research questions and addresses possible future research.

CHAPTER 2

R&D and Innovation in the Business Enterprise Sector

Technical innovation is considered as one of the most important drivers for economic growth (Rosenberg, 2004). R&D aims at creating new knowledge and new innovative products – this is the reason, why research is conducted in this domain and why analyzing its development is important for an economy. In this chapter we will firstly define innovation and R&D in the business enterprise sector. This also includes a discussion of innovation and R&D as drivers for economic growth, international competitiveness and the long-term prosperity of an economy. The chapter further presents innovation and R&D related patterns and trends that are derived from a number of national and international publications.

2.1 Definition of Innovation

2.1.1 Schumpeter Mark I & Mark II

The term *innovation* as it is known today was substantially shaped by the Austrian-American economist Joseph Alois Schumpeter. He describes innovation as *"the doing of new things or the doing of things that are already being done in a new way"* (Schumpeter, 1947, p. 151). In *The Theory of Economic Development* Schumpeter argues that the economic development is characterized by *"spontaneous and discontinuous change in the channels of flow, disturbance of equilibrium, which forever alters and displaces the equilibrium state previously existing"* (Schumpeter, 1934, p. 64). The disturbance of the equilibrium state can be caused either by technological changes or by organizational changes in the production of goods. Schumpeter sees the entrepreneur as the main origin for these changes. By developing new ideas and introducing new innovations to the market, entrepreneurs make existing products and services obsolete and thereby challenge established firms. This process of *creative destruction* is known as the Schumpeter Mark I regime (Carree et al., 2002; Schumpeter, 1912).

In later work Schumpeter focuses on the innovation activities of large, established firms. He lays out that there are periods of relative stability with low market entry rates with a few market dominating firms. The market dominating firms are those with superior products, technologies, or organizational capabilities and during these times they can generate great economic returns. These returns should be used for the development of the next generation of products and technologies in order to make profit from these inventions in the future and to keep the position as a market leader. Schumpeter argues that large companies are in advantage because they accumulate a great amount of knowledge within their research departments. This concept of *creative accumulation* is an integral component of the Schumpeter Mark II regime (Malerba, 2005; Carree et al., 2002; Schumpeter, 1942).

Literature often refers to industries in terms of the Schumpeter Mark I and Schumpeter Mark II regime. Thereby Schumpeter Mark I industries are characterized by creative destruction, i.e. sectors with relatively low entry barriers where innovation often emerges from new market entries. Examples for such industries are biotechnology or information and communication technologies. In contrast, Schumpeter Mark II industries show relatively high entry barriers and innovations are developed by large established companies. Malerba (2005) gives the semiconductor industry of the 1990s and mainframe computer firms from 1950 until 1990 as examples for this regime. Schumpeter Mark II industries are more likely to develop a concentrated market structure compared to Schumpeter Mark I industries, that commonly consist of several small companies (Carree et al., 2002; Fontana et al., 2012).

2.1.2 OECD Definition

One of the most widely used definitions for innovation today is provided by the OECD. It defines innovation as *"the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations"* (OECD and Eurostat, 2005, p. 11). The OECD lists four types of innovations: product, process, marketing, and organizational innovation.

2.1.3 Other Definitions

Most definitions see innovation as the combination of something new (an invention) and its economic application. Thus, an invention that is not successful on the market or never makes it to the market is no innovation. The following gives an overview of several widely used definitions:

- Porter (1990, p. 780) defines innovation exactly that way, as *"a new way of doing things (termed invention by some authors) that is commercialized"*.

- *"An invention is an idea, a sketch or model for a new or improved device, product, process or system. [...] An innovation in the economic sense is accompanied with the first commercial transaction involving the new product, product, system or device, although the word is used to describe the whole process."* – Freeman (1982, p. 6)

- *"Innovation [...] is generally understood as the successful introduction of a new thing or method. [...] Innovation is the embodiment, combination, or synthesis of knowledge in original, relevant, valued new products, processes, or services."* – Luecke and Katz (2003, p. 2)

2.1.4 Disruptive Innovation

Clayton Christensen introduced the term disruptive innovation in 1995 (Bower and Christensen, 1995). It describes *"a process by which a product or service takes root initially in simple applications at the bottom of a market and then relentlessly moves up market, eventually displacing established competitors"* (Christensen, 2017). Examples for disruptive innovations are personal computers that disrupted mainframe and mini computers, cell phones to fixed line phones, and discount retailers to full-service department stores. In the course of digitization in the past 20 years the number of disruptive innovations has increased and several (primarily) internet companies aim at disrupting traditional businesses.

Technologies develop along S-shaped paths and once they reach their technological limits, they are susceptible to being replaced by a new (disruptive) technology. The point of time when a new technology surpasses the limits of an existing one is hard to anticipate. Christensen argues that large, established firms typically do not invest in niche markets, because these markets are small, do not solve growth needs of large companies and markets that do not exist can not be analyzed. Disruptive technologies, however, often emerge from niche markets. Established businesses prefer incremental innovations, that are easier to manage and for which future sales are easier to foresee. These sustaining technologies improve the performance of existing, established products (Christensen, 2013).

2.1.5 Types of Innovation

Schumpeter distinguishes between five types of innovation, which are presented below (Schumpeter, 1934). Depending on the source, the different types of innovation vary, ffor example the above stated OECD's definition of innovation does not include market and input innovation, but marketing innovation (OECD and Eurostat, 2005). Others add further types such as service or design innovation (Pesendorfer, 1995; Berry et al., 2006).

Product Innovation

Product innovation describes the creation of a new product, which is not yet familiar to consumers, or the introduction of a new quality of a product, that is also yet unknown by the customers. The term *product* thereby refers to both goods and services. Significantly improved products are also considered as product innovations. According to the OECD and Eurostat (2005, p. 48), this significant improvement can be in the product's *"technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics."* Product innovations can be based on new knowledge or technologies, but they can also make use of already existing knowledge or technologies by finding new applications for it. Routine upgrades or seasonal changes do not count as product innovations. The same applies for changes in a product's design, that do not entail significant changes in the product's usage or characteristics (Schumpeter, 1934; OECD and Eurostat, 2005).

Examples for product innovations that were based on new technologies are the steam engine or the first microprocessors. An example for a new product that combined existing knowledge and technologies is the MP3 player; it combined existing software principles with miniaturised hardware components. The anti-lock braking system (ABS) and Global Positioning System (GPS) are examples of product innovations with significant improvements that consist of partial changes or additions to existing solutions (OECD and Eurostat, 2005; Naimi and Mark, 2010).

Process Innovation

A process innovation refers to the introduction of new, not yet implemented processes for producing goods or delivering them to customers. While product innovations create value by offering and selling new or improved products, process innovations allow a production or delivery of goods that is cheaper, faster or of higher quality and thereby creates value. This value may also be in form of a competitive advantage (Hill et al., 2014; OECD and Eurostat, 2005).

A popular example for a process innovation is the *Toyota Production System.* It comprises methods such as *lean manufacturing* and *just-in-time production* for a more efficient car production process (Hill et al., 2014). The introduction of a radio-frequency identification (RFID) goods-tracking system is an example of a new delivery method and thus process innovation (OECD and Eurostat, 2005).

Market Innovation

Schumpeter (1942, p. 82) sees market innovation as *"the opening up of new markets."* However, recent publications suggest that market innovation is broader: Kjellberg et al. (2015, p. 6) add to Schumpeter's definition that *"market innovation also comprises the successful change of existing market structure, the introduction of new market devices, the alteration of market behavior, and the reconstitution of market agents."*

Input Innovation

An input innovation is the development of a new source of raw materials or semi-finished products. This includes the substitution of a material with a cheaper one or with a material that was newly designed for a specific purpose. The resulting end-product may however not be altered at all by these changes (Kline and Rosenberg, 1986).

Organizational Innovation

Organizational innovation refers to the implementation of new structures, processes or strategies within an organization (Armbruster et al., 2008). The OECD and Eurostat (2005, p. 51) states that *"organisational innovations can be intended to increase a firm's performance by reducing administrative costs or transaction costs, improving workplace satisfaction (and thus labour productivity), gaining access to non-tradable assets (such as non-codified external knowledge) or reducing costs of supplies."*

Nowadays, organizational innovation often comes along with the introduction of a new software. For example the first introduction of a supply chain management system or the first implementation of a database for knowledge sharing among different divisions can be seen as organizational innovations (OECD and Eurostat, 2005).

2.2 Research and Experimental Development (R&D)

2.2.1 R&D in the Innovation Process

Research and Experimental Development (R&D) marks an important input and the starting point for the innovation process according to Brockhoff, which is depicted in Figure 2.1. The impuls for R&D can be direct or presumed, market- or knowledge-driven needs, irrespective of whether it has company-internal or external sources. R&D results in an invention that lays out the basis for the following innovation process (Brockhoff, 1994).

In the next step, the developed invention is introduced to the market. It should be mentioned that the innovation process does not necessarily need to run through all the outlined steps, it may be terminated at any time. A reason why an invention might not be introduced to the market, could for instance be a lack of personnel or financial resources or a negative economic evaluation. If the introduction to the market is successful, one speaks of an innovation in the narrow sense. This differentiation is crucial: An invention is not yet an innovation. Inventions include new ideas up to and including prototype construction or concrete concept development in the pre-market phase. Innovation in the economic sense can only be understood when its usefulness is recognized and a product, production process or business model is introduced or changed accordingly. It may be that the utility or value of an innovation is discovered only after a long period of time; many objects are "useless" at the moment of their creation (Brockhoff, 1994).

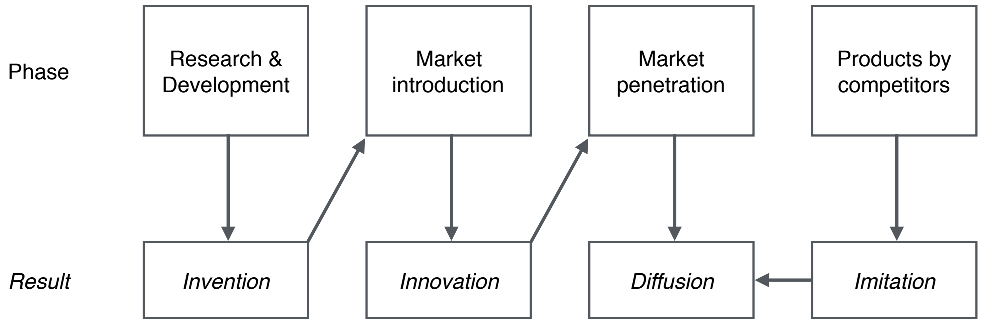

Figure 2.1: Innovation process according to Brockhoff (1994, p. 37)

Market penetration as the subsequent activity represents the adoption by customers and results in the diffusion of the innovation. One speaks of diffusion when the number of individual adopters of the innovation ensures that it is self-sustaining, i.e. when the introduced innovation is accepted and spreads among its aspired users (Greenhalgh et al., 2004). Motivated by the success of the innovator, new entrants come to the market and enter into competition by imitating the product or service. These imitations then again have an effect on the diffusion process (Heesen, 2009).

The model by Brockhoff is characterized by a linear order of steps: activities and results. For these kind of discrete processes Cooper (1994) has established the name *Stage-Gate* model. The stages represent the activities and the gates illustrate the results, that are decision-making points, at which the continuation of the innovation process is decided upon. The model proposed by Cooper is depicted in Figure 2.2. Thereby R&D – referred to simply as *Development* – again plays an important role. The strict series of stages and gates is often criticized as it is argued that there is an overlap and parallelization between the different phases (Cooper, 1994).

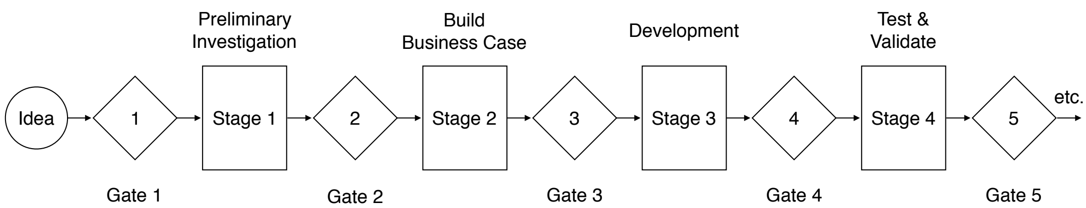

Figure 2.2: Stage-gate process (Cooper, 1994, p.5)

In a more recent publication Cooper (2014) acknowledges that his originally proposed model is outdated and that there is demand for a new model due to the changes in the economy (*"it is now faster paced, more competitive and global, and less predictable"*). He lists the following points of criticism: *"It is accused of being too linear, too rigid, and too* *planned to handle more innovative or dynamic projects. It's not adaptive enough and does not encourage experimentation. It's not context-based – one size should not fit all. Its gates are too structured or too financially based, and the system is too controlling and bureaucratic, loaded with paperwork, checklists, and too much non-value-added work."* Consequently he proposes an updated version of the original model with several iterations to include customer feedback in every stage. Thereby the process becomes more adaptive, flexible, agile, and accelerated (Cooper, 2014, p. 49 ff).

The models by Brockhoff (1994) and Cooper (1994) suggest that innovation is a linear process and that R&D is an integral part of it. Such classical, R&D-based innovation models have been challenged from different perspectives (Kirner et al., 2009). On the one hand it is argued that innovation processes are not linear in practice. Instead they tend to be much more dynamic, complex and interactive, as they often include several actors (for example suppliers and consumers) (Lundvall, 2016). On the other hand, several authors argue that some forms of innovation do not rely on R&D. Jensen et al. (2007) proposes two modes of innovation: First, the Science, Technology and Innovation mode that requires scientific and technical knowledge and that is usually driven by R&D. Second, the Doing, Using and Interacting mode that *"relies on informal processes of learning and experience-based know-how"* (Jensen et al., 2007, p. 1) which is often not based on R&D or only to a very limited extend. Thus, R&D is part of the innovation process in many cases, but it is not always pivotal.

2.2.2 Definition of R&D

In literature there are different definitions for the term *Research & Development* that are in essence very similar. Here, the often used definitions by Brockhoff (1994) and the OECD (2015b) will be discussed.

According to Brockhoff (1994, p. 22) technology is the accumulated knowledge that builds on a theoretical basis, it describes and explains functional principles and finds solutions to existing problems. Engineering uses this knowledge to create concrete products or processes. Finally, R&D is a combination of production factors that aim at the generation of new knowledge. The R&D process is target-oriented, implying that new knowledge is not gained by chance, and utilizes activities that may lead to a change in technology (an increase in knowledge) and consequently to new or improved products and services (Brockhoff, 1994, p. 35).

The OECD defines R&D as *"creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge"* (OECD, 2015b, p. 28). Activities that aim at increasing the existing knowledge and development of new products, are called R&D activities. R&D is the application of scientific principles to in contrast to pure trial and error.

When it comes to deciding what should be counted as R&D an what not, the OECD (2015b, p. 69) refers to *"the element of novelty [as] a basic criterion for distinguishing*

R&D from related activities." Education and training are in general not part of R&D, because they do not aim at the creation of new knowledge but the transfer of existing knowledge. Market research is excluded for the same reason. Several other activities, that are related to product or process innovations and therefore are often believed to be R&D activities, are in fact also no R&D activities: The acquisition of products and licenses, product design, trial production, as well as the acquisition of equipment and machinery – even if those are needed for a product or process innovation. (Smith, 2005) According to the OECD (2015b), R&D is characterized by five core criteria – starting with the already mentioned novelty. An activity has to fulfill the following criteria to be an R&D activity:

1. Novelty
2. Creativity
3. Uncertainty
4. Systematics
5. Transferability and/or reproducibility

First, R&D activities aim at deriving *new* knowledge by novel applications or interpretations of existing knowledge. As R&D aims at the creation of new knowledge, the outcome of an R&D activity is measured by the newly gained knowledge, not by new or improved products or processes. These products or processes result from the application of the knowledge. For the corporate sector, the degree of novelty should be determined by comparing the newly derived knowledge with the existing stock of knowledge in the respective industry. By definition, R&D does not include activities that aim at gaining knowledge by copying, imitating, or reverse engineering, because such derived knowledge is not new (OECD, 2015b).

Second, the concept of *creativity* implies that a project needs to be *"based on original, not obvious, concepts and hypotheses"* to be considered as an R&D project (OECD, 2015b, p. 47). These *creative* concepts and hypotheses are usually given by a researcher as input for an R&D project. Thus, routine changes to products or processes are not part of R&D activities. In the context of creativity, the area of the arts usually involves a lot of creative work, however the other criteria need to be fulfilled as well for an activity to qualify as R&D.

Third, uncertainty is another important aspect of R&D activities, be it in terms of the actual outcome or the amount of timely or financial resources that are necessary to achieve them. When it comes to deciding whether prototyping qualifies as an R&D activity, uncertainty serves as the key criterion: The OECD (2015b, p. 47) specifies R&D prototypes as *"models used to test technical concepts and technologies with a high risk of failure, in terms of applicability"*, whereas non-R&D prototypes are *"preproduction units used to obtain technical or legal certifications"*.

Fourth, an R&D project needs to be performed systematically, meaning that it needs to be planned and budgeted. Therefore, the objective of an R&D project, the process, and the sources of funding need to be described and documented (OECD, 2015b).

Finally, the result of an R&D project should have the ability to be transferred or reproduced. Transferability of the outcome means that the newly gained knowledge is shared with others to increase the stock of knowledge and to give others the chance to make use of this knowledge. Reproducibility describes that the outcome should be able to be reproduced in other experiments. Sometimes the outcome of an R&D project is subject to secrecy and protected by Intellectual Property Rights (IPRs). In that case the results are still shared with a limited number of people, who might use that knowledge (OECD, 2015b, p. 48).

2.2.3 Different Types of R&D

The OECD distinguishes between the following three types of R&D:

- **Basic research** comprises experimental and theoretical work in order to gain new knowledge, with no particular application in view. The results of basic research are usually published in scientific magazines and exchanged and discussed in expert circles. Because there is no direct commercial application for basic research in the short term, it typically takes place in the higher education and the government sector; occasionally business enterprises invest in basic research.
  Basic research can be further subdivided into pure basic research and oriented basic research: Oriented basic research is carried out with a specific use in view. The thereby generated knowledge is expected to be the basis for solving a current or future problem. The OECD gives research in the field of energy-saving technologies as an example. Pure basic research on the other hand, is carried out to further expand the available knowledge, without any application to practical problems in view (OECD, 2015b).

- **Applied research** is undertaken in order to extend the available knowledge. In contrast to basic research it is directed towards a specific objective or a practical application. Thereby the goal of applied research is either to find possible use-cases for the results of basic research or to find solutions to problems by developing new methods (OECD, 2015b).

- **Experimental development** is the systematic application of knowledge in order to create new products or processes or to improve existing products or processes. The applied knowledge may be gained through research or may come from practical experience. Experimental development also includes the generation of new knowledge that arises from the creation of new products or processes or the improvement of those.
  Experimental development is often confused with *product development*. While product development is the entire process of bringing a new product to the market,

which includes many subprocesses (or stages) from the initial idea to the introduction to the market, experimental development is just one part of that process: the stage of applying knowledge to create a new product or service. That stage ends when the above mentioned R&D criteria (novelty, creativity, uncertainty, systematics, and transferability and/or reproducibility) are no longer fulfilled.
Pre-production development does also not count as experimental development. Pre-production development for example describes non-experimental work on a defence or aerospace product or system before it heads into production. However the OECD (2015b, p. 52) states, that *"it is difficult to define precisely the cut-off point between experimental development and pre-production development; the distinction between these two categories requires "engineering judgement" as to when the element of novelty ceases and the work changes to routine development of an integrated system"*.

There is no specific order in which these three types of R&D activities occur. Experimental development might bring results that lead to basic research, and basic research can also lead to new products or processes directly (OECD, 2015b).

The distinction between the three types of R&D is often not straightforward and many organizations that are performing R&D, do not have a clear-cut separation of these three types. Therefore, the OECD provides a list of examples for different sectors and industries as to how to differentiate between basic research, applied research, and experimental development (OECD, 2015b).

2.2.4 R&D Expenditure

The measurement of money spent on R&D (R&D expenditure) is not only important for bookkeeping purposes, but also of considerable interest to economists and policy makers. There are several national and international statistics on R&D expenditure, measuring who conducts and who funds R&D, where it takes place and so on. These statistics give information about the development of the R&D expenditure and the effects of fiscal and financial incentives on it. Moreover, a lot of research on how R&D contributes to economic growth is based on data of R&D expenditure (OECD, 2015b).

Statistics and data on R&D expenditure often differentiates between *intramural* and *extramural* R&D expenditure. These two concepts are presented in the following.

Intramural R&D Expenditure

Intramural R&D expenditure subsumes all running costs plus gross fixed capital expenses for R&D within a statistical unit (such as a country, federal state, etc.) for a specific period, irrespective of the source of funding. Running costs for R&D primarily include labour costs for R&D personnel and non-capital purchases that support the R&D activities. Examples of such non-capital purchases are: (OECD, 2015b, pp. 112-115)

- books, journals, and reference materials
- lease of capital goods (machinery and equipment, etc.)
- license fees for software (for both systems and applications software)
- materials for laboratories (e.g. chemicals, animals, etc.)
- royalties or licences for the use of patents and IPRs
- rental of buildings
- subscription fees to libraries or scientific societies
- water and energy.

The most relevant fixed capital expenses are: (OECD, 2015b, pp. 119-121)

- land and buildings
- machinery and equipment
- capitalized computer software (e.g. long term licenses)
- other intangible assets, that are used for more than one year (e.g. patents and IPRs).

Extramural R&D Expenditure

In contrast to intramural R&D expenditure, extramural R&D expenditure describes funding or expenses for R&D performed outside the considered statistical unit. However, the separation between the two types is not always straightforward: For instance, costs for a non-R&D purchase (such as machinery or software) made abroad (or outside the statistical unit considered) that supports intramural R&D activities are counted towards intramural R&D expenditure (OECD, 2015b).

Figure 2.3 depicts the difference between intramural and extramural R&D expenditure with the flows of funding from the perspective of an R&D performer. Areas (1) and (2) comprise the intramural R&D activities, area (3) the funding for extramural R&D. Area (4) comprises players that outsource R&D to the R&D performer depicted in the center of the graph. Vice versa area (5) subsumes entities that perform R&D for the unit considered, i.e. internal funds are paid to an external unit to perform R&D for it. Due to the uncertainty of R&D, the return for these expenses is unknown a priori. Areas (6) and (7) are recipients and givers of R&D funds, but without giving or receiving a return. This lack of return is not because of the uncertainty of R&D, but because it is not agreed upon, for example when receiving or giving grants (OECD, 2015b).

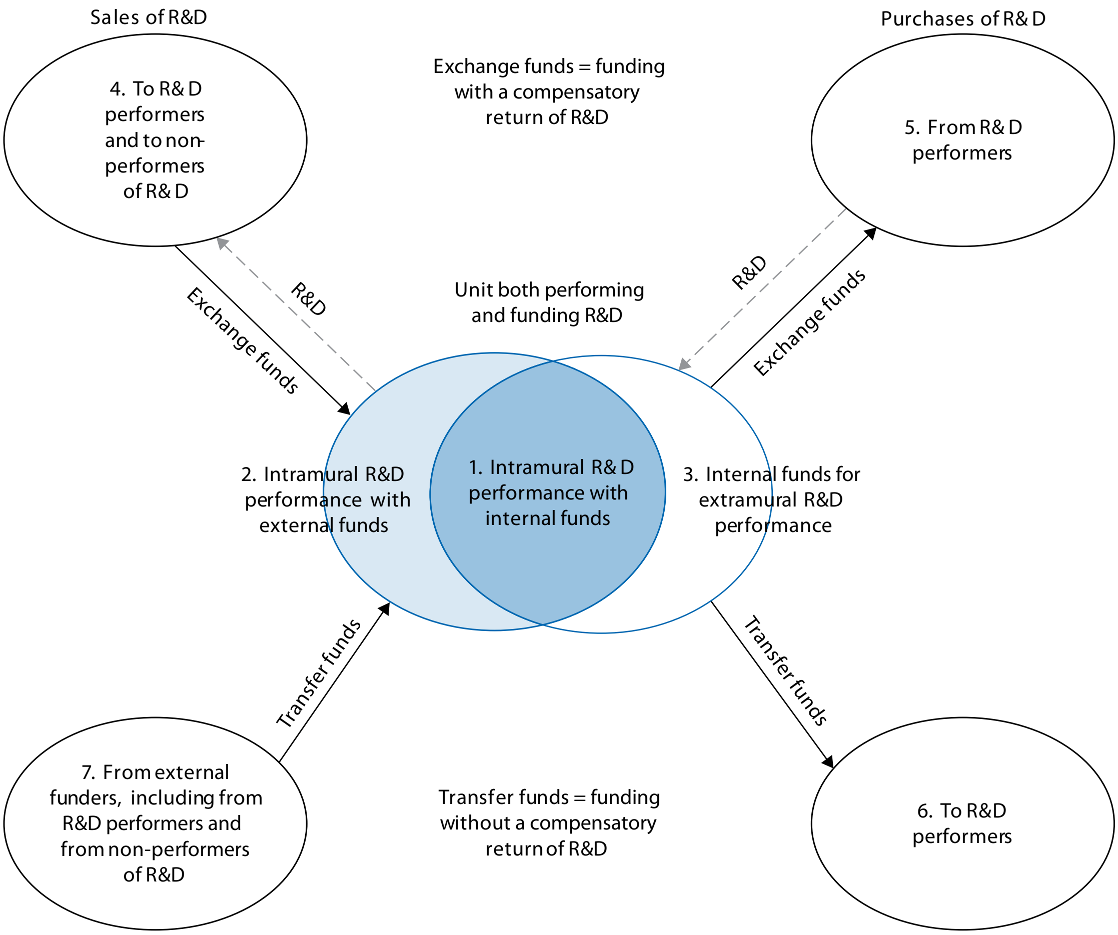

Figure 2.3: Intramural and extramural R&D expenditure and funding flows (OECD, 2015b, p. 129)

2.2.5 Institutional Sectors

The distribution of the total R&D expenditure on the three different types of R&D (basic research, applied research, and experimental development) varies depending on the type of the *institutional sector* (see Figure 2.4). The following sector classification according to the Frascati Manual is widely used, so also by Statistics Austria in their annual reports. It provides four sectors: the business enterprise sector, the government sector, the higher education sector, and the private non-profit sector (OECD, 2015b; Statistik Austria, 2015).

The distribution of the R&D expenditure on the different types of R&D for the business enterprise sector in Figure 2.4 is based on data for the year 2013 from Statistik Austria (2015) for Austria. The graph shows the percentage of the total R&D expenditure for the respective sector spent per type of R&D. It does not allow conclusions to be made about

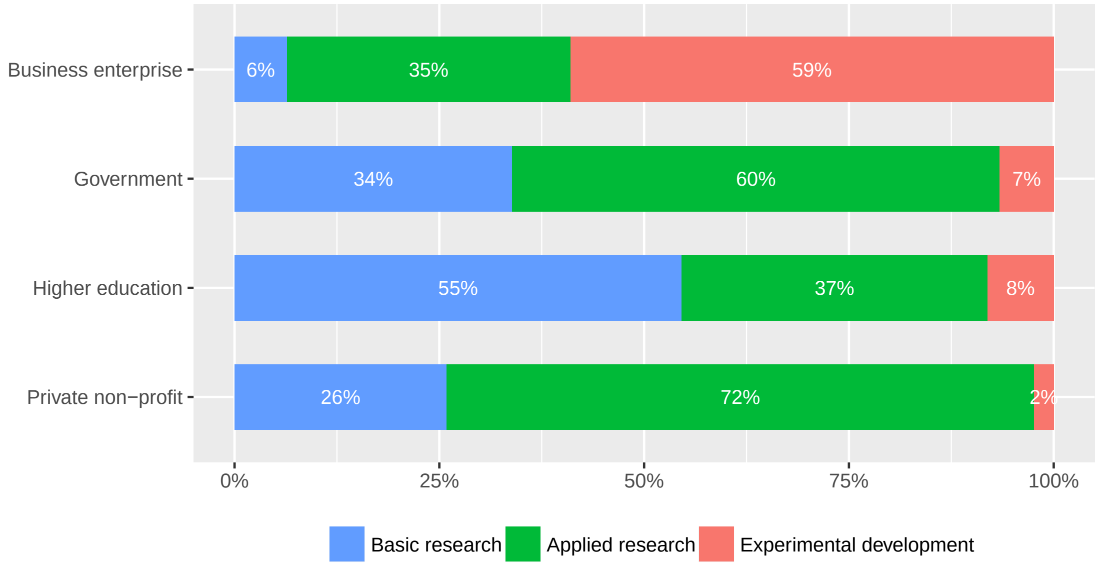

Figure 2.4: Distribution of the Business Expenditure on R&D (BERD) by type of R&D; data from 2013 from Statistik Austria (2015)

the absolute R&D expenditure. For example it is much higher in the business enterprise sector than the government sector.

Business Enterprise Sector

The business enterprise sector includes all resident corporations that aim at generating profit or financial gains for their shareholders and owners. It also includes non-resident enterprises that can be seen as resident because of their long-term commitment to a geographical location as well as all resident Non-Profit Institutions (NPIs) that produce goods or services for the market or serve businesses (OECD, 2015b).

Business enterprises usually do not perform a lot of basic research. This is because basic research does not have a particular application in view and firms are undoubtedly more interested in performing research with a potential outcome they can capitalize on. Applied research, which is directed towards a specific application or aims at solving a certain problem, is more attractive for companies and therefore more prevalent in this sector. Yet the largest part of the BERD is commonly spent on experimental development, aiming directly at the creation of new goods or services or the significant improvement of existing ones. Experimental development can include concept formulation, design and testing of alternatives, the construction of prototypes and the operation of pilot plants – each based on foregoing research or practical experience. As previously described, product development and any other activities that do not meet the criteria of novelty, creativity, uncertainty, systematics, transferability and/or reproducibility are not included in experimental development (nor any other type of R&D) (OECD, 2015b).

Figure 2.4 shows that experimental development in Austria accounts for the largest part of the R&D expenditure in the business enterprise sector. Applied research is significantly less important with values ranging from with 34.6% and the share of basic research is by far the lowest. The chart shows the distribution for Austria, but it is very similar in most developed countries.

Government Sector

The government sector includes all governmental entities at central (federal), regional (state) and municipal (local) level as well as social security funds. In many countries health-related R&D, performed in government-controlled hospitals and other healthcare institutions (that do not meet the criteria of the higher education sector), accounts for a significant part of the R&D expenditure in that sector. The government sector does not comprise enterprises which controlled by the government – these are included in the business enterprise sector. It does also not include higher education institutions – they fall into the higher education sector (OECD, 2015b).

Apart from health-related R&D, a significant part of the research performed by governments can be associated with policy-related studies: ex-ante or ex-post evaluations of policies as well as socio-economic research and simulations. Depending on whether this work is undertaken with a specific objective, it falls into the category of basic, applied research or even experimental development, if the research is undertaken with concrete products or services in mind (OECD, 2015b; Shapiro, 2013).

Higher Education Sector

According to the OECD (2015b, p. 260), the higher education sector consists of *"all universities, colleges of technology and other institutions providing formal tertiary education programmes, whatever their source of finance or legal status [and] all research institutes, centres, experimental stations and clinics that have their R&D activities under the direct control of, or administered by, tertiary education institutions."*

The largest part of the R&D expenditure of the higher education sector is usually spent on basic and applied research. The share spent on experimental development is much lower, because research in higher education is rarely directed towards the creation of new products or services (or the improvement of them). However, basic and applied research are no less important for an economy: In the long-term, the generated knowledge leads to more innovation and is often the basis for experimental development and the creation of new or improved goods or services (Department for Business, Innovation and Skills of the British Government, 2015; Shapiro, 2013).

The high proportion of basic research in the total R&D expenditure of the higher education sector can be seen in Figure 2.4. The share of applied research in this sector is also significant and makes up 37.3% in Austria. Experimental development is rather insignificant in the higher education sector.

Private Non-Profit Sector

The private non-profit sector includes NPIs that can not be classified to the business enterprise, government or Higher Education sector. These entities are mostly so called non-profit institutions serving households ("Private Organisationen ohne Erwerbszweck" in German), sometimes also households and private individuals. If however such an institution is owned or controlled by government units, it should be classified to the government sector. The same applies for the higher education and business enterprise sector. NPIs can be identified across all sectors. Examples for NPIs in the private non-profit sector are charitable organizations that provide services to households for free or at prices that are not economically significant (OECD, 2015b).

Because the private non-profit sector comprises all entities that do not fit into any other classification, the included entities are quite diverse. Thus, general statements about the distribution of the R&D expenditure can not be made. In Austria 25.9% of the total R&D expenditure of the private non-profit sector accounts for basic research, 71.7% for applied research, and only 2.4% for experimental development (see Figure 2.4) (Statistik Austria, 2015).

2.2.6 R&D Intensity

The R&D intensity is the most widely used indicator for measuring R&D and innovation activities (Smith, 2005). This thesis takes into account the R&D intensity on firm, industry, and national level, wich are presented below.

Firm Level

The R&D intensity on a company level is defined as the R&D expenditure divided by the revenue:

$$R\&D\,intensity_{\text{Firm}} = \frac{R\&D\,expenditure}{Revenue}$$

Industry Level

For industries it is calculated by dividing the BERD by the total revenue of the industry:

$$R\&D\,intensity_{\text{Industry}} = \frac{BERD}{Total\,revenue}$$

National Level

The R&D intensity for a country is defined as the percentage of the Gross domestic expenditure on R&D (GERD) to the Gross domestic product (GDP). GERD is defined as the sum of the entire intramural R&D expenditure within a country and for a given timeframe – usually one year. It includes R&D performed in the country considered that is financed from abroad, but excludes funding for R&D performed abroad (OECD, 2015b).

$$R\&D\,intensity_{\text{Country}} = \frac{GERD}{GDP}$$

A country's R&D intensity is often used as an indicator of technological progress in international comparisons. Developed countries and economies typically show a higher R&D intensity – however, a direct comparison of the R&D intensity between countries is only applicable to a limited extent, since the indicator is strongly influenced by the industrial structure. Countries which are specialized in research-intensive sectors (such as pharmaceuticals or IT) tend to have a higher R&D intensity than those with a large proportion of industries with low research volumes. Moncada-Paternò-Castello et al. (2010) show that the R&D intensity of European companies is low in international comparison due to sector specialization: While the automotive sector (average R&D intensity) is very dominant in the European Union (EU), the importance of the IT sector (both hardware and software as well as electronic devices) is relatively low. Consequently, the corporate sector in a country with an R&D quota, which is low in international comparison, can still be quite research-intensive (Godin, 2004; Sandven and Smith, 1998; Moncada-Paternò-Castello et al., 2010).

