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Innovation Activities of Firms in Germany – Results of the German CIS 2012 and 2014

Background Report on the Surveys of the Mannheim Innovation Panel Conducted in the Years 2013 to 2016

Vanessa Behrens (ZEW) · Marius Berger (ZEW)
Martin Hud (ZEW) · Paul Hünermund (ZEW)
Younes Iferd (ISI) · Bettina Peters (ZEW
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Table of Content

1 Introduction ... 11

2 The German Innovation Surveys 2013 to 2016 ... 14

2.1 Coverage and Sampling ... 14

2.2 Questionnaire, Field Work and Response ... 20

2.3 Data Processing, Non-response Correction and Weighting ... 27

3 Innovation Performance in a Long-term View ... 31

3.1 Share of Innovative Firms ... 32

3.2 Innovation Expenditures ... 38

3.3 Product Innovations ... 42

3.4 Process Innovations ... 46

4 Types of Innovation Activity and Innovation Projects ... 50

4.1 Types of Innovation Activity ... 50

4.2 Innovation Expenditure by Type of Activity ... 52

4.3 Innovation Projects ... 55

5 Financing of Innovation and Public Funding for Innovation ... 61

5.1 Sources of Financing Innovation and Investment ... 62

5.2 Extent of Financial Constraints for Innovation ... 67

5.3 Effect of Additional Internal Finance on Innovation ... 70

5.4 Use of Additional External Finance ... 75

5.5 Public Funding for Innovation ... 77

6 Innovation Networks ... 82

6.1 Use of Information Sources for Innovation ... 83

6.2 Innovation Cooperation ... 85

6.3 Product and Process Innovation Based on Collaboration ... 89

7 Barriers to Innovation ... 93

7.1 Prevalence of Innovation Barriers ... 94

7.2 Effects of Innovation Barriers ... 99

7.3 Increasing in Importance of Innovation Barriers ... 102

8 Protection of Innovation, Licensing, Standards and Certificates ... 104
8.1 Introduction ... 104
8.2 The Use of Formal IP Protection Methods ... 105
8.3 Importance of IPRs and Informal Protection Mechanisms in Securing Competitiveness of Innovations ... 107
8.4 Licensing, Sale and Purchase of Intellectual Property ... 110
8.5 Engagement in Standardisation, Certification and the Use of Certificates ... 111

9 Marketing and Organisational Innovation ... 114
9.1 Introduction ... 114
9.2 Prevalence of Marketing Innovation ... 115
9.3 Prevalence of Organisational Innovation ... 116
9.4 Link between Marketing, Organisational, Product and Process Innovations ... 118

10 Public Procurement and Innovation ... 121
10.1 Introduction ... 121
10.2 Award of Public Procurement Contracts ... 121
10.3 Relationship between Procurement Contracts and Innovation ... 123

11 Environmental and Energy-related Innovations ... 124
11.1 Introduction ... 124
11.2 Firms with Environmental Innovations ... 125
11.3 Share of Product-related Environmental Innovations ... 127
11.4 Drivers of Environmental Innovations ... 129
11.5 Product Innovations with Higher Energy Efficiency ... 130
11.6 Process Innovations Related to Energy Efficiency, Renewable Energies and Energy Supply Security ... 132

12 Digitalisation ... 135
12.1 Introduction ... 135
12.2 Diffusion of Digital Technologies ... 136
12.3 Expected Change in the Usage of Digital Technologies ... 139
12.4 Difficulties in Using Digital Technologies ... 141

13 Firm Strategies and Organisational Characteristics ... 145
13.1 Goals and Strategies ... 145
13.2 Ownership Structure: Family-owned Businesses ... 149
13.3 Company Events ... 150

14 Competitive Environment ... 153
14.1 Market Share and Number of Competitors ... 153
14.2 Main Geographical Markets ... 155
14.3 Competitive Environment of the Main Market ... 157

15 Innovation and Investment ... 161
15.1 Innovation and the Concept of Intangibles ... 161
15.2 Measuring Intangible Investment and the Innovation Share in Total Investment ... 162
15.3 Tangible and Intangible Investment by Industry ... 166
15.4 Total Investment 2006 to 2014 ... 172

16 References ... 176

17 Appendix: Questionnaires ... 184
17.1 2013 ... 184
17.2 2014 ... 193
17.3 2015 ... 198
17.4 2016 ... 208

List of Figures

Figure 3-1. Share of innovation-active firms in Germany 1992-2015 by R&D activity ... 33
Figure 3-2. Share of innovation-active firms in Germany 1997-2015 by main sector ... 33
Figure 3-3. Share of firms with continuous R&D activities 1993-2015 in Germany by main sector ... 34
Figure 3-4. Share of innovating firms 1992-2015 in Germany by main sector ... 35
Figure 3-5. Share of firms with product innovation and with process innovations 2000-2015 in Germany ... 36
Figure 3-6. Share of innovating firms 2006-2015 in Germany by size class ... 37
Figure 3-7. Share of firms with abandoned and with ongoing innovation activities 2001-2015 in Germany ... 38
Figure 3-8. Share of firms with only abandoned or ongoing innovation activities 2006-2015 in Germany ... 38
Figure 3-9. Innovation expenditure of firms in Germany 1992-2015 by main sector ... 39
Figure 3-10. Planned and realised innovation expenditure of firms in Germany 2006-2017 ... 40
Figure 3-11. Innovation expenditure of firms in Germany 1995-2017, by size class ... 41
Figure 3-12. Share of capital expenditure in total innovation expenditure 1995-2015, by main sector ... 41
Figure 3-13. Share of product innovations in total sales of firms in Germany 2000-2015, by main sector ... 43
Figure 3-14. Share of novel product innovations in total sales of firms in Germany 2000-2015, by main sector ... 44
Figure 3-15. Share of product innovators in Germany 2006-2015 by novelty of product innovation ... 44
Figure 3-16. Share of firms with market novelties by geographical market, and sales share of new-to-the-world product innovations in Germany 2012 and 2014 ... 45
Figure 3-17. Share of process innovators in Germany 2006-2015 by type of process innovation result ... 46
Figure 3-18. Indicators of process innovation success in firms in Germany 2000-2015 ... 47
Figure 3-19. Indicators of process innovation success in firms in Germany 2000/02 and 2015, by main sector ... 48

Figure 3-20. Share of firms with new-to-market process innovation in Germany 2008 and 2012, and by main sector (2014) ... 49
Figure 4-1. Types of activity of innovation-active firms in Germany 2012 ... 50
Figure 4-2. Number of different types of innovation activity conducted in innovation-active firms in Germany 2012 ... 52
Figure 4-3. Composition of innovation expenditure of firms in Germany 2012 by type of activity ... 53
Figure 4-4. Innovation expenditure of firms in Germany 2012 as a share of sale, by type of activity ... 53
Figure 4-5. Innovation expenditure of firms in Germany 2006-2015 by main expenditure category ... 54
Figure 4-6. Innovation expenditure of firms in Germany 2006-2015 by main expenditure category and main sector ... 54
Figure 4-7. Expenditure per innovation project 2010-2014, by main sector and size class ... 58
Figure 4-8. Estimated average length of innovation projects 2010-2014, by main sector and size class ... 59
Figure 4-9. Share of stopped innovation projects 2010-2014, by main sector and size class ... 60
Figure 5-1. Sources of funding for innovation and investment projects 2011-2013 ... 63
Figure 5-2. Sources of funding for innovation projects 2011-2013, by main sector ... 66
Figure 5-3. Not implemented innovation projects due to lack of finance 2011-2013, by main sector and size class ... 68
Figure 5-4. Characteristics of innovation projects not implemented due to lack of finance 2011-2013 ... 69
Figure 5-5. Characteristics of innovation projects not implemented due to lack of finance 2011-2013, by main sector ... 70
Figure 5-6. Use of additional cash (10% of last year's revenue), 2014 ... 71
Figure 5-7. Use of additional cash (10% of last year's revenue) 2014, by size class ... 72
Figure 5-8. Use of additional internal finance (10% of last year's revenue) 2014, by main sector ... 73
Figure 5-9. Implementation of additional innovation activities in case of additional cash among non-innovative firms 2014, by main sector and size class ... 74
Figure 5-10. Use of additional low-interest loans instead of additional cash for financing additional investment and innovation 2014, by main sector and size class ... 75

Figure 5-11. Proportion of firms with loan-financed innovation activities among all firms with cash-financed additional innovation activities, by main sector and size class ... 76
Figure 5-12. Public financial support to innovative firms by public funding body, 2010-2014 ... 78
Figure 5-13. EU, federal and state financial support to innovative firms, 2004-2014 ... 78
Figure 5-14. Public financial support to innovative firms 2010-2014 by public funding body and main sector ... 79
Figure 5-15. Public financial support to innovative firms 2010-2014 by public funding body and size class ... 80
Figure 6-1. Importance of information sources for innovation activities, 2010-2012 ... 84
Figure 6-2. Highly important information sources for innovation activities, 2010-2012, by main sector group and size class ... 85
Figure 6-3. Involvement in innovation cooperation, 2010-2014, by main sector group and size class ... 86
Figure 6-4. Type of cooperation partner, 2010-2014 ... 87
Figure 6-5. Most important type of cooperation partner, 2010-2014 ... 88
Figure 6-6. Development of product and process innovation, 2010-2014 ... 89
Figure 6-7. Development of product and process innovation by the enterprises alone, 2010-2014, by sector group and size class ... 91
Figure 6-8. Development of product and process innovation by the enterprises with external collaboration, 2010-2014, by sector group and size class ... 92
Figure 7-1. Barriers to innovation, 2004-2014, by firm group ... 95
Figure 7-2. Barriers to innovation, by sector group, 2004-2014 ... 96
Figure 7-3. Barriers to innovation, by size class, 2004-2014 ... 97
Figure 7-4. Frequencies of different types of innovation barriers in innovating firms, 2004-2014 ... 98
Figure 7-5. Innovation barriers in non-innovating firms, 2004-2014 ... 99
Figure 7-6. Effects of innovation barriers in innovating firms, 2004-2014 ... 100
Figure 7-7. Effects of different types of innovation barriers, 2012-2014 ... 101
Figure 7-8. Increasing importance of different innovation barriers, 2012-2014 ... 102
Figure 8-1. Use of IPRs by firms in Germany, 2012-2014 ... 105
Figure 8-2. Use of IPRs by firms in Germany, by main sector, size class and region ... 106
Figure 8-3. Importance of protection mechanisms in securing or increasing competitiveness of innovations introduced by German firms in 2010-2012 ... 108

Figure 8-4. Percentage of innovating firms that rated different protection mechanisms as highly effective in securing or increasing competitiveness of their innovations introduced in 2010-2012, by main sector 108
Figure 8-5. Share of firms that rated different protection mechanisms as highly effective in securing or increasing competitiveness of innovations introduced in 2010-2012, by size class 109
Figure 8-6. Licensing, sale and purchase of IP 2012-2014. 110
Figure 8-7. Licensing, sale and purchase of IP 2012-2014, by main sector, size class and region 111
Figure 8-8. Engagement in standardisation and certification 2012-2014 112
Figure 8-9. Engagement in standardisation and certification 2012-2014, by main sector, size class and region 113
Figure 9-1. Type of marketing innovation in firms in Germany, 2010-2014 115
Figure 9-2. Firms with marketing innovations in firms in Germany, 2010-2014, by main sector, size class and region 116
Figure 9-3. Type of organisational innovation in firms Germany, 2010-2014 117
Figure 9-4. Organisational innovation in firms Germany, 2010-2014, by main sector, size class and region 117
Figure 9-5. Combination of marketing and organisational innovations in Germany, 2010-2014, by main sector, size class and region 118
Figure 9-6. Combination of marketing/organisational innovation and product/process innovations in firms in Germany, 2010-2014, by main sector, size class and region 119
Figure 9-7. Firms with all four types of innovation, by main sector, size class and region 120
Figure 10-1. Share of firms in Germany with public procurement contracts from public institutions, 2010 to 2012 122
Figure 10-2. Firms in Germany with public procurement contracts 2010 to 201by2 awarding institution and by main sector, size class and region 122
Figure 10-3. Innovative firms in Germany that conducted innovation activities in the contest of public procurement contracts (2010 to 2012), by main sector and region 123
Figure 11-1. Environmental innovations in firms in Germany 2012- 2014 125
Figure 11-2. Environmental innovations in firms in Germany 2012-2014, by main sector, size class and region 126
Figure 11-3. Types of environmental innovations in firms in Germany 2012-2014 by contribution to environmental protection 127

Figure 11-4. Share of sales of product-related environmental innovations in firms in Germany 2014 128
Figure 11-5. Share of sales of product-related environmental innovations in firms in Germany 2014 by main sector, size class and region 129
Figure 11-6. Importance of motives for introduction of environmental innovations in firms in Germany 2012-2014 130
Figure 11-7. Diffusion of product innovations with lower energy consumption by usage of products in firms in Germany 2011-2013 by main sector, size class and region 131
Figure 11-8. Share of sales of product innovations with lower energy consumption by usage of products in Germany 2013 by main sector, size class and region 132
Figure 11-9. Diffusion of process innovations related to energy transition in firms in Germany 2011-2013 by main sector, size class and region 133
Figure 11-10. Diffusion of different types of process innovations related to energy transition in firms in Germany 2011-2013 by main sector, size class and region 134
Figure 12-1. Diffusion of digital technologies in firms in Germany 2016 by field of application 136
Figure 12-2. High degree of adoption of digital technologies in firms in Germany 2016, by area of application, and by main sector, size class and region 137
Figure 12-3. Diffusion of digital technologies in firms in Germany 2016 by industry 138
Figure 12-4. Diffusion of digital technologies in German firms in 2016 according to individual technologies 139
Figure 12-5. Expected change in usage of digital technologies in German firms in the next three to five years 140
Figure 12-6. Expected change in usage of digital technologies in German firms in the next three to five years, by main sector, size class and region 140
Figure 12-7. Difficulties in using digital technologies in German firms in 2016 141
Figure 12-8. Selected difficulties in using digital technologies with major importance to German firms in 2016, according to industry size class, and region 142
Figure 12-9. Major importance of the difficulties “shortage of IT skilled personnel” and “low IT skills of existing personnel” in German firms in 2016, according to industry 143
Figure 12-10. Major importance of the difficulties “general technical infrastructure” and “data security” in German firms in 2016, according to industry 144
Figure 13-1 Firm goals of firms in Germany (2012) 146
Figure 13-2. Goal “increasing turnover” by sector, size class, and region (2012) 146