These explanations for differences in the R&D intensity between two countries or regions are referred to as the intrinsic and the structural effect: The intrinsic effect suggests that the difference in the R&D expenditure comes from within the companies. It occurs when companies in one region invest on average more (or less) in R&D than their counterparts in another region. In contrast the structural effect finds the reason for a difference in the R&D spendings in the structure of the considered regions, as outlined above (Moncada-Paternò-Castello et al., 2010).

Since a high R&D intensity is in general desirable, politicians and policy makers often aim at a high value for R&D intensity and many countries set goals for that indicator to ensure economic development: Canada wants to at least rank fifth in the OECD ranking, Norway wants to reach the OECD average, and the EU has set reaching a GERD/GDP ratio of 3% as one of the five main targets of the Europe 2020 Strategy. This strategy was implemented in 2010, when the R&D spendings in Europe were below 2%, compared to 2.7% in the US and 3.1% in Japan (Smith, 2005; European Commission, 2010; OECD, 2016).

Figure 2.5 depicts the R&D intensities of OECD countries and their development from 1995 to 2015. In an EU comparison, Austria (3.12%) was second in 2015 only to Sweden (3.26%), followed by Denmark (3.03%), Finland (2.90%) and Germany (2.87%). The average EU-28 R&D intensity in 2015 was 2.03% (Polt et al., 2017).

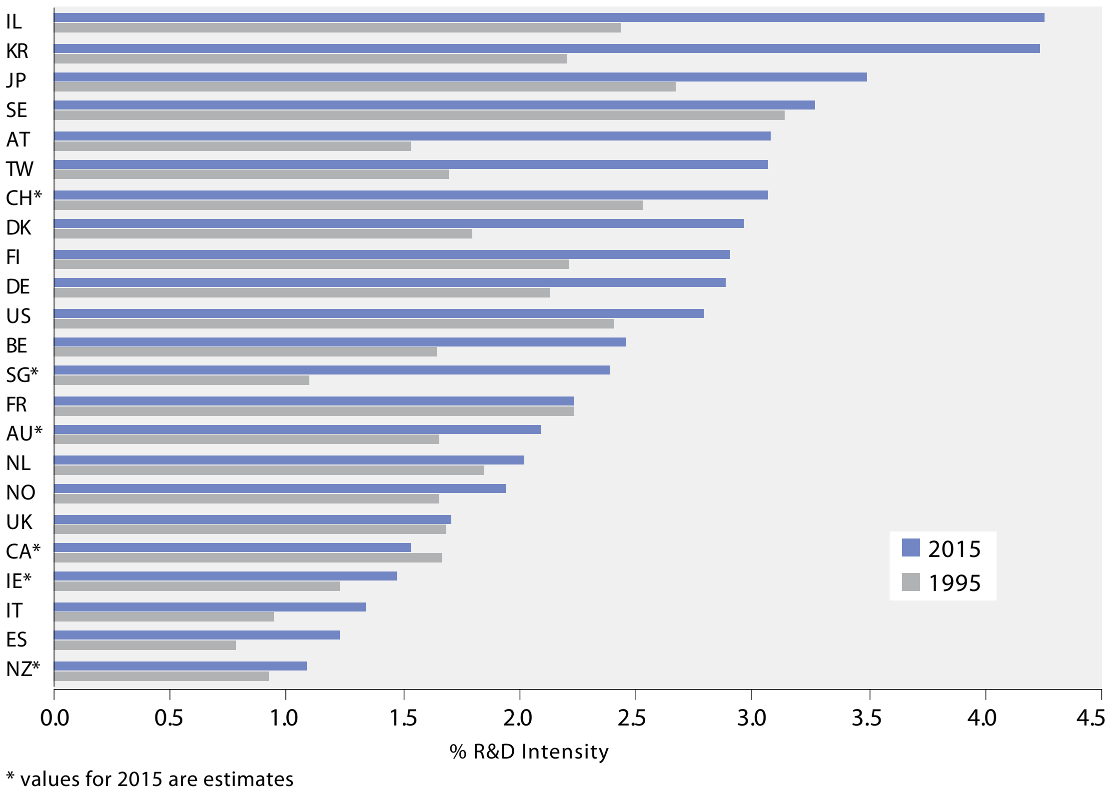

Figure 2.5: R&D intensities of OECD countries in 1995 and 2015 (Polt et al., 2017, p. 18)

2.2.7 Innovation, R&D and Economic Growth

Innovation and R&D are considered as key factors for economic growth, international competitiveness and for the long-term prosperity of an economy (Rosenberg, 2004). Endogenous growth theory holds that innovation and technological progress are the main contributors for overall economic growth. The theory suggests that technological progress is not the result of exogenous shocks, but the result of R&D activities (Romer, 1994). From the point of view of an individual company, the link between R&D expenditure and economic success is not inevitable: An innovation project can fail despite high financial and personnel efforts. From a macroeconomic point of view, however, a higher level of R&D expenditure is beneficial. Because of the risk diversification on many firms, a large number of innovative companies leads to more innovation successes and thus to more technological progress (Anger and Plünnecke, 2015). Particularly for rich, highly developed economies such as Austria, investments in R&D are necessary to maintain and further improve the economic status (Ecker et al., 2015).

There is no single agreed upon dimension for measuring and analyzing innovation activities. The by far most used source of information is indeed data on R&D expenditure. Other data that is used for the purpose of analyzing innovation, is data on patent applications, grants and citations, as well as bibliometric data (data on scientific publications and citations) (Smith, 2005; Bormann et al., 2012). Smith (2005) argues that using R&D expenditure as an indicator of innovation activities has the following benefits:

- It is often available for a long period.
- R&D expenditure provides a good comparability between countries.
- Data collected on R&D expenditure usually includes detailed classifications of the respective industries. These classifications are also available for many countries.

Measuring innovation activities and its effects is difficult, because innovation processes and methodologies are very complex and highly variable. There is no single correct way of doing innovation, instead there are several different approaches and ideas that lead to effective innovation. Kline and Rosenberg (1986) argue that the technological progress in product innovations can be seen as a black box, because there is no way of predicting the economic significance of it. Therefor the authors give the following arguments:

1. The challenges in different markets and the constraints that have to be met significantly vary from one industry to another.
2. The available knowledge is very different from industry to industry and from firm to firm.
3. As a consequence of the two prior points, the potential profitability of a new product is also very different with respect to the industry.

Another aspect that makes the measurement of effects of innovation difficult, is that innovations often generate benefits far from the areas where they were originally developed. An example therefor is the clothing industry, that profits from innovations in the fields of electronics, laser technology, and chemistry. Another prominent example is the adaption of personal computers across all industries and the resulting increase in productivity (Kline and Rosenberg, 1986).

An overall positive effect of innovation and R&D on firm performance is shown by several studies. It is agreed in literature that R&D intensive companies are more competitive with their products and thus perform better in the long-term (Kinkel et al., 2005). But the rates of returns vary in different sectors, they are usually higher in high tech sectors than low tech sectors (García-Manjón and Romero-Merino, 2012). The following provides an overview of recent studies in that domain.

R&D Intensity and Firm Growth in Austria

Falk (2012) investigated the relationship between R&D intensity and firm growth in Austria. The author used a dataset of 3,700 Austrian firms from the period of 1995 to 2006, which was provided by the Austrian Industrial Research Promotion Fund (FFG). Firms in Austria usually apply to the FFG for funding of R&D activities, therefore the dataset is very detailed and contains many small firms. The results show that a higher R&D intensity has a significant positive impact on both employment and sales growth in the two following years. The study also found that the positive impact on firm growth decreases over time – mainly because of diminishing returns to R&D. The authors list duplicate results from increased R&D activities as possible reasons therefor: The more researchers tackle the same or similar problems, the more likely it is that some of them come to similar results. They also found that there is a positive relation between R&D intensity and firm growth only to a certain level (the turning point is at an intensity significantly above 100%). What is more, shrinking firms do not benefit from R&D investments (Falk, 2012).

Growth of Europe's Largest R&D Performers

García-Manjón and Romero-Merino (2012) examined the effect of R&D on firm growth of Europe's largest R&D performing companies. Specifically, they used the Industrial R&D Investment Scoreboard dataset of the 1,000 top R&D spending firms in Europe for the period of 2003-2007. The authors conclude that a higher R&D intensity has a positive effect on the sales growth, but largely depends on the sector. They found that high-technology companies see the biggest and most certain returns for their R&D investments. In contrast, the benefits for low-technology industries and less-knowledge-intensive services are less certain.

R&D Performing SMEs

Entrepreneurship and young innovative firms are important for a country's economic development and employment growth. A review of several studies on the effects of entrepreneurship by Van Praag et al. (2007) comes to the following results: New firms do not only create jobs on their own, but they also affect regional employment growth because of spillover effects. Entrepreneurship further accounts for relatively much productivity growth and they are able to produce and commercialize high quality innovations. In contrast, established firms are no less important as they make up for a large part of productivity and growth. They provide a more secure and less volatile labor market as well as higher paid jobs.

In developed markets, such as Austria, Small and Medium-sized Enterprises (SMEs) of the medium and high-tech sectors are especially important for economic and employment growth (European Commission, 2008; Henrekson and Johansson, 2010). Companies in these sectors tend to be economically more successful if they show a high R&D. Those firms benefit from a higher number of interfirm alliances as a result of their R&D efforts.

This effect has not been observed for SMEs in low-tech sectors (Star and Wennberg, 2009; Nunes et al., 2012).

Growth from Non-R&D Based Innovation

As previously discussed, innovation does not necessarily have to rely on R&D (technological innovation) and can also be the result of experience-based learning and know-how (non-technological innovation). Kinkel et al. (2005) investigated growth opportunities along these different innovation paths based on German data from the *European Manufacturing Survey 2013*. They found that manufacturing firms with an R&D intensity of at least 6% showed much higher growth (in terms of employment) than their counterparts with an intensity below 2%. Strategies apart from the traditional R&D-based innovation approach can also lead to higher growth rates, for example through new product-service combinations or innovative techno-organizational processes. The authors conclude that a *"one dimensional understanding of innovation as research based development of high-tech products does probably not meet the demands of the variety of economically promising innovation strategies"* (Kinkel et al., 2005, p. 11). They propose the matrix depicted in Figure 2.6 for a holistic understanding of innovation.

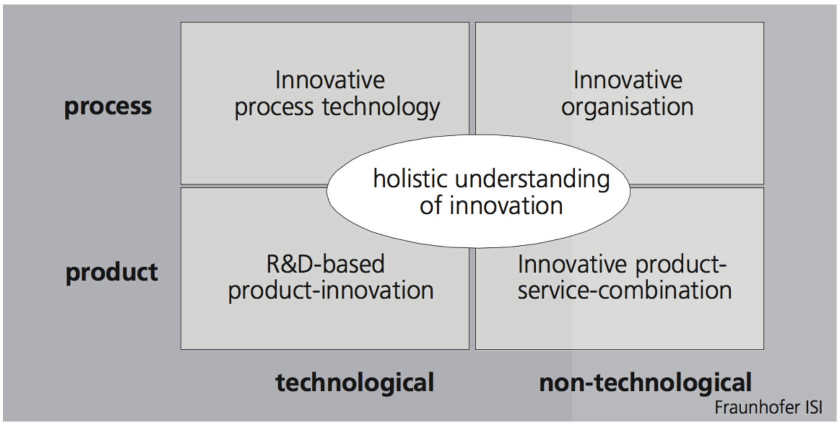

Figure 2.6: Matrix of a holistic understanding of innovation (Kinkel et al., 2005, p. 11)

2.3 R&D Development Patterns and Trends

2.3.1 Persistence of Innovation

Firms that innovated in past periods are more likely to also do so in subsequent periods. This phenomenon is referred to as *Persistence of innovation* (Peters, 2009; Clausen et al., 2011). Among all R&D performing companies, there is usually a core group of firms that continuously perform R&D, and another, much larger group of firms conducting R&D only sporadically (Malerba and Orsenigo, 1999; Bottazzi et al., 2001; Boschma and Frenken, 2006). The transition rates between these two groups are usually quite low, i.e.

there are only a few companies that move from one group to another (Colombelli and von Tunzelmann, 2011).

There are three major arguments that give explanations for the persistence of innovation:

First, the idea of *success breeds success* stresses that commercial success of previous innovations makes investments in current and future innovation activities possible (Phillips, 1971). Previously successful innovations and therefrom retained profits are important for the financing of further R&D activities and innovations (Nelson and Winter, 1982). This is especially important because of the uncertainty of R&D projects (Clausen et al., 2011). Bakker (2013) states that high-technology companies nowadays hold enormous amounts of cash, due of the high importance of R&D to them. He argues that R&D projects should be financed with cash rather than capital, primarily because they do not involve any bankable collateral due to the high uncertainty of R&D. As examples the author lists Apple that held USD 121bn in cash in 2012, Google USD 47bn, Facebook USD 11bn, and Amazon USD 5bn (Bakker, 2013). All these companies made their profits from previously successful innovations. The concept of success breeds success also suggests that a successful innovation broadens a firm's technological opportunities and thus makes subsequent innovation success more likely (Mansfield, 1968; Peters, 2009).

Second, persistence of innovation is the result of *learning by doing* and the accumulation of knowledge. Experience with R&D activities increases the firms' effectiveness of future R&D activities (Nelson and Winter, 1982). On the one hand this results from the knowledge gained at a process perspective, i.e. firms learn how to deal with the various tasks and steps of an R&D process and thus, are able to manage such processes more effectively in the future (Clausen et al., 2011; Rammer and Schubert, 2016). This also includes the management of relationships with external partners, for example the cooperation with universities, as well as the acquisition of external knowledge (Lundvall, 1988; Jensen et al., 2007; Cohen and Levinthal, 1990). On the other hand, knowledge itself is cumulative and R&D activities (activities that aim at increasing the stock of existing knowledge) require knowledge as an input (Clausen et al., 2011). Studies show that this is especially true in sectors with a higher concentration of R&D activities. This includes primarily high-tech and knowledge intensive sectors such as chemicals and electronics, and stands in contrast to traditional sectors, e.g. mechanical technologies. Those sectors with a higher concentration in R&D activities typically also show lower percentages of new entrants (the required stack of knowledge is an entry barrier) and consists of firms that are larger (Malerba and Orsenigo, 1996). These characteristics are typical for industries of the Schumpeter Mark II regime.

Third, the decision to perform R&D is a long-term decision due to the nature of sunk cost in R&D investments. Apart from building and equipping research facilities, it especially takes some great effort to build a team of researchers with the desired skills. The therefor required expenses are usually not recoverable and can therefore be seen as sunk costs (Peters, 2009). Once the research facilities are equipped and the team is built, discontinuing R&D would mean to lay off most of the R&D personell and thus lose most of the knowledge, since it is primarily embodied in the human capital of the researchers.

Source	Evidence for peristence	Period	Key results; data basis
Malerba and Orsenigo (1999)	Weak	1978-1999	Only a small fraction of firms were able to persist in patent activities continuously. Based on patent data from France, Germany, Italy, Japan, USA and the UK.
Roper and Hewitt-Dundas (2008)	Limited	1991-2002	Product and process innovation exhibits strong persistence. No evidence found that persistence is stronger among highly active innovators. Based on panel data from Ireland and Northern Ireland.
Peters (2009)	Strong	1994-2002	Past innovation has lower effect in the service sector than the manufacturing sector. Based on innovation panel data from Germany.
Raymond et al. (2010)	Limited	1994-2000	The study considered the claimed number of innovations introduced per firm and observation period. They find evidence for persistence in high-tech sectors, but only to a very limited extend in low-tech sectors. Their analysis is based on CIS data from Dutch manufacturing firms.
Clausen et al. (2011)	Strong	1995-2004	Different innovation strategies have a large effect on a firm's probability to repeatedly innovate and this effect is often larger than the "pure" effect of lagged innovation. There are differences between high-tech and low-tech sectors, insofar as low-tech sectors primarily show persistence in the area of process innovation. Based on CIS data from Norway.
Woerter (2014)	Strong	1996-2008	Persistence of innovation is more likely to be observed in markets with only a few direct competitors (between 6 and 10) and is very unlikely to be observed in markets with many competitors (more than 50). Based on firm-level panel data from Switzerland.
Máñez et al. (2015)	Strong	1990-2011	Persistence of innovation in SMEs is associated with the accumulation of R&D capital and with a self-sustained effect of engagement in R&D activities. It is also related to the hypotheses of success-breeds-success, sunk costs and demand-pull. The analysis is based on panel data of Spanish manufacturing firms.

Table 2.1: Overview of recent studies examining the persistence of innovation

Consequently, R&D is not something that can easily be stopped and then started again (Clausen et al., 2011). Sunk costs therefore are a barrier for non-R&D performers to start R&D activities, but they also prevent R&D performers from discontinuing R&D, because these costs can not be recovered and would incur again if the firm decides to again perform R&D (Peters, 2009).

Persistence of innovation has been observed and investigated by several studies. Table 2.1 provides an overview of recent studies examining this phenomenon in different countries and industries.

Besides the selected studies that are shown in Table 2.1, there are many others investigating the persistence of innovation. Bas and Latham (2009) and Antonelli et al. (2013) provide in-depth discussions of research in this domain. Most studies find that there is in fact strong evidence for persistence of innovation. While earlier studies were primarily based on patent data and found low persistence of innovation, later research had more data available (for instance from questionnaires such as the European-wide CIS), and found a higher number of persistent innovators (Clausen et al., 2011).

2.3.2 Increase in R&D Concentration

Across the world, the last decades have shown an increasing concentration in companies that dominate the global economy. According to a publication by the McKinsey Global Institute just 10% of the publicly held companies (around the globe) accounted for 80% of the profits in 2013 (Dobbs et al., 2015). The Economist (2016) argues that this effect is most visible in the United States (US), where the share of the GDP generated by the biggest companies (*Fortune* 100) increased from 33% in 1994 to 46% in 2013, and the share of these companies in the total revenues generated rose from 57% to 63% within that same period. From 1997 to 2013, the number of American firms listed on the stock market almost halved and the author suggests that the concentration in the market has lead to increased profit margins in direct proportion. The effects of market concentration are weaker in continental Europe, but also existent (The Economist, 2016).

In terms of R&D activities in the business enterprise sector, the increasing concentration also results in a higher concentration of R&D performing companies. This pattern was observed by a paper examining the development of innovation activities in Germany from 2001 to 2013. The authors found that the R&D expenditure increased substantially, but the number of firms performing R&D fell sharply; i.e. the innovation activities concentrated on fewer companies (Rammer and Schubert, 2016).

Another evaluation from Germany shows that the increase in innovation expenditure from 1995 until 2017 was almost entirely driven by large firms (Figure 2.7) (Behrens et al., 2017). Between 1995 and 2015 large firms (500 and more employees) increased their R&D spendings by 181 percent, while firms up to 499 employees spent only 15 percent more in the same period. The expected values for 2016 and 2017 further increase the spread between small and larger firms. These results also support the theory of an increase in concentration of R&D expenditure.

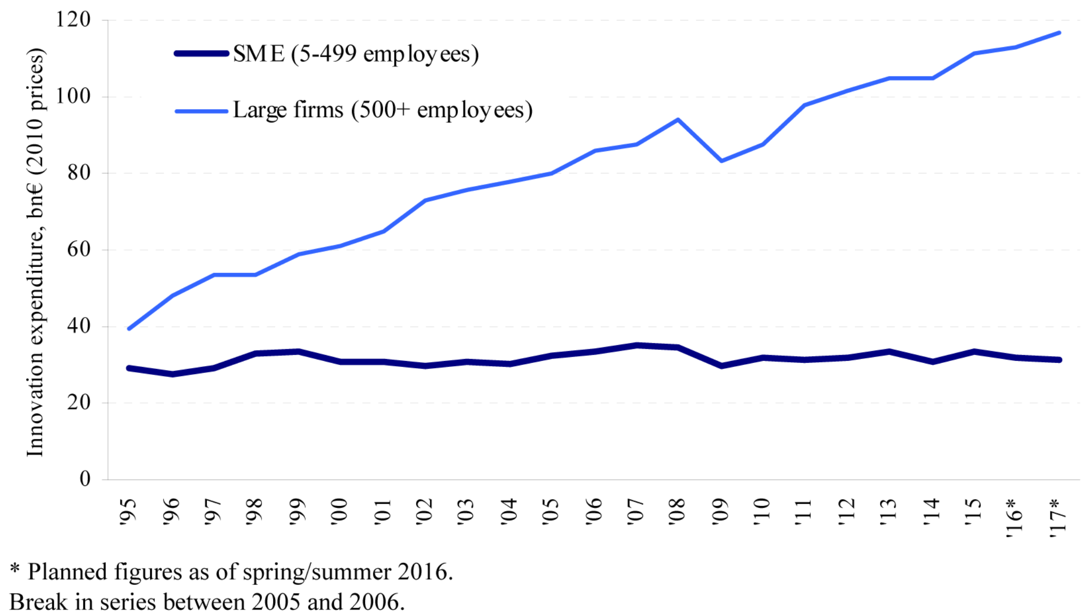

Figure 2.7: Innovation expenditure of firms in Germany 1995-2017 by firm size (Behrens et al., 2017, p. 41)

A growing concentration has also been observed in Switzerland, a country that is leading in several renowned international innovation rankings[1]. Arvanitis et al. (2017) point out that the number of R&D performing firms in Switzerland is currently declining in comparison to other countries. The nevertheless high R&D intensity in international comparison can be explained by the R&D-active companies that have intensified their efforts. The authors conclude that the concentration of innovation activities on a few large, innovation-intensive companies has the longer-term risk of a reduction in innovation activities and consequently a lower growth potential (Arvanitis et al., 2017).

2.3.3 Increasing Importance of the Service Sector

Over the past decades, the importance of the service sector increased in developed economies and by now typically accounts for more than two-thirds of the total value added. The US pioneered this trend and currently stand at a ratio of 75%. In Austria, the share of the service sector in the total value added is 71%. This is just slightly below the EU average of 74% (Schibany et al., 2007; OECD, 2017).

Accordingly, the OECD (2015c) reports that service companies account for a larger share

[1]Switzerland is currently leading in the Global Innovation Index (Dutta et al., 2016), the German Innovationsindikator (Weissenberger-Eibl et al., 2017) and the innovation-related parts of the Global Competitiveness Index (Schwab, 2016) – three periodically published and internationally respected innovation rankings (Polt et al., 2017).

of the BERD in most of its member countries (at least one third in most states). Figure 2.8 shows the percentage of the BERD in OECD countries spent by manufacturing and service industries in 2014 (or - if not available - for the latest year available) and 2004 (or the closest available year) in comparison. The data source is the OECD ANBERD database[2]. It shows that the share of services in the total BERD has increased considerably in most countries. Slovak Republic is the only exception with a significant decrease in the share of services.

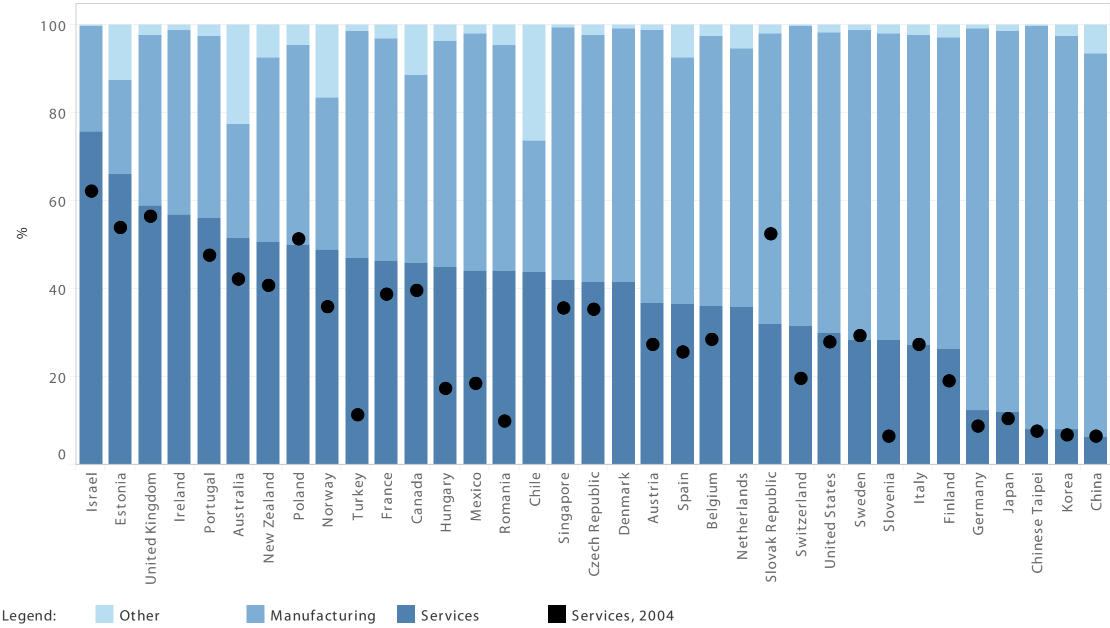

Figure 2.8: Share of BERD realized by service, manufacturing and others industries in 2014 (Fabien, 2017)

In comparison with the share of the service sector in the total value added, these figures show that firms in the service sector are in general less R&D active compared to companies in manufacturing industries. This trend is also reported by Schibany et al. (2007) in a study particularly for Austria.

2.3.4 Differences between Europe and the US

The BERD intensity[3] is 1.87% in the US[4] compared to 1.06% in Europe[5], both for 2013. Cincera and Veugelers (2014) argue that the differences in the BERD between Europe and the United States of America *"can be almost entirely explained by the EU having*

[2] `https://stats.oecd.org/Index.aspx?DataSetCode=ANBERD2011_REV3`

[3] Here calculated as the BERD in relation to the GDP.

[4] `http://dx.doi.org/10.1787/888933273275` (retrieved on 2017-09-02)

[5] `https://rio.jrc.ec.europa.eu/en/stats/business-enterprise-rd-expenditure-berd-source-funds-value-or-intensity` (retrieved on 2017-09-02)

fewer young leading innovators and, even more importantly, having fewer of these in new high-R&D intensive sectors" (Cincera and Veugelers, 2014, p. 14). They suggest that the reason therefore lays within the non-significant rates of return to R&D young European firms are able to generate. In contrast, young American firms can realize much higher rates of return to R&D. In the US, the rates of return to R&D for young companies are also higher compared to older companies, including the high-tech sector. In terms of suggestions for policy makers, the researchers suggest to not only decrease administrative burdens for young companies, but also to provide *"a healthy breeding ground where new ideas can incubate [...], access to early risk financing, access to risk-taking lead customers as well as access to frontier research"* (Cincera and Veugelers, 2014, p.15).

Figure 2.9 shows the ten publicly trading companies[6] with the highest R&D expenditure in 2016, according to Fox (2016). Six of them are from the US (Amazon, Alphabet, Intel, Microsoft, Apple, and Johnson & Johnson), only two from each Europe (Volkswagen and Roche) and Asia (Samsung and Toyota). Both Amazon and Alphabet (the parent company of Google) were not in that list just four years ago and if they continue at their current pace, they are expected to overtake Volkswagen in the highest R&D expenditure soon (Fox, 2016). With Amazon, Alphabet, Microsoft and Apple, the majority of companies dominating digital services are American. All these companies can be seen as disruptive innovators and built their market dominance over the last 10 to 20 years. In Europe there are no young (founded somewhere between 1990 and 2000), innovative companies with a growth rate comparable to these US counterparts (Hoyer, 2016).

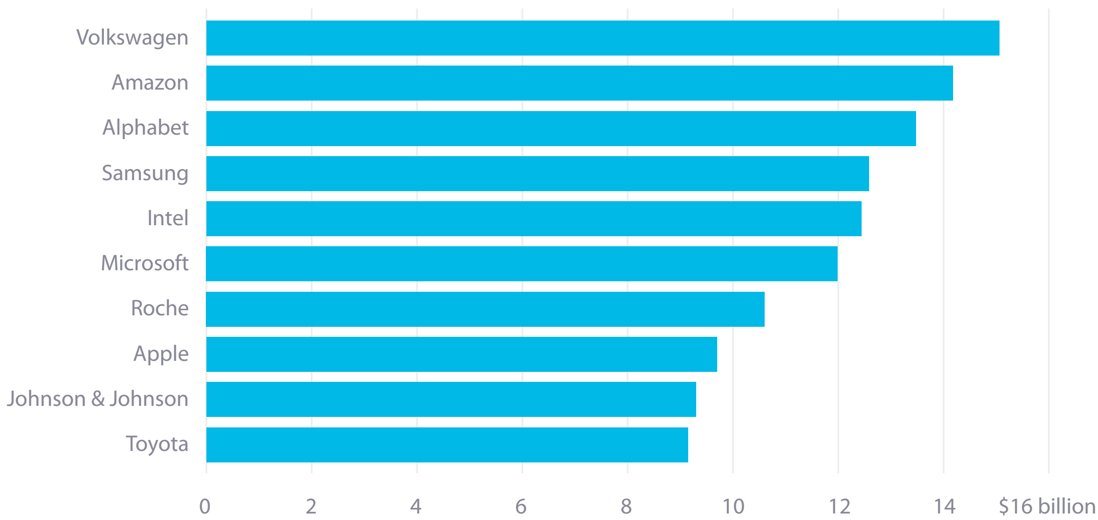

Figure 2.9: The global top ten R&D performers in 2016 (Fox, 2016)

There are also structural differences between the US and Europe that partly explain the

[6] If privately held companies would be included as well, Toyota would be replaced by the Chinese networking and telecommunications equipment manufacturer Huawei.

gap in the BERD: While America is stronger in the service sector, Europe is leading in the manufacturing sector. The EU in general specializes in medium-tech manufacturing sectors and has very few companies in the high-technology sector – a sector that usually is very R&D strong. The US in contrast has much more firms in the IT sector, which is very research-intensive (both hardware and software as well as electronic devices) (Cincera and Veugelers, 2014). US innovation pushed ahead of Europe in the 1990s as a result of missing investments in research and education in Europe. Yet there are other market-inherent reasons that helped service companies grow faster in the US: There are several different languages spoken all over Europe and different regulations for the same products across different countries. The US in contrast has one unified market, with one language and more unified regulation. This helps businesses, especially online-based service providers, to expand to a larger market more quickly (Hoyer, 2016).

2.4 R&D Expenditure and Innovation in Austria

2.4.1 Development of Business R&D Expenditure and Intensity

Table 2.2 shows the development of the R&D expenditure in Austria. The overall expenditure has more than doubled in the period of 2002 to 2013. For this positive development the business enterprise sector is mainly responsible. The business enterprise sector increased the R&D expenditure by 117%, followed by the private non-profit sector at 93%, the higher education sector at 84%, and the government sector with basically no change at all. The business enterprise sector accounts for 67% of the total R&D expenditure in 2002 and 72% in 2013 – the largest share across all sectors.

Sector	EUR'000 2002	EUR'000 2013	% Change 2002-2013
Higher Education	1,266,104	2,327,754	83.9
% of All	27.0	24.7	
Government	266,428	266,827	0.1
% of All	5.7	2.8	
Private non-profit	20,897	40,223	92.5
% of All	0.4	0.4	
Business enterprise	3,130,884	6,778,420	116.5
% of All	66.8	72.0	
Total	4,597,802	9,413,224	101.0

Table 2.2: Expenditure on R&D in Austria in 2002 and 2013 by sectors (Statistik Austria, 2005, 2015)

Regarding the development of the R&D expenditure in Austria, this data shows that the business enterprise sector is especially interesting and this is the reason why the focus of this thesis lies on the development of the BERD. Reinstaller and Unterlass (2012) investigated data of Austrian companies from 2004 to 2007 and found that the increase in the BERD in Austria mainly came from medium-tech industries – industries that are traditionally very strongly represented in Austria.

The R&D intensity of the Austrian business sector increased strongly since the beginning of the 1990s. It more than tripled from 0.9% in 1993 to 2.8% in 2013 (Falk, 2012; OECD, 2015c). With a value of 2.8%, the business R&D intensity in Austria is in the upper third of all OECD countries as of 2013. The average BERD of all OECD countries is 2.5% (OECD, 2015c). In terms of the reference group, which is also used for the comparison of Austria's performance in international innovation rankings (see Section 2.4.2), Figure 2.10 shows the increase in the R&D intensity in both absolute measures and in relation to other economies. This chart takes into account the overall economic R&D intensity, which increased significantly from 2% in 2001 to 2.95% in 2013. The economic R&D intensity is the R&D expenditure by firms, universities and the government in relation to the GDP. As previously discussed and shown in Table 2.2, the business enterprise sector is mainly responsible for this positive development. In contrast to Austria's positioning in other innovation related rankings, the economic R&D intensity of Austria is above the average of the reference group in 2013. Austria in international innovation rankings is discussed in Section 2.4.2. Therefore Polt et al. (2015, p. 24f.) conclude *"that Austria's development looks less favourable when taking a broader look at innovation capability, [...] which aside from R&D activities also includes the areas of education, science and society as well as the market results of R&D efforts."*

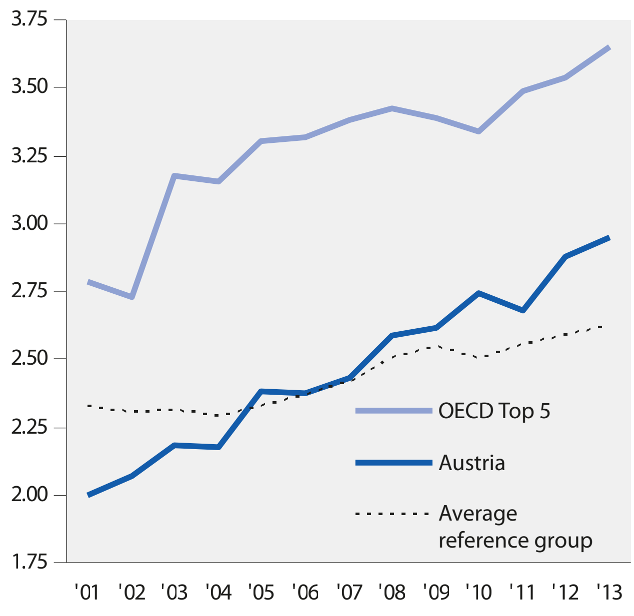

Figure 2.10: Increase of the Austrian economic R&D intensity from 2001 to 2013 (Polt et al., 2015, p. 25)

For a better comparability of the R&D intensity between different countries, the OECD also computes an *R&D intensity adjusted for industry structure*. This measure takes into account the industrial structure of a country and thereby a weighted average of the R&D intensities of the industrial sectors is derived, based on the ISIC classification. The adjusted R&D intensity for Austria is 3.3% and much higher than the unadjusted intensity. While Austria has the eighth highest unadjusted R&D intensity, it ranks fourth in the adjusted value (OECD, 2015c). It can be concluded that Austria's companies on average have a higher R&D intensity compared to companies in the same sectors in other countries.