Figure 13-3. Goal "reducing internal costs" by sector, size class, and region (2012)..... 147
Figure 13-4. Strategies of firms in Germany to meet their firm goals (2012)..... 148
Figure 13-5. Obstacles to achieving the firm's goals (2012) 148
Figure 13-6. Family-owned businesses in Germany 2014, by main sector, size class and region 149
Figure 13-7. Family-owned businesses to be handed over to the next generation (2014), by size class and region..... 150
Figure 13-8. Frequency of mergers & acquisitions, founding of subsidiaries, selling/closure of company parts and outsourcing of firm activities in firms in Germany, 2010-2014..... 151
Figure 13-9. Mergers & acquisitions and foundations by sector, size class and region (2014)..... 151
Figure 13-10. Mergers and acquisitions and foundations by sector, size class and region (2014) 152
Figure 14-1. Market share by sector, size, and region (2014), by main sector, size class and region..... 154
Figure 14-2. Number of main competitors (2012), by main sector, size class and region 155
Figure 14-3. Location of main market, 2012 and 2014, by main sector, size class and region 156
Figure 14-4. Characteristics of the competitive environment 2012 and 2014 158
Figure 14-5. Characteristics of the competitive environment (2014), by main sector, size class and region 159
Figure 14-6. Change in selling prices (2010-2012), by main sector, size class and region 160
Figure 15-1. Composition of total investment 2014, by main sector 167
Figure 15-2. Total investment by category as a percentage of total sales 2014, by main sector..... 168
Figure 15-3. Total investment as a percentage of total sales 2014, by industry..... 170
Figure 15-4. Expenditure for organisational innovation as a share of total (tangible) investment 2012, by main sector 171
Figure 15-5. Total investment 2006 to 2014, by main spending category 172
Figure 15-6. Development of total investment 2006-2014, by main spending category ... 173
Figure 15-7. Share of innovation expenditure and of capital expenditure in total investment 2006-2014 174

List of Tables

Table 2-1. Total population and sample size of MIP surveys 2013 to 2016 by sector, size class and region 18
Table 2-2. Content of MIP questionnaires in the survey years 2013 to 2016 21
Table 2-3. Drawing quote, response rate and sampling rate of MIP surveys 2013 to 2016 by sector, size class and region 24
Table 4-1. Types of activity of innovation-active firms in Germany 2012, by main sector and size class 51
Table 4-2. Number of innovation projects per innovative firm 2010-12 and 2012-14, by size class 57
Table 5-1. Sources of financing of innovation in Germany 2011-2013, by size class 66
Table 5-2. Use of additional cash (10% of last year's revenue) 2014, by size class 73
Table 15-1. Coverage of intangibles in innovation expenditure 162
Table 15-2. Categories of tangible and intangible investment and data sources 165
Table 15-3. Tangible and intangible investment 2014, by main sector 166
Table 15-4. Share of innovation-related expenditure in total tangible and intangible investment 2014, by main sector 169
Table 15-5. Change in total investment by spending category 2006 to 2014, by main sector 174

1 Introduction

Innovation is regarded as a key driver of productivity and market growth and thus has a great potential for increasing wealth. Surveying innovation activities of firms is an important contribution to a better understanding of the process of innovation and how policy may intervene to maximise the social returns of private investment into innovation. Over the past three decades, research has developed a detailed methodology to collect and analyse innovation activities at the firm level. The Oslo Manual, published by OECD and Eurostat (2005) is one important outcome of these efforts. In 1993 both organisations have started a joint initiative, known as the Community Innovation Survey (CIS), to collect firm level data on innovation across countries in concord (with each other). The German contribution to this activity is the so-called Mannheim Innovation Panel (MIP), an annual survey implemented with the first CIS wave in 1993. The MIP fully applies the methodological recommendations laid down in the Oslo Manual. It is designed as a panel survey, i.e. the same gross sample of firms is surveyed each year, with a biannual refreshment of the sample. The MIP is commissioned by the German Federal Ministry of Education and Research (BMBF) and conducted by the Centre for European Economic Research (ZEW) in cooperation with the Fraunhofer Institute for Systems and Innovation Research (ISI) and the Institute for Applied Social Science (infas).

This publication reports main results of the MIP surveys conducted in the years 2013, 2014, 2015 and 2016. The surveys of the years 2013 and 2015 were the German contribution to the CIS for the reference years 2012 and 2014.

The purpose of this report is to present descriptive results on various innovation indicators for the German enterprise sector. The report focuses on the following topics:

1. Innovation performance of the German enterprise sector across the period since the first CIS (1992 to 2015), covering indicators on innovation inputs (expenditure for product and process innovation), innovation results (introduction of product and process innovation) and innovation outputs (direct economic returns from innovations in terms of sales generated by new products and cost savings due to process innovation).
2. Innovation activities and the number and size of innovation projects.
3. Financing of innovation, the relevance of limited internal financial resources for restricting firms' innovation activities, and the role of public funding of innovation.
4. Innovation networks, revealed by co-operations, by the sources of information used for innovation projects, and by joint development of product and process innovations.
5. Barriers to innovation that hamper firms' efforts to develop and introduce new products and processes.
6. Protection mechanisms used to safeguard the returns from investment in innovations and the use of licensing, standards and certifications.

7. Marketing and organisational innovation as types of innovation that go beyond the traditional concept of technological innovation.
8. Public procurement and its role for innovation activities.
9. Environmental and energy-related innovations as special types of innovations.
10. Digitalisation and factors hampering the use and diffusion of digital technologies.
11. Firm objectives and strategies, obstacles for achieving firm objectives, organisational characteristics of firms.
12. Competitive environment of firms in terms of the degree and type of competition.
13. Tangible and intangible investment and the role of innovation in a firm's total activities to build up a stock of tangible and intangible capital.

Note that the first six thematic areas refer to product and process innovation only, whereas topics seven to nine apply a wider concept of innovation. Topics ten to thirteen cover issues related to innovation.

Each thematic focus is presented in a separate chapter. Tabulated results for each theme can be found in the Annex to this report. Before presenting these results, methodological issues of the 2013 to 2016 surveys of the MIP are set forth in the first chapter. This includes information on sampling, survey techniques, data processing, non-response treatment and weighting.

All values presented in tables and figures in this report – except when stated otherwise – are weighted results based on MIP survey data. The results are thus representative for the entire population of German enterprises. Results are broken down by sector, size class, and region (Eastern and Western Germany). With respect to industry, most results are broken down by four main sectors which are defined as follows:

- *R&D-intensive manufacturing* includes manufacture of chemical and pharmaceutical products, electronics and electrical equipment as well as machinery and transport equipment (divisions 20 to 21, 26 to 30 of NACE rev. 2).
- *Other manufacturing* comprises all manufacturing sectors apart from the R&D-intensive manufacturing sectors as well as mining, energy and water supply and waste management (divisions 5 to 19, 22 to 25, 31 to 39).
- *Knowledge-intensive services* include publishing, audiovisual and broadcasting activities, telecommunications, IT and other information services, banking and insurance, engineering offices, technical laboratories, consultancy and advertising and scientific R&D (divisions 58 to 66, 69 to 73).
- *Other services* entail wholesale trade, transportation incl. travel agencies, postal services, graphic design and photography, cleaning, security, provision of staff, office services and other support services (divisions 46, 49 to 53, 74, 78 to 82).

More detailed results by 21 sector groupings and by 8 size classes are available online from www.zew.de/innovation.

2 The German Innovation Surveys 2013 to 2016

This chapter describes the main characteristics of the methodology of the MIP surveys conducted in the four years 2013, 2014, 2015 and 2016. The chapter discusses the sector coverage, sampling methods, response rates, questionnaire (especially with respect to extensions to the harmonised CIS questionnaires), field work, data processing including item non-response treatment, and methods used for unit non-response correction and weighting of data.

2.1 Coverage and Sampling

The German innovation survey is designed as a panel survey (called Mannheim Innovation Panel, MIP) and is conducted annually. In line with the Oslo Manual (OECD and Eurostat, 2005), the survey is based on a stratified random sample of firms that covers enterprises with five or more employees from a wide area of economic activities. Based on an initial sample drawn in 1993, the same sample of firms is surveyed every year. In a biennial rhythm, the sample is refreshed to compensate for panel mortality and to account for the foundation of new firms. Panel mortality includes firms that ceased business as well as small and medium-sized firms (up to 499 employees) that did not respond in four consecutive survey waves. Large firms remain in the sample irrespective of their response behaviour. The same holds true for any firm that leaves the target population by either changing its main economic activity to one outside the core sectors or by shrinking below the five-employee threshold. Peters and Rammer (2013) provide details on panel mortality and firm participation over time.

Though the MIP is an annual panel survey, the survey is conducted differently in CIS years and non-CIS years. In CIS years, an extensive questionnaire (based on the harmonised CIS questionnaire) and the full panel sample are used. In non-CIS years, a shorter questionnaire focusing on key innovation variables and a reduced sample (focusing on firms participating more regularly in the survey) is used. This survey design implies that annual panel data is available only for a restricted set of variables.

The sector coverage of the MIP has changed over time. The first survey wave (conducted in 1993) included mining, manufacturing, energy and water supply, and construction as well as a few service sectors (wholesale trade, real estate, computer activities, management consulting, engineering, sewage and refuse disposal). In 1995, the panel was expanded to cover retail trade, sale and repair of motor vehicles, renting activities, and business-related services. From 2001 onwards, film and broadcasting were surveyed as well. In 2005, construction, retail trade, sale and repair of motor vehicles, real estate and renting activities were excluded from the target population as there was little demand for analyses of these sectors while the large number of enterprises in the population required a substantial share of the survey's resources. However, firms from these discarded sectors that had responded to the survey before 2005 still remained in the panel sample after 2005 and were contacted in later survey waves. For the sector composition of the MIP over time see Peters and Rammer (2013).

The MIP sample is stratified by sector, size class, and region. The number of cells varies by year owing to changes in the sector coverage and sector classification schemes. Until 2008, sector sampling was basically based on divisions (2-digit codes) of NACE rev. 1. From 2009 onwards, divisions of NACE rev. 2 are used for sector stratification. The change to the new classification had little impact on sampling in 2009 as a major refreshment of the MIP sample that took place in 2005 already responded to upcoming changes in the sector classification. For some groups (3-digit codes) of NACE rev. 1, which have become separate divisions in NACE rev. 2, separate strata had been introduced.[1] This procedure allowed re-stratifying of the 2007 and 2008 surveys and calculating weighted results using the NACE rev. 2 classification used for stratification from 2009 onwards which consists of 896 strata: 55 divisions and 1 group of NACE rev. 2 (all divisions of sections B, C, D, E, H, J, K plus divisions 46, 69, 71, 72[2], 73, 74, 78, 79, 80, 81, 82 and group 70.2), 8 size classes (5 to 9, 10 to 19, 20 to 49, 50 to 99, 100 to 249, 250 to 499, 500 to 999, 1,000 and more employees) and 2 regions (Western and Eastern Germany, the latter including Berlin).

The MIP sample is disproportionally drawn, i.e. the drawing probability varies by cell. Higher drawing probabilities are applied to cells from larger size classes, cells from Eastern Germany and cells with a high variation of innovation activities. A minimum of ten enterprises per cell are drawn. Firms with 500 or more employees are all sampled. In the absence of access to official business registers, the MIP sample was drawn from a firm data base called the Mannheim Enterprise Panel (MEP).[3] The MEP is also used as the database for refreshing the sample.

Data on the total number of firms in the target population of the survey are taken from the Business Register of the Federal Statistical Office (FSO). In Germany, business register data first became available in 2008, providing data for the current NACE (rev. 2) classification back to 2006. Before, the firm population was estimated using data of various official statistics for the different sectors covered by the MIP. Since sector statistics rarely reported enterprise data in such detail and definition as needed for establishing total population figures (e.g. many statistics did not cover small firms with less than 20 employees), ZEW had to estimate

1 This applied to NACE (rev. 1.1) 15.9, 22.1, 24.4, 36.1, 64.1, 64.3, all groups of 74, 92.1, 92.2.

2 Note that division 72 (R&D) does not include public research organisations such as Helmholtz Centres, the Max Planck Society, the Fraunhofer Society, Leibniz Institutes or other publicly owned or publicly financed research organisations. For weighting purposes, data on these organisations are excluded from total population figures.

3 This panel is a joint effort of ZEW and Creditreform, Germany's largest credit rating agency (see Bersch et al. 2014). The MEP includes literally all economically active enterprises in Germany, though some enter the database only some years after foundation. A comparison of the MEP with the Business Register of the Federal Statistical Office shows a very high compliance both in terms of the number of enterprises and the size and sector distribution. The MEP is constructed by ZEW through merging twice a year a copy of the current state of Creditreform's enterprise data with previous copies of this data, including data cleaning for multiple entries and identification of firm closures. The MEP contains, amongst others, data on an enterprise's economic activity (NACE 5-digit), location and number of employees.

incomplete data. The transfer to business register data resulted in a break in series for total population figures and correspondingly for weighted innovation data.

The MIP also includes a sample of enterprises that have received public funding from government agencies for R&D and innovation activities. These enterprises were drawn from a database on recipients of public R&D grants provided by the Federal Ministry of Research and Education (BMBF). The main purpose of including publicly funded firms is to generate a database for evaluation purposes (see for empirical applications Aschhoff, 2008; Czarnitzki and Fier, 2002, 2003). These firms are not considered for weighting purposes, unless a publicly funded enterprise has entered the MIP through random sampling.

The total population of enterprises in the target sectors and size classes of the MIP was 276,600 for the 2011 survey wave. This figure represents the number of economically active enterprises during the year 2010 (yearly average) based on data from the Business Register. For the 2016 survey, total firm population rose to an estimated 283,183 for the reference year 2015. ZEW had to estimate the total firm population for this year since no data from the Business Register had been released by the end of 2016. The core sample of the MIP covers 8.0 per cent of the total enterprise population in Germany (including firms outside the sector coverage and firms with less than 5 employees). From all enterprises with 5 or more employees, 44 per cent are within the sector coverage of the MIP. In 2015, the firms within the coverage of the MIP employed about 15.7 million persons and generated sales of about €5.26 trillion.

The total population figures for firms, employment and sales used in the MIP differ from those reported in the Business Register for several reasons. The number of firms is adjusted for large enterprise groups which do not report for each individual enterprise, but for the entire group. In addition, firms belonging to the public research sector as covered in the FSO statistics on government R&D (*Fachserie* 14, *Reihe* 3.6) and which are part of NACE 72 are excluded from total population figures as these organisations are not part of the target population of the MIP. Employment and sales figures of these organisations are subtracted as well. Employment figures in the Business Register do neither include civil servants (who are still a relevant number in sectors with large enterprises that emerged out of public administration, including railways, telecommunications, postal services and banking, in 2015 there total number was about 95,000) nor self-employed and family workers. The respective figures are added using information from company reports and structural business statistics. Sales figures for banks, insurances and other financial services (NACE 64 to 66) in the Business Register do only include sales subject to VAT, which is only a tiny share of total sales as defined in the MIP and in the CIS (which is gross interests receivable, gross commission income and similar income for banks and financial services, and gross premiums written for insurance services).

The sample size of the MIP for the CIS years was 34,977 in 2013 and 35,325 in 2015. In the non-CIS years 2014 and 2016, a smaller sample of 25,106 and 25,392 firms was used. The smaller samples in the non-CIS years have been drawn in a way to prefer firms that often participated in the survey before. This was done by ordering the full sample in each stratum in descending order according to the last survey participation and then drawing firms from each stratum until the target number of firms per stratum has been reached.

The MIP sample includes three groups of firms. The vast majority of the sample is firms from the target sectors and size classes of the survey. Their number was 29,605 and 30,090 in the CIS years 2013 and 2015, and 21,116 and 22,053 in the non-CIS years 2014 and 2016. A second group consist of firms outside the target sectors and size classes have been included if they responded in earlier years. Their number was 3,476 and 3,770 in the CIS years 2013 and 2015, and 2,839 and 2,290 in the non-CIS years 2014 and 2016. This group comprises firms with less than 5 employees and firms in sectors that have been part of the MIP in earlier years (including construction, real estate activities, and rental and leasing activities – NACE 41-43, 68, 77), but also some firms that changed their sector affiliation to a sector outside the MIP core sectors. A third group include firms that received public funding from a Federal government R&D programme. These firms are part of the sample in order to facilitate analysis of government funding impacts on innovation. Their number was 1,896 and 1,465 in the CIS years 2013 and 2015, and 1,151 and 1,049 in the non-CIS years 2014 and 2016. Firms from the second and third group are not considered for calculating weighted results.

Table 2-1 shows the absolute number of firms for the total population, the gross sample and the net sample broken down by industry, size class, and region. Details on the net sample are provided in the following section.

Table 2-1. Total population and sample size of MIP surveys 2013 to 2016 by sector, size class and region

Number of firms	Total population				Gross sample				Neutral Losses[a)]				Net sample[b)]				Add. large firms[c)]				NR interviews[d)]			
	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
Industry																								
10-12	16,695	16,145	15,874	15,731	1,757	1,246	1,761	1,256	195	122	277	128	327	256	258	235	35	40	33	31	380	307	367	266
13-15	2,426	2,341	2,302	2,345	1,118	763	1,127	841	149	86	202	91	237	200	209	161	6	8	6	5	244	182	236	176
16-17	4,849	4,784	4,711	4,673	1,019	721	1,041	789	105	77	146	69	213	185	177	156	10	16	15	15	252	171	219	169
20-21	2,235	2,317	2,385	2,418	1,125	835	1,109	838	135	113	173	111	253	190	212	150	52	60	54	52	230	222	227	190
22	5,068	4,992	4,925	4,910	897	712	911	701	92	82	115	73	195	173	168	167	11	12	11	12	235	200	245	168
23	3,528	3,521	3,510	3,569	703	522	721	522	82	46	107	68	154	131	139	111	14	8	12	11	163	135	161	135
24-25	22,264	22,042	21,740	21,639	2,056	1,573	2,144	1,667	197	176	273	160	488	392	414	361	44	44	45	38	547	424	557	473
26-27	7,870	7,747	7,626	7,753	2,172	1,644	2,125	1,571	241	184	319	185	442	377	439	343	77	76	74	72	605	475	475	395
28	10,608	10,526	10,440	10,427	1,720	1,277	1,683	1,205	164	125	228	138	331	274	307	238	64	82	70	78	477	347	391	307
29-30	2,104	2,127	2,143	2,242	1,016	728	1,060	807	145	109	207	135	175	142	149	122	73	73	63	61	224	154	184	158
31-33	14,655	14,865	14,675	14,873	2,045	1,564	2,053	1,568	219	173	293	159	410	344	360	296	24	25	25	20	565	447	491	415
5-9, 19, 35	2,422	2,242	2,434	2,544	1,116	830	1,159	913	135	103	202	103	264	207	227	209	55	60	62	63	236	185	225	195
36-39	4,526	4,602	4,636	4,772	1,359	964	1,346	1,038	176	114	199	102	378	297	349	321	10	10	8	10	254	206	266	211
46	39,171	39,222	38,835	38,625	1,349	886	1,365	919	163	106	223	109	250	200	232	218	33	37	25	26	261	191	257	184
49-53, 79	32,156	32,231	33,432	33,829	2,632	1,836	2,775	2,043	421	256	557	278	563	442	499	452	53	54	44	53	576	393	544	403
18, 58-60	8,101	8,093	7,942	7,879	1,698	1,194	1,745	1,281	231	155	343	146	323	248	274	255	21	20	21	21	371	287	361	295
61-63	13,297	13,747	14,317	14,878	2,032	1,344	1,942	1,366	328	190	432	221	354	278	279	229	31	29	26	27	460	328	388	322
64-66	6,833	6,196	6,594	6,689	1,533	1,093	1,610	1,230	196	121	248	135	267	215	252	203	81	89	92	92	319	259	263	217
69, 70.2, 73	17,099	17,546	18,030	18,472	1,920	1,249	1,928	1,344	263	156	379	149	364	301	349	321	10	10	10	11	346	240	301	260
71-72	31,360	31,842	32,009	32,724	1,911	1,337	1,735	1,309	235	173	305	139	464	366	412	368	13	14	10	12	505	341	414	360
74, 78, 80-82	29,333	30,522	30,838	32,191	2,156	1,406	2,263	1,650	381	206	485	225	365	289	338	267	37	33	29	36	427	283	358	303
others	-	-	-	-	1,643	1,382	1,722	534	197	170	242	64	424	393	429	111	16	14	8	13	439	386	430	135

Table 2-1. continued

	Total population				Gross sample				Neutral Losses[a)]				Net sample[b)]				Add. large firms[c)]				NR interviews[d)]			
	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
Size class																								
0-4	-	-	-	-	2,477	1,802	2,536	1,946	425	319	567	344	599	430	561	422					618	483	527	435
5-9	111,150	111,341	111,474	112,088	6,098	3,958	5,378	3,513	969	527	1,143	466	1,196	927	935	821					1,268	971	1,067	757
10-19	72,288	72,387	72,805	73,835	5,799	4,142	5,738	3,949	671	448	914	362	1,293	1,118	1,191	985					1,408	1,069	1,312	952
20-49	51,896	52,348	52,995	53,964	6,327	4,550	6,330	4,594	655	473	918	456	1,472	1,224	1,290	1,059			1		1,541	1,129	1,425	1,169
50-99	19,810	19,971	20,264	20,692	4,509	3,244	4,642	3,293	497	333	683	352	917	768	862	692	2	4	2	2	1,082	817	953	767
100-249	13,747	13,739	13,955	14,411	4,499	3,299	4,626	3,392	567	431	727	434	855	696	764	610	7	5	4	3	1,101	865	1,055	804
250-499	4,474	4,555	4,592	4,788	2,028	1,553	2,362	1,775	257	216	398	219	370	322	380	304	29	28	24	24	517	383	474	386
500-999	1,836	1,900	1,907	1,969	1,618	1,244	1,959	1,490	220	176	368	211	254	210	236	205	99	103	82	83	353	269	324	275
1,000	1,399	1,409	1,406	1,436	1,622	1,314	1,754	1,440	189	120	237	144	285	205	253	196	633	674	630	646	228	177	223	192
Region																								
Western G.	227,451	228,301	229,769	233,142	25,463	17,864	25,017	17,557	3,188	2,155	4,089	2,014	4,963	3,982	4,443	3,610	651	700	481	437	5,753	4,351	5,058	3,886
Eastern G.	49,149	49,349	49,629	50,041	9,514	7,242	10,308	7,835	1,262	888	1,866	974	2,278	1,918	2,029	1,684	119	114	262	322	2,363	1,812	2,302	1,851
Total	**276,600**	**277,650**	**279,398**	**283,183**	**34,977**	**25,106**	**35,325**	**25,392**	**4,450**	**3,043**	**5,955**	**2,988**	**7,241**	**5,900**	**6,472**	**5,294**	**770**	**814**	**743**	**759**	**8,116**	**6,163**	**7,360**	**5,737**
outside core[e)]					3,476	2,839	3,770	2,290	480	426	710	367	905	739	874	484	6	6	3	2	931	766	839	525
funded firms[f)]					1,896	1,151	1,465	1,049	239	129	203	120	470	358	373	304					498	365	405	304
Total for weighting	**276,600**	**277,650**	**279,398**	**283,183**	**29,605**	**21,116**	**30,090**	**22,053**	**3,731**	**2,488**	**5,042**	**2,501**	**5,866**	**4,803**	**5,225**	**4,506**	**764**	**808**	**740**	**757**	**6,687**	**5,032**	**6,116**	**4,908**

a) Firms not existing at the time of survey, double entries and newly drawn firms outside the size and sector coverage of the target population.
b) Firms that returned a completed questionnaire
c) Large firms for which data were collected from other sources, including split up of large multi-sector firms by business segments.
d) Firms that provided information in the non-response survey.
e) Firms that are smaller than 5 employees or in 'other sectors'; excluding funded firms added deliberately to the sample.
f) Firms that received public funding for innovation and that were added deliberately to the sample.

Source: ZEW, Mannheim Innovation Panel.

2.2 Questionnaire, Field Work and Response

While the MIP survey applies all the basic concepts and definitions of the harmonised CIS questionnaire, it includes a number of questions that go beyond the standard questionnaire:

- More detailed questions on direct economic outcomes of innovations, including success indicators for process innovations;
- Questions on planned innovation activities in the year of the survey and the following year, including estimates of planned innovation expenditure;
- Additional questions on innovation-related activities, including the number of innovation projects (both in 2013 and 2015), the share of innovation expenditure for product and for process innovation (in 2015), expenditure for marketing and organisational innovation (in 2013), and the relevance of obstacles to innovation (in 2015);
- Indicators of a firm's market environment, including the type of competition and a firms' market share;
- A considerably extended set of questions on firm characteristics, including financial data on exports, expenditure on material/purchased services, personnel, training and marketing, gross capital expenditure, the stock of fixed assets and the profit margin (pre-tax profits over sales).

In non-CIS years, the survey focuses on product and process innovation related questions, the expenditure for innovation activities related to product and process innovation (including planned activities and expenditure) and R&D activities. In addition, the 2014 survey included a question on financing of innovation which largely repeated a similar question contained in the 2007 MIP survey. The 2014 survey also included two short questions on the introduction of energy-related product and process innovations. The 2016 survey had a question on the use of digitalisation and obstacles that hinder the implementation of new digital technologies.

MIP questionnaires follow a common structure while the exact list of questions alters from year to year. There is a set of questions, however, that are used in exactly the same way every year to allow panel analysis for the corresponding variables. Table 2-2 provides an overview of the questions contained in the four survey waves 2013 to 2016. The questionnaires also include a list of examples for product and process innovation organised by four sector groupings (manufacturing, trade and transport, financial intermediation, business services/computing/media) in order to guide responding firms and facilitate a common understanding of innovation. The Appendix of this report contains English translations of the questionnaires used in the survey years 2013 to 2016.

In line with the harmonised CIS questionnaires, the MIP questionnaires include a set of questions that are only to be answered by firms with innovation activities. This filter applies to any firm that has introduced a product innovation or a process innovation or has ongoing or abandoned/stopped product/process innovation activities in the reference period (which is the reference year of the survey and the two previous years). The choice of a three year observa-

tion period for innovation activities is in line with the recommendations of the Oslo Manual and allows the identification of innovative firms in markets where firms may sustain an innovation-based competitive strategy even if innovating is only infrequent. Such markets are often characterised by long product life cycles or technology cycles. A multiannual reference period also enables observing related innovation activities that are spread over different calendar years, e.g. in case of a long duration of innovation projects. It is also beneficial to accurately capturing outputs and effects of innovations, such as sales with new products or effects on competition, growth or profitability. A drawback of a three-year reference period for a panel survey is, however, that the same innovation activity of a firm may be reported up to three times in consecutive survey waves which complicates the identification of the factors that may influence a firm's decision to innovate, as well as the link between innovation activities and performance.