Reinstaller and Unterlass (2012) investigated data of Austrian companies from 2004 to 2007 and came to similar conclusions for the considered period. They found that the R&D intensity of medium-tech industries (industries that are traditionally very strongly represented in Austria) is quite high compared to other companies within the same industry. The researchers link this relatively high R&D intensity to an improvement in product quality, because many companies in these sectors compete on high-quality in a high-priced market segment. What is more, the results also imply that a structural change towards high-tech companies is happening rather slowly in Austria (Reinstaller and Unterlass, 2012).

The implementation of the *Forschungsprämie* played an important role in the strong increase of the Austrian R&D expenses in the business enterprise sector. This funding by the Austrian state was introduced in 2002. Since 2011 it is the only fiscal instrument in Austria to promote R&D that is accessible to all firms. Over the years, the rate of funding was increased to currently 12%. In 2015, the Austrian state funded R&D expenses of about EUR 500 million. A study by Ecker et al. (2017) shows that this funding effected increasing R&D activities particularly among already R&D performing companies. The authors further showed, that R&D activities of multinational enterprises were relocated to Austria and that R&D activities of such firms were expanded because of the funding. On the other hand, the *Forschungsprämie* had little effect on companies with so far little or no R&D activities (Ecker et al., 2017).

2.4.2 Austria in International Innovation Rankings

The R&D intensity is an important indicator of a country's competitiveness and technological progress. As a sole indicator however, the R&D intensity is less significant and one should consider a number of measures instead. Therefore, this section examines Austria's position in different international innovation rankings for a holistic view. Such rankings compare several countries based on numerous indicators and derive strengths and weaknesses for the observed countries. In accordance with the Austrian Research and Technology Report 2015, Austria's positioning in the following four internationally established rankings is discussed (Polt et al., 2015):

- **European Innovation Scoreboard (EIS):** The EIS of the European Commission is published since 2001 and assesses the innovation performance of EU member states based on 25 indicatos. Between 2010 and 2015 this report was named *Innovation Union Scoreboard*.

- **Global Innovation Index (GII):** The GII compares the innovation performance of 127 countries and economies around the world based on 81 indicators. It is published by Cornell University, INSEAD, and WIPO.
- **Global Competitiveness Index (GCI):** The evaluation includes the innovation related parts of the GCI, which is published by the World Economic Forum. For the calculations of Austria's ranking and index, the mean value of the sub-indicators *Human capital and training*, *Technological readiness*, *Business sophistication*, and *Innovation* were taken.
- **Innovation Indicator (II):** The II is published by the Deutsche Akademie der Wissenschaften and the Bundesverband der Deutschen Industrie. It compares innovation related indicators in Germany with the world's leading industrialized countries as well as emerging countries.

Austria's position in the above listed rankings from 2002 to 2014 is shown in Table 2.3. Data for the respective years refer to the year in which it was published. The ranking refers to a reference group according to Polt et al. (2015). This group includes countries with at least 50% of Austria's GDP and at least 50% of Austria's population, excluding OPEC member countries. Besides Austria, the following countries are in this reference group: Australia, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Israel, Italy, Japan, the Netherlands, New Zealand, Norway, Singapore, South Korea, Spain, Sweden, Switzerland, Taiwan, the United Kingdom, and the US. Because the four rankings do not each include all of the before mentioned nations, the number of countries in the reference group is different for the rankings. There are 20 countries in the reference group of the EIS, 22 in the GII and II, and 23 in the GCI (Polt et al., 2015).

Ranking	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
EIS	13	15	15	14	14	13	11	10	14	14	13	13	14
GII	-	-	-	-	-	-	18	14	18	16	17	20	17
GCI	-	-	-	-	-	13	14	15	15	14	12	12	13
II	18	15	15	14	14	11	12	14	13	8	11	11	14

Table 2.3: Austria's position in international innovation rankings 2002-2014 within the reference group (Polt et al., 2015, p. 24)

Austria currently lies in the bottom half in all these rankings within the reference group. When looking at such rankings, it should be kept in mind that the ranking of a country not only depends on the considered country's performance, but on its relation to the other countries. Even if a country does improve in the measured indicators, it can still lose places if the other countries improve more quickly. To gain a thorough understanding of Austria' s development, we will also look at the ranking's indices for Austria in the period from 2002 to 2014 (see Figure 2.9).

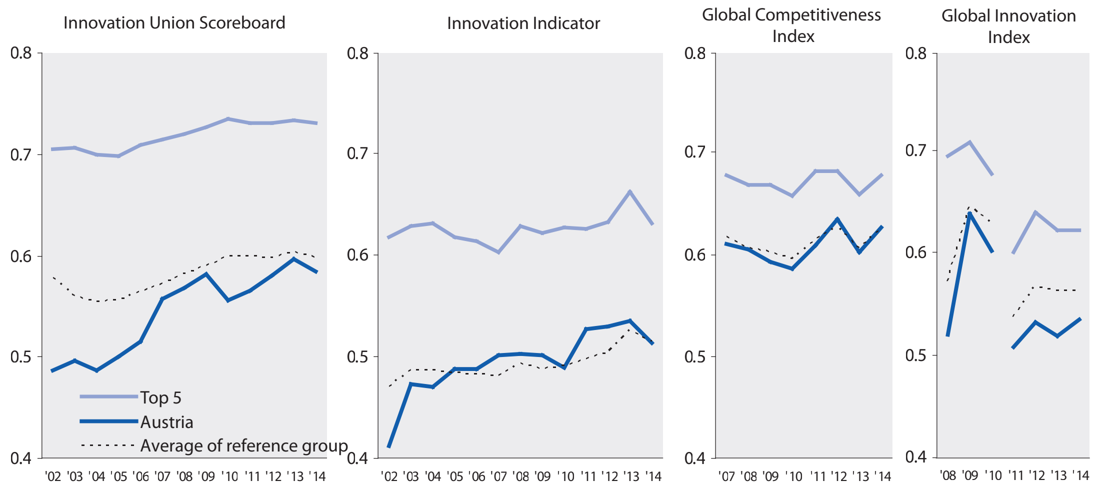

Figure 2.11: Austria's index score in international innovation rankings from 2002 to 2014 (Polt et al., 2015, p. 25)

All indexes in Figure 2.11 were transformed to a 0-1 scale, with higher values indicating a better performance. In terms of the EIS (in the figure above referred to as Innovation Union Scoreboard), Austria improved its rating from 0.49 in 2002 to 0.59 in 2014. In this period Austria could reduce its gap to both the reference group and the five leading countries. However, Austria's index score is still below the reference group's average. A similar development can be observed in the II with an increase from 0.41 in 2002 to 0.54 in 2013. Since 2003, the development of Austria was close to the average of the reference group. The GCI and GII indexes are only available for a shorter timeframe. Austria's development of the index of the innovation related parts of the GCI is very similar to the reference group's average. The gap between the top five performing countries and Austria also shrinked in this index. The GII is the only index of the selected ones, where Austria's innovation performance worsened over the examined time-frame. Polt et al. (2015) relate the low ranking in the GII to *"the inclusion of general economic conditions and a few rather unconventional indicators of innovation to measure knowledge and technology output."* The break in the series between 2010 and 2011 is due to changes in the scoring (Polt et al., 2015).

Altogether Austria shows strengths in the following innovation related fields (Polt et al., 2015):

- number in community designs,
- BERD,
- R&D expenditure of the public sector,
- proportion of the population aged between 20 and 24 with a higher-quality secondary school education, and

- number in international patent applications.

In contrast, the following weaknesses can be identified for Austria (Polt et al., 2015):

- non-R&D innovation expenditure,
- venture capital investments,
- knowledge-intensive services as a proportion of overall service exports, and
- share of doctoral students from outside of the EU.

2.5 Conclusions from Literature Research

Available studies show that the R&D expenditure in Austria increased stronger compared to other developed countries and that the business enterprise sector is mainly responsible for this strong growth. The R&D intensity of Austrian firms is higher than those of firms in the same sectors in other countries.

Over the past decades, there was a structural change towards more companies in the service sector. This development affects the R&D expenditure growth, since firms in the service sector are in general less R&D active than companies in manufacturing industries. The role of the structural change in the development of the R&D expenditure was examined by Reinstaller and Unterlass (2012) for the years 2004 to 2007. They found that the BERD increase in that period mainly came from firms in medium-tech industries. A structural change towards more high-tech related R&D was not reported.

The present results from literature research and global studies suggest that Schumpeter Mark II industries (established firms with large R&D departments that embody a lot of knowledge) increased their R&D expenses stronger than Schumpeter Mark I industries (young innovative firms that enter the market). On the one hand, small companies account for a large share of productivity growth and it was shown that they are successful in delivering high quality innovations. Additionally, disruptive innovators in high-tech sectors, such as Google or Amazon, became one of the most valuable companies and one of the top R&D performers in the world just within the last two decades. On the other hand, there are several factors that favor Schumpeter Mark II industries. The arguments of persistence of innovation strongly support the theory that established R&D performers tend to expand their R&D expenses faster. It was also shown that persistent innovators account for a large share in a country's R&D expenditure. Ecker et al. (2017) further reported positive effects from the *Forschungsprämie* particularly among already R&D performing companies in Austria. What is more, reports from other European countries (Germany and Switzerland) show that innovation activities concentrate on fewer – mainly large – companies, that in turn increase their spendings. All in all, the arguments in favor of Schumpeter Mark II industries (persistence of innovation, effects from the *Forschungsprämie*, and increasing concentration) outweigh those in favor of

Schumpeter Mark I industries (strong productivity growth and disruptive innovators in the digital economy). Together with observed weaknesses in the Austrian economy for the founding of new companies (e.g. availability of venture capital), literature research presents more arguments for an increase in R&D spendings among established R&D performers compared to new actors.

CHAPTER 3

Methodology

This chapter presents the methodology. This includes information about the dataset, the remote computation process, the used classifications, and the mathematical model of the shift-share analysis.

3.1 Dataset

3.1.1 Data Collection

The data which is used for the analysis was provided by Statistics Austria. It has been collected via the *F&E Erhebung* survey. Statistics Austria conducts this comprehensive survey on R&D expenditures of the Austrian corporate sector every two years and thereby collects data on personnel and financial resources related to R&D activities. Up to 2006 the surveys were conducted for even years, starting in 2007 for odd years. The legal basis for this survey is the R&D statistics regulation (*F&E-Statistik-Verordnung*) on a national level, which is in accordance with Decision 1608/2003/EC of the European Parliament and of the Council as well as the EU Regulation 995/2012. The surveys were carried out using the guidelines, definitions and standards of the Frascati Manual, which is employed in all OECD countries and thus the results of all OECD countries are comparable (Schiefer, 2015a).

The data collection aims at a full survey, i.e. gathering data of all R&D performing firms in Austria. In conformity with the Frascati Manual, the enterprise-type unit (legal units) served as the survey unit. The survey included all companies for which information on R&D activities from previous surveys or relevant documents, that suggest such activity, were available. The following measures were taken by Statistik Austria to ensure a full survey: (Schiefer, 2015a)

All companies in sectors that typically show a significant level of R&D activities and with 100 or more employees in 2013 were included. These sectors according to ÖNACE 2008 are listed in Table 3.1.

ÖNACE 2008	Description
A	Agriculture, forestry and fishing
B	Mining and quarrying
C	Manufacturing
D	Electricity, gas, steam and air conditioning supply
E	Water supply; sewerage, waste management and remediation activities
F	Construction
G 46	Wholesale, except of motor vehicles and motorcycles
H	Transportation and storage
J 58	Publishing activities
J 60	Programming and broadcasting activities
J 61	Telecommunications
J 62	Computer programming, consultancy and related activities
J 63	Information service activities
K	Financial and insurance activities
M 70	Activities of head offices; management consultancy activities
M 71	Architectural and engineering activities; technical testing and analysis
M 72	Scientific research and development
M 73.2	Market research and public opinion polling
R 92	Gambling and betting activities
S 95	Repair of computers and personal and household goods

Table 3.1: Sectors with a significant level of R&D activities (Schiefer, 2015a)

In addition, firms in other sectors than those listed in Table 3.1 and with less than 100 employees were included in the survey if there was information suggesting an R&D activity. The sources of information in 2013 primarily included the R&D surveys from 2009 and 2011, the list of applicants of the Austrian Research Promotion Agency (FFG), the CIS 2012, data from the federal states on R&D funding, information on patent applications, as well as media evaluations, press surveys, and research conducted by Statistics Austria.

Statistics Austria distinguishes between two domains in the survey – the *firmeneigener Bereich* and the *kooperativer Bereich*. The former domain comprises enterprises of the manufacturing and service sector with the aim of gaining a profit or other economic advantage. Both private and public companies are included. Institutions in the later domain carry out research and experimental development for companies. These institutions are not actively pursuing a profit or other economic advantage. A large number of these institutes are part of the Austrian Cooperative Research (ACR) network[1]. The later domain further includes: the Austrian Institute of Technology (AIT), the JOANNEUM RESEARCH Forschungsgesellschaft mbH and the competence centers initiated by the Competence Centers for Excellent Technologies (COMET) program. The survey units of this domain are exclusively of the ÖNACE divisions 62 (Computer programming, consultancy and related activities), 71 (Architectural and engineering activities; technical testing and analysis) and 72 (Scientific research and development) (Schiefer, 2015a).

In the *firmeneigener Bereich*, 6,979 survey units were recorded by the survey in 2013. 35% of the them were enterprises with 100 and more employees. The response rate was 96.7% in total in this domain. Among companies with 100 or more employees, the figure was 98.7%, among the other companies 95.6%. In the *kooperativer Bereich*, 72 survey units were recorded in 2013. The response rate was 100% in this domain (Schiefer, 2015a).

3.1.2 Survey

The "F&E Erhebung" questionnaires of 2002 and 2013 are attached in the Appendix. In addition to identification attributes (name of the firm, address, VAT identification number, company register, etc.), the following information is gathered through the survey (Bundeskanzleramt, 2017):

1. Employees:

1.1. Total number of employees by gender on an annual average

1.2. Total number of employees in R&D by gender on an annual average

1.3. The number of employees in R&D, broken down by categories of employees (scientists, engineers, higher-qualified non-scientific staff, and other non-scientific staff), each with the highest level of education completed and separated by gender

1.4. Employees in Full-Time Equivalents (FTEs) for R&D (total hours in the reporting year), broken down by categories of employees (scientists, engineers, higher-qualified non-scientific staff, and other non-scientific staff), each with the highest level of education completed and separated by gender

1.5. Percentage of R&D employees per federal state

2. Total revenue

3. Intramural R&D expenditure:

[1] The ACR institutes are listed on `http://www.acr.ac.at/acr-institute.html`.

3.1. Personnel expenses

3.2. Ongoing material expenditures

3.3. Investment expenditures for equipment

3.4. Investment expenditures for buildings and land

3.5. Intramural R&D expenditure divided by type of R&D (basic research, applied research, or experimental development) and socio-economic objectives

4. Extramural R&D expenditure:

4.1. To other companies

4.2. To universities / universities of applied sciences or technical colleges, or individual members of such institutions

4.3. To state institutions

4.4. To private non-profit institutions

4.5. To cooperative R&D facilities

4.6. To international organizations

5. Source of funding for R&D:

5.1. Own funds

5.2. Funds from other domestic enterprises

5.3. Funds from the public sector

5.4. Funds from the EU

5.5. Funds from the private non-profit sector

5.6. Funds from international organizations

5.7. Other funds from abroad

In order to reduce the effort for answering the questionnaire for small companies, manufacturing companies with less than 20 employees and enterprises of the service sector with less than five employees received a shortened survey. 75% of these companies – selected at random – received a questionnaire that asked for only a subset of the full survey. For instance the shortened survey did not ask for the breakdown of R&D personnel into scientists, engineers, higher-qualified non-scientific staff, and other non-scientific staff, the percentage of R&D employees per federal state, the personnel expenses on R&D, the division of R&D expenses into basic research, applied research, and experimental development, or the detailed allocation of the domestic extramural R&D expenditure (Schiefer, 2015a).

1,940 companies received a shortened survey in 2013. This equals approximately 28% of all units recorded in the proprietary domain. The missing data was estimated by backtracking on past surveys. Data for companies with no corresponding data from previous years were estimated through a nearest neighbor approximation. Since key figures (intramural R&D expenditure, total R&D employment) were queried in the shortened survey, only subdivisions and values of subcategories had to be estimated (for example personnel expenses and other ongoing expenses were estimated from the total R&D expenditure). Companies surveyed with shortened surveys only account for approximately 2% of the total intramural R&D expenditure in 2013, and therefore the influence of the estimates on the final results is very limited (Schiefer, 2015a).

3.1.3 Observations

In total the dataset contains observations of 4,682 Austrian companies. Table 3.2 shows the number of companies with at least one observation per category and for the respective year. Because the table shows the number of companies with observation and not the number of observations itself, the last column is not a row sum.

Category	2002	2013	Total
All R&D performing firms	**2,077**	**3,531**	**4,682**
of which only in one year	1,151	2,605	3,756
of which in both years	926	926	926
Firms with intramural expenditure	**1,942**	**3,322**	**4,395**
of which only in one year	1,073	2,453	3,526
of which in both years	869	869	869
Firms with only extramural expenditure	**135**	**209**	**329**
of which only in one year	120	194	314
of which in both years	15	15	15

Table 3.2: Number of companies in the dataset

The number of companies in the dataset is lower than the number of companies questioned by the survey, because the dataset does not include data for companies that were included in the survey, but did not perform R&D.

3.2 Exploratory Data Analysis

The dataset contains 127 attributes per observation. Besides an ID, there is no attribute such as company name, address, VAT identification number, company register, etc., that would allow to identify the company. However, due to the large number of attributes the possibility of identifying a single companies can not be ruled out (for instance via the attributes number of employees, revenue, and federal state). Therefore it can not be accessed directly, because the data is subject to legal confidentiality.

For this reason the analysis was realized as a remote computation. Statistics Austria provided us with a dummy dataset that contains the same variables as the *real* dataset, but with randomized data. Value ranges and correlations differ from the actual data because of the randomized values. Based on the dummy dataset, evaluations were created in R Markdown[2]. R Markdown combines R[3] and Markdown[4] to render R output to – amongst others – PDF documents, which were primarily used in the course of this evaluation. R itself is a free programming language for statistical calculations and representations. R can be extended by a lot of functionality through packages. For instance the package `dplyr`[5] was used for data manipulation, the packages `ggplot2`[6] and `riverplot`[7] for data visualization.

The scripts created with R Markdown were sent to Statistics Austria, who executed the scripts with the real dataset and sent back the results. This process is depicted in Figure 3.1. Compared to if the actual data could be used, this process required many iterations, which made the evaluations more complex and time intensive. In total the evaluation is based on ten reports. The response by Statistics Austria time was between several days and a few weeks (it should be noted that this period also included the holiday season). In case of errors in the evaluation, for example if invalid or non-existent data distorted the calculation (which could sometimes not be foreseen from the dummy dataset), evaluations had to be sent back and forth several times.

The analysis was an iterative process and started with reports on a very high level and gradually went more and more into detail. The degree of detail was limited by the legal confidentiality of the dataset, i.e. the results of the evaluations must not include groupings of four companies or fewer. This should eliminate the possibility of drawing conclusions on individual companies, which must be prevent by law. Such groupings are also kept confidential by the publications of Statistics Austria, for example R&D activities of companies in the ÖNACE divisions 14 (Manufacture of wearing apparel) and 19 (Manufacture of coke and refined petroleum products) are not published in the *Statistical Yearbook 2016* (Statistik Austria, 2015).

For the exploratory data analysis statistical methods were used, which include measures of central tendency, measures of dispersion, and hypothesis tests. For graphical representations box plots, histograms, scatterplots, and Q-Q plots were used amongst others. These basic statistical methods and techniques shall not be discussed in detail here, but instead, explanations are given with the presentation of the results, where appropriate. The figures in the evaluation were created with the aforementioned R packages.

[2] http://rmarkdown.rstudio.com
[3] https://www.r-project.org
[4] https://daringfireball.net/projects/markdown/
[5] https://cran.r-project.org/web/packages/dplyr/dplyr.pdf
[6] http://ggplot2.org
[7] https://cran.r-project.org/web/packages/riverplot/riverplot.pdf

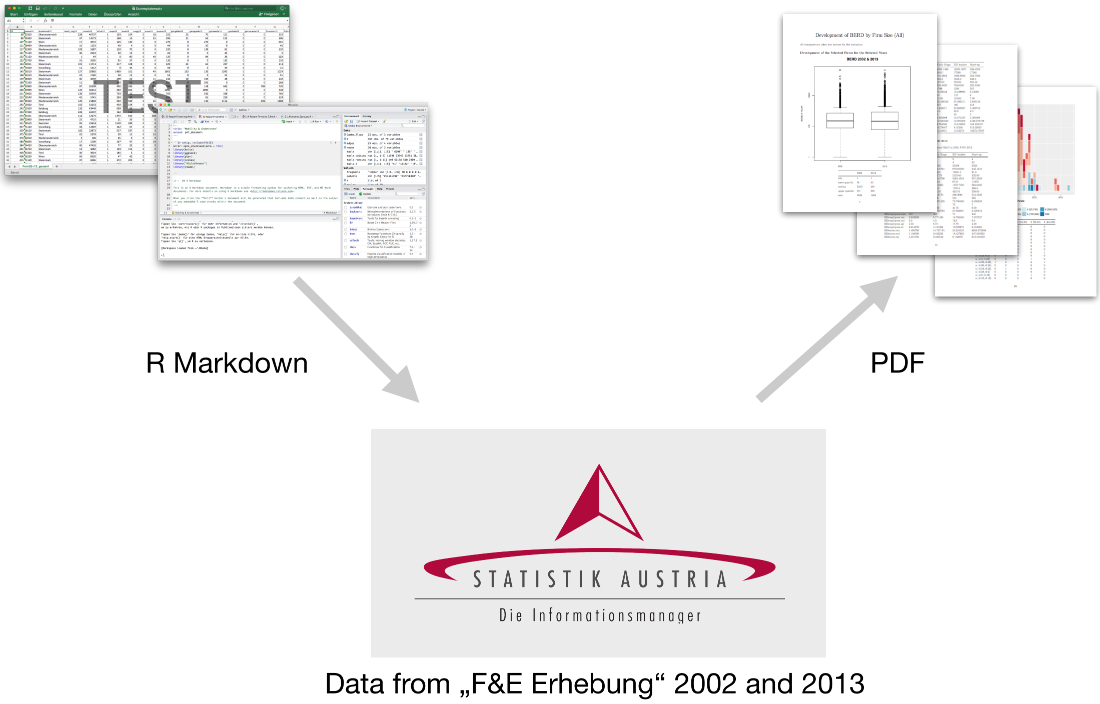

Figure 3.1: Remote computation process

The numbers in the dataset are not deflated. Since price increases in salary levels and prices for other R&D input factors (e.g. raw materials or capital goods) are included in the numbers, the increase in the R&D expenditure is nominal and not real. In order to ensure comparability with publications by Statistics Austria and other studies, the results are not indexed in this thesis either. For a comparison the inflation rate and the GDP from 2002 to 2013 are used (see Table 3.3).

3.3 Grouping and Classification of Companies

This work only takes into account the business enterprise sector. It does not include the government sector, higher education sector, and the private non-profit sector. This section provides an overview of the grouping and classification of companies in the business enterprise sector which is used for the evaluation.

3.3.1 Firm Size Classification

For the grouping of business enterprises based on their size, this thesis follows the suggestion of the Frascati Manual of the OECD with size classes based on the number of persons employed. These size classes according to the OECD (2015b, p. 206) are:

Year	Inflation rate	Price index (2002=100)	GDP growth	GDP index (2002=100)
2002	1.8	100.0	1.7	100.0
2003	1.3	101.3	0.8	100.8
2004	2.1	103.4	2.7	103.5
2005	2.3	105.8	2.1	105.7
2006	1.5	107.4	3.4	109.3
2007	2.2	109.8	3.6	113.2
2008	3.2	113.3	1.5	114.9
2009	0.5	113.8	-3.8	110.6
2010	1.9	116.0	1.9	112.7
2011	3.3	119.8	2.8	115.8
2012	2.4	122.7	0.7	116.6
2013	2.0	125.2	0.1	116.7

Table 3.3: Inflation rate and GDP growth in Austria from 2002 to 2013 (Statistik Austria, 2017)

- 1-4
- 5-9
- 10-19
- 20-49
- 50-99
- 100-249
- 250-499
- 500-999
- 1,000-4,999
- 5,000 and above

These ten classes are summarized into five size groups for a better overview at some points. Thereby the first two classes (1-9 employees) form the group of *micro*-sized firms, the following two classes with 10-49 employees the *small* group, with 50-249 employees the *medium* group, with 250-999 the *large* group, and business enterprises with 1,000 employees and above are in the group of *very large* firms.

3.3.2 Classification of Economic Activity (ÖNACE)

Every company in Austria is assigned to a ÖNACE subclass, according to its economic activity. Statistics Austria records this information and the ÖNACE classification is provided for every entry in the dataset. During the analysis and evaluation this information is used as set forth in the following.

ÖNACE is based on NACE, the classification system for economic activities in the European Union. NACE is the abbreviation for the French term ***n**omenclature statistique des **a**ctivités économiques dans la **C**ommunauté **e**uropéenne*. ÖNACE is the national adaption of this classification for Austria and the NACE classification itself is derived from ISIC, the United Nations' International Standard Industrial Classification of all Economic Activities. Because of the relations between the classification systems, economies can be compared on an international level and global evaluations are possible (Eurostat, 2008).

The NACE classification system builds on a hierarchical structure with four levels (Eurostat, 2008):

1. Level 1: 21 sections identified by alphabetical letters
2. Level 2: 88 divisions identified by a two-digit numerical code
3. Level 3: 272 groups identified by a three-digit numerical code
4. Level 4: 615 classes identified by a four-digit numerical code

These four levels are the same in all states of the EU. ÖNACE adds a fifth digit to the four-digit NACE code, which is specific to Austria. The current NACE revision is version 2 which was released in 2008. Accordingly ÖNACE was also revised in that year, but instead of version 2 the current revision is referred to as ÖNACE 2008. Unless otherwise specified, all NACE references in this work use this revision.

Technological Intensity in Manufacturing Industries

Companies in the manufacturing sector are classified using a four-tier model. This follows the suggestion of the OECD. The basic criterion on which industries are classified is the BERD / production ratio. High-tech industries typically show an ratio of above 5%, medium high-tech industries of between 3% and 5%, medium low-tech industries of between 1% and 3%, and low-tech industries of below 1% Smith (2005).

The classification of technological intensity in manufacturing industries follows the Eurostat aggregation, which is based on NACE level 2 (divisions) (Eurostat, 2016):

- **High-tech industries:** NACE 21 (Manufacture of basic pharmaceutical products and pharmaceutical preparation) and NACE 26 (Manufacture of computer, electronic and optical products).

- **Medium high-tech industries:** NACE 20 (Manufacture of chemicals and chemical products), NACE 27 (Manufacture of electrical equipment), NACE 28 (Manufacture of machinery and equipment n.e.c.), NACE 29 (Manufacture of motor vehicles, trailers and semi-trailers), and NACE 30 (Manufacture of other transport equipment).

- **Medium low-tech industries:** NACE 19 (Manufacture of coke and refined petroleum products), NACE 22 (Manufacture of rubber and plastic products), NACE 23 (Manufacture of other non-metallic mineral products), NACE 24 (Manufacture of basic metals), NACE 25 (Manufacture of fabricated metals products, excepts machinery and equipment), and NACE 33 (Repair and installation of machinery and equipment).

- **Low-tech industries:** NACE 10 (Manufacture of food products), NACE 11 (Manufacture of beverages), NACE 12 (Manufacture of tobacco products), NACE 13 (Manufacture of textiles), NACE 14 (Manufacture of wearing apparel), NACE 15 (Manufacture of leather and related products), NACE 16 (Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials), NACE 17 (Manufacture of paper and paper products), NACE 18 (Printing and reproduction of recorded media), NACE 31 (Manufacture of furniture), and NACE 32 (Other manufacturing).

Technological Intensity in the Service Sector

Industries in the service sector can be classified in knowledge-intensive and less knowledge-intensive services. Following the Eurostat definition, these two sectors are further subdivided in sub-sectors, again based on NACE division level (Eurostat, 2016):

- **Knowledge-intensive services:**
  - **Knowledge-intensive market services:** NACE 50 (Water transport), NACE 51 (Air transport), NACE 69 (Legal and accounting activities), NACE 70 (Activities of head offices; management consultancy activities), NACE 71 (Architectural and engineering activities; technical testing and analysis), NACE 73 (Advertising and market research), NACE 74 (Other professional, scientific and technical activities), NACE 78 (Employment activities), and NACE 80 (Security and investigation activities).
  - **High-tech knowledge-intensive services:** NACE 59 (Motion picture, video and television programme production, sound recording and music publishing activities), NACE 60 (Programming and broadcasting activities), NACE 61 (Telecommunications), NACE 62 (Computer programming, consultancy and related activities), NACE 63 (Information service activities), and NACE 72 (Scientific research and development).

  - **Knowledge-intensive financial services:** NACE 64 (Financial service activities, except insurance and pension funding), NACE 65 (Insurance, reinsurance and pension funding, except compulsory social security), and NACE 66 (Activities auxiliary to financial services and insurance activities).
  - **Other knowledge-intensive services:** NACE 58 (Publishing activities), NACE 75 (Veterinary activities), NACE 84 (Public administration and defence; compulsory social security), NACE 85 (Education), NACE 86 (Human health activities), NACE 87 (Residential care activities), NACE 88 (Social work activities without accommodation), NACE 90 Creative, arts and entertainment activities), NACE 91 (Libraries, archives, museums and other cultural activities), NACE 92 (Gambling and betting activities), and NACE 93 (Sports activities and amusement and recreation activities).

- **Less knowledge-intensive services:**
  - **Less knowledge-intensive market services:** NACE 45 (Wholesale and retail trade and repair of motor vehicles and motorcycles), NACE 46 (Wholesale trade, except of motor vehicles and motorcycles), NACE 47 (Retail trade, except of motor vehicles and motorcycles), NACE 49 (Land transport and transport via pipelines), NACE 52 (Warehousing and support activities for transportation), NACE 55 (Accommodation), NACE 56 (Food and beverage service activities), NACE 68 (Real estate activities), NACE 77 (Rental and leasing activities), NACE 79 (Travel agency, tour operator reservation service and related activities), NACE 81 (Services to buildings and landscape activities), NACE 82 (Office administrative, office support and other business support activities), and NACE 95 (Repair of computers and personal and household goods).
  - **Other less knowledge-intensive services:** NACE 53 (Postal and courier activities), NACE 94 (Activities of membership organisation), NACE 96 (Other personal service activities), NACE 97 (Activities of households as employers of domestic personnel), NACE 98 (Undifferentiated goods- and services-producing activities of private households for own use), and NACE 99 (Activities of extraterritorial organisations and bodies).

Other Industries

Some industries can not decidedly be classified as manufacturing or service industries. A classification of their technological intensity is therefore also not possible. Firms in these categories are nevertheless included in the following analysis, in the group *Others*. The following NACE divisions fall into this category:

- NACE 01 (Crop and animal production, hunting and related service activities)
- NACE 02 (Forestry and logging)

- NACE 03 (Fishing and aquaculture)
- NACE 05 (Mining of coal and lignite)
- NACE 06 (Extraction of crude petroleum and natural gas)
- NACE 07 (Mining of metal ores)
- NACE 08 (Other mining and quarrying)
- NACE 09 (Mining support service activities)
- NACE 35 (Electricity, gas, steam and air conditioning supply)
- NACE 36 (Water collection, treatment and supply)
- NACE 37 (Sewerage)
- NACE 38 (Waste collection, treatment and disposal activities; materials recovery)
- NACE 39 (Remediation activities and other waste management services)
- NACE 41 (Construction of buildings)
- NACE 42 (Civil engineering)
- NACE 43 (Specialised construction activities)

3.3.3 Firm Classification Based on R&D Expenditure and Intensity

After we got back initial results from the first scripts from Statistics Austria, we started to develop a model to classify the R&D performing firms in Austria. The purpose of this classification is to answer the research question addressing whether new actors could establish themselves in research intensive groups. The following classification is based on the work of Barber and Crelinsten (2004), a study that examined the R&D spendings of Canadian companies from 1994 to 2001. The thresholds and categories are adjusted for the Austrian data as set forth in the following.

First, the companies are separated by the R&D intensity into three categories: Firms with an R&D intensity below 3%, firms with an intensity between 3% and 50%, and companies with a 50% or higher R&D intensity. The threshold of 3% was chosen, as it is the median R&D intensity of all R&D performing companies in Austria in 2002 (rounded to a whole number). We kept the threshold of 50% used by Barber and Crelinsten (2004). They identified companies in this category as startups as they argued that *"Startup firms do not have significant revenues to cover both their R&D and operating costs. They are therefore financed by lenders or investors. Most are spending more than 100% of their revenue and so are drawing on the economy and not yet contributing to it."* (Barber and Crelinsten, 2004, p. 2). The data in Austria also shows that the majority of firms in this category spends more than 100% of their revenue on R&D and so we stuck with this threshold.

In a next step, a threshold for the absolute R&D expenditure was set to distinguish between companies with an expenditure that is high in relation to their revenue, and those that show a high spending in absolute terms. The chosen value of EUR 1.2 million approximately reflects the upper quartile of the R&D expenditure of the long-term R&D performers in 2002. The threshold in 2013 is higher and is set at EUR 1.5 million as it includes the inflation of 25.2% for the considered period. This distinction is only made for the research intensive groups (above 3% R&D intensity), because we are mainly interested in the development of research-intensive companies.

Finally, the following groups result based on the above criteria:

1. **Moderate R&D Performers:** Firms with less than 3% R&D intensity.
2. **Early Stage:** Firms with an intensity between 3 and 50% and an absolute R&D expenditure below EUR 1.2 million in 2002 or EUR 1.5 million in 2013. Unfortunately, we do not have information on the firm age, so the name of the group reflects the fact that we assume that these firms are at the beginning of their economic activity.
3. **R&D Leaders:** This category comprises companies that spent 3-50% of their revenue on R&D and show an absolute R&D expenditure above EUR 1.2 million in 2002 or EUR 1.5 million in 2013.
4. **Startups:** This group includes companies that have very high R&D intensity (50% and more), but low absolute spendings (less than EUR 1.2 million in 2002 or EUR 1.5 million in 2013).
5. **Research Centers:** Finally, firms that show both a high R&D intensity (50% and more) and a high absolute R&D expenditure. Initially this group was not planned, but it turned out that there are several firms in Austria that fall into this category – firms that are clearly not startups, but research institutes with the primary goal to conduct R&D.

3.4 Shift-share Analysis

Shift-share analysis is a standard method for investigating whether the increase in the R&D intensity is the result of a structural change towards more R&D intensive industries, or whether it is due to more R&D intensive production at otherwise similar economic structures (Leo et al., 2006).