Table 2-2. Content of MIP questionnaires in the survey years 2013 to 2016

	2013	2014	2015	2016
General business information (sales, exports, employees)	i	i	i	i
Characteristics of the market environment	x		x	
Organisational characteristics of the firm	x		x	
Product and process innovation	i	i	i	i
Ongoing, abandoned and planned innovation* activities	i	i	i	i
Total innovation* expenditure, incl. planned expenditure	i	i	i	i
Innovation* activities and expenditure by type	x			
Number of innovation* projects	i		i	
Research and experimental development activities	x	x	x	x
Public support to R&D and innovation*	i		i	
Financing of investment and innovation*		x		
Co-operation on innovation*	i		i	
Information sources for innovation*			x	
Obstacles to innovation*	x			
Marketing and organisational innovation	i		i	
Objectives and strategies of firms, obstacles for achieving objectives	x			
Energy-related innovations*		x		
Environmental innovations			x	
Protection of innovation and a firm's IP	x		x	
Use of licensing, standards and certification			x	
Digitalisation				x
Financial data (costs of personnel, material & services, training, marketing, software, acquiring fixed assets; net stock of fixed assets, profit margin)	i		i	

i: Question used in identical form in each survey year.
x: Question used in specific form in the respective survey year.
* Innovation refers to product and process innovation only.

The MIP survey can be filled in both on paper and online. All firms were able to choose between the paper and the online version. Access to the online version was provided through a firm identification number and password which were communicated to the firm on a cover letter sent along with the paper version of the questionnaire. The share of online responses was 32 per cent in 2013, 38 per cent in 2014, 36 per cent in 2015 and 39 per cent in 2016. An analysis of online responders shows that these firms are on average larger, more innovative and more often come from research and knowledge intensive industries. The past participation

behaviour in the MIP has no significant impact on the probability to respond online. In particular, offering an online option did not result in a higher response of firms which refused to participate in prior survey waves.

In each survey year, the questionnaire was sent to firms in late February. For most firms, contact data of individuals responsible for responding to the survey are available from earlier waves, facilitating the distribution of questionnaires and increasing comparability of data across different survey waves. Beginning in the end of March, non-responding firms were contacted on telephone and asked to fill in the questionnaire. Those willing to respond received another copy of the questionnaire by postal mail. Firms that refused on telephone to participate in the survey were asked to participate in a non-response (NR) survey (see below for more details). Firms that did not respond until six weeks after having received the second copy of the questionnaire were reminded a second time by telephone. In case firms were still willing to participate, another copy of the questionnaire was sent to them.

During the field work, information has been received on firms that ceased business or were not able to be contacted for other reasons.[4] In 2013, 4,450 neutral losses have been recorded (= 12.6 per cent of the gross sample). This figure rose to 5,955 firms in 2015 (= 16.8 per cent of the gross sample). In the non-CIS survey years, the share of losses was lower (12.1 per cent in 2014, 11.8 per cent in 2016). The share of neutral losses is high in service sectors, particularly transportation, computer services, technical services and consultancy/advertising, and among small firms.

The number of received completed questionnaires was 7,241 in 2013, 5,900 in 2014, 6,472 in 2015 and 5,294 in 2016. The response rate (share in gross sample net of neutral losses) was 23.7, 26.7, 22.0, and 23.6 per cent, respectively. Response rates do not vary substantially among sectors and size classes, except for very small firms below the 5 employee threshold since this size class includes only firms that responded in some of the previous survey waves. Table 2-3 reports these and other key response characteristics of the surveys by industry, size class and region. The higher response rates in non-CIS years reflect the focus of the sample on firms with a higher probability to respond. The majority of responding firms used the paper version of the questionnaire.

The low response rate in the MIP, which is typical for voluntary enterprise surveys in Germany, raises the issue of a potential non-response (NR) bias in terms of innovation activities. In order to identify whether and to what extent such a bias exists, a comprehensive non-response survey was performed. This survey was designed in two parts. As mentioned above, a first round of non-response interviews was conducted during the telephone reminder. Considering the responses by strata of the first round, a stratified random sample of non-responding firms was drawn for the second round of NR interviews. For each stratum, a min-

4 This includes firms that could not be reached by telephone despite at least five trials at different times of the day and different days during the week.

imum number of NR interviews had been defined. In order to attain this number in case of firms refusing to participate in the NR survey, substitutes from the same strata of refusing firms were drawn. The NR survey was conducted by telephone and contained four yes/no questions on product innovation, process innovation, ongoing innovation activities and abandoned/stopped innovation activities as well as a question on in-house R&D activities (with the answering options no, occasional and continuous). In addition, firms were asked to report the total number of employees and shortly describe their main product group. This information was used to check the sector and size class assignment of the firm. The total number of NR interviews was 7,214 in 2013, 5,900 in 2014, 6,472 in 2015 and 5,294 in 2016.

Adding questionnaire responses and NR interviews gives the total number of firms for which information on their innovation activities has been collected. The respective coverage rate was 52.8 per cent in 2013, 58.4 per cent in 2014, 49.6 per cent in 2015 and 52.6 per cent in 2016.

In order to increase representativeness of data particularly with regard to indicators that relate to expenditure, employment or sales figures, a special effort was undertaken to survey as many large firms as possible. Large firms were defined as enterprises employing more than 5,000 persons at German locations, or being one of the three largest enterprises within a sector. In order to determine this group of firms, information from the MEP as well as other publicly available company data was used. Out of this group of firms, about one of five returned a completed questionnaire. For all other firms, key survey data (including information on product and process innovation, innovation expenditure and R&D activity as well as employment and financial data) was collected using financial reports and other company publications as well as data from other available sources, including the MEP. In case of missing data, longitudinal imputation using firm information from previous years was applied (see the next section for more details on imputation methods used in MIP).

Table 2-3. Drawing quote, response rate and sampling rate of MIP surveys 2013 to 2016 by sector, size class and region

Percent	Drawing quota[a)]				Share of losses[b)]				Response rate[c)]				Coverage rate[d)]				NR-interview rate[e)]				Sampling rate[f)]			
	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
Industry																								
10-12	10.0	7.3	10.4	7.4	11.1	9.8	15.7	10.2	20.9	22.8	17.4	20.8	47.5	53.6	44.3	47.2	31.4	36.6	30.6	30.5	2.0	1.7	1.6	1.5
13-15	42.9	30.4	45.6	32.4	13.3	11.3	17.9	10.8	24.5	29.5	22.6	21.5	50.3	57.6	48.8	45.6	33.6	38.8	33.2	30.1	9.0	8.1	8.5	6.4
16-17	20.1	14.3	20.9	15.9	10.3	10.7	14.0	8.7	23.3	28.7	19.8	21.7	52.0	57.8	45.9	47.2	36.4	38.4	31.1	30.6	4.4	4.0	3.8	3.4
20-21	45.9	32.5	42.7	31.8	12.0	13.5	15.6	13.2	25.6	26.3	22.6	20.6	54.0	65.4	52.7	53.9	32.7	44.9	32.9	34.5	11.5	8.8	9.3	6.6
22	16.5	13.2	17.2	13.3	10.3	11.5	12.6	10.4	24.2	27.5	21.1	26.6	54.8	61.1	53.3	55.3	39.2	44.8	39.6	37.3	3.8	3.4	3.3	3.3
23	18.3	13.7	19.1	13.3	11.7	8.8	14.8	13.0	24.8	27.5	22.6	24.4	53.3	57.6	50.8	56.6	35.8	39.7	34.6	40.3	4.1	3.6	3.8	3.1
24-25	8.5	6.6	9.2	7.1	9.6	11.2	12.7	9.6	26.3	28.1	22.1	24.0	58.0	61.6	54.3	57.9	41.0	43.8	39.3	42.5	2.2	1.8	2.0	1.7
26-27	23.5	18.1	24.3	17.5	11.1	11.2	15.0	11.8	22.9	25.8	24.3	24.7	58.2	63.6	54.7	58.4	42.2	46.0	36.2	39.6	5.3	4.8	5.6	4.4
28	14.3	10.9	14.5	10.5	9.5	9.8	13.5	11.5	21.3	23.8	21.1	22.3	56.0	61.0	52.8	58.4	40.4	42.5	35.7	39.7	3.1	2.9	3.1	2.5
29-30	45.9	32.4	46.6	33.8	14.3	15.0	19.5	16.7	20.1	22.9	17.5	18.2	54.2	59.6	46.4	50.7	35.1	36.5	28.1	30.9	10.5	9.0	9.0	6.9
31-33	12.6	9.5	12.6	9.4	10.7	11.1	14.3	10.1	22.5	24.7	20.5	21.0	54.7	58.7	49.8	51.9	40.4	43.4	35.5	37.8	2.5	2.1	2.3	1.9
5-9, 19, 35	42.4	34.9	43.8	33.2	12.1	12.4	17.4	11.3	26.9	28.5	23.7	25.8	56.6	62.2	53.7	57.7	35.2	39.4	33.1	35.1	11.7	10.8	10.5	9.2
36-39	28.2	19.6	27.2	20.3	13.0	11.8	14.8	9.8	32.0	34.9	30.4	34.3	54.3	60.4	54.3	57.9	31.9	37.7	33.5	34.7	7.8	6.1	7.0	6.3
46	3.0	2.0	3.1	2.1	12.1	12.0	16.3	11.9	21.1	25.6	20.3	26.9	45.9	54.9	45.0	52.8	28.5	34.0	28.6	31.6	0.6	0.5	0.6	0.5
49-53, 79	7.6	5.3	7.6	5.4	16.0	13.9	20.1	13.6	25.5	28.0	22.5	25.6	53.9	56.3	49.0	51.4	35.9	36.1	32.4	31.8	1.7	1.4	1.4	1.3
18, 58-60	19.1	13.3	19.7	14.5	13.6	13.0	19.7	11.4	22.0	23.9	19.5	22.5	48.7	53.4	46.8	50.3	32.8	36.9	32.5	34.1	3.7	3.0	3.3	3.1
61-63	12.2	7.8	11.2	7.4	16.1	14.1	22.2	16.2	20.8	24.1	18.5	20.0	49.6	55.0	45.9	50.5	34.6	38.1	31.9	35.5	2.1	1.6	1.7	1.3
64-66	20.3	15.8	21.7	16.2	12.8	11.1	15.4	11.0	20.0	22.1	18.5	18.5	49.9	57.9	44.6	46.8	31.4	36.9	25.3	26.1	4.2	4.0	4.3	3.5
69, 70.2, 73	9.3	5.8	8.9	5.9	13.7	12.5	19.7	11.1	22.0	27.5	22.5	26.9	43.5	50.4	42.6	49.5	26.9	30.6	25.3	30.0	1.7	1.3	1.5	1.3
71-72	4.3	3.1	4.2	3.0	12.3	12.9	17.6	10.6	27.7	31.4	28.8	31.5	58.6	61.9	58.5	63.2	41.9	43.2	40.9	45.3	1.0	0.8	0.9	0.9
74, 78, 80-82	6.6	4.1	6.6	4.6	17.7	14.7	21.4	13.6	20.6	24.1	19.0	18.7	46.7	50.4	40.8	42.5	31.0	32.0	25.3	26.9	1.2	0.9	1.0	0.8
others					12.0	12.3	14.1	12.0	29.3	32.4	29.0	23.6	60.8	65.4	58.6	55.1	43.2	47.5	41.0	37.8				

Table 2-3. continued

	Drawing quota[a)]				Share of losses[b)]				Response rate[c)]				Coverage rate[d)]				NR-interview rate[e)]				Sampling rate[f)]			
	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
Size class																								
0-4					17.2	17.7	22.4	17.7	29.2	29.0	28.5	26.3	59.3	61.6	55.3	53.5	42.5	45.9	37.4	36.9				
5-9	4.9	3.1	4.3	2.9	15.9	13.3	21.3	13.3	23.3	27.0	22.1	26.9	48.0	55.3	47.3	51.8	32.2	38.8	32.3	34.0	0.9	0.7	0.7	0.7
10-19	7.0	4.9	6.9	4.9	11.6	10.8	15.9	9.2	25.2	30.3	24.7	27.5	52.7	59.2	51.9	54.0	36.7	41.5	36.1	36.6	1.5	1.3	1.4	1.2
20-49	10.9	7.7	10.7	7.8	10.4	10.4	14.5	9.9	26.0	30.0	23.8	25.6	53.1	57.7	50.2	53.8	36.7	39.6	34.6	38.0	2.5	2.0	2.1	1.8
50-99	21.1	15.0	21.4	15.1	11.0	10.3	14.7	10.7	22.9	26.4	21.8	23.5	49.9	54.6	45.9	49.7	35.0	38.2	30.8	34.1	4.2	3.5	3.9	3.2
100-249	30.9	22.8	31.5	22.8	12.6	13.1	15.7	12.8	21.7	24.3	19.6	20.6	49.9	54.6	46.8	47.9	35.8	39.9	33.7	34.3	5.9	4.8	5.1	4.1
250-499	43.1	32.5	49.3	35.8	12.7	13.9	16.9	12.3	20.9	24.1	19.3	19.5	51.7	54.8	44.7	45.9	37.2	38.2	30.2	31.2	8.1	6.9	8.2	6.4
500-999	84.9	62.8	99.3	73.9	13.6	14.1	18.8	14.2	18.2	19.7	14.8	16.0	50.5	54.5	40.4	44.0	33.2	34.5	25.1	27.0	17.7	14.7	15.2	13.2
1,000	111.9	90.8	120.3	98.8	11.7	9.1	13.5	10.0	19.9	17.2	16.7	15.1	80.0	88.4	72.9	79.8	33.5	35.3	28.4	29.0	53.0	48.3	51.1	44.0
Region																								
Western G.	9.5	6.6	9.3	6.5	12.5	12.1	16.3	11.5	22.3	25.3	21.2	23.2	51.0	57.5	47.7	51.0	34.2	38.7	31.6	33.8	2.0	1.6	1.8	1.5
Eastern G.	16.2	12.2	17.5	13.6	13.3	12.3	18.1	12.4	27.6	30.2	24.0	24.5	57.7	60.5	54.4	56.2	40.2	41.7	36.3	36.3	3.9	3.3	3.4	3.0
Total	**10.7**	**7.6**	**10.8**	**7.8**	**12.7**	**12.1**	**16.9**	**11.8**	**23.7**	**26.7**	**22.0**	**23.6**	**52.8**	**58.4**	**49.6**	**52.6**	**35.7**	**39.6**	**32.9**	**34.6**	**2.3**	**1.9**	**2.1**	**1.8**
outside core[e)]					13.8	15.0	18.8	16.0	30.2	30.6	28.6	25.2	61.5	62.6	56.1	52.6	44.7	45.9	38.4	36.5				
funded firms[f)]					12.6	11.2	13.9	11.4	28.4	35.0	29.6	32.7	58.4	70.7	61.6	65.4	42.0	55.1	45.6	48.7				
Total for weighting	**10.7**	**7.6**	**10.8**	**7.8**	**12.6**	**11.8**	**16.8**	**11.3**	**22.7**	**25.8**	**20.9**	**23.0**	**51.5**	**57.1**	**48.2**	**52.0**	**34.4**	**38.0**	**31.7**	**33.8**	**2.3**	**1.9**	**2.1**	**1.8**

a) Gross sample (excluding firms from outside coverage and deliberately added funded firms) as a percentage of total population.
b) Neutral losses as a percentage of gross sample.
c) Responding firms as a percentage of gross sample net of neutral losses.
d) Responding firms plus NR-interviews as a percentage of gross sample net of neutral losses.
e) NR-interviews as a percentage of all non-responding firms.
f) Responding firms (including non-responding large firms for which data have been collected from other sources) excluding firms from outside coverage and deliberately added funded firms as a percentage of total population.