The R&D intensity of the Business enterprise sector is defined as the quotient of the R&D expenditure x and the overall value added y. This value corresponds to the sum of the R&D intensities of all sectors ($\frac{x_\mathrm{i}}{y_\mathrm{i}}$), each weighted by the sector's share in the total value added:

$$\frac{x}{y} = \sum_{i=1}^{N} \left(\frac{x_\mathrm{i}}{y_\mathrm{i}}\right) * \frac{y_\mathrm{i}}{y}$$

A change in the R&D intensity over time can then be decomposed into the structural effect, the interaction effect, and the diffusion effect:

$$\begin{aligned}\left(\frac{x}{y}\right)_{\text{t}} - \left(\frac{x}{y}\right)_{\text{t-1}} = & \sum_{i=1}^{N}\left(\frac{x_{\text{it}}}{y_{\text{it}}}\right) * \left[\left(\frac{y_{\text{it}}}{y_{\text{t}}}\right) - \left(\frac{y_{\text{it-1}}}{y_{\text{t-1}}}\right)\right] && \text{Structural effect}\\ & + \sum_{i=1}^{N}\left[\left(\frac{x_{\text{it}}}{y_{\text{it}}}\right) - \left(\frac{y_{\text{it-1}}}{y_{\text{it-1}}}\right)\right] * \left(\frac{y_{\text{it}}}{y_{\text{t}}}\right) && \text{Diffusion effect}\\ & + \sum_{i=1}^{N}\left[\left(\frac{x_{\text{it}}}{y_{\text{it}}}\right) - \left(\frac{y_{\text{it-1}}}{y_{\text{it-1}}}\right)\right] * \left[\left(\frac{y_{\text{it}}}{y_{\text{t}}}\right) - \left(\frac{y_{\text{it-1}}}{y_{\text{t-1}}}\right)\right] && \text{Interaction effect}\end{aligned}$$

The structural effect describes the difference that is based on a changed economic structure, whereby the R&D intensity remains constant within the sectors; i.e. the effect results from the change between the sectors. It is greater the more the share of R&D intensive sectors increases, or the more the contribution of little R&D intensive sectors to the overall economic value added decreases. In contrast, the diffusion effect measures the effect that is based on the change in the sectoral R&D intensities. It is greater if the R&D intensity of R&D strong sectors increases. Finally, the interaction effect results from a link between the two previous effects. It is all the greater, the stronger the weight of those sectors is, which show increasing R&D intensities (Leo et al., 2006).

CHAPTER 4

Empirical Results

This chapter is divided into five sections. The first three sections each present a different level on which the development and structural change is examined. The first section in this chapter presents the overall findings and gives a broad overview of how BERD in Austria has developed from to 2002 to 2013. Section 2 introduces a classification of all companies into five groups based on R&D intensity and absolute R&D expenditure of each company. Section 3 examines the phenomenon of persistence of innovation in Austria. Therefore only companies with an R&D expenditure in both 2002 and 2013 are considered – these companies are referred to as *long-term R&D performers* in this thesis. Since two data points exist for these companies, that section covers their growth and the mobility between different groups and size categories. The results from the shift-share analysis are presented in Section 4.4. Finally, this chapter concludes with a critical reflection discussing the validity of the results as well as the limitations of this work.

4.1 General Development from 2002 to 2013

This section provides a general overview of the development of the R&D expenditure from 2002 to 2013. For these two years all R&D performing companies in Austria are taken into account.

4.1.1 R&D Performing Companies

The number of R&D performing companies increased strongly from 2002 to 2013. 1,942 Austrian companies showed R&D expenses in 2002. Eleven years later in 2013, this number has increased by 71% to 3,322. However, this growth is very different depending on the size of the company and the industry.

R&D Performers per Firm Size

Table 4.1 shows the number of companies per firm size for 2002 and 2013. The first column in Table 4.1 denotes five firm size categories. The second column subdivides these categories into ten size classes and shows the number of employees for each class. A square bracket indicates that the number is included in the respective class, a parenthesis that the number is not included. For instance in the first row the number of employees is denoted as [1, 5) and therefore contains companies with below five employees, firms with five employees are in the next class. The last two columns then state the number of firms for each class in 2002 and 2013.

Firm Size	Employees	Firms 2002	Firms 2013	% Change
Micro	[1, 5)	209	752	259.8
	[5, 10)	170	383	125.3
Small	[10, 20)	250	422	68.8
	[20, 50)	310	508	63.9
Medium	[50, 100)	241	342	42.0
	[100, 250)	405	463	14.3
Large	[250, 500)	184	239	29.9
	[500, 1,000)	114	141	23.7
Very Large	[1,000, 5,000)	53	66	24.5
	[5,000	6	6	0
Total		1,942	3,322	71.1

Table 4.1: Number of Austrian companies per firm size with an R&D expenditure in 2002 or 2013

The category of the smallest companies shows the by far largest increase. The number of R&D-active micro-sized firms (less than 10 employees) has increased by 194% from 2002 to 2013. In the same period, the number of small-sized firms (10 to 50 employees) has increased by 66%, medium-sized firms (50 to 250 employees) by 25%, large firms (250 to 1,000 employees) by 28%, and the number of very large firms (1,000 employees and above) showed the smallest increase with 22%. Overall, the number of R&D performers has increased across all company sizes.

The increase in the number of R&D performing firms is not only due to newly founded companies, but also because of Austrian companies that changed and split up into several independent entities. An example for that is the *Siemens AG Österreich*: Austrian Siemens companies were transformed into Infineon companies in 1999. In 2005, Siemens acquired the *VA Technologie AG*, but had to sell the *Andritz Hydro GmbH* which was required by the EU competition authority. In 2011, Siemens sold the *Siemens IT Solutions* *and Services* to *Atos Origin*, which resulting in the newly founded *Atos IT Solutions and Services GmbH* (Siemens AG Österreich, 2017). Every legal company unit appears as a separate entity in the data and references to formerly existing firms are not possible.

R&D Performers per Industry

The structure of the R&D performing companies in terms of industries has changed from 2002 to 2013: While the majority of the R&D performers in 2002 were in manufacturing industries (1,164; 59.9% of all R&D performers), most R&D performing firms in 2013 came from the service sector (1,759; 53.0% of all R&D performers). In 2013 1,423 R&D performers came from manufacturing industries (42.8% of all), which reflects an increase of 22.3% in the number of firms for the considered period. In contrast, the number of R&D performers in the service sector increased by 156.4%, from 686 firms in 2002 (35.5% of all). The number of companies in other industries, which are not classified as manufacturing industries or services, increased by 52.5% from 92 in 2002 (4.7% of all) to 140 in 2013 (4.2% of all). Table 4.2 shows the number of firms per industry in detail.

Industry	Firms 2002	Firms 2013	% Change
High-tech	141	197	39.7
Medium high-tech	436	539	23.6
Medium low-tech	315	404	28.3
Low-tech	272	283	4.0
Knowledge-intensive market services	201	553	175.1
High-tech knowledge-intensive services	278	794	185.6
Knowledge-intensive financial services	11	7	-36.4
Other knowledge-intensive services	32	53	65.6
Less knowledge-intensive market services	163	348	113.5
Other less knowledge-intensive services	1	4	300.0
Other	92	140	52.2
Total	1,942	3,322	71.1

Table 4.2: Number of Austrian companies per industry with an R&D expenditure in 2002 or 2013

4.1.2 BERD

In 2002 the BERD in Austria was EUR 3,131 million, by 2013 this value has more than doubled to EUR 6,778 million. Table 4.3 shows how these total expenses are distributed among the different firm sizes. The last column states the relative change from 2002 to 2013 in percent, whereby an increase is not explicitly denoted with a plus sign.

Firm Size	Employees	Aggregated 2002	Aggregated 2013	% Change
Micro	[1, 5)	28,020	71,086	153.7
	[5, 10)	29,370	88,746	202.2
Small	[10, 20)	73,459	158,514	115.8
	[20, 50)	136,876	369,791	170.2
Medium	[50, 100)	147,570	386,792	162.1
	[100, 250)	344,207	826,458	140.1
Large	[250, 500)	422,494	808,180	91.3
	[500, 1,000)	546,190	1,322,081	142.0
Very Large	[1,000, 5,000)	718,944	2,466,323	243.0
	[5,000	683,754	280,449	-59.0
Total		3,130,884	6,778,420	116.5

Table 4.3: Aggregated BERD in EUR'000 per firm size for 2002 or 2013

With one exception, the BERD increased across all classes. Only in the class of 5,000 and more employees the aggregated BERD declined from 2002 to 2013. In contrast, the class with 1,000 to 5,000 employees showed the strongest growth. The decrease in the aggregated expenditure in the group of the largest companies might be due to an R&D strong company that reduced its staff number or was split up, and therefore switched the class. This could explain the strong decrease in the one class and the strong increase in the other one. In addition, there are only six companies in the class of 5,000 and more employees. Consequently, changes in the expenditure of a single company in this class have a strong weight in the class sum. The aggregated BERD in the remaining classes increased consistently, with values between 91.3% (250 to 500 employees) and 202.2% (5 to 10 employees).

Average R&D Spendings

The average R&D expenditure of an Austrian R&D performing company increased from EUR 1,612k in 2002 to EUR 2,040k in 2013. This overall increase of 26.6% is just slightly above the inflation rate of 25.2% for the given timeframe. However, the results differ depending on the company size as shown in Figure 4.1 (see Table A1 for detailed values).

The overall modest growth (just slightly above the inflation rate) can be explained by the large number of micro-sized companies with less than five employees, which on average show even a decline in R&D spendings. Due to their high number, these firms have a strong weight in the overall average. In the remaining categories the average R&D spendings in 2013 were higher than in 2002 and well above the inflation rate. Especially medium, large and very large firms increased their spendings. In the area of micro and small sized companies, where the number of companies has increased particularly strongly, the growth in average R&D spendings was lower.

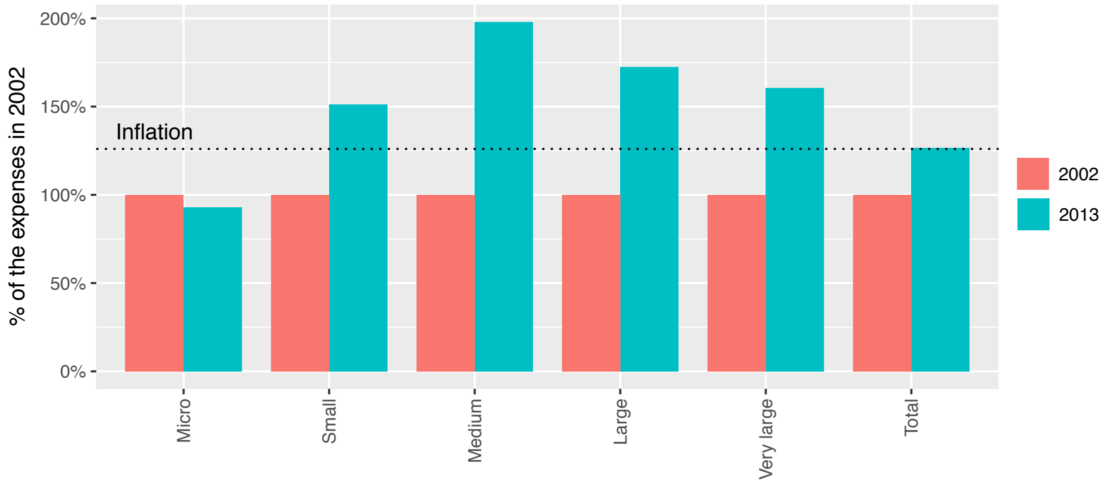

Figure 4.1: Average BERD in 2013 in percent of 2002 per firm size

BERD per Industry

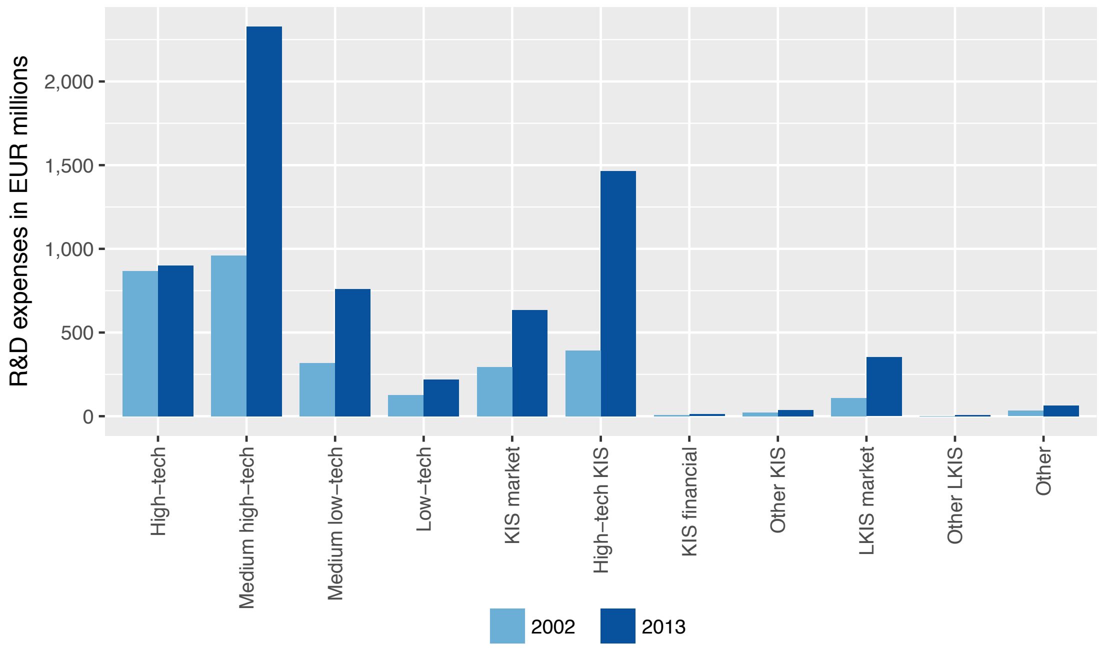

Figure 4.2: Aggregated R&D expenditure in manufacturing industries, knowledge-intensive services (KIS), and less knowledge-intensive services (LKIS)

The BERD increased in all manufacturing industries and all Knowledge Intensive Services (KIS). In case of the Less Knowledge Intensive Services (LKIS), the R&D expenses increased only in the less knowledge-intensive market services but declined in the group of other less knowledge-intensive services. The aggregated BERD per industry is shown in Figure 4.2 and Table A3 in the appendix.

The development of the aggregated BERD per industry does not reflect the number of firms per industry (as shown in Table 4.2): In 2002, manufacturing industries, which made up 59.9% of all firms, accounted for 72.6% of the total BERD. In that year, companies in the service sector (35.3% of all) were responsible for only 13.9% of the total BERD. In 2013, the majority of the R&D performing companies were in the service sector (53%), the share of the manufacturings industries decreased to 42.8%. Nevertheless, manufacturing industries still accounted for the larger part of the BERD (62%). The service sector made up for 37% of the total R&D expenditure of the business sector in 2013. Consequently, manufacturing industries tend to have higher average R&D expenses. This is shown in Figure 4.3 with the average R&D expenditure per industry in decreasing order of the expenditure in 2013. The top three spending industries in 2013 are from manufacturing sectors: high-tech and medium high-tech manufacturing industries show much higher average R&D expenditures than all others.

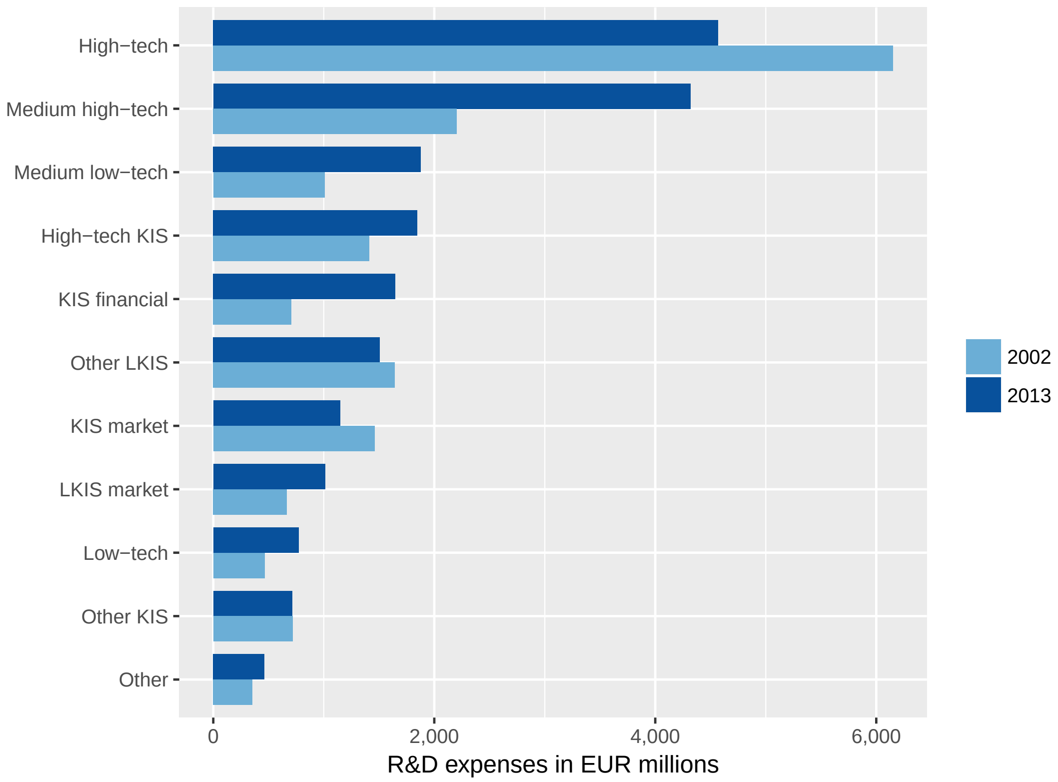

Figure 4.3: Average R&D expenditure per industry

High-tech industries and high-tech knowledge-intensive services account for EUR 2,440 million of the EUR 3,647 million BERD increase from 2002 to 2013. Accordingly, these two industries together are responsible for 66.9% of the increase. The decomposition of the BERD increase per industry is shown in Figure 4.4. There is no sector with an absolute decline in R&D expenditure in the period investigated. It is remarkable that most of the growth does not come from high-tech manufacturing firms, but from medium high-tech. This supports the hypothesis that Austria's catching up was due to upgrades in medium tech-sectors.

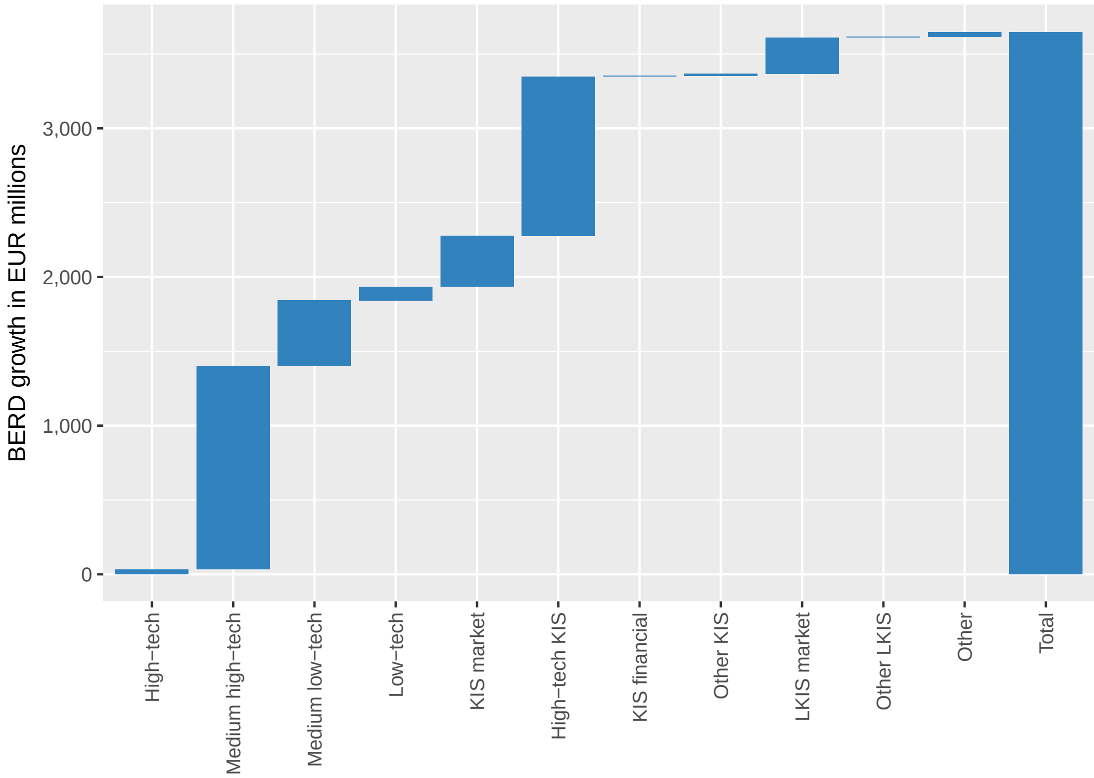

Figure 4.4: Increase in R&D expenditure from 2002 to 2013 per industry sector

4.1.3 R&D intensity

This section deals with the development of the R&D intensity from 2002 to 2013. While the previous section looked at the R&D spendings in absolute terms, this section considers the firms' R&D expenditure relatively, i.e. in relation to the revenue. Consequently, a growth in R&D intensity implies that the R&D expenditure grew stronger than the revenue, whereas a decline implies the opposite. A consistent value indicates that the ratio did not change.

Figure 4.5 and Table 4.4 show the overall development of the R&D intensity for all R&D

performing Austrian firms. The R&D intensity is calculated as stated in Section 2.2.6. Most notably, the median R&D intensity increased from 3.44% in 2002 to 7.25% in 2013, i.e. half the firms in 2002 spent less than 3.44% of their revenue on R&D and half of the firms spent more than 3.44% (vice versa with 7.25% for 2013). The intensity at the lower (25% of the data) and upper quartiles (75% of the data) increased as well. These results show that the R&D performing companies did not only increase their R&D spendings in absolute numbers, but also in relation to their revenue.

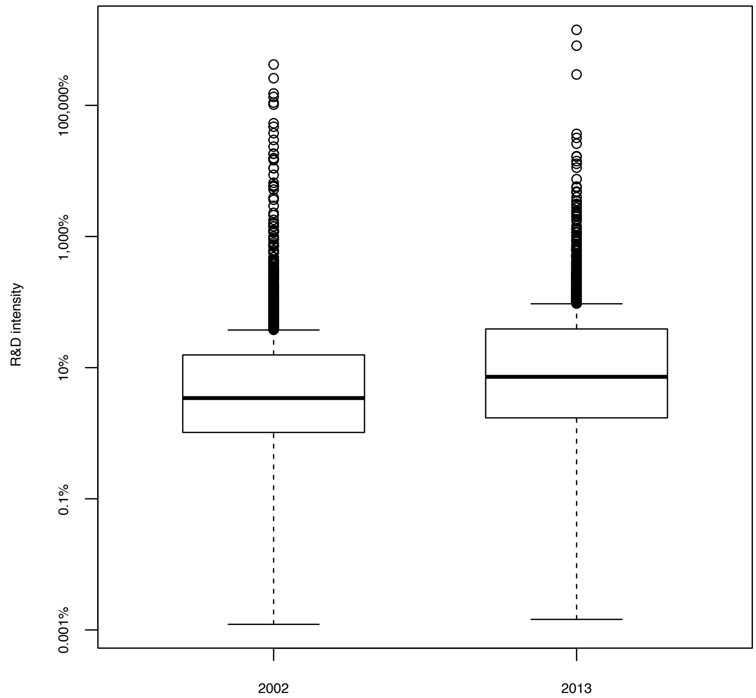

Figure 4.5: Boxplot of the R&D intensity of all Austrian firms in 2002 and 2013, with the y-axis logarithmized

	2002	2013
Lower whisker	0.001%	0.001%
Lower quartile (Q_1)	1.03%	1.72%
Median	3.44%	7.25%
Upper quartile (Q_3)	15.64%	38.92%
Upper whisker	37.50%	94.29%

Table 4.4: R&D intensity of all Austrian firms in 2002 and 2013

The increase in the median R&D intensity for all firms is the result of an increased R&D intensity across all firm size classes. It is mainly due to the large number of new micro and small sized companies – companies that show a much higher R&D intensity than larger firms. Figure 4.6 and Table A4 show the R&D intensity per firm size class and year. Overall it can be said that the R&D expenditure grew stronger than the revenue across all firm sizes.

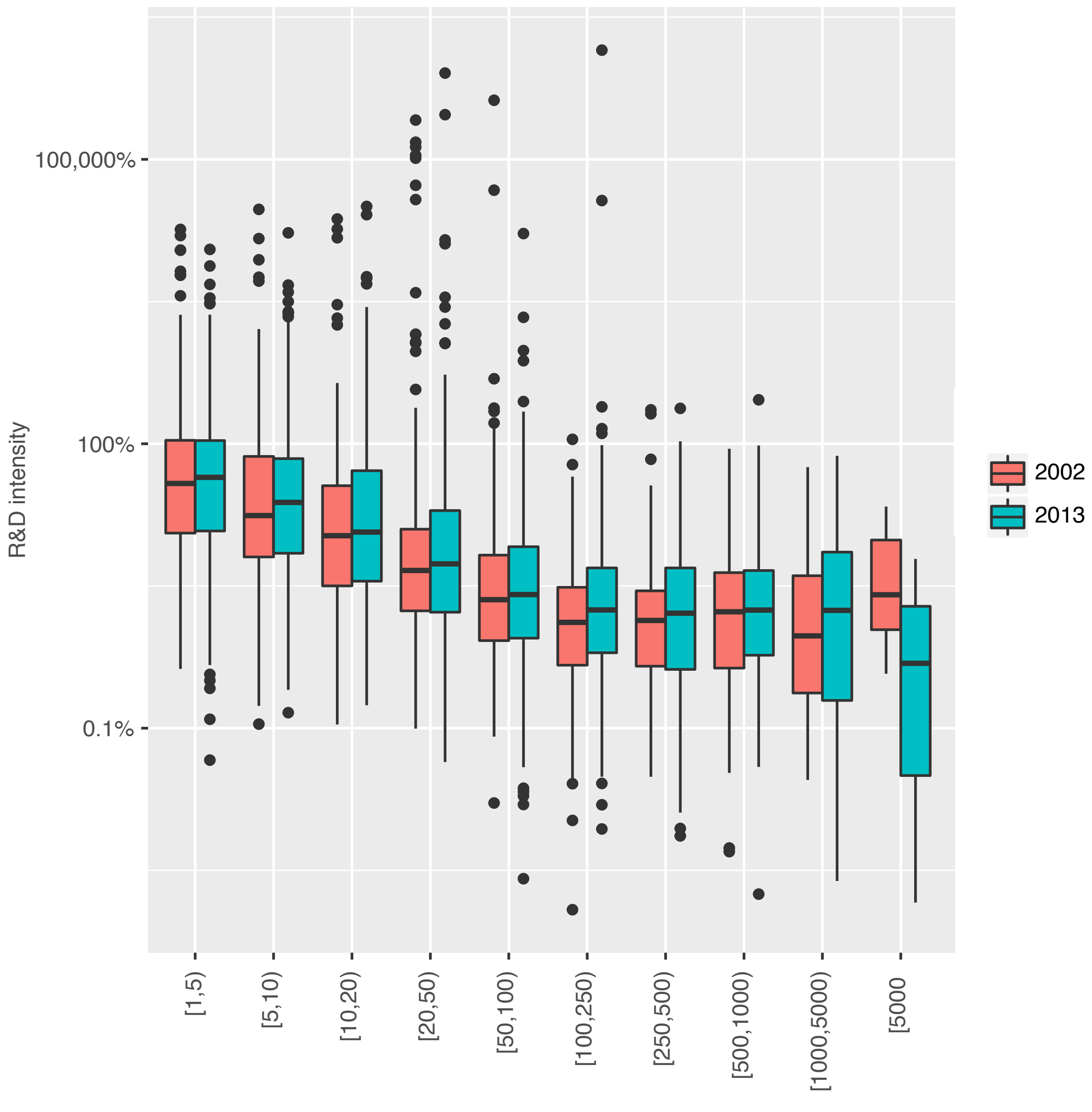

Figure 4.6: Boxplot of the R&D intensity of all Austrian firms in 2002 and 2013 per firm size class, with the y-axis logarithmized

The R&D intensity increased across all firm size classes, except the class with 5,000 and more employees. But since there are only six observations in this size class for both years (see Table 4.1), the results are more strongly influenced by individual observations and thus less significant.

In the remaining classes, the median R&D intensity increased particularly strongly in the size classes of one to five and five to ten employees, as well as the second largest class with 1,000 to 5,000 employees. The R&D intensity of the smallest size class is extremly high in 2013: With a median of 51%, half of the 752 companies in that class spent more than half of their revenue on R&D. The later two size classes have already shown a strong increase in the average BERD. Thus, these companies increased not only their absolute spendings, but also their spendings in relation to the revenue. However, the size class for large companies had a much lower median R&D intensity compared to all other size classes in 2002 and growth from low level is easier to achieve.

4.2 Firm Classification Based on R&D Expenditure and Intensity

For a better understanding of the research intensive companies, a classification based on R&D intensity and absolute R&D expenditure is used. This classification is introduced in Section 3.3.3, where we also explained how we derived the thresholds for the five groups.

The groups are shown in Figure 4.7 with their number of firms in 2002 and 2013.

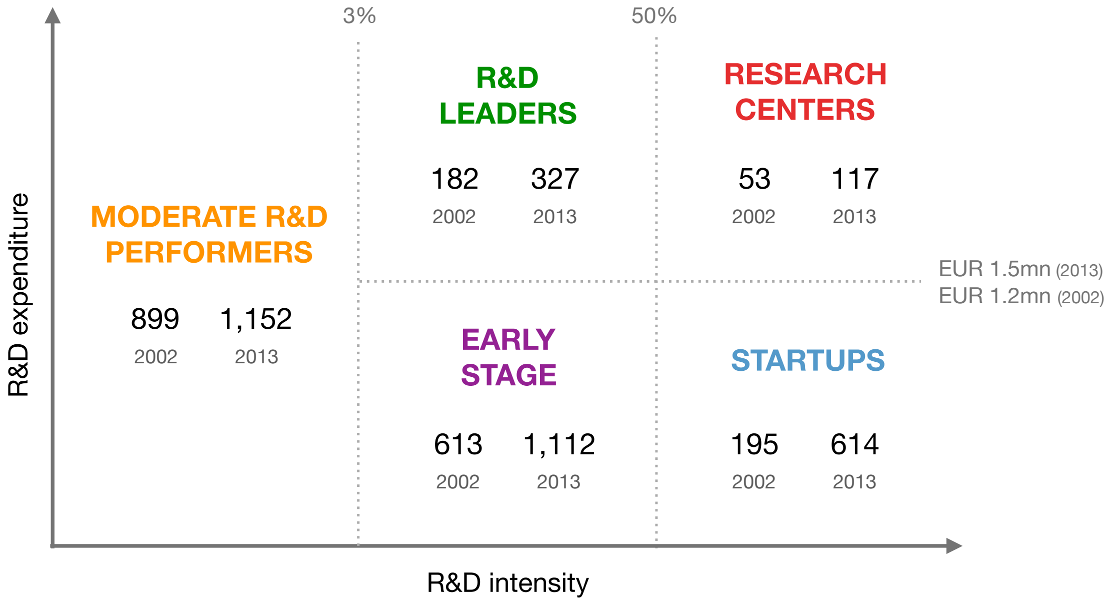

Figure 4.7: Number of firms in each of the 5 groups

The Moderate R&D Performers are the largest group in 2002 and make up almost 50% of the R&D performing firms. This is due to the threshold of the 3% R&D intensity, which is close to the overall median R&D intensity of 3.4% in 2002. The next largest group are firms in Early Stage, followed by Startups, R&D Leaders, and finally the Research Centers.

This order has not changed by 2013, however some groups have shown stronger growth than others. The number of firms in the Startup group has more than tripled and the number of Research Centers has more than doubled. The growth rates for the R&D Leader and Early Stage group were 79.7% and 81.4% respectively. The Moderate R&D Performers showed the lowest increase, which arises from the increase of the median R&D intensity to above 7% in 2013.

4.2.1 Moderate R&D Performer Group

Table 4.5 shows the median values for the Moderate R&D Performer group in 2002 and 2013. This group contains firms of all different sizes – from 1 employee up to 48,716.

Because the firms are so diverse, the standard deviation for the measures is higher than for the other groups. This holds true for all measures except the R&D intensity, because it is limited to values between 0 and 3%. With a median of 0.9% in 2002 and 1% in 2013 and a mean of 1% in 2002 and 1.1% in 2013 it is at the lower side of this range and shows just minor growth in the period considered. Consequently this group really contains firms that predominantly have a low R&D intensity, that is far off the Austrian target for 2020 of 3.76% (total R&D expenditure / GDP ratio).

Measure	2002	2013	% change 2002-2013	% per Year
Revenue (EUR'000)	€ 24,009	€ 22,370	-6.8	-0.6
R&D Expenditure (EUR'000)	€ 160	€ 150	-6.3	-0.6
R&D Intensity	0.9	1.0	4.7	0.4
Employees	141	101	-28.4	-3.0
R&D Employees (FTE)	1.9	1.7	-13.1	-1.3

Table 4.5: Median measures for the Moderate R&D Performer group

Firm Size

The group of Moderate R&D Performers contains firms of all size categories, which is shown in Table 4.6. Out of all groups, the Moderate R&D Performers represent the largest group in both 2002 and 2013. More than two thirds of medium to very large firms are in this group in 2002. By 2013 this share has decreased, but the majority of firms with 50 or more employees is still in this group. The share of small and especially micro sized firms is lower. For these size categories the share in 2002 and 2013 remained almost the same. Over all size categories, the share of Moderate R&D Performers has decreased from 2002 to 2013.

Industries

Moderate R&D Performers are in manufacturing industries. Out of the 899 companies in the Moderate R&D Performer group in 2002, 714 are in manufacturing industries and 117 are in the service sector. 61.3% of all firms that are in manufacturing industries in 2002 are Moderate R&D Performers, compared to only 17.1% of the service sector. In the manufacturing industries in 2002, the Moderate R&D Performers are mostly of the low-tech industry (82% of all firms in low-tech industries are Moderate R&D Performers), medium-low-tech (74% of all medium-low-tech), and medium high-tech (53% of all medium high-tech) industry. In terms of services, the Moderate R&D Performers are predominantly found in the less knowledge-intensive market service sector (41% of all). There are also 11 knowledge-intensive financial service providers that make up 100% of all firms in the knowledge-intensive financial service sector, i.e. there is no other

Size Category	2002	2013	% change 2002-2013	% per Year
Micro	35	103	194.3	10.3
% of all Groups	9.2	9.1	-1.7	–
Small	174	288	65.5	4.7
% of all Groups	31.1	31.0	-0.33	–
Medium	438	473	8.0	0.7
% of all Groups	67.8	58.8	-13.3	–
Large	212	245	15.6	1.3
% of all Groups	71.1	64.5	-9.4	–
Very Large	40	43	7.5	0.7
% of all Groups	67.8	59.7	-11.9	–

Table 4.6: Firms per size category for the Moderate R&D Performer group

knowledge-intensive financial service company in any other group and no such firm with an R&D intensity above 3%.

By 2013, the number of firms in the service sector increased stronger than the number of manufacturing industries in the Moderate R&D Performer group, but manufacturing industries still account for the majority with 741 of 1,152 companies. Although the share of the Moderate R&D Performers in the total number of manufacturing industries has decreased, still more than half (52%) of all of manufacturing industries are Moderate R&D Performers and therefor have an R&D intensity below 3%. 317 firms of the Moderate R&D Performers in 2013 are of the service sector. They account for 18% of all companies in services, which is a slight increase compared to 2002. Moderate R&D Performers in manufacturing industries in 2013 are still predominantly found in low-tech industries (76% of all), medium-low-tech (65% of all), and medium high-tech (44% of all) industries. The percentage of Moderate R&D Performers in high-tech decreased from 21% to 14%. In the service sector overall, the Moderate R&D Performers are still primarily less knowledge-intensive market service providers (45% of all). The number of companies in knowledge-intensive financial services decreased from 11 to 7 and, even more interestingly, 2 out of this 7 companies are in the Startup group in 2013, presumably so-called *Fintechs*. The number of firms per industries are shown in Table A5 for 2002 and Table A6 for 2013.

Share in All Groups

From 2011 to 2013, the importance of the Moderate R&D Performer group in the Austrian R&D activies of the business enterprise sector has decreased, because its share in the number of R&D performing companies, the total R&D expenditure, and in the number of R&D employees decreased, as shown in Table 4.7. The percentage of the total revenue and the total number of employees which the Moderate R&D Performers make up for decreased as well – but at a much lower rate than the measures of the R&D activities.

Although there are less firms in the Moderate R&D Performer group than in the Early Stage and Startup group combined, their share in the overall R&D expenditure and R&D employment is higher. The reason therefor is the high share of medium, large and very large firms that are in this group. Because these firms are larger, they have a higher revenue and even though their R&D intensity is much lower, their absolute spendings are higher at last.

Measure	2002	2013	% change 2002-2013	% per Year
Number of Companies	899	1,152	28.1	2.3
% of Companies for all Groups	46.3	33.5	-25.1	–
Revenue (EUR'000)	€70,761,200	€126,184,453	78.3	5.4
% of Total Revenue for all Groups	75.6	73.6	-2.7	–
R&D Expenditure (EUR'000)	€564,232	€859,673	52.4	3.9
% of Total R&D Expenditure for all Groups	18.0	12.7	-29.6	–
Number of Employees	294,702	336,626	14.2	1.2
% of Total Employees for all Groups	70.4	64.8	-7.9	–
Number of R&D Employees (FTE)	5171.6	7073.3	36.8	2.9
% of Total R&D Employees for all Groups	19.3	15.2	-21.2	–

Table 4.7: Aggregated measures for the Moderate R&D Performer group

4.2.2 Early Stage Group

The median measures of the Early Stage group are shown in Table 4.8. The median R&D expenditure decreased from 2002 to 2013, although the median R&D intensity increased. This can be explained by the strong growth in small and especially micro-sized firms and also reflects in the decrease of the median revenue as well as in the lower number of employees in this group. Maybe the decreasing average revenue and average R&D expenditure are due to the fact that Statistics Austria has improved their data collection process and was able to identify more R&D performing firms in 2013 than 2002.

Firm Size

Table 4.9 shows that the Early Stage group contains most micro and small sized firms in 2002 (over 50%). Although the absolute numbers of micro and small sized firms have increased in 2013, the share of these firms over all groups has decreased, but still no other group contains more firms of these size categories. The share of medium sized firms stayed almost the same in both years. There are no large or very large firms in this group in 2002. 4 large firms are in this group in 2013, but the percentage of all large firms that are in the Early Stage group is very low.

Measure	2002	2013	% change 2002-2013	% per Year
Revenue (EUR'000)	€1,774	€1,173	-33.9	-3.7
R&D Expenditure (EUR'000)	€188	€146	-22.6	-2.3
R&D Intensity	8.8	10.9	24.0	2.0
Employees	16	11	-31.3	-3.3
R&D Employees (FTE)	2.3	2.0	-13.0	-1.3

Table 4.8: Median measures for the Early Stage group

Size Category	2002	2013	% change 2002-2013	% per Year
Micro	198	517	161.1	9.1
% of all Groups	52.2	45.6	-12.8	–
Small	294	446	51.7	3.9
% of all Groups	52.5	48.0	-8.7	–
Medium	121	145	19.8	1.7
% of all Groups	18.7	18.0	-3.8	–
Large	0	4	–	–
% of all Groups	0	1.0	–	–
Very Large	0	0	–	–
% of all Groups	0	0	–	–

Table 4.9: Firms per size category for the Early Stage group

Industries

311 companies of the 613 in the Early Stage group in 2002 are in the service sector, fewer firms (282) are in manufacturing industries. The 311 companies in the service sector in the Early Stage group account for 45% of all firms in the service sector in 2002. The 282 companies in manufacturing industries account only for 24% of all manufacturing firms that performed R&D in 2002. By 2013, the number of both manufacturing industries and services increased, but the growth in firms in the service sector was much stronger with 431 additional firms compared to only 60 additional companies in manufacturing industries. The share of firms in the Early Stage group in all firms of the service sector remained almost the same at 42%, and also the share of the Early Stage group in all manufacturing industries did not change and remained at 24%. With 45% in 2002 and

42% in 2013, there is no other group with a higher share in firms in the service sector, neither in 2002 nor in 2013.

In manufacturing industries, companies of the Early Stage group are mostly high-tech and medium high-tech firms. The firms in the Early Stage group account for a large percentage of all high-tech companies: 48% in 2002 and 49% in 2013. The share of the Early Stage group in medium high-tech industries is much lower with 29% in 2002 and 24% in 2013. In terms of the service sector, the Early Stage group accounts for a large share in all subcategories, except the knowledge-intensive financial services. The large share can be explained by the overall high number of companies in the Early Stage group. The Early Stage group is the second largest of the five groups in both 2002 and 2013. The numbers in detail are stated in the appendix in Table A5 for 2002 and Table A6 for 2013.

Share in All Groups

Table 4.10 shows the aggregated measures for the Early Stage group. Although the number of firms in this group increased strongly and their share in the overall Austrian R&D performing firms increased as well, their share in the R&D expenditure of the Austrian business enterprise sector fell. Comparing the growth rates of the different measures, the number of R&D employees has grown just as strong as the number of companies. The aggregated R&D expenditure increased even stronger. In contrast, the aggregated revenue and number of employees increased at a lower rate. This indicates a higher R&D intensity, just like the increased median R&D intensity showed.

Measure	2002	2013	% change 2002-2013	% per Year
Number of Companies	613	1,112	81.4	5.6
% of Companies for all Groups	31.6	33.5	6.0	–
Revenue (EUR'000)	€ 2,523,570	€ 3,933,227	55.9	4.1
% of Total Revenue for all Groups	2.7	2.3	-14.9	–
R&D Expenditure (EUR'000)	€ 173,214	€ 328,669	89.7	6.0
% of Total R&D Expenditure for all Groups	5.5	4.8	-12.4	–
Number of Employees	19,963	26,791	34.2	2.7
% of Total Employees for all Groups	4.8	5.2	8.3	–
Number of R&D Employees (FTE)	2150.7	3901.2	81.4	5.6
% of Total R&D Employees for all Groups	8.0	8.4	4.5	–

Table 4.10: Aggregated measures for the Early Stage group

4.2.3 R&D Leader Group

The R&D Leaders show the highest median R&D expenditure and highest number in R&D employees.

Measure	2002	2013	% change 2002-2013	% per Year
Revenue (EUR'000)	€50,311	€50,739	0.9	0.1
R&D Expenditure (EUR'000)	€3,475	€3,852	10.8	0.9
R&D Intensity	8.1	8.5	4.8	0.4
Employees	285	227	-20.4	-2.0
R&D Employees (FTE)	34.8	31.0	-10.9	-1.0

Table 4.11: Median measures for the R&D Leader group

Firm size

The number of firms per size category in the R&D Leader group are shown in Table 4.12. In contrast to the two previous groups, the share of firms in this group has increased across all size categories. The number of small and medium sized firms grew particularly strongly, however in the case of the small firms from a rather low level. The share of R&D Leaders increases with the size category: The larger a firm is, the more likely it is an R&D Leader. This holds true for both years.

Size Category	2002	2013	% change 2002-2013	% per Year
Micro	0	3	–	–
% of all Groups	0	0.3	–	–
Small	9	28	211.11	10.9
% of all Groups	1.6	3.0	87.3	–
Medium	73	145	98.6	6.4
% of all Groups	11.3	18.0	59.4	–
Large	82	123	50	3.8
% of all Groups	27.5	32.4	17.6	–
Very Large	18	28	55.6	4.1
% of all Groups	30.5	38.9	27.5	–

Table 4.12: Firms per size category for the R&D Leader group

Industries

R&D Leaders are predominantly companies in manufacturing industries. 79% of the companies in the R&D Leader group are in manufacturing industries in 2002 (144 of 182) and 78% in 2013 (255 of 327). Within the manufacturing industries, most companies are in high-tech or medium high-tech sector. In 2002 there are 37 high-tech companies (26% of all high-tech firms are R&D Leaders) and 71 medium high-tech firms (16% of all). The number of firms in both categories increased by 2013: The number of high-tech companies increased to 45 (23% of all), and the number of medium high-tech firms increased particularly strongly to 143 (27% of all). The number of medium-low-tech companies also increased strongly from 28 firms in 2002 to 51 in 2013, but the share of R&D Leaders in the overall number in medium-low-tech industries remained low with 9% in 2002 and 13% in 2013.

The number of firms in the service sector in the R&D Leader group is much lower than the number of firms in manufacturing industries and the lowest across all groups. Only 5% of all R&D performing companies in the service sector are R&D Leaders in 2002 and even only 4% in 2013. R&D Leaders are mostly found in the category of high-tech knowledge-intensive services and, surprisingly, less knowledge-intensive services. The R&D Leaders in high-tech knowledge-intensive services account for only 5% of all firms in that group in 2002 and 2013. The share of R&D Leaders in all less knowledge-intensive services decreased from 9% in 2002 to 5% in 2013.

Measure	2002	2013	% change 2002-2013	% per Year
Number of Companies	182	327	79.7	5.5
% of Companies for all Groups	9.4	9.8	5.0	–
Revenue (EUR'000)	€ 19,754,404	€ 39,405,586	99.5	6.5
% of Total Revenue for all Groups	21.1	23.0	8.9	–
R&D Expenditure (EUR'000)	€ 1,903,093	€ 3,775,173	98.4	6.4
% of Total R&D Expenditure for all Groups	60.8	55.7	-8.4	–
Number of Employees	97,637	139,246	42.6	3.3
% of Total Employees for all Groups	23.3	26.8	15.0	–
Number of R&D Employees (FTE)	14,881.6	23,187.5	60.0	4.4
% of Total R&D Employees for all Groups	55.7	51.3	-7.8	–

Table 4.13: Aggregated measures for the R&D Leader group

Share in All Groups

The aggregated R&D expenditure of the R&D Leader group accounts for more than half of the total Austrian BERD in both 2002 and 2013. Also more than 50% of the R&D

personnel is employed by firms in the R&D Leader group. The just under ten percent of the Austrian R&D performing companies are therefore deservedly called *R&D Leaders*.

4.2.4 Startup Group

In comparison to the Early Stage group, firms in the Startup group are typically smaller. Their median revenue and number of employees is much lower, but still the median R&D expenditure of these firms is higher in both years. The number of R&D employees is quite similar in these two groups, in 2002 the median value of the Startups is slightly higher, in 2013 the one of the Early Stage group.

Measure	2002	2013	% change 2002-2013	% per Year
Revenue (EUR'000)	€110	€87	-21.4	-2.2
R&D Expenditure (EUR'000)	€231	€150	-35.1	-3.8
R&D Intensity	129.5	124.9	-3.6	-0.3
Employees	5	3	-40.0	-4.5
R&D Employees (FTE)	2.6	2.1	-21.2	-2.1

Table 4.14: Median measures for the Startup group

Firm Size

The firms per size class for the Startup group are shown in Table 4.15. This group consists mostly of firms that are micro sized, i.e. firms that have less than 10 employees. Several companies are also small sized, but their share in the Startup group is much lower. Apart from that, firms of larger size categories are extremely unlikely to be Startups.

The number of firms in the Startup group increased from 2002 to 2013 both in absolute and relative terms. Especially the number of micro sized firms grew, so that by 2013 almost half of them were in this group.

Industries

The number of companies in the Startup group is much higher in the service sector compared to manufacturing industries. Only 10% of the firms in the Startup group are in manufacturing industries in 2002 and only 12% in 2013. Because the number of firms in the Startup group increased strongly from 2002 to 2013, the share of this group in the overall R&D performing manufacturing industries and service sector increased. 2% of all manufacturing industries were in the Startup group in 2002 (19 firms) and 6% in 2013 (75 firms). The proportion of firms in the Startup group in the service sector increased from 26% in 2002 (175 firms) to 30% in 2013 (525 firms).

Size Category	2002	2013	% change 2002-2013	% per Year
Micro	141	506	258.9	12.3
% of all Groups	37.2	44.6	19.8	–
Small	52	106	103.8	6.7
% of all Groups	9.3	11.4	22.7	–
Medium	2	1	-50	-6.1
% of all Groups	0.3	0.1	-59.9	–
Large	0	1	–	–
% of all Groups	0	0.3	–	–
Very Large	0	0	–	–
% of all Groups	0	0	–	–

Table 4.15: Firms per size category for the Startup group

Firms in the Startup group in manufacturing industries are mostly in the high-tech subcategory, accounting for 5% of all high-tech companies in 2002 and 14% in 2013. Followed by companies in medium high-tech, which account for only 1% of all firms in that category in 2002 and 4% in 2013. Startups in the service sector are mostly found in high-tech knowledge-intensive services, more than half of the companies in the Startup group are in this category in both 2002 and 2013. They account for 36% of all firms in this category in 2002 and 39% in 2013. The second largest category is the one of knowledge-intensive market services, where Startups represent 27% of all firms in both years.

Share in All Groups

All firms in the Startup group together account for 2.1% of the total Austrian BERD in 2002, which is shown together with other aggregated measures for this group in Table 4.16. Even though the number of firms in this group tripled (it increased stronger than in any other group), the aggregated expenses of Startups in 2013 still make up only 2.5% of the total BERD in 2013. Overall, this group remains quite insignificant for the R&D activities in the Austrian economy. In terms of the aggregated R&D employment, the Startups have (in relation) increased their number more than any other group. Also their share in the total number of R&D employees increased stronger compared to all other groups.

It is noticeable that the relation of the R&D expenditure to the R&D employment is the lowest in this group with an average of EUR 77,211 per R&D employee in 2013. In the Early Stage group this ratio is slightly higher with EUR 84,249. The R&D Leaders and Research Centers show the highest average R&D expenditure per R&D employee with EUR 158,504 and EUR 174,955 respectively. The Moderate R&D Performers are inbetween with an average of EUR 121,538. An explanation therefor could be that employees in Startups and in general small or micro sized firms (what most firms in the Startup and Early Stage group are) often hold shares or are compensated with shares of a company and therefore receive a lower nominal compensation.

Measure	2002	2013	% change 2002-2013	% per Year
Number of Companies	195	614	214.9	11.0
% of Companies for all Groups	10.0	18.5	84.1	–
Revenue (EUR'000)	€54,150	€149,214	175.6	9.7
% of Total Revenue for all Groups	0.1	0.1	50.4	–
R&D Expenditure (EUR'000)	€64,353	€172,242	167.7	9.4
% of Total R&D Expenditure for all Groups	2.1	2.5	23.6	–
Number of Employees	1,564	3,880	148.1	8.6
% of Total Employees for all Groups	0.4	0.7	100.1	–
Number of R&D Employees (FTE)	850.7	2,230.8	162.2	9.2
% of Total R&D Employees for all Groups	3.2	4.8	51.0	–

Table 4.16: Aggregated measures for the Startup group

4.2.5 Research Center Group

The Research Center group has a higher median R&D intensity than the Startup group and consequently the highest across all groups in both 2002 and 2013. As shown in Table 4.17, Research Centers are typically medium sized firms with significant revenue and even higher R&D expenditure. Because their R&D expenditure is typically higher than their revenue (median R&D intensity of 180% in 2002 and 125% in 2013), these companies have to rely on external funding for their R&D activities.

Measure	2002	2013	% change 2002-2013	% per Year
Revenue (EUR'000)	€1,654	€2,730	65.1	4.7
R&D Expenditure (EUR'000)	€2,366	€3,298	39.4	3.1
R&D Intensity	180.1	125.4	-30.4	-3.2
Employees	32	39	21.9	1.8
R&D Employees (FTE)	24.0	28.0	16.7	1.4

Table 4.17: Median measures for the Research Center group

Firm Size

The group of the *Research Centers* consists largely of companies that are small or medium sized. Especially the number of medium sized firms in this category increased from 2002 to 2013. Table 4.18 shows the number of all firms per size category for this group.

There is a small number of micro sized companies (less than 10 employees) in this group, which is surprising because the threshold for the absolute R&D expenditure in this group is EUR 1.2 million in 2002 and EUR 1.5 million in 2013. Moreover, there are more micro and small sized firms in the *Research Center* group than in the *R&D Leaders* group, which also has the threshold of EUR 1.2 million resp. EUR 1.5 million in absolute R&D expenditure, but a lower R&D intensity.

Size Category	2002	2013	% change 2002-2013	% per Year
Micro	5	6	20	1.7
% of all Groups	1.3	0.5	-59.9	–
Small	31	62	100	6.5
% of all Groups	5.5	6.7	20.4	–
Medium	12	41	241.7	11.8
% of all Groups	1.9	5.1	174.2	–
Large	4	7	75	5.2
% of all Groups	1.3	1.84	37.2	–
Very Large	1	1	0	0
% of all Groups	1.7	1.4	-18.1	–

Table 4.18: Firms per size category for the Research Center group

Industries

Only 9% of the companies in the Research Center group are in manufacturing industries in 2002 and even only 9% in 2013. Most Research Centers are in the service sector and over two-thirds (68% in 2002 and 69% in 2013) of them provide high-tech knowledge-intensive services. The firms in the Research Center group represent 13% of all companies in the high-tech knowledge-intensive service sector in 2002 and 10% in 2013. Even though the number of Research Centers in that category more than doubled from 36 companies in 2002 to 81 in 2013, the overall number of firms in the category of high-tech knowledge-intensive services increased even stronger. Apart from that category, 11% of the Research Centers in 2002 (12% in 2013) are in the category of knowledge-intensive market services.

Share in All Groups

The Research Centers show the largest relative growth in R&D spendings and the largest increase in the average R&D expenditure across all five groups. They also increased their share in the total Austrian BERD more than any other group: while they only accounted for 13.6% in 2002, by 2013 the aggregated BERD of the Research Center group makes up for almost one quarter of the corporate R&D expenditure in Austria.

The increase of the R&D employment compared to the increase in the number of all employees is slightly lower. This is in contrast to all other groups, where the average number of R&D employees increased usually much stronger than the number of all employees.

Measure	2002	2013	% change 2002-2013	% per Year
Number of Companies	53	117	120.8	7.5
% of Companies for all Groups	2.7	3.5	29.1	–
Revenue (EUR'000)	€450,617	€1,704,227	278.2	12.9
% of Total Revenue for all Groups	0.5	1.0	106.4	–
R&D Expenditure (EUR'000)	€425,992	€1,642,663	285.6	13.1
% of Total R&D Expenditure for all Groups	13.6	24.2	78.1	–
Number of Employees	4,893	12,612	157.8	9.0
% of Total Employees for all Groups	1.2	2.4	107.9	–
Number of R&D Employees (FTE)	3,672.94	9,389.1	155.6	8.9
% of Total R&D Employees for all Groups	13.7	20.2	47.2	–

Table 4.19: Aggregated measures for the Research Center group

4.3 Long-term R&D Performers

This section examines the development of companies that performed R&D in both 2002 and 2013. In this thesis these companies are referred to as long-term R&D performers. There are 869 firms that performed R&D in both years. Companies that have changed their legal unit between 2002 and 2011 (for instance due to a merger or split-up) appear as new companies in the dataset. The founding date of companies and information whether firms previously existed under a different name or legal status are not included in the dataset. Therefore, the present number of long-term R&D performers can be seen as a lower bound.

4.3.1 R&D Expenditure of Long-term R&D Performers

Although the share of the long-term R&D performers in the total number of R&D performing companies is relatively low, they made up for 70.7% of the total BERD in 2002 and 62.1% in 2013.

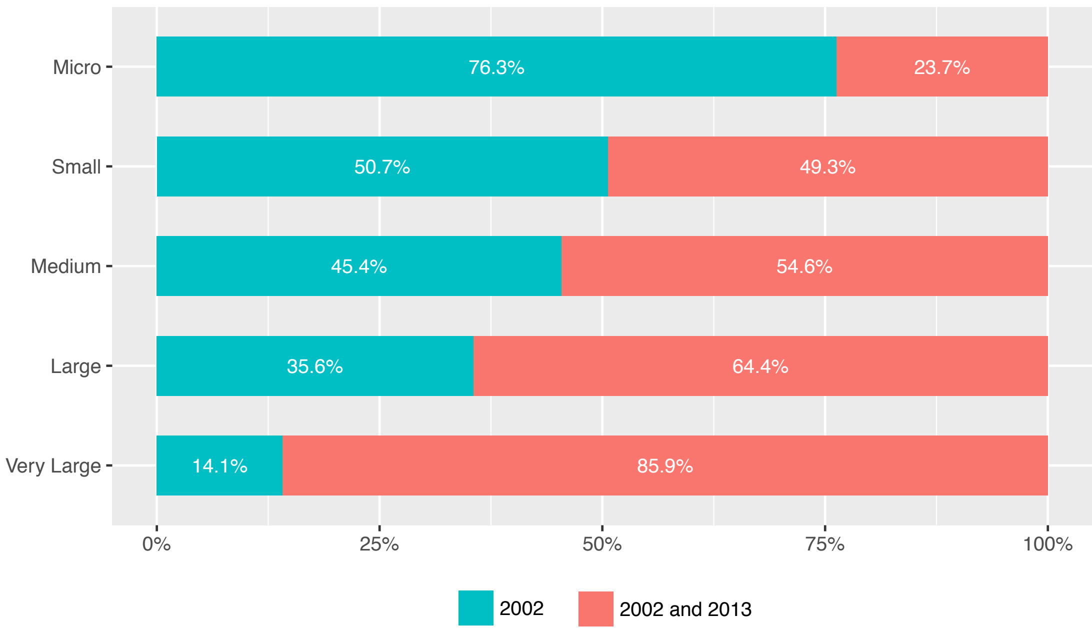

Figure 4.8: Share of the total BERD spent by long-term R&D performers per firm size in 2002

Figure 4.8 shows the share of the total BERD per firm size category that is spent by long-term R&D performers in 2002. The red bar indicates the percentage spent by long-term R&D performers, the green bar the share spent by the others. For example in the category of micro-sized companies the aggregated BERD was EUR 57,390k in 2002 (see Table 4.3), thereof long-term R&D performers spent EUR 13,592k in 2002 – which makes 23.7%.

The share of the long-term R&D performers in the total BERD increases with the firm size. Since the number of long-term R&D performers also increases with the firm size, the question arises which of those two factors grew stronger. This information along with the data for Figure 4.8 is given in Table 4.20. Comparing the last two columns in that table, it becomes clear that the long-term R&D performers' share in the total BERD is larger than the share of the long-term R&D performers in the firms for every size category. The difference between the share in the total BERD and the share in total firms is particularly high for small and very large firms. It follows that the average R&D expenditure for long-terme R&D performers is higher than the average expenditure for the other companies across all firm size categories, but especially for small and very large firms.

Firm Size	Aggregated BERD	Share in Total BERD	Share in Total Firms
Micro	13,592	23.7%	23.5%
Small	103,794	49.3%	41.4%
Medium	268,355	54.6%	49.4%
Large	624,307	64.4%	63.8%
Very Large	1,204,292	85.9%	66.1%
Total	2,214,340	70.7%	44.7%

Table 4.20: BERD of the long-term R&D performers in 2002 per firm size category in EUR'000, in percent of the BERD per firm size category, and the share of long-term R&D performers per firm size category in 2002

Just like in 2002, the long-term R&D performers' share in the total BERD in 2013 is higher than their share in number of total firms in 2013 – among all size categories. Consequently the average R&D expenditure across these five categories is also higher than for the other firms in 2013. This is shown in Figure 4.9 and Table 4.23.

4.3.2 Firm Size of Long-term R&D Performers

Of 1,942 companies that performed R&D in 2002, 869 also did in 2013 – that's 44.7% of the companies that show a long-term commitment to R&D, given the two years. And in percent of the 3,326 companies in 2013, only 26.1% performed R&D 11 years before.

Figure 4.10 and Table 4.22 show that the share of long-term R&D performers in 2002 increases with the firm size category. The size categories are the same as in the previous section. While only 23.5% of the firms in the smallest category are long-term R&D performers, their share makes up almost two-thirds of the largest category. In the firm size categories in between, the proportion rises steadily.

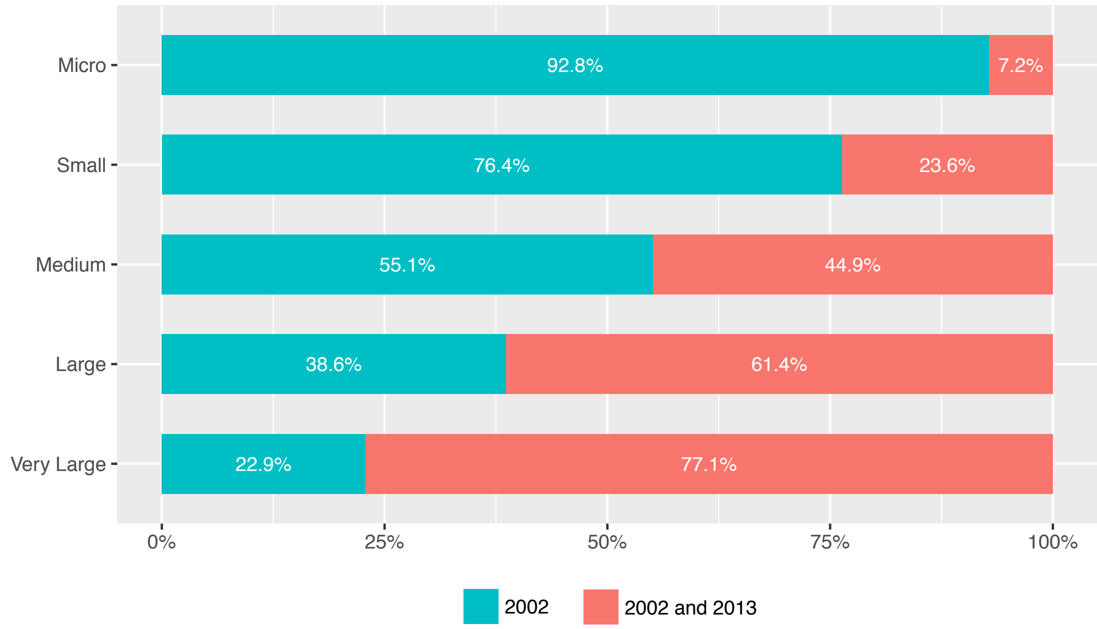

Figure 4.9: Share of the total BERD spent by long-term R&D performers per firm size in 2013

Firm Size	Aggregated BERD	Share in Total BERD	Share in Total Firms
Micro	11,473	7.2%	5.8%
Small	124,938	23.6%	20.8%
Medium	544,299	44.9%	42.0%
Large	1,307,192	61.4%	59.7%
Very Large	2,219,058	80.8%	62.5%
Total	4,206,960	62.1%	26.2%

Table 4.21: BERD of the long-term R&D performers in 2013 per firm size category in EUR'000, in percent of the BERD per firm size category, and the share of long-term R&D performers per firm size category in 2013

Also in 2013 the percentage of firms that performed R&D differs greatly depending on the company size: As depicted in 4.11, the data shows that the larger a company, the more likely it has already performed R&D in the past.

More than one third (1,135) of the firms that performed R&D in 2013 employ nine people or fewer, accordingly these businesses are classified as micro-enterprises. Of these micro-enterprises only 66 also performed R&D in 2002, which is less than 6%. In the case

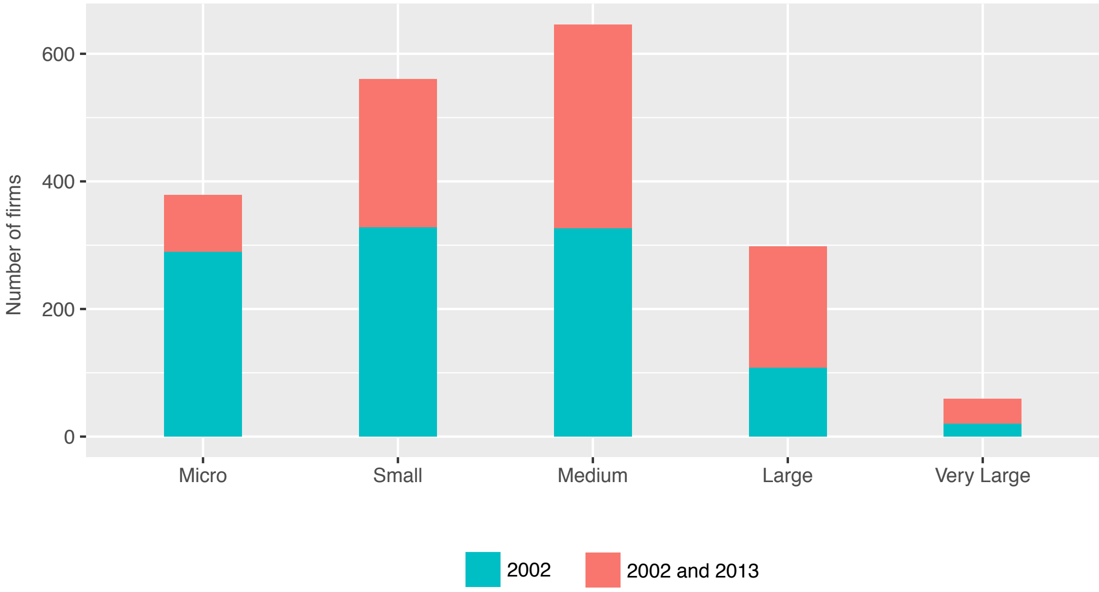

Figure 4.10: Firm size of the Austrian companies that performed R&D in 2002 and in 2013

Firm Size	Firms Total	Long-term R&D Performers	Share in Total Firms
Micro	379	89	23.5%
Small	560	232	41.4%
Medium	646	319	49.4%
Large	298	190	63.8%
Very Large	59	39	66.1%
Total	1,942	869	44.7%

Table 4.22: Number of Austrian companies and long-term R&D performers per firm size for 2002

of small enterprises (10 to 49 employees), this number lies slightly above 20%, with 193 out of 930 firms that performed R&D in both years. For medium-sized companies (50 to 249 employees), the share of companies that performed R&D in 2002 increases to 42% (338 of 805 firms). 227 of 384 large companies (250 to 999 employees) showed an R&D expenditure in both years, which equals 59,1%. With 62.5% and 45 of 72 companies this percentage is even higher for very large enterprises (1,000 employees and more).

Possible explanations for the small share of long-term R&D performers among micro-

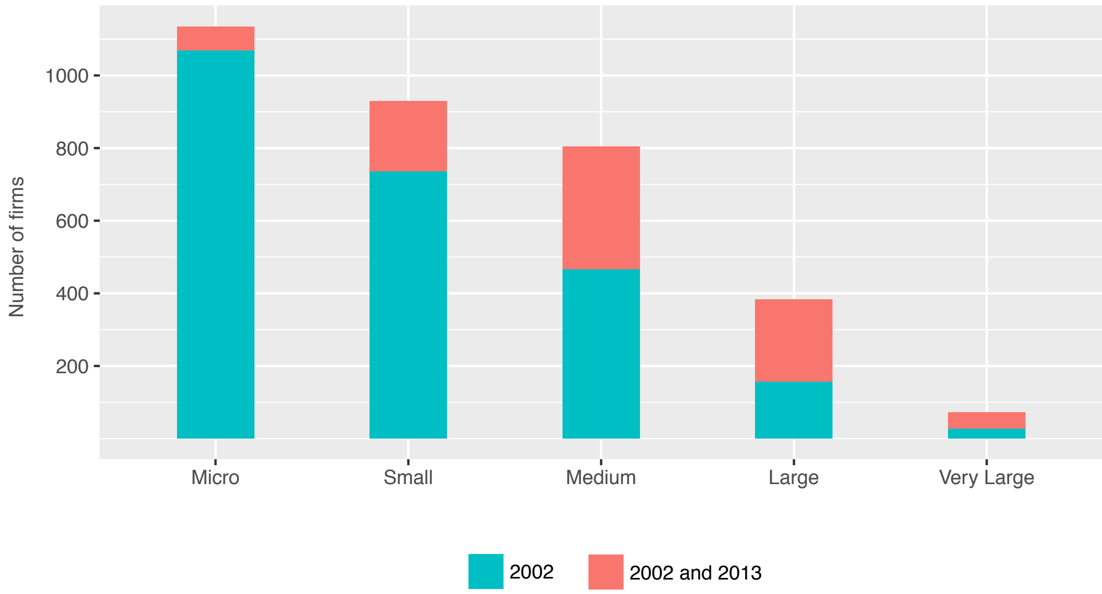

Figure 4.11: Firm size of the Austrian companies that performed R&D in 2013 and in 2002

Firm Size	Firms Total	Long-term R&D Performers	Share in Total Firms
Micro	1,135	66	5.8%
Small	930	193	20.8%
Medium	805	338	42.0%
Large	380	227	59.7%
Very Large	72	45	62.5%
Total	3,322	869	26.2%

Table 4.23: Number of Austrian companies and long-term R&D performers per firm size category for 2013

enterprises and small companies could be the survival rates of businesses, the growth of companies during their lifetime and the general arguments that explain the persistence of innovation (see Section 2.3.1). Newly founded companies are typically small businesses, of which just under 60% exist five years later.[1] Together with the fact that successful companies grow during their lifetime, there is a lot of mobility in the categories, which is

[1] 59.17% of enterprises born in 2007 still existed in 2012 – in Austria across all sectors (OECD, 2015a, p. 61).

addressed in the following section.