Source: ZEW, Mannheim Innovation Panel.

In addition, an attempt was made to differentiate data from large multi-product enterprises which have main economic activities in more than one sector (as defined by NACE divisions by sector). For some large enterprises this was done by addressing the questionnaire to individual business units representing activities in a certain sector. For other enterprises, enterprise data were broken down by sector data using segment reporting information from company reports or similar sources. One should note that this procedure concerned only a small number of enterprises since most large corporations have organised their business activities in a network of subsidiaries which typically represent single-sector enterprises.

These activities resulted in additional observations that were used for extrapolating figures to the target population. In 2013, 710 additional large firm observations were taken into account. This figure was 814 in 2014, 743 in 2015 and 759 in 2016. As a result, the coverage rate in the largest size class (1,000 and more employees) is about 80 per cent. In terms of the number of employees and sales volumes covered by the extended sample, the coverage rate is close to 100 per cent. Consequently, employment and sales weights in the highest size class are close to 1.0 in most sectors.

The sample size of the random sample in the MIP core sectors and size classes (drawing quota) represent 10.7 and 10.8 percent of the total population in the CIS years 2013 and 2015, and 7.6 and 7.8 percent in non-CIS years 2014 and 2016. High drawing quotas were applied for medium-sized and large firms and for most manufacturing sectors, while the metal industry, wholesale trade, transportation, consultancy/advertising and other business services show particularly low drawing quotas, reflecting the high share of small firms and a low variation in innovation intensities in these sectors. A drawing quota of more than 100 per cent for the largest size class reflects the deliberate addition of business units of large multi-sector enterprises to the sample as well as some discrepancy between the Business Register and the MEP.

The sampling rate, which is the sum of responses (including additional observations for large firms, but excluding responses from outside the core coverage and from deliberately added funded firms) as a share of the total population, was 2.3 per cent in 2013, 1.9 per cent in 2014, 2.1 per cent in 2015 and 1.8 per cent in 2016. This means that the average weight a firm in the net sample receives was about 43 in 2013 and about 56 in 2016. Sampling rates are high for manufacturing sectors (more than 10 per cent in 2013 for chemicals/pharmaceuticals, vehicles and energy/mining/oil products) and low for most service sectors (less than 1.0 per cent in wholesale and engineering/R&D services).

For weighted results, not only the net sample is used but also information from NR interviews is critical since NR results may significantly change weights (see next section for more detail). The extended sampling rate including NR observations was 4.8 per cent in 2013, 3.8 per cent in 2014, 4.3 per cent in 2015 and 3.6 per cent in 2016 which means that in 2013 about 1 out of 21 firms in the total population has been surveyed.

2.3 Data Processing, Non-response Correction and Weighting

Raw data are checked for logical consistency and likely typing errors, especially with respect to statements on financial data. In order to correct likely inconsistencies and errors, firm data from previous survey waves are consulted. Sometimes, firms are contacted by telephone for clarification purposes. The MIP survey nowadays refrains from follow-up contacts to fill in item non-response. Past experience showed that contact persons find it very difficult to add missing information after some time has passed since filling in the questionnaire originally and can only rarely provide accurate data on variables for which no data was provided in the questionnaire. For weighting purposes, imputation methods are used to estimate firm-specific values in case of item non-response, applying both longitudinal and cross-section imputation methods.

Longitudinal imputation rests on firm-specific data from previous survey waves. Two different methods are employed. For missing variables that directly relate to other non-missing variables, the respective firm-specific relation in the most recent survey wave (within the last five waves) for which both variables are positive is used to impute the missing value. For variables not directly related to any other variable, or in case no pair of positive observations is available for related variables within the last five survey waves, the last positive value reported by the respective firm is used and weighted with a trend for this variable to estimate the current value. The trend is calculated as the mean change in the respective variable based on all firms belonging to the same sector as the firm with missing value and that provided positive data for the respective variable both in the current wave and in the wave for which the most recent data is available for the firm with missing value. In case of quantitative data, which typically vary by firm size such as innovation expenditure, imputation is based on size-related indicators (e.g. innovation expenditure per unit of sales) in order to control for changes in variables due to firm growth or decline.

Cross-section imputation is used for variables that were either not surveyed in previous waves or for which too little information is available to perform longitudinal imputation. Cross-section imputation substitutes missing values by the mean value in a firm's strata.

Information from the NR survey is used to identify a potential response bias between innovating and non-innovating firms and to adjust weights accordingly. For this purpose, the realised non-response sample is regarded as being representative for all non-responding firms in the gross sample.

For extrapolating numbers to the target population, non-response correction factors are calculated in each stratum separately for innovators and non-innovators by applying the following procedure. n_h is the number of firms in stratum h of the gross sample, consisting of the number of responding firms $n_{R,h}$, and the number of non-responding firms, k_h:

$$n_h = n_{R,h} + k_h$$

Among the number of non-responding firms k_h, a subsample of non-responding firms is surveyed in the non-response survey labelled $n_{NR,h}$ (with $n_{NR,h} \leq k_h$).

The number of innovating firms in the response and in the non-response sample is $inno_{R,h}$ and $inno_{NR,h}$, respectively. The share of innovators p in both samples is thus given by

$$p_{R,h} = \frac{inno_{R,h}}{n_{R,h}} \quad \text{and} \quad p_{NR,h} = \frac{inno_{NR,h}}{n_{NR,h}} .$$

Assuming that the results of the non-response survey represent all non-responding firms of the gross sample, the number of innovators in stratum h can be calculated as

$$inno_h = inno_{R,h} + p_{NR,h} \cdot k_h .$$

The share of innovators in stratum h is thus given by

$$p_h = \frac{inno_h}{n_h} = \frac{inno_{R,h} + p_{NR,h} \cdot k_h}{n_{R,h} + k_h} = p_{R,h} \cdot \frac{n_{R,h}}{n_h} + p_{NR,h} \cdot \frac{k_h}{n_h} .$$

As a results, the non-response correction term for innovators ($corr_{h,1}$) and for non-innovators ($corr_{h,0}$) in stratum h can be calculated as follows:

$$corr_{h,1} = \frac{p_h}{p_{R,h}} \quad \text{and} \quad corr_{h,0} = \frac{1 - p_h}{1 - p_{R,h}} .$$

Weighting aims at estimating parameters for the population based on parameters observed for the sample. The population N represents all firms out of which n firms of the gross sample have been drawn. The MIP applies simple weights for qualitative variables such as the number of innovators and bounded weights for quantitative variables such as innovation expenditure or sales with new products (see Cochran, 1972; Rendtel, 1987). Simple weighting implies that only information from the sample is used to estimate the unknown parameter in the population. In contrast, bounded weighting methods use auxiliary information about the population in order to estimate unknown population parameters based on sample information. For instance, if innovation expenditure is correlated with turnover, the estimation of the innovation expenditure in the population can be improved if we do not only take into account information about the innovation expenditure in the sample but if we additionally use known information about the turnover in the population (external auxiliary information). In the following, we explain both methods and their implementation in the MIP in more detail.

Simple weights (w) are equal to the inverse of the sample rate π of firm i in stratum h (N being the number of firms in the population and n the number of firms in the net sample):

$$w_{hi} = \pi_{hi}^{-1} = \pi_h^{-1} = \frac{N_h}{n_h} \quad \text{for } i \in h ,$$

Since the sample rate π is identical for all firms in stratum h, we can neglect subscript i. For a variable Y in the population, for instance the number of innovators, we can get an unbiased estimate $\hat{Y}$ by calculating

$$\hat{Y} = \sum_{h=1}^{H} \sum_{i=1}^{n_h} w_{hi} \cdot y_{hi} = \sum_{h=1}^{H} \frac{N_h}{n_h} \sum_{i=1}^{n_h} y_{hi} ,$$

with y_{hi} being the variable value of firm i in stratum h and H being the number of strata.

Actually, the calculation of simple weights w in the German CIS data has been refined by additionally distinguishing two stages. The first stage accounts for the (inverse) probability of firm i being in the gross sample while the second stage considers the responding behaviour of firms in the gross sample (for the additional non-response correction, see below). Weights are derived as the product of the inverse of the gross sample rate and the inverse of the response rate:

$$w_{hi} = \frac{1}{\pi_{hi}} \cdot \frac{1}{\tau_{hi}} = \frac{1}{\pi_h} \cdot \frac{1}{\tau_h} = \frac{1}{\frac{n_h}{N_h}} \cdot \frac{1}{\frac{m_h}{n_h}} = \frac{1}{\frac{m_h}{N_h}} = \frac{N_h}{m_h} \quad \text{for all firms } i \in h.$$

$\pi_{hi} = \frac{n_h}{N_h}$ denotes the gross sample rate of firm i in stratum h and $\tau_{hi} = \frac{m_h}{n_h}$ is the response rate of firm i in stratum h. m_h measures the number of responding firms in stratum h ($=n_{R,h}$).

When calculating the response rates, the MIP considers a potential distortion because of differences in the response behaviour of innovators and non-innovators. This implies that the inverse response rate of innovators in stratum h is calculated as the inverse average response rate in stratum h multiplied by the non-response correction term for innovators in stratum h ($corr_{h,1}$). An analogue definition is applied for the inverse response rate of non-innovators.

These preliminary weights are then adjusted to the number of firms in stratum h in the total population N_h. As a result, simple (i.e. firm-based) weights for innovators ($k=1$) and non-innovators ($k=0$) in stratum h are defined as follows

$$\begin{aligned} w_{hi,k} = w_{h,k} &= \frac{1}{\pi_h} \cdot \frac{1}{\tau_h} \cdot corr_{h,k} \cdot \frac{N_h}{\sum_{k=0,1} \sum_{i=1}^{m_{h,k}} \frac{1}{\pi_h} \cdot \frac{1}{\tau_h} \cdot corr_{h,k}} = \frac{N_h}{m_h} \cdot corr_{h,k} \cdot \frac{N_h}{\sum_{k=0,1} \sum_{i=1}^{m_{h,k}} \frac{N_h}{m_h} \cdot corr_{h,k}} \\ &= \frac{N_h}{m_h} \cdot corr_{h,k} \cdot \frac{N_h}{\frac{N_h}{m_h} \sum_{k=0,1} \sum_{i=1}^{m_{h,k}} corr_{h,k}} \\ &= N_h \cdot \frac{corr_{h,k}}{m_{h,0} \cdot corr_{h,0} + m_{h,1} \cdot corr_{h,1}}, \end{aligned}$$

with $m_{h,1}$ and $m_{h,0}$ being the number of innovators and non-innovators in the response sample in stratum h.

Bounded weights are calculated based on auxiliary information about either turnover (wt) or the number of employees (we) in the population in stratum h. More precisely, a bounded weight is calculated by multiplying the simple weight in stratum h with the inverse of a correction term ($factor$) for each stratum h. The correction factor is the ratio of the weighted sum of turnover (weighted sum of number of employees) derived from using the simple weights to the sum of turnover (sum of number of employees) in the population. For instance, the bounded weight based on turnover (wt) in stratum h is defined as:

$$wt_h = w_h \cdot \frac{1}{factor_h},$$

which implies

$$wt_h = \frac{N_h}{m_h} \cdot \frac{1}{\frac{\frac{N_h}{m_h}\sum_{i=1}^{m_h} x_{hi}}{\sum_{i=1}^{N_h} X_{hi}}} = \frac{N_h}{m_h} \cdot \frac{1}{\frac{\frac{N_h}{m_h}\sum_{i=1}^{m_h} x_{hi}}{X_h}} = \frac{N_h}{m_h} \cdot \frac{1}{\frac{N_h}{m_h}\sum_{i=1}^{m_h} x_{hi}} \cdot X_h = \frac{1}{\sum_{i=1}^{m_h} x_{hi}} \cdot X_h$$

with X_h being the sum of turnover of firms in stratum h in the population and x_{hi} denoting turnover of responding firm i in stratum h. It follows that

$$\hat{Y} = \sum_{h=1}^{H}\left(wt_h \cdot \sum_{i=1}^{m_h} y_{hi} \right) = \sum_{h=1}^{H}\left(\frac{1}{\sum_{i=1}^{m_h} x_{hi}} \cdot X_h \cdot \sum_{i=1}^{m_h} y_{hi} \right) = \sum_{h=1}^{H}\left(\frac{\sum_{i=1}^{m_h} y_{hi}}{\sum_{i=1}^{m_h} x_{hi}} \cdot X_h \right).$$