4.3.3 Mobility in Firm Size

The long-term R&D performers have changed over the course of time, they have shrunk, grown or may not have changed in their size. Since there is data for both years for these 869 companies, the firms can be divided into size categories in each year and it can be examined how they developed from 2002 to 2013. Figure 5.1 shows this development in form of a Sankey diagram. It shows the five size categories for each year, with the firm size for 2002 on the left side and the size for 2013 on the right.

Figure 5.1 shows that growth over more than one firm size category is very rare. The exact values are shown in Table 4.24 as a transition matrix. The horizontal dimension indicates the firm size category for 2002, the vertical dimension for 2013. Diagonal elements (highlighted in bold) give the number of firms that remained in the same category for both years, elements right to the diagonal grew in relation to number of employees, elements left to the diagonal shrunk. The sum of a row gives the number of long-term R&D performers for the respective size category in 2002, the sum of a column the count in 2013 – these sums are provided in Figure 5.1. For example there were 89 micro sized long-term R&D performers in 2002. 53 of them were micro sized in 2013 as well, 35 companies grew to small firms, and one firm increased to a medium sized company in terms of employees. This company is the only long-term R&D performer with a growth over more than one firm size category for the considered period.

		2013				
		Micro	Small	Medium	Large	Very large
2002	Micro	**53**	35	1	0	0
	Small	12	**142**	78	0	0
	Medium	1	15	**235**	68	0
	Large	0	1	23	**152**	14
	Very large	0	0	1	7	**31**

Table 4.24: Transition matrix of long-term R&D performers per firm size category

The other way around there were three companies that have shrunk more than one category – one company each in the size categories of medium, large and very large firms.

The data shows that most long-term R&D performers have not changed in terms of firm size category. If they changed the category, they rather grew than shrunk. Overall, there were 196 companies that increased with respect to their number of employees, that are 23% of all long-term R&D employees. 60 long-term R&D performers (7%) shrunk and the majority (71%) has not changed the size category.

Small firms were more than six times more likely to grow than to shrink. Medium sized firms were four times more likely to grow than to shrink. For large companies this trend is reversed, they were 1.7x more likely to shrink. No statement can be made about micro sized and very large firms, because they could (besides not changing the category) only grow or shrink, given these five categories.

4.3.4 Development of the R&D Expenditure

In total, the long-term R&D performers increased their spendings from EUR 2,214 million to 4,207 million, which is an increase of 90%. The median R&D expenditure in 2002 was EUR 374k and has risen to EUR 679k in 2013.

Firm Size as of 2002

Table 4.25 shows the long-term R&D performers per size category with their aggregated R&D spendings for 2002 and 2013. The firm size for both columns refers to the year 2002, this makes it possible to understand how the companies of the different firm sizes have developed over the years. For example a firm that had 200 employees in 2002 and 300 in 2013 is categorized as a medium sized firm (50 to 250 employees) for both years.

Firm size	Aggregated BERD 2002 in EUR'000	Aggregated BERD 2013 in EUR'000	% Change
Micro	13,592	36,201	166.3%
Small	103,794	273,716	163.7%
Medium	268,355	691,431	157.7%
Large	624,307	1,230,508	97.1%
Very Large	1,204,292	1,975,104	64.0%
Total	2,214,340	4,206,960	90.0%

Table 4.25: Aggregated BERD of long-term R&D performers in EUR'000 per firm size (as of 2002) for 2002 and 2013

The smaller a long-term R&D performer, the more it has increased its R&D spendings in relative terms. The 89 micro sized firms with less than 10 employees in 2002 spent in total 166% more on R&D in 2013. Small companies (232 in 2002) are almost on the same level with an overall increase of 164%. Medium sized firms (319 in 2002) are only slightly below that value with plus 158%. The growth rates for large (190 in 2002) and very large firms (39 in 2002) are still considerable but notably lower with 97% and 64% respectively.

The strong increase among the small companies is not surprising for the following reasons: First, the share of micro and small-sized long-term R&D performers among all firms in

2002 and 2013 is much lower compared to larger firm size categories. 76.5% of the micro sized R&D performers in 2002 did not show an R&D expenditure in 2013. Likewise, 94.2% of the micro-sized R&D performers in 2013 did not perform R&D in 2002. The share for small sized firms that did not perform R&D in the other year are comparable at 58.6% in 2002 and 79.2% in 2013. These numbers can be explained by the survival rates of enterprises, which was 59.2% from 2007 to 2012 (the longest period for which this data is available) in Austria (OECD, 2015a, p. 61). Firms that survive over a period of 11 years tend to grow and consequently increase their R&D spendings, this results in an above-average growth for the few companies that appear in both years. Second, small companies start from a much lower level in absolute R&D spendings and thus have more potential for growth.

In absolute numbers the increases are higher for larger firms: The increase in the aggregated BERD for the very large long-term R&D performers is higher than in any other group (plus EUR 771 million). Together the 39 very large long-term R&D performers increased their R&D expenditure more than the 190 large R&D performers (in total plus 606 million). These 190 companies, in turn, showed a higher growth than the 319 medium sized long-term R&D performers (plus 423 million). It is not surprising, that the growth in aggregated BERD of the small and micro sized long-term R&D performers is lower, because also their count is lower. Small firms increased their R&D expenditure by EUR 170 million in total, micro sized firms by EUR 22 million. Again, all firm size categories refer to the year 2002, regardless of whether they would be in a different category in 2013. The figures in this paragraph arise from Table 4.25.

The long-term R&D performers increased their aggregated R&D spendings by 90% from 2002 to 2013. However, not all 869 of them raised their spendings: While 73% of the long-term R&D performers increased their R&D expenditure, 27% reduced it over the years. Figure 4.12 and Table A8 give the number of long-term R&D performers per firm size class that increased, decreased, or did not change the R&D expenditure. As before, the firm size refers to the year 2002.

Among the five size categories, micro-sized firms have the highest share of companies with a decreasing R&D expenditure. 38% of them spent less on R&D in 2013 than 2002. Remarkably, the aggregated BERD of the micro sized firms showed the largest relative increase over all categories (as discussed before). Consequently, the 62% of the micro sized companies, that have not cut their expenditures, have strongly increased their spendings in order to achieve the overall strong growth in this group. In the other four categories, the proportion of companies with a decreasing R&D expenditure is each quite similar with values between 25 and 28%.

Firm Size as of Year Considered

Table 4.26 shows the average R&D spendings per firm size class for 2002 and 2013. Unlike before, the size classes refer to the size of the respective firm for the year considered. This means that a company that has grown from 200 to 300 employees is also in a higher

Figure 4.12: Number of long-term R&D performers per firm size (as of 2002) with an increase and decrease in R&D expenditure from 2002 to 2013

class in 2013 than it was in 2002. The average expenditures and changes shown therefore relate solely to the firm size and not to the initial size in the year 2002. Through this classification, the data is also comparable to the overall average BERD per firm size (see Table A1).

Only the classes of the smallest and the largest firms expose a decrease in the average R&D expenditure. These two classes also show a negative trend in the overall results that is even worse if the long-term R&D performers are excluded. In the class of below five employees, the number of companies has decreased from 45 to 27, whereby the 27 companies (that are categorized in this size class in 2013) had an average R&D expenditure of EUR 116k in 2002 – the exact same value as in 2013. Consequently, these companies have not changed their R&D spendings on average. It also implies, that those companies that have grown out of this class, have had higher R&D spendings in 2002. Overall, a negative development results for this class altogether. The cause for the decreased expenditure in the class of 5000+ employees is unclear and due to the small number of firms very dependent on single observations. It is however noticeable, that the average expenditure in 2002 was very high and despite the decline, the average R&D

Firm size	Employees	Average 2002	Average 2013	% Change
Micro	[1, 5)	141	116	-17.7
	[5, 10)	165	214	30.0
Small	[10, 20)	307	454	47.9
	[20, 50)	545	735	34.9
Medium	[50, 100)	652	1,393	113.7
	[100, 250)	930	1,745	87.6
Large	[250, 500)	2,634	3,684	39.7
	[500, 1,000)	4,285	8,747	104.1
Very Large	[1,000, 5,000)	15,706	45,646	190.6
	[5,000	163,638	128,151	-21.7
Total		2,548	4,841	90.0

Table 4.26: Average BERD in EUR'000 per firm size for 2002 and 2013 for long-term R&D performers

expenditure in the class of 5,000+ employees is still much higher compared to all other firm size classes in 2013.

4.3.5 Development of the R&D Intensity

The median of the R&D intensity of all long-term R&D performers is presented in Figure 4.13 and Table 4.27. It increased from 3.0% in 2002 to 3.4% in 2013. This increase is not as stark compared to all firms and in comparison the median of the R&D intensity of the long-term R&D performers is lower in both years. Main reason for this lower value is the smaller share of micro and small sized firms in the long-term R&D performers, because these firms show a much higher R&D intensity than larger firms (see Table A4). As presented in Section 4.3.2, the share of the long-term R&D performers in all R&D performing companies in 2002 is 44.7% overall, but the share of micro and small sized firms is only 23.5% and 41.4% respectively. In 2013 that is even clearer: The long-term R&D performers account for 26.2% of all R&D performers, but only 5.8% of the micro and 20.8% of the small sized firms – and especially these categories induced the rise in the overall intensity in 2013.

Figure 4.14 (with the data given in Table A9) shows a decreasing R&D intensity of micro (one to five employees) and small (ten to 50 employees) sized firms, whereas the median intensity across all other categories increased from 2002 to 2013 – again with the exception of companies with 5,000 employees and above. The firm size hereby refers to the year 2002 for both years, regardless whether a firm has grown or shrunk by 2013. That way each size class has the same companies in both years and the development of

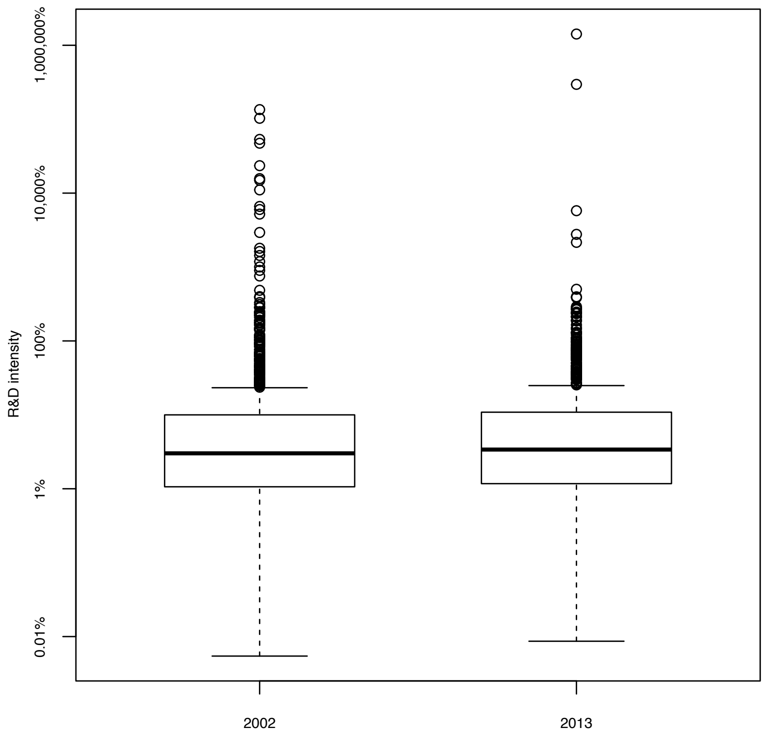

Figure 4.13: R&D intensity of all long-term R&D performers in 2002 and 2013, with the y-axis logarithmized.

	2002	2013
Lower whisker	0.005%	0.009%
Lower quartile (Q_1)	1.06%	1.17%
Median	3.02%	3.39%
Upper quartile (Q_3)	9.99%	10.86%
Upper whisker	23.28%	24.88%

Table 4.27: R&D intensity of long-term R&D performers in 2002 and 2013

their R&D intensity over the years is evident.

Table 4.28 shows the R&D intensity of the long-term R&D performers in comparison to the intensity of all firms. Unlike Table A9, the companies' firm sizes refer to the respective year. Consequently, the column stating the median R&D intensity for the long-term R&D performers is exactly the same as in the previous table, but the second column differs as it reflects the firmsize as of 2013. The data is compared to the R&D intensity of all firms and the higher value is each highlighted in bold.

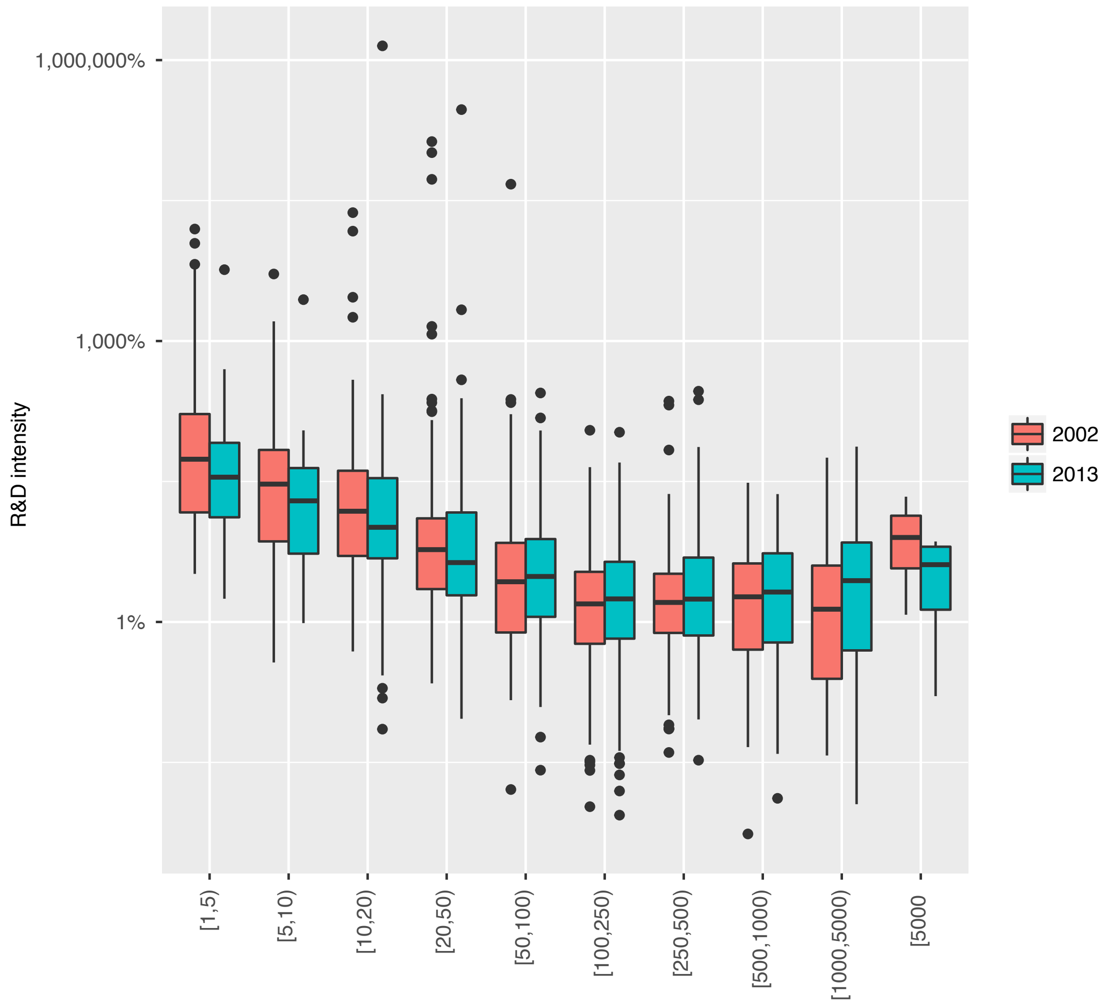

Figure 4.14: R&D intensity of the long-term R&D performers in 2002 and 2013 per firm size class (as of 2002)

It shows that the intensity of the long-term R&D performers is higher across all size classes in 2002. In 2013 this holds true only for firms with 50 employees or more. Long-term R&D performers are companies that exist for at least 11 years (2002-2013). It is unknown how long the other firms have already been operating, but especially in the area of very small companies one could assume several newly founded companies. One might think that small, young companies make less revenue in comparison to longer existing firms of the same size (in terms of employees). Consequently the higher intensity of micro and small-sized firms in 2013 could result therefrom. However, this assumption is rejected by the data: The average revenue for firms with below five and five to ten employees is lower for the long-term R&D performers compared to all firms. For the size classes in the category of small firms (10 to 20 and 20 to 50 employees) the average revenue of

	Median 2002		Median 2013	
Firm size class	All	Long-term	All	Long-term
[1, 5)	38.16%	**54.71%**	**51.01%**	45.28%
[5, 10)	17.49%	**29.66%**	**24.08%**	22.60%
[10, 20)	10.72%	**15.22%**	**11.76%**	10.86%
[20, 50)	4.61%	**5.92%**	**5.42%**	5.20%
[50, 100)	2.27%	**2.69%**	2.57%	**3.08%**
[100, 250)	1.31%	**1.56%**	1.77%	**2.26%**
[250, 500)	1.37%	**1.62%**	1.63%	**1.94%**
[500, 1,000)	1.69%	**1.86%**	1.77%	**2.09%**
[1,000, 5,000)	0.94%	**1.37%**	1.75%	**3.59%**
[5,000	3.33%	**8.56%**	0.51%	**4.42%**

Table 4.28: R&D intensity of the long-term R&D performers compared to all firms for 2002 and 2013 (firm size as of the respective year)

the long-term R&D performers is a little bit higher. Overall, however, one cannot say that small long-term R&D performers have higher revenue. Also when looking at the revenue of the remaining size classes, no clear pattern emerges. Apart from the already discussed arguments for persistence of innovation (see Section 2.3.1), no definite cause for the higher intensity of long-term R&D performers can be deduced.

4.3.6 Long-term R&D Performers in the R&D Expenditure / Intensity Groups

Table 4.29 shows the number of long-term R&D performers in each of the five groups, which were introduced in Section 4.2. For 2002 and 2013 the table shows the absolute number of long-term R&D performers per group and the share of the long-term R&D performers in the total number of companies for each group.

Group	2002		2013	
	Firms	% in All	Firms	% in All
Moderate R&D Performers	424	47.2	412	35.8
Early Stage	232	37.8	193	17.4
R&D Leaders	120	65.9	183	56.0
Startups	66	33.8	39	6.4
Research Centers	27	50.9	42	35.9

Table 4.29: Number of long-term R&D performers and their share in each of the five groups

Most long-term R&D perfomers are in the group of Moderate R&D Performers, which contains firms that have an R&D intensity below 3%. The number of companies in this group is slightly lower in 2013 compared to 2002. The number of long-term R&D perfomers in the Early Stage and Startups group has also decreased, and in compared to the Moderate R&D Performer group, their share in the overall number of firms in their respective group decreased even stronger. The lower share of long-term R&D performers in the Early Stage and Startups group can be explained by the survival rates of newly founded enterprises and the growth of those companies that survive. First, about 90% of the Startups and about 80% of the firms in the Early Stage group in 2002 did not show an R&D expenditure again in 2013 – either because they did not exist any more or because they did not perform R&D any more. Although the first argument seems to be more likely, it can not be concluded for sure from this evaluation, because there is no distinction in dataset with regards to firms that do no longer perform R&D, but still exist and those that no longer exist. Second, we see a decrease in the absolute numbers of companies in the Startup and Early Stage group in 2013, which implies that some of these companies must have changed their group by 2013. The mobility between the groups is specifically addressed in the next section.

Only the number of long-term R&D performers in the R&D Leader and the Research Center group has increased in absolute terms. in 2013, more than half of the R&D Leaders are firms that already performed R&D in 2002 – a much higher share than in any other group. The number of the long-term R&D performers in Research Centers also increased strongly and despite the decline their share is the second highest of all groups, although practically the same as the share of the Moderate R&D Performers (see Table 4.29).

Figure 4.15: Structure of the long-term R&D performers compared to all firms for 2002 and 2013

The structure of the long-term R&D performers is different compared to the structure of all firms. Figure 4.15 shows the difference for the years 2002 (lighter bars) and 2013 (darker bars). A positive value indicates that long-term R&D performers are found in the respective groups in higher numbers compared to the overall distribution, a negative value indicates the opposite. Consequently, long-term R&D performers are overrepresented in the groups of Moderate R&D Performers, R&D Leaders, and Research Centers. In contrast, their number is lower in the Early Stage and Startup group. Thus, long-term R&D performers are more likely to be in groups with a high absolute R&D expenditure (R&D Leaders and Research Centers include only firms with an R&D expenditure of at least EUR 1.2 million in 2002 and EUR 1.5 million in 2013; in the case of the Moderate R&D Performers there is no separation between companies with a high and low absolute R&D expenditure). This trend has intensified by 2013 because many long-term R&D performers grew from 2002 to 2013 and at the same time expanded their R&D expenditure, e.g. they developed from a firm in the Early Stage group to an R&D Leader.

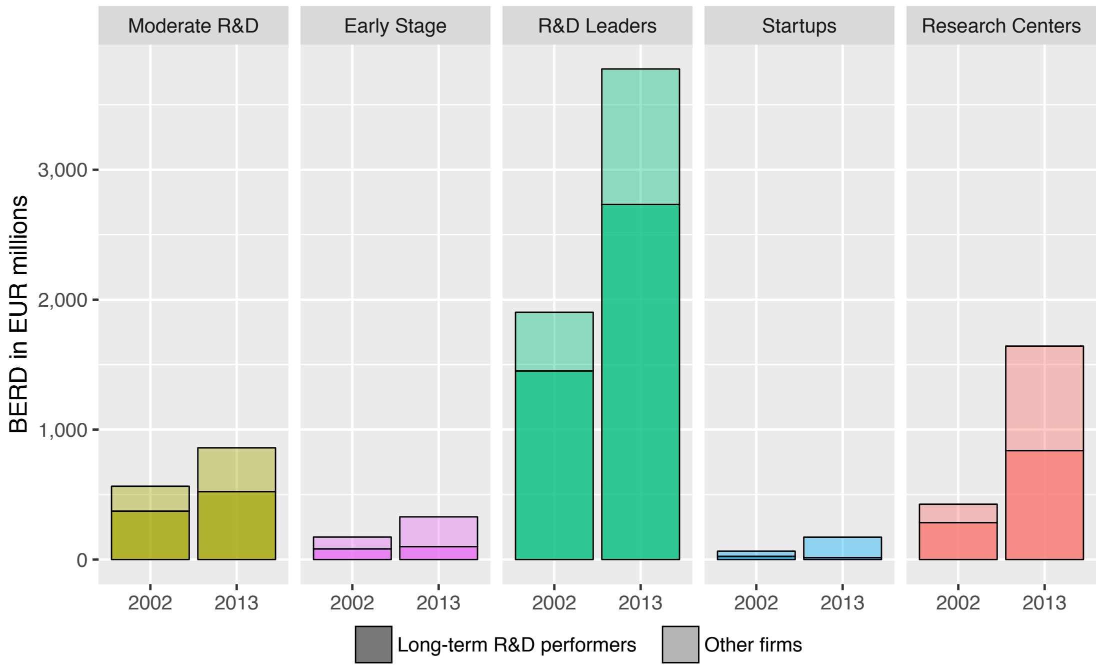

Figure 4.16: BERD of the long-term R&D performers, compared to the overall BERD

The share of the long-term R&D performers in the BERD per group correlates with the structure found above. Figure 4.16 shows the long-term R&D performers' share in the total BERD per group (see Table A10 for exact values). The darker bars represent the share of the long-term R&D performers, the lighter bars the difference to the remaining firms (the total BERD in that group). The long-term R&D performers account for large shares in the Moderate R&D Performer, R&D Leader, and Research Center group – those groups where the long-term R&D performers are overrepresented. Their share in the Early Stage and especially the Startup group is low. Overall, the share of the long-term

R&D performers decreased from 2002 to 2013, which is due to the increase in new R&D performing firms.

We tested whether the difference in R&D expenditure between the longterm R&D performers and the other companies is significant. Because the sample is not normally distributed (we used the Shapiro-Wilk test to test for normality), a simple t-test could not be used. Therefore we examined a Wilcoxon rank sum test (Wilcoxon, 1945). The results of these tests on the absolute R&D expenditure in 2002 for all five groups are summarized in Table 4.30. The null hypothesis (that the R&D expenditure mean is equal) can be rejected in all cases, because the *p-value* is always below the confidence level of 0.95 (significance). Consequently, the average of the R&D expenditure of the longterm R&D performers is significantly different from the other R&D performing firms.

Group	Test results	
	W	*p-value*
Moderate R&D Performers	67643	2.2e-16
Early Stage	31242	1.979e-09
R&D Leaders	3640	0.8123
Startups	3496	0.04988
Research Centers	282	0.2229
All groups	320750	2.2e-16

Table 4.30: Wilcoxon rank sum test for comparing longtime R&D performers to other R&D performing firms

4.3.7 Mobility in the R&D Expenditure / Intensity Groups

The previous section already showed that the number of long-term R&D performers in the R&D Leader and Research Center group increased in contrast to all other groups. This section examines the mobility between the groups in detail – for example how many Startups made it to R&D Leaders. Figure 4.17 depicts this development graphically and Table 4.31 states the number of firms as a transition matrix, with the row-sums representing the number of firms per group in 2002 and the sum of a column the number in 2013.

Across all groups, the majority of firms remained in the same group in 2002 and 2013. In the Moderate R&D Performer group, 326 out of 424 companies in 2002 remained in the same group, 63 companies increased their R&D intensity and moved to the R&D Leader group in 2013, and 35 firms moved to the Early Stage group, i.e. they also increased their R&D intensity, but their absolute R&D spendings were below EUR 1.5 million. No company that was a Moderate R&D Performer in 2002 moved to the Startup or Research Center group in 2013, the groups with an R&D intensity of 50% or more. In

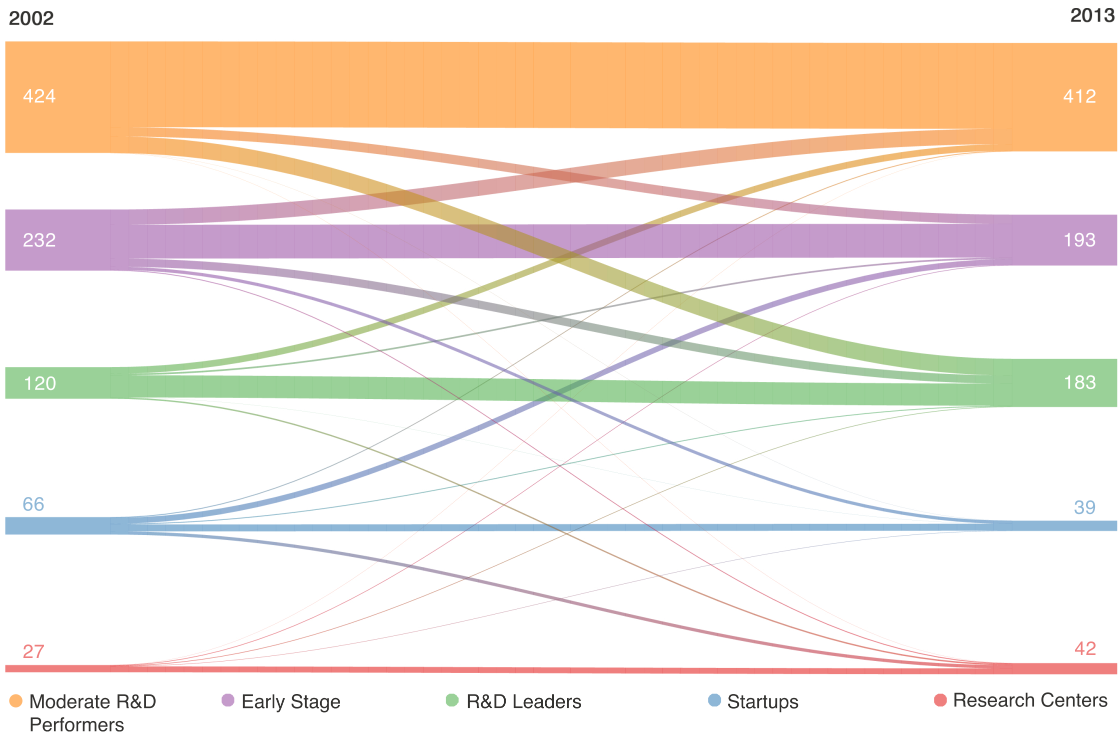

Figure 4.17: Mobility of long-term R&D performers in terms of the five groups

contrast, there are 3 companies that were a Startup in 2002 and became a Moderate R&D Performer in 2013.

Most of the companies that were in the Early Stage group in 2002 and did change their group, moved to the Moderate R&D Performer group, i.e. they lowered their R&D spendings in relation to their revenue. Several firms also became R&D Leaders, which means that these firms increased their R&D spendings to above EUR 1.5 million but kept an R&D intensity between 3 and 50%. Significantly fewer companies of the Early Stage group increased their R&D intensity to above 50% and ended up in the Startup or Research Center group in 2013.

The R&D Leader group is especially interesting, because it is one of the two groups that increased among the long-term R&D performers. Along with the Research Center group, companies that were in either one of these two groups had the highest probability of remaining in the same group in 2013. Companies that left the R&D Leader group from 2002 to 2013 were most likely to move to the Moderate R&D Performer group, presumably medium or large sized firms with a lowered R&D intensity. A few firms also moved to the Early Stage or Research Center group. No company that was an R&D Leader in 2002 moved to the Startup group in 2013. Firms that moved to the R&D Leader group in 2013 mostly came from the Moderate R&D Performer and the Early Stage group. Only a few companies of the Startup or Research Center group became

		2013				
		Moderate R&D Performers	Early Stage	R&D Leaders	Startups	Research Centers
2002	Moderate R&D Performers	**326**	35	63	0	0
	Early Stage	58	**128**	31	12	3
	R&D Leaders	25	6	**84**	0	5
	Startups	3	22	3	**26**	12
	Research Centers	0	2	2	1	**22**

Table 4.31: Transition matrix of long-term R&D performers per R&D expenditure / intensity group for 2002 and 2013

R&D Leaders in 2013. In relation to the number of all companies per group (including also non long-term R&D performers), companies in the Moderate R&D Performers group were most likely to become R&D Leaders – 7% of the companies in this group in 2002 did so. Followed by companies in the Early Stage and Research Center group with 5.1% and 3.8%. Only 1.5% of the companies in the Startup group became R&D Leaders in 2013.

The development from 2002 to 2013 shows that companies of the Startup group were four times more likely to end up in the Research Center group than in the R&D Leader group. The threshold in absolute R&D expenditure in both groups is EUR 1.5 million in 2013, but the Research Centers have an R&D intensity of at least 50%, just like the firms in the Startup group. Most Startups however, moved to the Early Stage group.

The Research Center group shows the highest percentage of firms that remained in the same group. If they changed their group, they moved to the R&D Leader, Early Stage or Research Center group, but not the Moderate R&D Performer group.

4.4 Shift-share Analysis

The shift-share analysis is based on data of the R&D expenditure per industry (see Table A3) and the *value added at factor cost and investments* (*Bruttowertschöpfung zu Faktorkosten und Investitionen* in German) per industry for the years 2002 and 2013. The numbers for the value added at factor cost and investments per industry could not be taken from the dataset which is used for the exploratory data analysis, because it includes only R&D performing companies. The shift-share analysis, however, should reflect the entire economy and take into account all businesses. Therefore we used numbers published in the yearly reports by Statistik Austria (2005, 2015). Between 2002 and 2013, the NACE classification system changed and consequently the classification of technological intensity (which is based on NACE divisions) – this is the reason why we could not divide the firms in the exact same sectors which were presented in Section 3.3.2. We had to use a slightly different grouping in the service sector, which distinguishes only between high-tech knowledge-intensive, other knowledge-intensive and less knowledge-intensive services. Any firms that could not be assigned to those groups based on their NACE division, are not included in the shift-share analysis. The results of the shift-share analysis are presented in Table 4.32.

Industry	Structural effect	Diffusion effect	Interaction effect	Δ R&D intensity
Manufacturing				
High-tech	-0.357	0.005	-0.002	-0.354
Medium high-tech	-0.095	0.644	-0.058	0.491
Medium low-tech	-0.032	0.206	-0.019	0.156
Low-tech	-0.053	0.096	-0.036	0.006
Services				
High-tech KIS	-0.102	0.843	-0.200	0.542
Other KIS	0.312	-0.114	-0.099	0.099
LKIS	0,003	0.111	0.003	0.117
Total	**-0.324**	**1.792**	**-0.412**	**1.056**

Table 4.32: Shift-share analysis

The shift-share analysis finds that the R&D intensity of the listed industries increased by 1.06% from 2002 to 2013. This increase is the result of a higher R&D intensity within the industries (diffusion effect). The medium high-tech manufacturing industries and the high-tech knowledge-intensive services mainly contributed to this development. The structural and the interaction effect are both negative. Thus, the R&D intensity increase is not because of a higher contribution to the overall economic value by those industries that had a high R&D intensity in 2002. The high-tech manufacturing industries largely account for the negative structural effect. The negative interaction effect implies that the contribution to the overall economic value does not correlate with the increase in

R&D intensity. Altogether the shift-share analysis shows that the increase of the R&D intensity of the Austrian Business enterprise sector is the results of an intensification of R&D in all industries and not because the R&D intensive sectors in the Austrian economy have grown particularly strongly.

4.5 Critical Reflection

Finally, in the critical reflection the validity of the presented results as well as the limitations of this work are discussed.

4.5.1 Validity of the Results

Since the used dataset is not public, other researchers essentially can not assess the correctness of the data analysis and the presented results. However, there are several publications with numbers based on the same dataset (Statistik Austria (2005), Statistik Austria (2015), Schiefer (2015a), and Schiefer (2015b)). So we did cross checks on the number of firms, the R&D expenditure, the total employment, the R&D employment, and the revenue with the listed reports to detect errors and miscalculations. That way we found that the number of R&D performing companies in 2013 in our results differs by 4 compared with Statistik Austria (2015). We checked that with Andreas Schiefer from Statistics Austria and learned that a firm was split up into five institutes in the Statistical Yearbook which explains the difference. In accordance with the Frascati Manual (OECD, 2015b), these institutes were later merged together to a single observation in the data so that every observation corresponds to a legal unit.