Taking non-response correction terms into account, bounded weights *wt* for innovators *(k=1)* and non-innovators *(k=0)* in stratum *h* can be calculated as

$$wt_{h,k} = \frac{1}{\pi_h} \cdot \frac{1}{\tau_h} \cdot corr_{h,k} \cdot \frac{1}{\frac{\sum_{k=1,0}\left[\sum_{i=1}^{m_{h,k}}\left(\frac{1}{\pi_h}\cdot\frac{1}{\tau_h}\cdot korr_{h,k}\cdot x_{ih}\right)\right]}{X_h}} = \frac{corr_{h,k}}{corr_{h,0}\cdot\sum_{i=1}^{m_{h,0}} x_{ih} + corr_{h,1}\cdot\sum_{i=1}^{m_{h,1}} x_{ih}} \cdot X_h$$

and thus an estimate of variable Y in the population is given by

$$\hat{Y} = \sum_{h=1}^{H}\left[\sum_{k=1,0}\left(wt_{h,k} \cdot \sum_{i=1}^{m_{h,k}} y_{ih} \right)\right] = \sum_{h=1}^{H}\left[wt_{h,0}\cdot\sum_{i=1}^{m_{h,0}} y_{ih} + wt_{h,1}\cdot\sum_{i=1}^{m_{h,1}} y_{ih} \right]$$

$$= \sum_{h=1}^{H}\left[\sum_{k=1,0}\left(\frac{corr_{h,k}}{corr_{h,0}\cdot\sum_{i=1}^{m_{h,0}} x_{ih} + corr_{h,1}\cdot\sum_{i=1}^{m_{h,1}} x_{ih}} \cdot \sum_{i=1}^{m_{h,k}} y_{ih} \right)\cdot X_h\right].$$

3 Innovation Performance in a Long-term View

A main purpose of the innovation survey in Germany is to monitor innovation activities and outputs in the German business sector. By conducting the survey on an annual basis, survey results allow for identifying short-term changes in innovation performance as well as long-term trends and the role of business cycle fluctuations and other changes in the environment for innovation. This chapter provides a long-term view on innovation performance of firms in Germany, employing data from all survey waves back to the reference year 1992. Due to changes in statistical classifications, the underlying total firm population data, and the survey instrument (e.g. sequencing of questions, definitions), a number of breaks in time series occur. The perhaps most significant change refers to the extension of the definition of 'innovation' in the business sector proposed in the 2005 revision of the Oslo Manual. In addition to product and process innovation, the revision added marketing and organisational innovation as further types of business innovation. Data on these new types following the Oslo Manual definitions have first been collected in the 2007 MIP survey, but are not available for earlier years. For the long-term analysis in this chapter, innovation and innovation activities refer to product and process innovation only.

In the first two years of the MIP, only firms from manufacturing (incl. mining, utilities and construction) have been surveyed. In the survey year 1995, the target population was extended to a large number of service sectors. From 1997 on, service sectors were surveyed on an annual base. In the survey year 2003, a few more services sectors (broadcasting and motion pictures) were added while from survey year 2005 on, some service sectors (incl. retail trade, repair of motor vehicles, real estate, rental and leasing) ceased to be surveyed. In order to allow a long-term comparison despite the changing sector composition of the target population, data for reference years 2004 and earlier have been recalculated for the four main sectors using the following sector definition based on the NACE rev. 1.1 divisions and groups: R&D-intensive manufacturing: 24, 29-35, other manufacturing: 10-23, 25-28, 36-41, knowledge-intensive services: 64.3, 65-67, 72-73, 74.1-74.4, other services: 51, 60-63, 64.1, 74.5-74.8, 90.

Another change relates to data on total firm population. For the reference year 2006, data from the official Business Register of the Federal Statistical Office became available for the first time. From that reference year on, total population figures are taken from the Business Register. Before, data from various sector-specific statistics have been used. Using Business Register data led to an increase in the number of firms in manufacturing, while for some service sectors the number of firms decreased. There were also changes in employment and sales data. As total population data determine the weights used to calculate indicators, some indicator series show a break in 2006. In order to assess the magnitude of the break, indicators for the year 2006 have been calculated both on the previous and the new total population figures. In 2008, a new sector classification (NACE rev. 2) came in force which also had impacts on total population figures as some activities were added to the target population of the innovation survey. In order to avoid two breaks in series, the new sector classification has been applied from the reference year 2006 on.

A further break in series occurred in the reference year 2000 with respect to product and process innovation and indicators relating to these two types of innovation. In the 2001 survey, a new sequencing of the questions on product and process innovation was used, separating the two questions into two blocks. Before, the MIP had a single question on both types. As a consequence of the separation, the share of firms reporting both types of innovations fell strongly. Another change in the 2001 survey concerned the question on the sales share of product innovations. Until the 2000 survey, three categories of products had been distinguished: new products, significantly improved products, and all other products. From 2001 on, the first two categories have been merged into one. As a consequence, the share of sales from new or significantly improved products was much lower than the sum of the two categories in the years before. As no information on the magnitude of change that can be attributed to the altered questionnaire design is available, indicators on product and process innovation are reported only from the reference year 2000 on. From the 2001 survey on, the definition of product innovation clarified that the mere sale of innovations that have been developed solely by others is not to be regarded a product innovation. This caused a drop in the share of innovators in several service sectors by about 10 percentage points. The share on innovators in other services is therefore reported only from the reference year 2000 on.

The indicators reported in this study deviate from those reported in Eurostat's CIS statistics for two reasons: First, the data presented here includes firms with 5 to 9 employees, whereas this size class is excluded from CIS statistics. In addition, the MIP target population includes more service sectors than the core service sectors of the CIS, namely legal and accounting services, management consultancy, other professional and scientific services, employment activities, travel agencies, security activities, services to buildings, and other business support services. The total firm population of the MIP exceeds the CIS total firm population by about 145,000 firms, which is 105 percent of the total firm population based on core CIS sectors and size classes.

3.1 Share of Innovative Firms

One key indicator of innovation performance of the business sector is the share of innovative firms. The innovation survey provides two types of measures. One gives the share of firms that have conducted innovation activities within the previous three-year period ('innovation-active firms'). The other gives the share of firms that have introduced product or process innovations within the previous three year period ('innovating firms'). While the former informs about how many firm have decided to invest into innovation, the latter reports how many firms have been able to complete innovation activities by bringing a product innovation to the market or applying a process innovation within the firm.

The share of innovation-active firms in Germany shows a falling trend over the past twenty years (Figure 3-1). In 1999, 64.1 percent of all firms of the innovation survey's target population conducted innovation activities. In 2015, this figure fell to 43.6 percent. There is as substantial annual fluctuation in the share. When splitting by R&D activity, it becomes obvious that the fluctuation is driven by innovation-active firms without in-house R&D activity. The

share of innovation-active firms with in-house R&D activity has increased since the 1990s. The share of firms with continuous in-house R&D activity has been rather stable over the past 15 years whereas the share of firms with occasional in-house R&D activity shows a slightly falling trend since the mid of the 2000s.

Figure 3-1. Share of innovation-active firms in Germany 1992-2015 by R&D activity

No data on innovation-active firms with no in-house R&D activity available before 1997.
* break in series.
Source: ZEW, Mannheim Innovation Panel.

Figure 3-2. Share of innovation-active firms in Germany 1997-2015 by main sector

* break in series.
Source: ZEW, Mannheim Innovation Panel.

The share of innovation-active firms varies greatly among sectors (Figure 3-2). In R&D-intensive manufacturing in most years more than 80 percent of all firms reported innovation activities. Only recently this share fell to 73 percent. In other manufacturing the share of innovation-active firms never exceeded 65 percent and was only 44 percent in 2015. Knowledge-intensive services show a similar share of innovation-active firms, and also the development over time is very similar. In other services, the share of innovation-active firms strongly declined between 1999 and 2002 (from more than 60 to below 40 percent) and remained at that level since then, though annual fluctuations are markedly in this sector.

The share of firms with continuous R&D activity is an indicator for the incidence of innovation activities based on own creative work and with a strategic view, as continuous R&D involves certain fixed costs and investment in firm-specific assets. The indicator peaked at 14.7 percent in 2003 and dropped to 12 percent and slightly below from 2006 on (Figure 3-3). When considering the fall in the indicator level in 2006 due to changes in total population figures and the target population of the survey, the share of firms with continuous R&D remained rather stable over the past 15 years. At the sector level, the share increased in R&D-intensive manufacturing after 2006 and exceeded the 2003-level when adjusting for the break in series in all years except 2015. In other manufacturing, slightly more than 10 percent of all firms conduct in-house R&D on a continuous base. This share has hardly changed over the past 20 years when excluding the effect of the break in series in 2006. For knowledge-intensive services, one can observe a light decline of the indicator, though the share increased in 2015 again to 15.4 percent. In other services, only a tiny share of all firms conducts in-house R&D. In most years, the indicator is between 2 and 3 percent.

Figure 3-3. Share of firms with continuous R&D activities 1993-2015 in Germany by main sector

Note that in 1997, and in 1993 and 1995 for services, no data had been collected. Values shown for these years are based on linear interpolation.
* break in series.

Source: ZEW, Mannheim Innovation Panel.

The second indicator on the incidence of innovation in the firm sector –the share of innovating firms- shows similar results (Figure 3-4). In 1999, the indicator peaked at 55.5 percent and since then shows a clear downward trend. In 2015, only 35.2 percent of all firms had introduced product or process innovations. Again, the share of innovating firms in R&D-intensive manufacturing is substantially higher than in the other sectors. Knowledge-intensive services have a slightly higher share of innovating firms compared to other manufacturing. In both sectors the share of innovating firms is steadily declining since the end of the 1990s. In R&D-intensive manufacturing the innovator share was constant at around 75 percent throughout the 2000s and declined only in recent years. In other services, less than 30 percent of firms have introduced product or process innovations in the past seven years. Compared to the late 1990s, the share of innovators has fallen less strongly than in the other sectors.

Figure 3-4. Share of innovating firms 1992-2015 in Germany by main sector

Data for other services before 2000 are estimates in order to adjust for a break in series due to changes in the definition of innovation. No data have been collected for the year 1995 in services. Values shown for 1995 are based on linear interpolation.
* break in series.
Source: ZEW, Mannheim Innovation Panel.

For all four sectors, the share of innovating firms peaked in the second half of the 1990s, first in R&D-intensive manufacturing, last in other services, and least markedly in knowledge-intensive services. The high level of innovation in that period may be associated with the rapid diffusion of new IT-based innovation at that time. Many firms introduced E-commerce and other Internet-based services for the first time, and new business models emerged ('new economy'). Interestingly, no such development can be seen in more recent years, though public attention towards digitalisation and its likely impacts on innovation has been growing again.

Both the share of product innovators and the share of process innovators have been declining since the year 2000 (Figure 3-5). In 2000, 41 percent of all firms had introduced product innovation and 35 percent process innovation. In 2015, the respective shares were at 27 and

22 percent, respectively. Interestingly, the two shares go in different directions in most years, i.e. an increase in the share of product innovators is accompanied by a decrease in the share of process innovators and vice versa.

Figure 3-5. Share of firms with product innovation and with process innovations 2000-2015 in Germany

Data for other services before 2000 are estimates in order to adjust for a break in series due to changes in the definition of innovation. No data have been collected for the year 1995 in services. Values shown for 1995 are based on linear interpolation.
* break in series.
Source: ZEW, Mannheim Innovation Panel.

The share of innovating firms clearly increases by size class (Figure 3-6). Among firms with 1,000 or more employees, more than 80 percent are innovators. This share continuously decreases by size class. Among firms with 5 to 9 employees, only 30 percent were innovating firms in 2015. From 2006 to 2015, there is only one year in which a size class' innovator share was above the one of the next higher size class (10 to 19 employees in 2006). The very stable and consistent pattern of the share of innovating firms by size class –which can be found also for the share of innovation-active firms- points to various barriers of smallness for realising innovation. First, developing and implementing innovations often requires the combination of different, complementary assets (skilled personnel, creative employees, technological capacities, financial resources, strategic capabilities). Small firms face more difficulties to provide all these assets at the same time. Secondly, some innovation activities are associated with fixed costs, such as running a laboratory or releasing an employee from ordinary work in order to deal with innovation issues. The higher the share of fixed costs in total costs, the more difficult it will be to maintain such activities. Thirdly, some innovation activities require a certain minimum size in order to be conducted in an efficient way, i.e. innovation projects cannot be divided discretionary in order to align with a firm's available resources. If resources are scare and minimum project size is high, firms will refrain from entering into innovation. Fourthly, small firms face more difficulties to obtain external funding for innovation (in order to compensate for scare internal resources) due to high information asymmetries between the firm and external investors or lenders.

Figure 3-6. Share of innovating firms 2006-2015 in Germany by size class

Source: ZEW, Mannheim Innovation Panel.

In 2015, the share of innovating firms in Germany was 35.2 percent, compared to a share of 43.6 percent with innovation activities. The difference between the two indicators is determined by firms with innovation activities that did not result (yet) in innovation (i.e. the implementation of a new or significantly improved product or process). On the one hand, this includes firms with ongoing innovation activities that may yield to innovations later. On the other hand, firms may have been unsuccessful with their innovation activities and stopped them before implementation (abandoned innovation activities). The share of firms with ongoing innovation activities at the end of the reference year is around 30 percent in most years and does not show a clear trend (Figure 3-7). There is significant fluctuation in the share. The share of firms with abandoned innovation activities substantially increased between 2007 and 2013. This increase may partly reflect the more difficult economic conditions following the financial and economic crises 2008/09. In 2013, 14 percent of all firms in Germany stopped innovation activities before completion. In 2007, this share was only 5 percent.

The share of firms with only ongoing or abandoned innovation activities increased from about 7 percent in 2006 and 2007 to 15 percent in 2010 and decreased to about 8 percent in 2014 and 2015 (Figure 3-8). The majority of these firms had only ongoing or both ongoing and abandoned innovation activities. The share of firms with only abandoned innovation activities never exceeded 2 percent except in 2010 when 2.3 percent of all firms stopped innovation activities before completion and had neither ongoing nor completed innovation activities. In 2015, 0.5 percent of all firms had only abandoned innovation activities, which is the second lowest figure since 2006. However, the share of firms with both ongoing and abandoned innovation activities but no introduction of innovations increased after the financial crisis in 2008. This figure was 6.4 percent in 2010 and went down to 3.3 percent in 2016. In 2006, only 0.4 percent of all firms showed this pattern of innovation activity.

Figure 3-7. Share of firms with abandoned and with ongoing innovation activities 2001-2015 in Germany

* break in series.

Source: ZEW, Mannheim Innovation Panel.

Figure 3-8. Share of firms with only abandoned or ongoing innovation activities 2006-2015 in Germany

Source: ZEW, Mannheim Innovation Panel.

3.2 Innovation Expenditures

A key indicator for the amount of resources devoted to innovation is the expenditure that firms spend on innovation. Innovation expenditure include all in-house and extramural R&D expenditure as well as other expenditure undertaken for developing and introducing innovations such as investment in tangible or intangible assets, expenditure for design, training or marketing, and expenditure for conceptual and preparatory work in the context of innovation.

In 2015, firms in Germany spent €157.4bn on innovation. 20 years before, innovation expenditure was €60.7bn. Part of this huge increase is due to inflation. But also in real terms, the growth in innovation expenditure over the past two decades was considerably. Using the GDP deflator, innovation expenditure in real terms grew by 111 percent between 1995 and 2015 (Figure 3-9).

R&D-intensive manufacturing accounts for the largest fraction of total innovation expenditure (65 percent in 2015). This sector also shows the strongest increase since 1995 (168 percent in real terms). Knowledge-intensive services account for 16 percent of total innovation expenditure in 2015. This sector expanded innovation expenditure close to the average rate (107 percent). Other manufacturing contributed 14 percent to total innovation expenditure, compared to 23 percent in 1995. In real terms, innovation expenditure in this sector grew by only 27 percent over the past 20 years. An even lower growth rate (21 percent) is reported for other services. Their share in total innovation expenditure decreased from 10 to 6 percent between 1995 and 2015. This development clearly shows the shift in innovative capacities in the German economy towards R&D-intensive and knowledge-intensive sectors.

Figure 3-9. Innovation expenditure of firms in Germany 1992-2015 by main sector

* Planned figures as of spring/summer 2016.
Break in series between 2005 and 2006.
Source: ZEW, Mannheim Innovation Panel.

The MIP survey also contains a question on the amount of innovation expenditure planned for the two years following the reference year (i.e. the year in which the survey is conducted and the next year). For 2016, firms planned to increase innovation expenditure by 1.6 percent compared to the 2015 level. In real terms, this would mean the same level as in 2015. For 2017, a stronger increase of 3.7 percent is foreseen.

Over the past ten years, planned innovation expenditure for the year following the reference year was quite close to the actual figure for that year collected in next year's innovation survey (Figure 3-10). 2015 was the first year that did deviate from this pattern. In the 2015 survey, firms planned only slightly higher innovation expenditure for 2015 compared to 2014 (2.8 percent). Actually, innovation expenditure increased in 2015 compared to 2014 by 8.8 percent. Planned innovation expenditure for the year following the survey year turns out to be rather imprecise. It tends to be significantly lower than realised innovation expenditure in years when spending for innovation increases while it is too high for years of decreasing innovation expenditure (2009, 2014). This result suggests that innovation budgets of firms do not follow a medium-term planning but are adjusted on an annual base, reflecting changes in the business environment.

Figure 3-10. Planned and realised innovation expenditure of firms in Germany 2006-2017

* Planned figures as of spring/summer 2016.
Source: ZEW, Mannheim Innovation Panel.

The strong increase in innovation expenditure in the German business sector over the past 20 years was almost entirely driven by large firms (Figure 3-11). Their spending for innovation increased in real terms by 181 percent between 1995 and 2015. Small and medium-sized firms up to 499 employees expanded innovation budgets in the same period by 15 percent only. Their spending level in 2015 did not exceed the level already reached at the end of the 1990s in real terms. Planned innovation expenditure for 2016 and 2017 continues the spread between smaller and larger firms.

Figure 3-11. Innovation expenditure of firms in Germany 1995-2017, by size class

* Planned figures as of spring/summer 2016.
Break in series between 2005 and 2006.
Source: ZEW, Mannheim Innovation Panel.

Figure 3-12. Share of capital expenditure in total innovation expenditure 1995-2015, by main sector

* Break in series between 2005 and 2006.
Source: ZEW, Mannheim Innovation Panel.

A significant share of total innovation expenditure is capital expenditure for tangible assets (mostly machinery and equipment), software and some other intangible assets that can be capitalised (e.g. purchase of intellectual property like patents or trademarks, but excluding capitalised development costs). The share of capital expenditure in total innovation expenditure shows a declining trend for the past 15 years (Figure 3-12). In 1999, 45 percent of total innovation expenditure was capital expenditure, compared to less than 30 percent in 2015. The

importance of capital expenditure varies greatly among sectors. In other services, which includes wholesale trade and transport, its share is between 50 and 70 percent whereas this share is between 20 and 40 percent in R&D-intensive manufacturing. In other manufacturing, about 50 percent of all innovation expenditure is capital expenditure. The declining trend of the indicator is mainly driven by R&D-intensive manufacturing and knowledge-intensive services. In other services, the share of capital expenditure increased during the 2000s and remained stable in other manufacturing.

3.3 Product Innovations

In order to gain returns from innovation expenditure, firms need to yield economic results from innovations. Different indicators have been proposed to measure such economic results. For product innovation, the sales generated by new or significantly improved products have been frequently used both by firms and in innovation statistics. Related to total sales, it provides an indicator of how innovative a firm's product portfolio is. There are at least two important drawbacks of this indicator when using it for measuring product innovation results across time and firms. First, the indicator captures the gross earnings from product innovations but does not show whether product innovations have been sold with profits and at what level of profits. Selling product innovations with a low profit margin may increase sales volumes but limit the returns on the innovation expenditure made for these product innovations. Secondly, the sales share of product innovations is strongly affected by the product life cycle as the indicator requires to defining a reference period in which the product innovations had been put on the market. In innovation statistics, a three-year period is being used. If products are outdated rapidly, either because of technological change or because of changes in consumer preferences, and are hence replaced by new products after a short period of market presence, the indicator will be higher compared to a situation when products can be sold unchanged for a long term. Nevertheless, the sales share of product innovations has proved to be a useful indicator for firms' product innovation success in many studies (see Klingebiel and Rammer, 2014; Leiponen and Helfat, 2010; Laursen and Salter, 2006).

Despite the increasing volume of innovation expenditure and an increasing share of innovation expenditure in total sales, the sales share of product innovations shows a decreasing trend over the past 15 years (Figure 3-13). In 2000, 20.5 percent of total sales in firms from Germany were new or significantly improved products that have been introduced in the past three years. This share fell to 12.3 percent in 2009 and did not increase much since then. In 2015, 13.3 percent of sales originated from product innovations. The sales share of product innovations is highest is R&D-intensive manufacturing (34 percent in 2015) and much lower in all other main sectors. In knowledge-intensive services, about 10 percent of total sales can be attributed to new or significantly improved services. In other manufacturing, this share was about 7 percent and in other services about 5 percent. In all four main sectors, the indicator is currently below the level of the early 2000s. The strongest decrease is to be observed in other manufacturing.

Figure 3-13. Share of product innovations in total sales of firms in Germany 2000-2015, by main sector

* Break in series between 2005 and 2006.
Source: ZEW, Mannheim Innovation Panel.

Product innovations may represent different degrees of novelty. In order to qualify as a product innovation, the product has to be new or significantly improved from the viewpoint of the innovating firm. Such innovations may often be copied or slightly adapted from other firms. Other product innovations may be new to the market, i.e. they represent a solution that has not been offered yet by any other firm. This type of product innovation is called 'market novelties'. Note that the market is defined by the innovating firm and may be confined to a geographical market or a market of a specific group of customers. The MIP includes another measure of novelty of product innovation which refers to the fact whether a product innovation had any predecessor product within the innovating firm or not. If the latter is the case, the product innovation has opened up a new product line within the firm. These 'product-line novelties' may be market novelties at the same time, though firms may adopt product ideas from competitors when entering new market segments. Data on product-line novelties has been collected since the 2003 survey. This indicator is not used in the CIS. From both types of novelties one may expect higher returns for the innovating firm. Market novelties may allow for a higher mark-up and hence higher profits since the innovator enjoys a monopoly position at least for some time. Product-line novelties may accelerate sales levels as firms approach new group of customers or offer new types of offerings to their existing customers. Higher sales growth may transfer to decreasing unit costs if firms are able to leverage scale economies.

The share of market novelties in total sales was 3.0 percent in 2015, implying that only 22 percent of all sales with product innovations were generated by new-to-the-market products. The share of market novelties in total sales of product innovations has been quite steady for the past ten years (Figure 3-14). In the early 2000s, however, about 30 percent of new product sales were market novelties, and the share of market novelties in total sales was above 5 per-

cent. Product-line novelties account for a similar share in total sales. In 2015, the indicator was at 2.9 percent, compared to 5.8 percent in 2002.

Figure 3-14. Share of novel product innovations in total sales of firms in Germany 2000-2015, by main sector

* Break in series between 2005 and 2006.
Source: ZEW, Mannheim Innovation Panel.

Figure 3-15. Share of product innovators in Germany 2006-2015 by novelty of product innovation

Source: ZEW, Mannheim Innovation Panel.

The very similar values for market novelties and product-line novelties suggest that the two types of product innovation may overlap to a large extent. While the MIP does not survey the two indicators in a way that would allow for calculating the overlap, data on the share of firms

with these types of product innovation show a rather small overlap (Figure 3-15). In 2015, 5.3 percent of all firms introduced both market novelties and product-line novelties while 2.5 percent had market novelties but no product-line novelties, and 6.3 percent had product-line novelties but no market novelties. This means that only 37 percent of firms with either of the two types of novelties had both of them. This share was about 45 percent in the years 2006 to 2010 but declined as the share of firms with market novelties and the share of firms with product-line novelties has been declining too. In 2015, 7.7 percent of all firms had market novelties, compared to 13.1 percent in 2006. For product-line novelties, the respective shares are 11.6 percent and 17.9 percent. The share of firms with neither market novelties nor product-line novelties has also been decreasing, from 15.6 to 12.8 percent.

For market novelties, the CIS added two additional questions beginning with the reference year 2012. A first question asked about the geographical market to which the novelties refer to, distinguishing national, European and world market. A second question asked for the share in total sales that have been generated by market novelties that were new to the world. While the CIS provided pre-defined categories to be ticked, the MIP asked for the actual percentage. This allows calculating the exact share of sales from now-to-the-world product innovations.

Figure 3-16. Share of firms with market novelties by geographical market, and sales share of new-to-the-world product innovations in Germany 2012 and 2014

Source: ZEW, Mannheim Innovation Panel.

The results from the first question show that in 2014, 4.5 percent of all firms introduced at least one market novelty that was new to the world (Figure 3-16). This share was almost the same two years before (4.4 percent). Compared to all firms with market novelties, 51 percent (2014) had at least on new-to-the-world market novelty. In 2012, this share was somewhat smaller (44 percent). In 2014, 4.1 percent of all firms reported to have introduced a market novelty that was new to the world. 1.5 percent of all firms introduced market novelties that were new to Europe but not new to the world. 2.8 percent had market novelties that were only new to the German market. The share of firms with market novelties only new to Germany or

Europe was lower in 2014 as compared to 2012. In 2014, 1.0 percent of all sales of firms from Germany (within the target population of the MIP) were due to new-to-the-world product innovations. This share went down from 1.2 percent in 2012. The highest share is reported by R&D-intensive manufacturing (3.3 percent in 2014, 4.4 percent in 2012). In the other three sectors, new-to-the-world product innovations contribute a tiny share to total sales ranging between 0.6 percent (knowledge-intensive services) and 0.2 percent (other services).

3.4 Process Innovations

In addition to sales of product innovations, process innovation can also contribute to returns on innovation expenditure. While process innovation are often viewed as mainly contributing to firm performance by reducing unit costs, new or improved processes may also alter the quality of output and hence generate returns rather via sale volumes and prices rather than at the cost side. The MIP has been collecting information on the cost side of process innovation results since the second survey wave. Firms are asked to report whether process innovation contributed to a decrease in unit costs or cost per operation, and what the percentage of this cost saving was. Since 2002, the MIP added a question on whether process innovation contributed to an increase in the quality of output, and how much sales increased due to this higher quality.

Figure 3-17. Share of process innovators in Germany 2006-2015 by type of process innovation result

Source: ZEW, Mannheim Innovation Panel.

The results of both questions show that the share of process innovators reporting quality results is much higher than the share of process innovators with cost reduction (Figure 3-17). In 2015, 9.6 percent of all firms had process innovation that led to a decrease in unit costs. This is 44 percent of all process innovators. The share of cost-reducing process innovators was higher during the years of the financial and economic crisis (2008: 15.4 percent). But even in

these years, not more than half of process innovators yielded cost reductions. With respect to quality improvements, 12.9 percent of all firms reported that process innovation increase the quality of output in 2015, which is 59 percent of all process innovators. This share was substantially higher in earlier years (2008: 22.3 percent), implying that at that time more than 70 percent of all process innovators yielded quality improvements. The share of firms with both cost reducing and quality improving process innovation was 7.1 percent in 2015, compared to almost 12 percent in 2007 and 2008.

The average share of unit cost reduction from process innovation went down from 5.3 percent in 2000 to 3.4 percent in 2015 (Figure 3-18). There were two periods of declining cost saving shares: One from 2001 to 2003, and another one from 2010 to 2014. While the former period was a time of very low expansion of the German economy and a decreasing rate of utilisation of production capacity, the latter period was characterised by a strong increase in production (particularly in 2010 and 2011). The increase in sales that can be attributed to quality improvement shows a falling trend, from 4.5 percent in 2002 to 1.8 percent in 2015. As increase in sales is measured in nominal values, the lower level of inflation in more recent years may explain part of this change.

Figure 3-18. Indicators of process innovation success in firms in Germany 2000-2015

Source: ZEW, Mannheim Innovation Panel.