4.5.2 Validity of the Dataset

The dataset for the analysis was provided by Statistics Austria. Every two years, Statistics Austria sends a questionnaire to Austrian firms to collect that data. The queried firms are required by law to fill in this form. Based on these results, the official data on the R&D expenditure of the Austrian business enterprise sector is derived. In this respect, the analysis is based on the official Austrian data and to the best of the author's knowledge, there is no better data source available (with observations on firm level). Despite the legal basis for the data collection, it can not be ruled out that inaccurate statements are made knowingly or unknowingly. Ecker et al. (2017) found that data on R&D funding in the dataset does not match the data of the federal ministry of finance (data from tax assessments). The numbers in the dataset are below those of the federal ministry. A possible reason is that the amount of funding is not yet fixed at the time of the data collection. Data on funding of R&D is therefore not included in this work; a comprehensive report on funding of R&D in Austria since 2002 is given by Ecker et al. (2017), which is based on several data sources.

4.5.3 Limitations

The work has some limitations that are primarily rooted in the indirect access to the data:

- **Remote computation:** Due to confidentiality requirements, we could not access the dataset directly. It was not allowed, because firms could be possibly identified through the number of attributes in the dataset and Statistics Austria must prevent this due to current legal regulations. Thus, time and organisational effort was higher despite very good cooperation with Statistics Austria. We were also restricted in the number of analyzes that we were able to perform on the dataset and so we could for example not test the statistical significance of all developments.
- **Only aggregated results:** Because of the confidentiality requirements, we were also only allowed to get aggregated results; i.e. aggregations of least three observations. Together with the previous point, this is the reason why we could only perform very basic calculations on the data we got back from the remote computations and all calculations that required data on firm-level had to be run remotely by Statistics Austria. So although the dataset is on a firm level, the results are on an aggregated level because firms must not be identifiable.
- **No data about the firms' age:** The dataset does not include information about the age of the R&D performing firms. This information could be used to validate our assumptions in the grouping of firms in the Early Stage and Startup groups. It would also be interesting for the distinction between Schumpeter Mark I and Mark II industries.
- **Data for only two years:** The focus of this work was to examine the development of the R&D expenses for the longest period available – which is currently 2002 to 2013. The years inbetween were not included in the provided dataset. This could have provided more detailed insights for certain developments. For example the strong increase in the number of small firms could be the result of an improved data gathering by Statistics Austria.

CHAPTER 5

Conclusion and Future Work

5.1 Conclusion

The aim of this work was to investigate the role of the structural change in the rise of the R&D expenditure of Austria's business enterprise sector. Therefor we used firm-level data provided by Statistics Austria for the years 2002 and 2013. We only considered intramural R&D expenditure for the analysis. Due to confidentiality requirements we could not access the dataset directly, so the analysis was carried out as a remote computation.

The work started with a literature review and the definition of innovation. Today's understanding of innovation was largely shaped by Schumpeter, who first described the importance of innovation in the economic development. Schumpeter outlines two main sources for economic innovations: First, the entrepreneur who introduces new innovations to the market and thereby challenges established firms. This idea of *creative destruction* is the main concept of the Schumpeter Mark I regime. Second, established companies with large research departments that accumulate great amounts of knowledge and that are therefore able to "automate" the innovation process. The *creative accumulation* is an integral component of the Schumpeter Mark II regime.

R&D is related to innovation because R&D aims at generating new knowledge and at finding applications for that new knowledge. These applications are inventions by definition and only result in innovations if they are successful on the market. There are several studies that deal with the effects of R&D on firm growth and economic development. It is generally agreed that R&D is a key factor for economic growth and for the long-term prosperity of an economy (Rosenberg, 2004). However, innovation is not exclusively the result of R&D, innovation can for example also originate from experience-based learning or simple trial and error (Kinkel et al., 2005).

We also looked for patterns and current trends in innovation and R&D related publications: *Persistence of innovation* describes the phenomenon that firms which innovated in past periods are more likely to also do so in subsequent periods (Peters, 2009; Clausen et al., 2011). These persistent innovators are typically found to form a core group among all innovating firms and to be responsible for a significant share of the total R&D expenditure (Malerba and Orsenigo, 1999; Bottazzi et al., 2001; Boschma and Frenken, 2006). Another trend we observed, is an increase in concentration of the R&D expenditure. For example in the period of 2001 to 2013, Rammer and Schubert (2016) found that the R&D expenditure in Germany increased substantially, but the number of R&D performing firms decreased at the same time. In terms of differences between Europe and the US, Europe has less firms in high-tech sectors and US innovation pushed ahead of Europe in the 1990s. As a result, disruptive innovators of high-tech sectors (especially IT) from the US became some of the largest firms globally just within the last decades, while Europe is lagging behind (Cincera and Veugelers, 2014; Hoyer, 2016). Amazon or Google are examples for such companies; these two firms even made it among the top ten R&D spending firms globally in 2016 (Fox, 2016). In summary, the persistence of innovation and increase in concentration suggest an increase in R&D expenditure among established R&D performers (Schumpeter Mark II). In contrast we did not find strong support for R&D growth of young firms in Europe (Schumpeter Mark I).

The results are summarized in the following, each addressing a research questions:

1. Growth in R&D expenditure in relation to the firm size.
2. New actors in the group of research-intensive companies.
3. Structural change with reference to the industry sectors.

R&D Expenditure Growth in Relation to Firm Size

The results show that large companies are mainly responsible for the increase in R&D expenditure from 2002 to 2013. Although the number of micro and small sized companies that perform R&D increased strongly from 2002 to 2013, the average R&D expenditure increased particularly strongly amongst medium and large firms. The strong increase in R&D performing companies is in contrast to the development in most other countries: Germany and Switzerland also reported a growth in R&D expenditure over the last years (although at a lower rate than Austria), but the number of R&D performing companies decreased – especially the number of small and micro sized firms (Rammer and Schubert, 2016; Arvanitis et al., 2017).

Despite the strong growth in the number of micro (+200% from 2002 to 2013) and small sized companies (+66%), the share of these firms in the total BERD increased just slightly from 9% in 2002 to 10% in 2013. In contrast, the large and very large firms made up for 72% of the overall BERD in 2013 (76% in 2002). So even if the small firms continue to increase their R&D expenses at their current pace, they are still far from the level of the larger businesses, and if the larger firms would not have increased their R&D expenditure, the growth of the Austrian BERD would not be near the observed rate (see Table 4.3).

Based on the data at firm-level, we examined the R&D expenditure growth of those firms that performed R&D in both years. To the best of the author's knowledge, the development of these companies has never been investigated in Austria before. These long-term R&D performers account for the majority of the Austrian BERD, while their share in the total number of R&D performing companies is much lower (see Table 4.20 and 4.23). Consequently, these companies are of high importance for the Austrian BERD.

Our results in terms of the long-term R&D performers show the following:

1. Companies which were micro, small, and medium sized in 2002 increased their R&D spendings strongly – at an average rate above 150%.
2. Several long-term R&D performers grew in size and are in a different size category in 2013 than 2002.
3. The majority of the long-term R&D performers (73%) increased their R&D spendings from 2002 to 2013.
4. Medium, large, and very large firms in 2013 spent notably more than those firms that were in these size categories in 2002.
5. The average R&D expenditure of long-term R&D performers in the micro and small firm size category increased at a much lower rate compared to the other categories. In some size classes it even decreased. Also in consideration of the inflation rate of 25%, the growth in these categories is modest.

We also examined the mobility of the longterm R&D performers to understand how the R&D performing firms developed from 2002 to 2013 (see Figure 5.1 and Table 4.24). Most firms remained in the same size category, several firms increased in their size and a much lower number of firms decreased with respect to the number of their employees. However, growth over more than one firm size category is very rare. There is only one company that grew over two categories – from a micro sized firm to a medium sized one. The other way around, there were three companies that shrunk more than one category – one company each in the size categories of medium, large and very large firms.

New Research Intensive Actors

We developed a classification model of five groups to examine the development of the firms' R&D activities. Therefore we considered the R&D expenditure and intensity of every individual firm and classified each firm accordingly. This model is based on the work of Barber and Crelinsten (2004).

The number of firms in the research intensive groups (R&D Leader and Research Center group) increased significantly from 2002 to 2013. This increase can be ascribed to both long-term R&D performers and companies that did not perform R&D in 2002. It should be mentioned in this context that companies that have changed their legal unit between

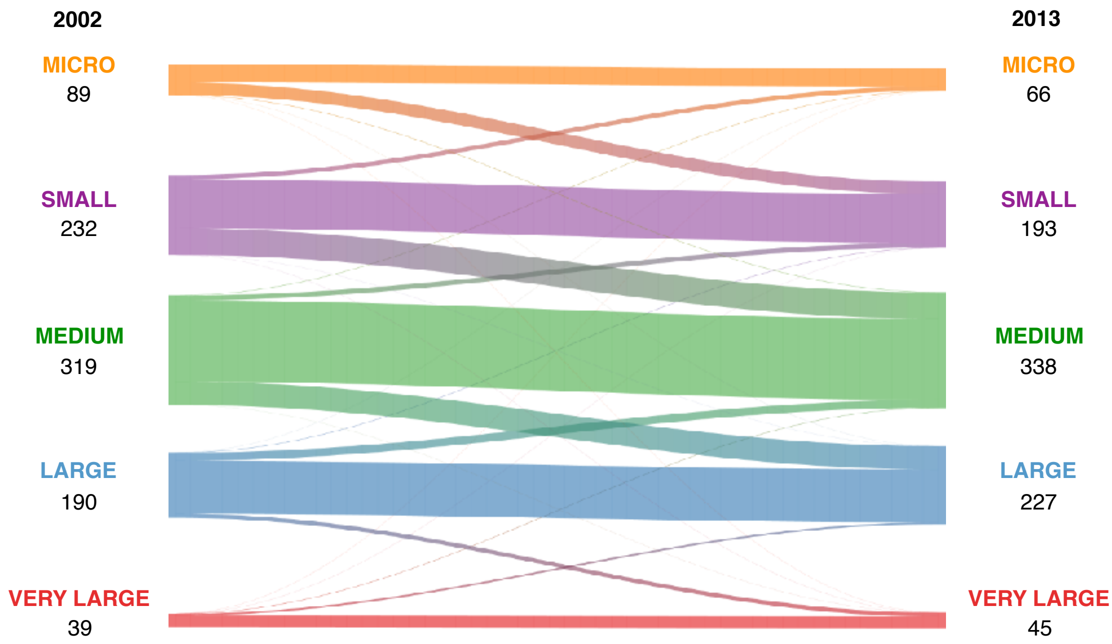

Figure 5.1: Mobility of long-term R&D performers in firm size

2002 and 2011 (for instance due to a merger or split-up) appear as new companies in the dataset.

The number of firms in the R&D Leader group increased from 182 in 2002 to 327 in 2013. This group includes all firms with an R&D intensity between 3 and 50% and an R&D expenditure above EUR 1.2 million (in 2002) or EUR 1.5 million (in 2013). The number of long-term R&D performers in this group rose from 120 (2002) to 183 (2013), in 2002 they accounted for 66% of all R&D Leaders and in 2013 for 56% (see Figure 4.7 and Table 4.29). Consequently, more new actors than long-term R&D performers entered this group from a numbers perspective. In terms of the R&D expenses however, the long-term R&D performers account for a much larger share in the R&D Leader group than the new actors: 76% in 2002 and still 72% in 2013, despite the many new firms that came into this group (see Figure 4.16 and Table A10).

The other group which contains research-intensive firms is the Research Center group. It includes firms with an R&D intensity above 50% and an absolute expenditure of at least EUR 1.2 million in 2002 or EUR 1.5 million in 2013. The number of companies in this group rose from 53 in 2002 to 117 in 2013. The number of long-term R&D performers in the Research Centers developed from 27 to 42 in the observed period. Consequently the share of the long-term R&D performers also decreased in this group, from 51% to 36%, so again more new actors came into this research-intensive group. And just like before, the long-term R&D performers still account for a larger share of the expenses in this group: 67% in 2002 and 51% in 2013.

In terms of mobility of the long-term R&D performers, there are only a few firms that developed from research-intensive groups with low absolute R&D expenditure (Early Stage and Startup group) to research-intensive groups with a high absolute expenditure (R&D Leader and Research Center group). Many of the firms that moved to the R&D Leader group were in the Early Stage or Moderate R&D Performer group in 2002. Only a few firms from the Startup and Research Center group moved there. Those firms among the R&D Leaders with the highest absolute expenditure in 2013 were almost exclusively R&D Leaders already in 2002 or came from the Moderate R&D Performers group, i.e. they increased their intensity. Long-term R&D performers in the Research Center group in 2013 were mostly in that group in 2002 already or came from the Startup group, i.e. they increased their absolute spendings to above EUR 1.5 million.

Structural Change in Industry Sectors

Across all industries the high-tech knowledge-intensive services showed the largest increase in the aggregated BERD (+273%, see Table A3). The medium high-tech sector also demonstrated strong growth from a high level (+142%). Together these two sectors account for two thirds of the BERD increase from 2002 to 2013. Overall, the aggregated BERD increased across all sectors – except the high-tech manufacturing sector – at rates above the inflation rate. A structural change towards more high-tech industries can therefore not be reported for the period 2002-2013. These findings are in line with those by Reinstaller and Unterlass (2012), who examined data from 2004 to 2007.

To examine the structural change between 2002 and 2013, we looked at the share of each industry in the overall Austrian BERD per year and compared these values. The difference is then calculated as:

$$Diff_{\mathrm{Ind}} = \frac{BERD^{\mathrm{Ind}}{}_{13}}{\sum(BERD^{\mathrm{Ind}}{}_{13})} - \frac{BERD^{\mathrm{Ind}}{}_{02}}{\sum(BERD^{\mathrm{Ind}}{}_{02})}$$

where $BERD^{\mathrm{Ind}}{}_{\mathrm{Year}}$ is the aggregated BERD per industry for the respective year. The result is shown in Figure 5.2 (see Table A11 for exact values).

High-tech industries accounted for 28% of the total BERD in 2002, but that share halved to only 13% in 2013 – thus the strong decline of 14%. Low-tech industries also slightly reduced their share by 1%. In contrast high-tech knowledge-intensive services and medium high-tech industries increased their contribution to the Austrian BERD. The higher share of the service sector in the total BERD (14% in 2002, 37% in 2013) follows the development observed in most developed countries. This development is at the expense of the manufacturing industries' share, which declined from 73% in 2002 to 62% in 2013.

Even though firms in manufacturing industries account for a majority of the Austrian BERD, more than half of the companies in these industries have an R&D intensity below 3% (61% of all firms in manufacturing industries in 2002 and 52% in 2013 are in the

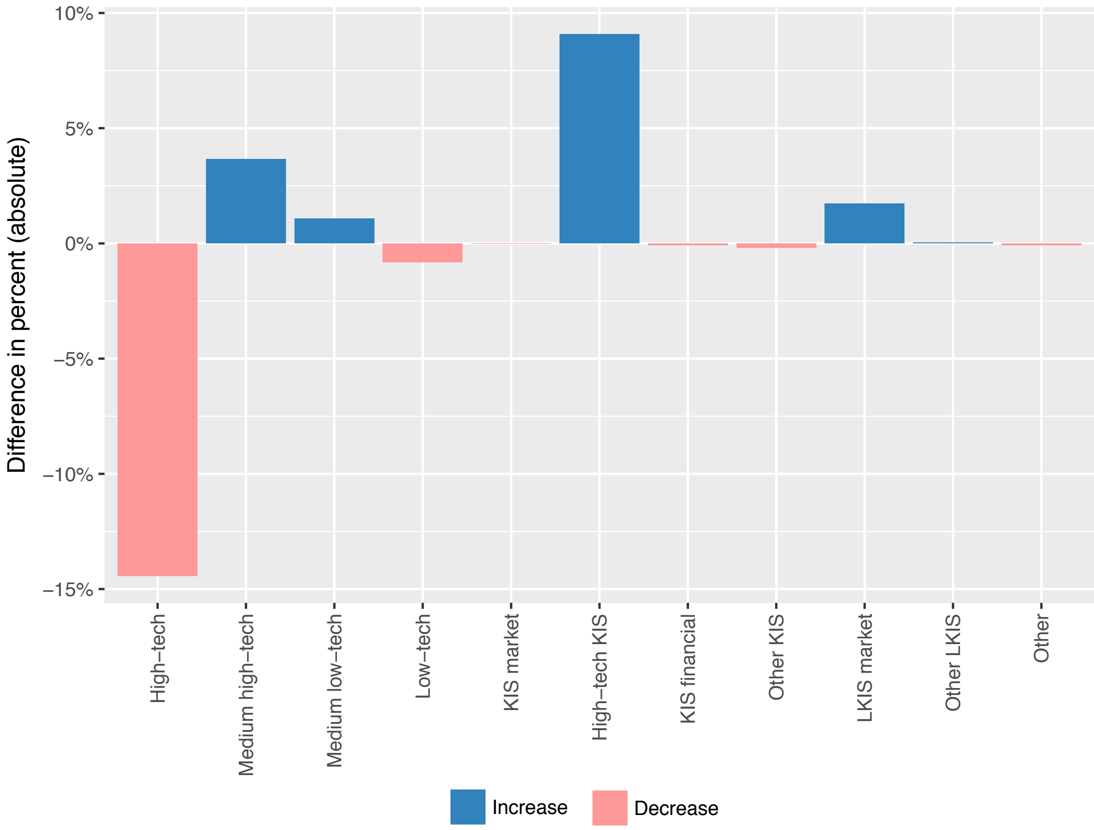

Figure 5.2: Share in the total Austrian BERD per sector in 2013 compared to 2002

Moderate R&D Performer group; all firms with an R&D intensity below 3% are in this group). At the same time, the high-tech and medium high-tech industries make up the largest part of the firms in the R&D Leader group (includes all firms with an R&D expenditure above EUR 1.2 million in 2002 or EUR 1.5 million in 2013 and an R&D intensity between 3 and 50%). 27% (16% in 2002) of all firms in the medium high-tech and 23% (26% in 2002) of all firms in the high-tech sector are in this group in 2013. In contrast the percentage of firms from the service sector in the R&D Leader group is quite low: 5% in 2002 and even only 4% in 2013. Besides the R&D Leader group, the Research Center group also has a large share in the Austrian BERD. High-tech knowledge intensive services account for the largest part (68% in 2002, 69% in 2013) of all industries in this group. The minority of firms in that group belongs to manufacturing industries (9% in both 2002 and 2013).

The results from the shift-share analysis support our previous findings that the medium high-tech industries and high-tech knowledge-intensive services are mainly responsible for the increase in the overall R&D intensity. These two industries strongly increased their R&D intensity, but their contribution to the overall economic value did increase at a lower level. Yet, they account for over 50% of the Austrian BERD in 2013 and that regardless of the fact, that just slightly above 40% of all R&D performing firms are in these two industries. Altogether the shift-share analysis shows that the increase of the R&D intensity of the Austrian business enterprise sector is the result of an intensification of R&D across all industries and not because the R&D intensive sectors in the Austrian economy have grown particularly strongly.

All in all, it can be said that well-established, leading R&D performers (in terms of Schumpeter Mark II) played a more important role in the growth of the R&D expenses from 2002 to 2013 compared to small companies (in terms of Schumpeter Mark I). The number of companies of small or micro size and in the Startup group increased sharply, but at the same time the much larger share in the increase comes from large and very large firms as well as companies in the R&D Leader and Research Center group. We found very few firms that developed from small R&D strong companies to R&D Leaders. Concerning the phenomenon of persistence of innovation, companies that performed R&D in both 2002 and 2013 account for the majority of the Austrian BERD and they are strongly represented amongst the R&D leading groups.

5.2 Future Work

This thesis followed a quantitative approach and examined changes in the contribution of different groups of firms to the total R&D expenditure. These findings have raised several questions in need of further investigation.

On the one hand, there are questions that need to be answered by qualitative research (e.g. through interviews): What are the motives of Austrian firms in expanding their R&D activities? Did multinational enterprises chose Austria for new R&D departments, and if so why? And to what extent did the "Forschungsprämie" influence these decisions?

On the other hand, further analysis of the used dataset can also be of interest: This analysis was only based on at most two data points per firm; one for the year 2002 and one for the year 2013. An analysis of data in the years between would better reflect the development of persistent innovators. With regard to the other results, however, new findings are rather not expected by examining data from the years in between.

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Acronyms

ACR Austrian Cooperative Research. 41

AIT Austrian Institute of Technology. 41

BERD Business Expenditure on R&D. 17, 19, 29, 31, 32, 35, 36, 47, 53, 55–59, 62, 70, 72, 75–78, 82–85, 90, 98, 99, 101–103, 105–108, 132, 133, 135

CIS Community Innovation Survey. 26, 27, 40

COMET Competence Centers for Excellent Technologies. 41

EIS European Innovation Scoreboard. 33–35

EU European Union. 20, 33, 42

FFG Austrian Industrial Research Promotion Fund. 23

FTEs Full-Time Equivalents. 41

GCI Global Competitiveness Index. 34, 35

GDP Gross domestic product. 19, 20, 27, 29, 32, 34, 45, 64

GERD Gross domestic expenditure on R&D. 19, 20

GII Global Innovation Index. 34, 35

II Innovation Indicator. 34, 35

IPRs Intellectual Property Rights. 13, 15

KIS Knowledge Intensive Services. 58

LKIS Less Knowledge Intensive Services. 58

NPIs Non-Profit Institutions. 17, 19

R&D Research and experimental Development. 1–5, 9–33, 35–37, 39–45, 50–103, 105–109, 132

SMEs Small and Medium-sized Enterprises. 23, 24, 26

US United States. 27, 29–31, 34

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Appendix

The Appendix includes:

1. Questionnaire from the F&E Erhebung 2002
2. Questionnaire from the F&E Erhebung 2013
3. Detailed Data

Questionnaire from the F&E Erhebung 2002

STATISTIK AUSTRIA
Die Informationsmanager

Bundesanstalt Statistik Österreich
DIREKTION VOLKSWIRTSCHAFT
Wissenschafts- und Technologiestatistik
Hintere Zollamtsstraße 2b, 1035 Wien, Postfach 6000
Tel.: (01) 711 28-7054, Fax: (01) 711 28-7680
E-Mail: Andreas.Schiefer@statistik.gv.at
URL: http://www.statistik.at
DVR: 0000043

Falls die Firmenbezeichnung oder Anschrift unrichtig ist, wird um Korrektur gebeten.

ERHEBUNG ÜBER FORSCHUNG UND EXPERIMENTELLE ENTWICKLUNG (F&E) 2002

- **Bitte beachten Sie:** Für Ihr Unternehmen besteht **Auskunftspflicht** auf Grund des Bundesstatistikgesetzes 2000, BGBl. I 163/1999, in der Fassung BGBl. I Nr. 71/2003 und der F&E-Statistik-Verordnung der Bundesministerin für Bildung, Wissenschaft und Kultur, des Bundesministers für Verkehr, Innovation und Technologie und des Bundesministers für Wirtschaft und Arbeit, BGBl. II Nr. 396/2003.
- **Bitte füllen Sie die erste Seite auf jeden Fall aus - auch wenn es in Ihrem Unternehmen keine F&E-Aktivitäten gibt!**
- **Die Angaben werden gemäß § 17 Bundesstatistikgesetz 2000 streng vertraulich** behandelt und **ausschließlich für statistische Zwecke** in einer Weise verwendet, dass Rückschlüsse auf Ihr Unternehmen ausgeschlossen sind.
- **Machen Sie Ihre Angaben bitte nur für das Unternehmen**, das auf dem **Adressetikett** angegeben ist. Schließen Sie bitte sämtliche ÖSTERREICHISCHEN Standorte des Unternehmens mit ein!
- Personenbezogene Begriffe beziehen sich auf beide Geschlechter.
- **Berichtszeitraum** ist das Kalenderjahr **2002.** Bei einem vom Kalenderjahr abweichenden Wirtschaftsjahr ist Berichtszeitraum das letzte vor dem 31. 12. 2002 abgeschlossene Wirtschaftsjahr. Liegt ein Rumpfwirtschaftsjahr vor, wird gebeten, für diesen Zeitraum zu berichten und die Dauer dieses Zeitraumes hier anzugeben:

  Rumpfwirtschaftsjahr von ………………………… bis ………………………… .

I) Hat Ihr Unternehmen im Jahr 2002 INTERNE F&E durchgeführt (d.h. selbst und innerhalb des Unternehmens F&E durchgeführt, auch wenn dies gegebenenfalls im Auftrag von Kunden geschehen ist)?

Bitte die Definition von F&E auf Seite 6 des Erhebungsformulars, unten, beachten!

Ja ☐ **Nein** ☐ → ***Sollte Ihr Unternehmen selbst keine interne F&E durchgeführt, aber F&E-Aufträge an Dritte außer Haus vergeben haben, dann beantworten Sie bitte noch die Frage VII !***

Sachbearbeiter/in: ______________________ **Tel.:** ______________

E-Mail: ______________________ **http: //** ______________________

Datum: ______________ **Unterschrift (firmenmäßige Zeichnung):** ______________________

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II) INTERNE F&E-AUSGABEN 2002

Ausgaben für F&E-Aktivitäten innerhalb Ihres Unternehmens, unabhängig davon, wer die Finanzierung dafür bereitstellt; d.h. inklusive von im Auftrag für Dritte durchgeführte F&E. Einzubeziehen sind nur tatsächlich angefallene Ausgaben **ohne USt., ohne** Berücksichtigung von **Abschreibungen** und ohne Gegenrechnung von eventuell erzielten Erlösen aus F&E-Ergebnissen.

Die Definition der internen F&E-Ausgaben entspricht der Definition der Forschungsaufwendungen, die im Rahmen der Geltendmachung des "Forschungsfreibetrages neu" zu Grunde gelegt wird. Ebenso entsprechen die "Gesamtausgaben für innerbetriebliche F&E", die in der Leistungs- und Strukturerhebung (LSE) der Statistik Austria erfragt werden, dieser Definition.

Laufende Ausgaben für F&E **(in 1 000 €)**

Löhne und Gehälter für in F&E Beschäftigte ....

Einschließlich Arbeitgeberbeiträge zur Sozialversicherung, Wohnbauförderungsbeiträge und sonstiger Personalaufwand (insbes. freiwillige Sozialleistungen).
Ausgaben für Personal, das nicht ausschließlich in F&E tätig ist, sind nur ANTEILIG zu berücksichtigen.

Andere laufende Ausgaben für F&E ....

Gesamte laufende Sachausgaben für F&E und anteilige Gemeinkosten für F&E (z.B. Material und Verbrauchsgüter, wie Chemikalien, Bücher, Werkzeuge, Haus- und Raumkosten wie Gas, Wasser, Beheizung, Beleuchtung, Mieten; Verwaltungsausgaben, Versicherungen, Steuern und öffentliche Abgaben, etc.)

Zusammen ....

Investitionsausgaben für F&E

(in 1 000 €)

Ausgaben für Gebäude und Grundstücke

Erwerb von Liegenschaften, Neubauten, Zubauten, wertsteigernde Reparaturen, etc. ....

Ausgaben für Anlagen und Ausstattung

Maschinen, Geräte, Fahrzeuge, Einrichtung, Software; Wertgrenze: Stückwert von mehr als € 400,- ....

Zusammen ....

GESAMTE INTERNE F&E-AUSGABEN 2002 ....

Die Summe der internen F&E-Ausgaben 2002 sollte jenem Wert entsprechen, der im Falle der Geltendmachung des "Forschungsfreibetrags neu" anzugeben ist!

III) AUFTEILUNG DER INTERNEN F&E-AUSGABEN 2002 NACH FORSCHUNGSARTEN

Falls keine entsprechenden Aufzeichnungen existieren, geben Sie bitte möglichst genaue Schätzwerte an!

Grundlagenforschung .... %

Originäre Untersuchungen mit dem Ziel, den Stand des Wissens zu vermehren, ohne Ausrichtung auf ein spezifisches praktisches Ziel.

Angewandte Forschung .... %

Originäre Untersuchungen mit dem Ziel, den Stand des Wissens zu vermehren, jedoch mit Ausrichtung auf ein spezifisches praktisches Ziel.

Experimentelle Entwicklung .... %

Der systematische Einsatz des Wissens mit dem Ziel, neue oder wesentlich verbesserte Materialien, Vorrichtungen, Produkte, Verfahren oder Systeme hervorzubringen.

100 %

IV) INTERNE F&E-AUSGABEN 2002 NACH SOZIO-ÖKONOMISCHEN ZIELSETZUNGEN

Falls in Ihrem Unternehmen F&E-Ausgaben für die nachgenannten Kategorien anfallen, geben Sie bitte jene Anteile an (in %), die auf Ausgaben für diese Zielsetzungen im Rahmen der gesamten F&E-Tätigkeit Ihres Unternehmens entfallen.

F&E für Produkte zum Einsatz in der Landesverteidigung .... %

F&E für Produkte zur Vermeidung, Identifizierung und Beseitigung von Umweltbelastungen ... %

Questionnaire from the F&E Erhebung 2002 (3/6)

V) AUFTEILUNG DER LAUFENDEN INTERNEN F&E-AUSGABEN 2002 NACH PRODUKTGRUPPEN

Einzutragen ist derjenige Prozentsatz der laufenden internen F&E-Ausgaben, der jenen Produktgruppen, Erzeugnisbereichen, Dienstleistungen oder Verfahren zugerechnet werden kann, für welche 2002 F&E durchgeführt wurde.
Maßgeblich für die Zuordnung zu den entsprechenden unten angeführten Kategorien ist demnach das Produkt bzw. die Produktgruppe, die Dienstleistung oder das Herstellungsverfahren, zu dessen Entwicklung 2002 F&E betrieben wurde.

Die Schwerpunkte Ihrer F&E-Tätigkeit müssen nicht mit den Haupterzeugnissen Ihres Unternehmens übereinstimmen.

Land- und Forstwirtschaft

Erzeugnisse der Land- und Forstwirtschaft, Fischerei und Fischzucht	%

Bergbau, Gewinnung von Steinen und Erden

Bergbau, Gewinnung von Steinen und Erden	%

Sachgütererzeugung

Nahrungs-, Genussmittel und Getränke	%
Tabakerzeugnisse	%
Textilien und Textilwaren (ohne Bekleidung)	%
Bekleidung (inkl. Pelzwaren)	%
Ledererzeugnisse, Schuhe	%
Holzerzeugnisse (ohne Möbel)	%
Erzeugnisse aus Papier und Pappe	%
Verlags- und Druckereierzeugnisse, Verfahren zur Vervielfältigung von bespielten Ton-, Bild- und Datenträgern	%
Kokereierzeugnisse, Mineralölerzeugnisse, Spalt- und Brutstoffe	%
Chemikalien und chemische Erzeugnisse (ohne pharmazeutische Erzeugnisse)	%
Pharmazeutische Erzeugnisse	%
Gummi- und Kunststoffwaren	%
Glas, Waren aus Steinen und Erden	%
Roheisen und Stahl, Ferrolegierungen; Rohre, andere Erzeugnisse aus Eisen und Stahl	%
NE-Metalle; Leichtmetallgießerei; Schwermetallgießerei	%
Metallerzeugnisse (ohne Maschinenbau)	%
Maschinenbau	%
Büromaschinen, Datenverarbeitungsgeräte und Datenverarbeitungseinrichtungen	%
Geräte der Elektrizitätserzeugung, -verteilung u.ä.	%
Elektronische Bauelemente	%
Rundfunk-, Fernseh- und Nachrichtentechnik (ohne elektronische Bauelemente)	%
Medizintechnik	%
Mess-, Steuer- und Regelungstechnik, Optik	%
Kraftwagen und Kraftwagenteile	%
Schiffbau	%
Schienenfahrzeugbau	%
Luft- und Raumfahrzeugbau	%
Krafträder, Fahrräder, Behindertenfahrzeuge und sonstiger Fahrzeugbau	%
Möbel	%
Schmuck, Musikinstrumente, Sportgeräte, Spielwaren, sonstige Erzeugnisse	%
Rückgewinnung (Recycling)	%

Energieversorgung und Wasserversorgung

Energieversorgung und Wasserversorgung	%

Bauwesen

Bauwesen	%

Dienstleistungen

Handel; Instandhaltung und Reparatur von Kraftfahrzeugen und Gebrauchsgütern	%
Beherbergungs- und Gaststättenwesen	%
Landverkehr; Transport in Rohrfernleitungen; Schifffahrt; Flugverkehr; Hilfs- und Nebentätigkeiten für den Verkehr, Reisebüros	%
Postdienste und private Kurierdienste	%
Fernmeldedienste	%
Kredit- und Versicherungswesen	%
Softwareentwicklung (Herstellung von Standard- und Individualsoftware)	%
Datenverarbeitung und Datenbanken	%
Andere: Realitätenwesen, Vermietung beweglicher Sachen ohne Bedienungspersonal, Erbringung von unternehmensbezogenen Dienstleistungen	%
Öffentliche, soziale und persönliche Dienstleistungen	%

GESAMT .... **100** %

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VI) FINANZIERUNG DER INTERNEN F&E-AUSGABEN 2002 **(in 1 000 €)**

Gesamte interne F&E-Ausgaben (= Summe Frage II) ....

Finanziert aus

1. **Eigenen Mitteln des Unternehmens** (unter Einschluss **aller** Kredite und Darlehen, z.B. auch von Darlehen des FFF) ....

Sowie Finanzierung, welche keine Kredite oder Darlehen einschließt:

2. **Mittel von anderen inländischen Unternehmen**
   - *Mittel von inländischen verbundenen Unternehmen* ....
   - *Mittel von anderen inländischen Unternehmen* ....
3. **Mittel aus dem öffentlichen Sektor**
   - *Bund* ....
   - *Länder (einschließlich Wien)* ....
   - *Gemeinden (ohne Wien)* ....
   - *Kammern* ....
   - *Sozialversicherungsträger* ....
   - *Forschungsförderungsfonds für die gewerbliche Wirtschaft (FFF)* ....
   - *Sonstige* (bitte finanzierende Stellen hier angeben): ____________
4. **Mittel von privaten Institutionen ohne Erwerbscharakter,** welche nicht primär für Unternehmen tätig sind, sowie von privaten Haushalten (Privatpersonen) ....
5. **Mittel von der Europäischen Union** ....
6. **Mittel von internationalen Organisationen** (z.B. FAO, ESA, OECD), auch wenn ihr Sitz im Inland liegt (IAEA, UNIDO) ....
7. **Sonstige Mittel aus dem Ausland**
   - *Mittel von ausländischen verbundenen Unternehmen* ....
   - *Mittel von anderen ausländischen Unternehmen* ....
   - *Sonstige Finanzierung aus dem Ausland* ....

VII) EXTERNE AUSGABEN FÜR F&E 2002

Ausgaben für F&E-Aufträge, die vom Unternehmen an Dritte außer Haus vergeben wurden.

F&E-Aufträge an inländische Einrichtungen **(in 1 000 €)**

- Inländische verbundene Unternehmen ....
- Andere inländische Unternehmen ....
- Universitäten und Fachhochschulen oder einzelne Angehörige von solchen ....
- Sonstige staatliche Einrichtungen (ausgenommen Universitäten und Fachhochschulen) ....
- Private Institutionen ohne Erwerbscharakter ....
- Kooperative F&E-Einrichtungen ....

F&E-Aufträge an ausländische Einrichtungen **(in 1 000 €)**

- Ausländische verbundene Unternehmen ....
- Andere ausländische Unternehmen ....
- Ausländische staatliche Einrichtungen ....
- Internationale Organisationen ....
- Andere ....

VIII) BESCHÄFTIGTE IN F&E 2002

Die Zuordnung der Beschäftigten zu den Personalkategorien "Wissenschaftler und Ingenieure", "höherqualifiziertes nichtwissenschaftliches Personal" und "sonstiges nichtwissenschaftliches Personal" erfolgt grundsätzlich auf Grund ihrer Funktion, nicht auf Grund ihrer formalen Ausbildung.

Ein **Vollzeitäquivalent** kann einem Personenjahr gleichgesetzt werden, d.h. einem ganzjährig Vollbeschäftigten entspricht 1,0 VZÄ. Dementsprechend sind für eine Person, die rund 30% ihrer Arbeitszeit der F&E und die übrige Arbeitszeit anderen Tätigkeiten widmet, 0,3 VZÄ für F&E anzusetzen. Für einen vollbeschäftigten Forscher, der nur ein halbes Jahr im Unternehmen angestellt war, sind demnach 0,5 VZÄ für F&E zu berechnen.

Die Vollzeitäquivalente für F&E und der angegebene Personalaufwand (Löhne und Gehälter für in F&E Beschäftigte - siehe Frage II) sollten aufeinander abgestimmt sein!

Personalkategorie	**Höchste abgeschlossene Ausbildung**	**Anzahl der Beschäftigten in F&E im Jahr 2002**		**Vollzeit-äquivalente für F&E im Jahr 2002** (gerundet auf 1 Dezimalstelle)	
		männlich	weiblich	männlich	weiblich
Wissenschaftler und Ingenieure Personen (einschl. Führungskräfte der F&E-Verwaltung), die neue Erkenntnisse, Produkte, Verfahren, Methoden und Systeme konzipieren oder schaffen.	Universität: **Doktoratsstudium** (Second degree: **nach** Abschluss eines Diplomstudiums)				
	Universität (oder Fachhochschule): **Diplomstudium** (First degree: z.B. Mag., Dipl.Ing., Dkfm., Dr.med., etc.)				
	Abgeschlossene nichtuniversitäre Postsekundarausbildung oder Universitätsausbildung nicht abgeschlossen				
	Meisterprüfung oder Werkmeisterausbildung				
	Reifeprüfung (Matura), Abschluss einer mittleren Schule, Lehrabschluss				
	Sonstige Ausbildung				
	Wissenschaftler und Ingenieure zusammen				
Höherqualifiziertes nichtwissenschaft-liches Personal Personen (Techniker, Laboranten, Techn. Zeichner u.ä.), die technische Hilfsarbeiten in Verbindung mit F&E - normalerweise unter Leitung und Aufsicht eines Wissenschaftlers oder Ingenieurs - ausführen.	Universitäts- oder Fachhochschulstudium				
	Abgeschlossene nichtuniversitäre Postsekundarausbildung oder Universitätsausbildung nicht abgeschlossen				
	Meisterprüfung oder Werkmeisterausbildung				
	Reifeprüfung (Matura), Abschluss einer mittleren Schule, Lehrabschluss				
	Sonstige Ausbildung				
	Höherqualifiziertes nichtwissenschaftliches Personal zusammen				
Sonstiges nichtwissen-schaftliches Personal	**Hilfspersonal zusammen:** Facharbeiter, ungelernte und angelernte Hilfskräfte, Büropersonal, sonstiges Verwaltungsper-sonal und Schreibkräfte, die **direkt im F&E-Bereich** tätig sind.				

S U M M E				
	Z U S A M M E N		**Z U S A M M E N**	

- 6 -

IX) STANDORT(E), AN DEM/DENEN DIE F&E-TÄTIGKEIT DES UNTERNEHMENS DURCHGEFÜHRT WIRD

Führte das Unternehmen im Jahr 2002 seine F&E-Tätigkeit ausschließlich am Hauptstandort des Unternehmens durch?

(Hauptstandort = Anschrift auf dem Adressetikett auf Seite 1 des Fragebogens)

Ja ☐ → ***Bitte weiter zu Frage X!***

Nein ☐

↓

Nennen Sie bitte das Bundesland oder die Bundesländer, in dem/in denen sich 2002 die Standorte der F&E-Tätigkeit des Unternehmens befanden. Wir ersuchen um eine ***prozentuelle Verteilung des F&E-Personals*** *auf diese Standorte.*

Bundesland	**Anteil der Beschäftigten in F&E im Jahr 2002**
	%
	%
	%
GESAMT	**100 %**

X) ÖSTERREICHISCHER FORSCHUNGSSTÄTTENKATALOG

Ich (Wir) erkläre(n) mich (uns) damit einverstanden, dass der Name und die Anschrift des Unternehmens, der Name des Inhabers bzw. Leiters des Unternehmens und die wirtschaftliche Haupttätigkeit in der Neuauflage des **ÖSTERREICHISCHEN FORSCHUNGSSTÄTTENKATALOGES** veröffentlicht und an Interessenten auch in Form eines Auszuges aus dem Forschungsstättenkatalog übermittelt werden.

Unterschrift (firmenmäßige Zeichnung)

Ja ☐ **Nein** ☐ → ***Ende der Befragung.***

↓

Name des/der Inhaber(s) bzw. Leiter(s) des Unternehmens (falls der Eintrag in den Forschungsstättenkatalog gewünscht wird)**:**

(1) (Zuname) (Vorname) (Akad. Grad, Titel)

(handelsrechtliche Position im Unternehmen)

(2) (Zuname) (Vorname) (Akad. Grad, Titel)

(handelsrechtliche Position im Unternehmen)

Angaben zum Unternehmen

(Telefon) (Fax)

(E-Mail) http: **//** (Homepage)

Definition:

FORSCHUNG UND EXPERIMENTELLE ENTWICKLUNG (F&E): In Übereinstimmung mit dem Frascati-Handbuch 2002 der OECD, welches die international und insbesondere auch in der EU gültigen Standards und Richtlinien für die F&E-Statistik enthält, wird **F&E als schöpferische Tätigkeit** definiert, **welche auf systematische Weise unter Verwendung wissenschaftlicher Methoden mit dem Ziel durchgeführt wird, den Stand des Wissens zu vermehren sowie neue Anwendungen dieses Wissens zu erarbeiten**.

Siehe auch die Definitionen der Forschungsarten unter Frage III auf Seite 2!

VIELEN DANK FÜR IHRE MITARBEIT!

Questionnaire from the F&E Erhebung 2013

Erhebungsbogen A

STATISTIK AUSTRIA
Die Informationsmanager

Bundesanstalt Statistik Österreich
DIREKTION BEVÖLKERUNG
Wissenschaft, Technologie, Bildung
Guglgasse 13, 1110 Wien
Tel.: (01) 711 28-7054, Fax: (01) 711 28-7680
E-Mail: FuE@statistik.gv.at; URL: http://www.statistik.at
DVR: 0000043

ERHEBUNG ÜBER FORSCHUNG UND EXPERIMENTELLE ENTWICKLUNG (F&E) 2013

- Bitte beachten Sie: Für Ihr Unternehmen besteht **Auskunftspflicht** auf Grund des Bundesstatistikgesetzes 2000, BGBl. I Nr. 163/1999, zuletzt geändert durch das Bundesgesetz BGBl. I Nr. 40/2014, und der F&E-Statistik-Verordnung, BGBl. II Nr. 396/2003, zuletzt geändert durch die Verordnung BGBl. II Nr. 150/2008.
- **Bitte füllen Sie die erste Seite auf jeden Fall aus - auch wenn es in Ihrem Unternehmen keine F&E-Aktivitäten gibt!**
- Die Angaben werden streng vertraulich behandelt und ausschließlich für statistische Zwecke in einer Weise verwendet, dass Rückschlüsse auf Ihr Unternehmen ausgeschlossen sind.
- Machen Sie Ihre Angaben bitte nur für das Unternehmen, das auf dem Adressetikett angegeben ist. Schließen Sie bitte die Hauptniederlassung und alle Zweigniederlassungen des Unternehmens in Österreich und dem Ausland mit ein. NICHT EINZUSCHLIESSEN sind jene Niederlassungen im Ausland, die auf Dauer eingerichtet sind und für die ein eigener Rechnungsabschluss oder eine vergleichbare Dokumentation verfügbar ist.
- **Berichtszeitraum ist das Jahr 2013.** Entspricht Ihr Wirtschaftsjahr nicht dem Kalenderjahr, dann berichten Sie bitte für das letzte vor dem 31.12.2013 abgeschlossene Wirtschaftsjahr. War das Unternehmen 2013 kürzer als 12 Monate wirtschaftlich tätig, dann berichten Sie bitte für dieses Rumpfwirtschaftsjahr und geben Sie Beginn und Ende hier an:

Rumpfwirtschaftsjahr (kürzer als 12 Monate) von ☐☐☐ bis ☐☐☐

i **Definition von FORSCHUNG UND EXPERIMENTELLER ENTWICKLUNG (F&E):** F&E wird als schöpferische Tätigkeit definiert, welche auf systematische Weise unter Verwendung wissenschaftlicher Methoden mit dem Ziel durchgeführt wird, den Stand des Wissens zu vermehren sowie neue Anwendungen dieses Wissens zu erarbeiten (lt. Frascati-Handbuch 2002 der OECD).

1 INTERNE F&E: Hat Ihr Unternehmen im Jahr 2013 selbst und innerhalb des Unternehmens Forschung und experimentelle Entwicklung (F&E) durchgeführt? Ja ☐ Nein ☐ →

Sollte Ihr Unternehmen 2013 keine interne F&E durchgeführt, aber F&E-Aufträge an Dritte außer Haus vergeben haben, dann beantworten Sie bitte noch die Frage 6, Seite 3!

i Interne F&E umfasst sowohl F&E, die das Unternehmen für eigene Verwendung durchführt als auch F&E, die das Unternehmen im Auftrag von Kunden und Kundinnen durchführt.

Dieser Fragebogen wird ausgefüllt von:

Name ____________________ Telefon ____________________

Funktion im Unternehmen ____________________

E-Mail ____________________

Website ____________________

____________________ Datum

____________________ Unterschrift einer zeichnungsberechtigten Person

Erhebungsbogen A

2 AUSGABEN FÜR INTERNE F&E 2013

i Ausgaben für F&E-Aktivitäten innerhalb Ihres Unternehmens, unabhängig davon, wer die Finanzierung dafür bereitstellt; d.h. inklusive von im Auftrag für Dritte durchgeführter F&E. Einzubeziehen sind nur tatsächlich angefallene Ausgaben ohne USt., ohne Berücksichtigung von Abschreibungen und ohne Gegenrechnung von eventuell erzielten Erlösen aus F&E-Ergebnissen.
Die Definition der internen F&E-Ausgaben entspricht der Definition der Forschungs- und Entwicklungsausgaben, die im Rahmen der Geltendmachung der „Forschungsprämie" zu Grunde gelegt wird. Anders als bei der Steuererklärung sind hier aber auch jene Ausgaben, die durch Zuschüsse (Beihilfen) finanziert werden, voll einzubeziehen. Ausgaben für „Auftragsforschung", also für außer Haus von Dritten durchgeführte F&E, sind nicht hier, sondern unter Frage 6 (Seite 3), Ausgaben für externe F&E, anzugeben.

(in 1 000 EUR)

Laufende Ausgaben für F&E

Löhne und Gehälter für in F&E Beschäftigte .... ☐

i Bruttolöhne und -gehälter (einschl. aller vom Arbeitnehmer/von der Arbeitnehmerin zu entrichtenden und vom Arbeitgeber/von der Arbeitgeberin einbehaltenen Steuern, Sozialabgaben und sonstigen Abzüge); gesetzliche Pflichtbeiträge des Arbeitgebers/der Arbeitgeberin für die Arbeitnehmer/Arbeitnehmerinnen (Sozialabgaben, vom Entgelt abhängige Abgaben und Pflichtbeiträge) und sonstiger Personalaufwand (z.B. freiwillige Sozialleistungen).
Löhne und Gehälter für Beschäftigte, die nur einen Teil ihrer Arbeitszeit der F&E gewidmet haben, bitte nur mit dem F&E-Anteil einschließen!

Andere laufende Ausgaben für F&E .... ☐

i Gesamte laufende Sachausgaben für F&E (z.B. Material, Verbrauchsgüter, Energie, Mieten), anteilige Gemeinkosten für F&E (z.B. Verwaltungsausgaben, Versicherungen, Steuern, Abgaben, Instandhaltung und Reparatur, Reinigung etc.) und Investitionen in Wirtschaftsgüter für F&E bis zur Wertgrenze von 400 EUR Stückwert.
Bitte nicht einschließen: Ausgaben für externe F&E (siehe Seite 3, Frage 6) und Abschreibungen.

Investitionsausgaben für F&E

(Investitionen im Jahr 2013, die der F&E dienen, auch anteilig gerechnet. Abschreibungen sind nicht zu berücksichtigen!)

Ausgaben für Gebäude und Grundstücke .... ☐

i Erwerb von Liegenschaften, Neubauten, Zubauten, wertsteigernde Reparaturen etc.

Ausgaben für Anlagen und Ausstattung .... ☐

i Maschinen, Geräte, Fahrzeuge, Einrichtung, Software; Wertgrenze: Stückwert von mehr als 400 EUR

GESAMTE AUSGABEN FÜR INTERNE F&E 2013 .... ☐

3 AUSGABEN FÜR INTERNE F&E 2013 NACH FORSCHUNGSARTEN

(Ordnen Sie bitte Ihre F&E-Ausgaben jener Kategorie oder jenen Kategorien zu, die auf Ihre F&E-Tätigkeiten zutreffen!)

i Originäre Untersuchungen mit dem Ziel, den Stand des Wissens zu vermehren, ohne Ausrichtung auf ein spezifisches praktisches Ziel.	**Grundlagenforschung**	%
i Originäre Untersuchungen mit dem Ziel, den Stand des Wissens zu vermehren, jedoch mit Ausrichtung auf ein spezifisches praktisches Ziel.	**Angewandte Forschung**	%
i Der systematische Einsatz des Wissens mit dem Ziel, neue oder wesentlich verbesserte Materialien, Vorrichtungen, Produkte, Verfahren oder Systeme hervorzubringen.	**Experimentelle Entwicklung**	%
		100 %

4 AUSGABEN FÜR INTERNE F&E 2013 NACH SOZIO-ÖKONOMISCHEN ZIELSETZUNGEN

i Falls in Ihrem Unternehmen F&E-Ausgaben für die angeführten Kategorien anfallen, geben Sie bitte jene Anteile an (in %), die auf Ausgaben für diese Zielsetzungen im Rahmen der gesamten F&E-Tätigkeit Ihres Unternehmens entfallen.

F&E für Produkte zum Einsatz in der Landesverteidigung	%
F&E für Produkte zur Vermeidung, Identifizierung und Beseitigung von Umweltbelastungen	%

Seite 2

Erhebungsbogen A

5 FINANZIERUNG DER AUSGABEN FÜR INTERNE F&E 2013

(in 1 000 EUR)
(a - g)

GESAMTE AUSGABEN FÜR INTERNE F&E 2013 (= SUMME FRAGE 2) ....

finanziert aus:

a. Eigenen Mitteln des Unternehmens
(einschließlich Kredite und Darlehen, auch geförderte Darlehen wie z.B. der FFG[1])) ....

Sowie Finanzierung, welche keine Kredite oder Darlehen einschließt:

b. Mittel von anderen inländischen Unternehmen

Mittel von inländischen verbundenen Unternehmen ....

Mittel von anderen inländischen Unternehmen ....

c. Mittel aus dem öffentlichen Sektor

Bund (ohne Forschungsprämie) ....

Forschungsprämie (§ 108c EStG 1988 i.d.g.F.) ....

Länder (einschließlich Wien) ....

Gemeinden (ohne Wien) ....

Zuschüsse der FFG[1]) ....

Sonstige (bitte finanzierende Stelle(n) hier angeben):

d. Mittel von privaten Institutionen ohne Erwerbscharakter,
welche nicht primär für Unternehmen tätig sind, sowie von Privatpersonen ....

e. Mittel von der Europäischen Union (EU) ....

f. Mittel von internationalen Organisationen
wie z.B. ESA, OECD, FAO, auch jene mit Sitz im Inland wie z.B. IAEA, UNIDO ....

g. Sonstige Mittel aus dem Ausland

Mittel von ausländischen verbundenen Unternehmen ....

Mittel von anderen ausländischen Unternehmen ....

Sonstige Finanzierung aus dem Ausland ....

6 AUSGABEN FÜR EXTERNE F&E 2013

Hat Ihr Unternehmen im Jahr 2013 F&E-Aufträge an Dritte außer Haus vergeben? Ja ☐ Nein ☐

Bei „Nein": Bitte weiter mit Frage 7! Wurde weder interne F&E durchgeführt noch externe F&E beauftragt, ist die Erhebung beendet.

F&E-Aufträge an inländische Einrichtungen	(in 1 000 EUR)	**F&E-Aufträge an ausländische Einrichtungen**	(in 1 000 EUR)
Inländische verbundene Unternehmen..		Ausländische Tochtergesellschaften ...	
Andere inländische Unternehmen		Andere ausländische verbundene Unternehmen	
Universitäten und Fachhochschulen oder einzelne Angehörige von solchen..		Sonstige ausländische Unternehmen..	
Sonstige staatliche Einrichtungen (ohne Universitäten und Fachhochschulen)		Ausländische staatliche Einrichtungen	
Private Institutionen ohne Erwerbscharakter		Internationale Organisationen	
Kooperative F&E-Einrichtungen		Andere	

[1]) Österreichische Forschungsförderungsgesellschaft mbH

Seite 3

Erhebungsbogen A

7 BESCHÄFTIGTE IN F&E 2013

i Das sind sowohl unselbstständig als auch selbstständig Beschäftigte, die im Jahr 2013 direkt mit F&E-Arbeiten befasst waren oder in F&E-Management oder F&E-Verwaltung direkte Dienstleistungen für F&E erbracht haben.

Personalkategorie	Höchste abgeschlossene Ausbildung	Anzahl der Beschäftigten in F&E im Jahr 2013		Vollzeitäquivalente für F&E im Jahr 2013 (gerundet auf 1 Dezimalstelle)	
		Männer	Frauen	Männer	Frauen
Wissenschaftler und Wissenschaftlerinnen, Ingenieure und Ingenieurinnen i Personen, die neue Erkenntnisse, Produkte, Verfahren, Methoden oder Systeme konzipieren oder schaffen und Führungskräfte aus F&E-Management und F&E-Verwaltung.	Universität: **Doktoratsstudium** (Second degree: **nach** Abschluss eines Diplom- oder Masterstudiums)				
	Universität oder Fachhochschule: **Diplom- oder Masterstudium** (First degree: z.B. Mag., Dipl.-Ing., Dkfm., Dr.med.)				
	Universität oder Fachhochschule: **Bachelor-, Bakkalaureatstudium** oder Kurzstudium				
	Abgeschlossene nichtuniversitäre Postsekundarausbildung (Zugangsvoraussetzung: Matura oder gleichwertige Qualifikation), z.B. Kolleg				
	Meisterprüfung oder Werkmeisterausbildung				
	Matura an einer berufsbildenden höheren Schule (HTL, HAK, HBLA etc.)				
	Matura an einer allgemeinbildenden höheren Schule (AHS), Abschluss einer berufsbildenden mittleren Schule (BMS), Lehrabschluss				
	Sonstige Ausbildung				
Wissenschaftler und Wissenschaftlerinnen, Ingenieure und Ingenieurinnen zusammen		(a)	(a)	(a)	(a)
Techniker und Technikerinnen und andere höher qualifizierte Beschäftigte i Personen (Laboranten und Laborantinnen, technische Zeichner und technische Zeichnerinnen u.Ä.), die technische Arbeiten in Verbindung mit F&E ausführen.	Universität: **Doktoratsstudium** (Second degree: **nach** Abschluss eines Diplom- oder Masterstudiums)				
	Universität oder Fachhochschule: **Diplom- oder Masterstudium** (First degree: z.B. Mag., Dipl.-Ing., Dkfm., Dr.med.)				
	Universität oder Fachhochschule: **Bachelor-, Bakkalaureatstudium** oder Kurzstudium				
	Abgeschlossene nichtuniversitäre Postsekundarausbildung (Zugangsvoraussetzung: Matura oder gleichwertige Qualifikation), z.B. Kolleg				
	Meisterprüfung oder Werkmeisterausbildung				
	Matura an einer berufsbildenden höheren Schule (HTL, HAK, HBLA etc.)				
	Matura an einer allgemeinbildenden höheren Schule (AHS), Abschluss einer berufsbildenden mittleren Schule (BMS), Lehrabschluss				
	Sonstige Ausbildung				
Techniker und Technikerinnen und andere höher qualifizierte Beschäftigte zusammen		(b)	(b)	(b)	(b)
Sonstige Beschäftigte zusammen		(c)	(c)	(c)	(c)

i Facharbeiter und Facharbeiterinnen, ungelernte und angelernte Hilfskräfte, Büro- und sonstiges Verwaltungspersonal, die direkt für F&E tätig sind.

	Anzahl der Beschäftigten		Vollzeitäquivalente	
BESCHÄFTIGTE IN F&E 2013 INSGESAMT	(a+b+c)	(a+b+c)	(a+b+c)	(a+b+c)
	Männer + Frauen		Männer + Frauen	

! Die Summe der Vollzeitäquivalente für F&E und die Löhne und Gehälter für in F&E Beschäftigte (Seite 2, Frage 2) bitte aufeinander abstimmen!

Seite 4

Erhebungsbogen A

8 STANDORT(E) DER F&E-TÄTIGKEIT DES UNTERNEHMENS 2013

i Berücksichtigen Sie bitte nur jene Standorte, die zu Ihrem Unternehmen gehören und auf Dauer eingerichtet sind.

Hat das Unternehmen im Jahr 2013 seine F&E-Tätigkeit ausschließlich am Hauptstandort des Unternehmens durchgeführt?

i Hauptstandort = Anschrift auf dem Adressetikett auf Seite 1 des Fragebogens.

Ja ☐ → *Bitte weiter zu Frage 9!*

Nein ☐

Kreuzen Sie bitte das Bundesland an, in dem sich im Jahr 2013 der Standort der F&E-Tätigkeit des Unternehmens befunden hat.
Falls das Unternehmen F&E-Standorte in zwei oder mehr Bundesländern hatte, ist zusätzlich anzugeben, wie sich die Beschäftigten in F&E auf diese Standorte verteilt haben (in %).

☐ Burgenland	%
☐ Kärnten	%
☐ Niederösterreich	%
☐ Oberösterreich	%
☐ Salzburg	%
☐ Steiermark	%
☐ Tirol	%
☐ Vorarlberg	%
☐ Wien	%
	100 %

9 ÖSTERREICHISCHER FORSCHUNGSSTÄTTENKATALOG

i Der österreichische Forschungsstättenkatalog ist ein von der Statistik Austria erstelltes Verzeichnis von F&E durchführenden österreichischen Unternehmen und anderen F&E-Einrichtungen. Der Eintrag ist **kostenfrei.**

Ich erkläre mich damit einverstanden, dass der Name und die Anschrift des Unternehmens, der Name des F&E-Verantwortlichen oder der F&E-Verantwortlichen bzw. des Leiters oder der Leiterin des Unternehmens und die wirtschaftliche Haupttätigkeit in der Neuauflage des österreichischen Forschungsstättenkataloges veröffentlicht und an Interessenten und Interessentinnen auch in Form eines Auszuges aus dem Forschungsstättenkatalog übermittelt werden.

Ja ☐ Unterschrift einer zeichnungsberechtigten Person

Nein ☐ → *Bitte weiter zur Seite 6, Frage 10!*

Ansprechperson für F&E bzw. Leiter oder Leiterin des Unternehmens:

Herr / Frau *) Zuname Vorname

Akad. Grad Titel handelsrechtliche Position im Unternehmen

Angaben zum Unternehmen für den Eintrag im Forschungsstättenkatalog:

+43 (0) / -
Vorwahl Telefonnummer Durchwahl

+43 (0) / -
Vorwahl Faxnummer Durchwahl

E-Mail-Adresse

http://
Website

*) Nichtzutreffendes bitte streichen.

Seite 5

Erhebungsbogen A

10 ZEITAUFWAND FÜR DIE BEANTWORTUNG DIESES FRAGEBOGENS

Um die Belastung der Unternehmen durch statistische Erhebungen mit Auskunftspflicht messen zu können, bitten wir Sie noch um folgende Angaben:

Wie viele Personen waren an der Datensammlung für diese F&E-Erhebung und an der Ausfüllung dieses Fragebogens beteiligt? .... ☐ Person(en)

Wie hoch veranschlagen Sie den gesamten Zeitaufwand für Datensammlung und Ausfüllung? .... ☐ Stunde(n) ☐ Minuten

i Bitte addieren Sie den Zeitaufwand aller an der Beantwortung beteiligten Personen zu einer Gesamtsumme in Stunden und Minuten.

RAUM FÜR KOMMENTARE ZUR F&E-ERHEBUNG:

Danke für Ihre Mitarbeit!

Seite 6

Detailed Data

Firm Size	Employees	Average 2002	Average 2013	% Change
Micro	[1, 5)	134.1	94.5	-29.5
	[5, 10)	172.8	231.7	34.1
Small	[10, 20)	293.8	375.6	27.8
	[20, 50)	441.5	727.9	64.9
Medium	[50, 100)	612.3	1,131.0	84.7
	[100, 250)	849.9	1,785.0	110.0
Large	[250, 500)	2,296.2	3,381.5	47.3
	[500, 1,000)	4,791.1	9,376.5	95.7
Very Large	[1,000, 5,000)	13,565.0	37,368.5	175.5
	[5,000	113,959.0	46,741.5	-59.0
Overall		1,612.2	2,040.5	26.6

Table A1: Average BERD in EUR'000 per firm size for 2002 and 2013

Firm size	Employees	2002	2013
Micro	[1, 10)	1.8%	2.4%
Small	[10, 50)	6.7%	7.8%
Medium	[50, 250)	15.7%	17.9%
Large	[250, 1,000)	30.9%	31.4%
Very large	[1,000	44.8%	40.5%
Total		100.0%	100.0%

Table A2: Share in the total R&D expenditure per firm size category

Industry	Aggregated 2002	Aggregated 2013	% change
High-tech	867,329	900,248	3.8
Medium high-tech	960,681	2,327,971	142.3
Medium low-tech	317,040	758,958	139.4
Low-tech	126,501	218,461	72.7
Knowledge-intensive market services	293,364	634,960	116.4
High-tech knowledge-intensive services	392,492	1,465,406	273.4
Knowledge-intensive financial services	7,774	11,529	48.3
Other knowledge-intensive services	22,986	37,759	64.3
Less knowledge-intensive market services	108,575	352,313	224.5
Other less knowledge-intensive services	1,642	6,030	267.2
Other	32,500	64,785	99.3
Total	3,130,884	6,778,420	116.5

Table A3: Aggregated BERD per industry in 2002 or 2013 in EUR'000

		2002			2013	
Firm size class	Q_1	Median	Q_3	Q_1	Median	Q_3
[1, 5)	11.43%	38.16%	108.70%	13.28%	51.01%	140.64%
[5, 10)	6.40%	17.49%	75.61%	7.00%	24.08%	69.74%
[10, 20)	3.16%	10.72%	36.28%	3.57%	11.76%	52.72%
[20, 50)	1.72%	4.61%	12.72%	1.67%	5.42%	19.87%
[50, 100)	0.84%	2.27%	6.69%	0.88%	2.57%	8.21%
[100, 250)	0.46%	1.31%	3.06%	0.62%	1.77%	4.91%
[250, 500)	0.45%	1.37%	2.82%	0.42%	1.63%	4.91%
[500, 1,000)	0.42%	1.69%	4.54%	0.59%	1.77%	4.74%
[1,000, 5,000)	0.24%	0.94%	4.06%	0.17%	1.75%	7.23%
[5,000	1.06%	3.33%	11.66%	0.01%	0.51%	2.75%

Table A4: R&D intensity of all Austrian firms in 2002 and 2013 per firm size class

Industry	Moderate R&D Performers	Early Stage	R&D Leaders	Startups	Research Centers
High-tech	29	67	37	7	1
Medium-high-tech	229	128	71	6	2
Medium-low-tech	232	51	28	3	1
Low-tech	224	36	8	3	1
High-tech knowledge-intensive services	14	115	13	100	36
Knowledge-intensive market services	26	109	6	54	6
Knowledge-intensive financial services	11	0	0	0	0
Other knowledge-intensive services	0	18	3	9	2
Less knowledge-intensive market services	66	69	15	12	1
Other less knowledge-intensive services	0	0	0	0	1
Other	68	20	1	1	2
Total	899	613	182	195	53

Table A5: Number of firms per group and industry in 2002

Industry	Moderate R&D Performers	Early Stage	R&D Leaders	Startups	Research Centers
High-tech	27	96	45	27	2
Medium-high-tech	236	130	143	23	7
Medium-low-tech	262	77	51	13	1
Low-tech	216	39	16	12	0
High-tech knowledge-intensive services	48	317	35	313	81
Knowledge-intensive market services	106	267	12	149	19
Knowledge-intensive financial services	5	0	0	2	0
Other knowledge-intensive services	2	33	4	11	3
Less knowledge-intensive market services	155	123	18	49	3
Other less knowledge-intensive services	1	2	0	1	0
Other	94	28	3	14	1
Total	1,152	1,112	327	614	117

Table A6: Number of firms per group and industry in 2013

Firm size	Employees	Aggregated 2002	Aggregated 2013	Change
Micro	[1, 5)	6,327	14,974	136.7%
	[5, 10)	7,265	21,227	192.2%
Small	[10, 20)	29,190	98,360	279.0%
	[20, 50)	74,604	175,356	135.0%
Medium	[50, 100)	66,530	145,759	119.1%
	[100, 250)	201,825	545,672	170.4%
Large	[250, 500)	302,951	565,764	86.8%
	[500, 1,000)	321,356	664,744	106.9%
Very Large	[1,000, 5,000)	549,739	1,671,706	204.1%
	[5,000	654,553	303,398	-53.6%
Total		2,214,340	4,206,960	90.0%

Table A7: Aggregated BERD of long-term R&D performers in EUR'000 per firm size (as of 2002) for 2002 and 2013

Firm size	Employees	Increase	Decrease	No change
Micro	[1, 5)	27	18	0
	[5, 10)	28	16	0
Small	[10, 20)	67	28	0
	[20, 50)	104	33	0
Medium	[50, 100)	80	22	0
	[100, 250)	158	58	1
Large	[250, 500)	89	26	0
	[500, 1,000)	53	21	1
Very Large	[1,000, 5,000)	26	9	0
	[5,000	2	2	0
Total		634	233	2

Table A8: Number of long-term R&D performers per firm size (as of 2002) with an increase, a decrease, or no change in R&D expenditure from 2002 to 2013

		2002			2013	
Firm size class	Q_1	Median	Q_3	Q_1	Median	Q_3
[1, 5)	14.17%	54.71%	168.58%	12.51%	35.16%	82.92%
[5, 10)	7.25%	29.66%	69.08%	5.37%	19.64%	44.07%
[10, 20)	5.05%	15.22%	41.20%	4.76%	10.25%	34.41%
[20, 50)	2.22%	5.92%	12.82%	1.91%	4.31%	14.84%
[50, 100)	0.76%	2.69%	7.10%	1.13%	3.06%	7.82%
[100, 250)	0.59%	1.56%	3.43%	0.66%	1.76%	4.39%
[250, 500)	0.76%	1.62%	3.27%	0.72%	1.75%	4.87%
[500, 1,000)	0.51%	1.86%	4.23%	0.60%	2.08%	5.41%
[1,000, 5,000)	0.25%	1.37%	4.00%	0.50%	2.76%	7.05%
[5,000	3.33%	8.56%	16.71%	1.45%	4.42%	6.66%

Table A9: R&D intensity of the long-term R&D performers in 2002 and 2013 per firm size class (as of 2002)

Group	2002		2013	
	Aggregated	% in All	Aggregated	% in All
Moderate R&D Performers	372,638	66.0	522,198	60.7
Early Stage	82,130	47.4	99,499	30.3
R&D Leaders	1,451,788	76.3	2,732,668	72.4
Startups	24,183	37.6	14,786	8.6
Research Centers	283,601	66.6	837,809	51.0
Total	2,214,340	70.7	4,206,960	62.1

Table A10: BERD for the long-term R&D performers per group in EUR'000

Industry	Share 2002	Share 2013	% change
High-tech	27.7	13.3	-14.4
Medium high-tech	30.7	34.3	3.7
Medium low-tech	10.1	11.2	1.1
Low-tech	4.0	3.2	-0.8
Knowledge-intensive market services	9.4	9.4	0.0
High-tech knowledge-intensive services	12.5	21.6	9.1
Knowledge-intensive financial services	0.2	0.2	-0.1
Other knowledge-intensive services	0.7	0.6	-0.2
Less knowledge-intensive market services	3.5	5.2	1.7
Other less knowledge-intensive services	0.1	0.1	0.0
Other	1.0	1.0	-0.1
Total	100.0	100.0	0.0

Table A11: Share per industry in the Austrian BERD

	2002		2013	
Quantile	EUR'000	Share in %	EUR'000	Share in %
[0, 5)	2,180,498	69.64	4,862,884	71.74
[5, 10)	309,836	9.90	675,052	9.96
[10, 15)	172,215	5.50	368,782	5.44
[15, 20)	111,298	3.55	234,945	3.47
[20, 25)	77,627	2.48	161,446	2.38
[25, 30)	60,181	1.92	112,519	1.66
[30, 35)	45,164	1.44	87,289	1.29
[35, 40)	36,502	1.17	65,829	0.97
[40, 45)	29,282	0.94	51,103	0.75
[45, 50)	23,597	0.75	38,690	0.57
[50, 55)	18,827	0.60	31,509	0.46
[55, 60)	16,008	0.51	24,082	0.36
[60, 65)	13,399	0.43	16,649	0.25
[65, 70)	10,500	0.34	16,167	0.24
[70, 75)	8,320	0.26	10,565	0.24
[75, 80)	6,144	0.20	8,867	0.16
[80, 85)	5,559	0.18	5,658	0.13
[85, 90)	3,278	0.10	3,403	0.08
[90, 95)	1,872	0.06	2,162	0.03
[95, 100]	777	0.02	819	0.01

Table A12: R&D concentration in Austria