The decline in the share of unit cost reduction was strongly driven by R&D-intensive manufacturing (Figure 3-19). The indicator went down from 7.7 percent in 2000 to 4.0 percent in 2015. A less marked decline can be observed in other manufacturing. In knowledge-intensive services, unit cost reduction was higher in 2015 (4.5 percent) than in 2000 (4.0 percent). Other services report a small decrease. The increase in sales owing to quality improvement was significantly lower in all sectors when the years 2015 and 2002 are compared. The strongest decrease is reported for knowledge-intensive services (from 5.9 to 2.2 percent).

Figure 3-19. Indicators of process innovation success in firms in Germany 2000/02 and 2015, by main sector

Source: ZEW, Mannheim Innovation Panel.

For the reference year 2008, the CIS added a question on the novelty of process innovation asking firms whether any of their process innovation was new to their market, meaning that no other enterprise in the firm's market has applied these process innovations before. Firms could also respond by 'not known' as it may be unknown to many firms what processes other firms in their market do apply. The question has been repeated in the MIP once since then, for the reference year 2012. The results show that there is indeed a significant lack of transparency of process technology applied by competitors. About a third of all process innovators say that they do not know whether their process innovations have been new to their market (Figure 3-20). 12 percent of all process innovators in 2012 reported that their process innovation was new to the market. Compared to 2008, the share went down by 4 percentage points.

The highest share of process innovators with new-to-market process innovations is found in R&D-intensive manufacturing (2012: 17 percent), followed closely by other manufacturing (15 percent). In services, the indicator is clearly smaller at 8 to 9 percent. In R&D-intensive manufacturing, 42 percent of process innovators say that they do not know whether their process innovations were new to their market. In other services, this share is significantly smaller (26 percent). In the service sectors, 32 percent (other services) and 38 percent (knowledge-intensive services) of process innovators are not aware whether their process innovations were new to their market.

Figure 3-20. Share of firms with new-to-market process innovation in Germany 2008 and 2012, and by main sector (2014)

Source: ZEW, Mannheim Innovation Panel.

4 Types of Innovation Activity and Innovation Projects

Firms can conduct a variety of activities for developing and introducing innovations. In the previous chapter, firms with in-house R&D activity have been separated from other innovation-active firms. In addition to in-house R&D, the CIS distinguishes seven other types of activity that innovation-active firms (with respect or product or process innovation) may perform in the course of their attempt to develop and introduce innovations. The MIP does not include this question on an annual base. Within the five survey waves 2013 to 2016, only the 2013 survey contained this question.

4.1 Types of Innovation Activity

The results show that the most widespread innovation activity is the acquisition of machinery, software and other tangible assets (Figure 4-1). 60 percent of all innovation-active firms conducted this type of activity. Training activities are the second most widespread innovation activity (57 percent), followed by other preparations (44 percent). 40 percent of all innovation-active firms conducted in-house R&D. 27 percent of all innovation-active firms had marketing activities, and the same share had design activities. The acquisition of other external knowledge (such as the purchase of IP from other organisations) was reported by 22 percent of innovation-active firms while 16 percent had extramural R&D. 8 percent of innovation-active firms reported that they did not perform any of these activities as part of their innovation efforts. This group mainly consists of small firms in other manufacturing and other services. Many of these firms may perform innovation activities in an unstructured, holistic way and on an ad-hoc base and are hence not able to assign their innovation activities to any of the pre-defined types.

Figure 4-1. Types of activity of innovation-active firms in Germany 2012

Source: ZEW, Mannheim Innovation Panel.

The four main sectors show different most widespread types of activity (Table 4-1). In R&D-intensive manufacturing, 76 percent of all innovation-active firms conduct in-house R&D. The second most widespread type is other preparations (74). In other manufacturing, 64 percent of innovation-active firms acquired machinery, software or other tangible assets. Training is the second most widespread activity in this sector (50 percent). In knowledge-intensive services, training is conducted by 67 percent of all innovation-active firms, making this activity to the most common one. In other services, acquisition of machinery, software etc. (57 percent) and training (55 percent) are the two most common types of innovation activities.

Broken down by size class, firms with 1,000 or more employees show the highest share for each type of activity and small firms always show the lowest. This result basically reflects that large organisations show a higher number of innovation projects (see sub-chapter) which increases the probability that different types of activities are performed in the same period and the same organisation. Size differences are particularly large for external R&D and the acquisition of external knowledge and rather low for training, design and other preparations.

Table 4-1. Types of activity of innovation-active firms in Germany 2012, by main sector and size class

	in-house R&D	external R&D	acqu. mach., softw.	acqu. ext. knowl.	training	marketing	design	other preparations	none of these 8 activ.
R&D-intensive manufacturing	76	32	65	23	54	42	38	74	3
Other manufacturing	43	16	64	18	50	24	31	48	9
Knowledge-intensive services	43	15	57	29	67	30	26	41	7
Other services	17	10	57	18	55	20	20	29	11
5-9 employees	31	14	55	22	54	20	25	36	9
10-19 employees	39	13	54	18	55	27	26	42	9
20-49 employees	42	14	63	21	55	27	24	47	11
50-99 employees	48	21	70	23	65	36	34	54	5
100-249 employees	61	28	75	24	68	43	37	61	3
250-499 employees	66	37	75	38	72	44	46	68	2
500-999 employees	69	46	76	47	74	54	45	69	3
1,000+ employees	76	63	89	69	78	62	53	73	0

Source: ZEW, Mannheim Innovation Panel.

The vast majority of innovation-active firms conduct more than one activity within a three-year reference period (Figure 4-2). Only 15 percent of innovation-active firms report only one activity (in addition to the eight percent that do not report any of the eight listed types). 24 percent conduct two different types, 19 percent three different types and 15 percent four different types. About 11 percent of all innovation-active firms perform five or more different types, with roughly 1 percent conducting all eight types. The latter group mostly consists of large firms.

Figure 4-2. Number of different types of innovation activity conducted in innovation-active firms in Germany 2012

Source: ZEW, Mannheim Innovation Panel.

4.2 Innovation Expenditure by Type of Activity

While a very high share of all innovation-active firms conducts training, marketing, design or other preparatory activities as part of their innovation activity, the share of these activities in total innovation expenditure is rather low at 19 percent in 2012 (Figure 4-3). 42 percent of all innovation expenditure in that year was spent on in-house R&D. External R&D had a share of 9 percent in total innovation expenditure. For the acquisition of machinery, software and other tangible assets firms spent 28 percent of total innovation budget while only 2 percent was spent of the acquisition of other external knowledge. R&D-intensive manufacturing shows the highest share for both in-house and external R&D, the two categories total to 62 percent of all innovation expenditure. In other services, R&D accounts for only 6 percent of total innovation budgets. In this sector, acquisition of machinery, software etc. is by far the main spending category (70 percent). This type of activity accounts for 41 percent of all innovation expenditure in other manufacturing and tops R&D expenditure (35 percent). The highest share for other innovation expenditure is reported for knowledge-intensive services (28 percent), which is the same figure as for the acquisition of machinery, software etc. R&D expenditure account for 41 percent of all expenses for innovation in this sector.

Relating the amount of expenditure for each category to total sales allows to comparing the importance of the respective type of innovation expenditure across sectors (Figure 4-4). The results show that R&D-intensive manufacturing shows the highest value for each category. Sector differences are smallest for expenditure on the acquisition of machinery, software and other tangible assets. R&D- intensive manufacturing invested 1.76 percent of total sales in 2012 on this type of innovation expenditure. In both service sectors, the figure was 0.46 percent and in other manufacturing 0.59 percent. For in-house R&D, expenditure per sales was 4.16 percent in R&D-intensive manufacturing but only 0.03 percent in other services.

Figure 4-3. Composition of innovation expenditure of firms in Germany 2012 by type of activity

Source: ZEW, Mannheim Innovation Panel.

Figure 4-4. Innovation expenditure of firms in Germany 2012 as a share of sale, by type of activity

Source: ZEW, Mannheim Innovation Panel.

While the MIP does not collect data on the amount of innovation expenditure by type of activity on an annual base, two broad categories of expenditure are surveyed annually, R&D expenditure and capital expenditure. R&D expenditure covers both in-house and external R&D. Capital expenditure are by and large equivalent to the sum of expenditure for the acquisition of machinery, software etc. and of other external knowledge, but also include capital expenditure for R&D. In order to exclude the latter from capital expenditure and hence enable the calculation of the amount of other expenditure (by subtracting R&D expenditure and capital expenditure net of R&D-related capex from total innovation expenditure), the share of capital expenditure in total R&D expenditure was estimated using sector-specific data on this share from the R&D survey (see Eckl et al., 2015).

Figure 4-5. Innovation expenditure of firms in Germany 2006-2015 by main expenditure category

* excluding capital expenditure for R&D, which is part of R&D.
Source: ZEW, Mannheim Innovation Panel.

Figure 4-6. Innovation expenditure of firms in Germany 2006-2015 by main expenditure category and main sector

* excluding capital expenditure for R&D, which is part of R&D.
Source: ZEW, Mannheim Innovation Panel.

Over the past ten years, the share of R&D expenditure in total innovation expenditure increased significantly from below 50 percent in 2006 to 2008 to 56 percent in 2014 and 2015 (Figure 4-5). The share of capital expenditure (net of capital expenditure for R&D) went down from more than 30 percent to 26 percent. The share of other innovation expenditure shows a slight decline from 20 to 18 percent. A main driver for this shift is the strong expansion of innovation expenditure in R&D-intensive manufacturing as well as in knowledge-

intensive services while innovation expenditure grew only moderately in the other two sectors. As R&D-intensive manufacturing and knowledge-intensive services show a higher share of R&D expenditure and a lower one for capital expenditure, the different sector dynamics also change the composition of innovation expenditure.

But also within each main sector, the share of each expenditure category in total innovation expenditure has changed over the past ten years (Figure 4-6). In R&D-intensive manufacturing, the share of R&D expenditure increased while the other two categories were decreasing. In other manufacturing, little changes occurred when comparing the years 2006 and 2015, but there was quite some fluctuation in the share of each category. Knowledge-intensive services report an increasing share for R&D expenditure and a slightly falling share for the two other categories, though the share of other expenditure tends to fluctuate quite substantially. In other services, the share of R&D expenditure rose at the expense of capital expenditure. Also here the share of other expenditure shows high volatility.

4.3 Innovation Projects

In the 2009 survey, the MIP started to collect data on the number of innovation projects that a firm conducted within the three-year reference period and which were related to product and process innovations, including all R&D projects. The number of innovation projects was broken down by completed projects during the reference period, projects stopped before completion, and projects that were ongoing at the end of the reference period. In addition, firms were asked to provide the number of innovation projects that were started during the reference period. The main purpose of this question was to get more insight into how innovation expenditure are allocated to different innovations, and the extent to which innovation efforts are successful or stopped before an innovation is introduced (see Klingebiel and Rammer, 2014; Klingebiel and Adner, 2015). The question on innovation projects has been repeated every second year since the 2009 survey. First results from the surveys 2009 and 2011 have been reported in Aschhoff et al. (2013). This section builds upon this report and updates the findings for the surveys 2013 and 2015, using the same structure of presentation in order to facilitate comparison.

Surveying the number of innovation projects rests on the assumption that innovation activities of firms are typically organised in the form of a project. An innovation project is a dedicated activity based on a plan that defines the objectives, the approach to achieve these objectives, and the resources and time needed. Innovation projects may refer to an entire product or process innovation, starting from generating the idea up to market introduction. However, some firms may split innovations into several projects, each representing a certain stage in the development and implementation of an innovation. For instance, the research needed to solve a certain technical problem may be defined as a separate project which feeds into successive development and design activities. For this reason, there may be firms with completed innovation projects that did not introduce any product or process innovation in the same period of time. In addition, firms may complete innovation projects in terms of finding a technological solution to a certain innovative idea but refrain from using this finding to introduce a new

product or process because of unfavourable market conditions or a lack in funds. But firms may also introduce several innovations that emerged from one and the same innovation project. But firms may also introduce some product or process innovations without related innovation projects, for example if innovations are rather incremental and are introduced as part of routine activities in production or marketing. For all these reasons, the number of innovation projects will not relate to the actual number of innovations (i.e. introduced new or significantly improved products and new introduced new or significantly improved processes).

When surveying the number of innovation projects, the MIP refrains from providing lengthy definitions and explanations of 'innovation project' but rather leaves it to the responding firm to use that definition of project that the firm usually applies. When calculating the total number of innovation project, it is assumed that every innovation-active firm conducts innovation projects. For firms not reporting the number of innovation projects, the number has been imputed using the volume of innovation expenditure as a key reference variable. One should note that the share of item non-response is very high for this question (38.5 percent in 2013, 34.4 percent in 2015) and weighted results are hence subject to a much greater statistical error than any other variable reported in this report.

In the three years 2012 to 2014, the estimated number of innovation projects conducted by firms in Germany was about 705,000. Roughly 386,000 of these projects have been completed successfully within this period, approximately 71,000 were stopped before completion, and about 247,000 were still ongoing at the end of 2014. About two thirds of these projects (465,000) were started within the three year period. The results of the 2013 survey, which refer to the three year period from 2010 to 2012, show a slightly lower total number of innovation projects (684,000), caused by a lower number of successfully completed projects (342,000), a similar number of projects that were stopped before completion (72,000) and a higher number of ongoing projects at the end of 2012 (270,000). The number of projects newly started within the reference period was clearly smaller (345,000) and was also below the respective number for the 2008-2010 reference period (360,000). One may suppose that the sharp economic crisis which broke out in autumn 2008 and heavily affected the firms' financial situation in 2009 and 2010 had an impact on the decrease in the number of newly started innovation projects. In the period before the crises (2006 to 2008), more than 540,000 innovation projects were started by firms in Germany.

On average, an innovative firm conducted 5.6 projects during 2012 and 2014, compared to 5.0 during 2010 and 2012 (Table 4-2). Size differences in the number of innovation projects per firm are considerable (see Table 4-2). Large firms with 1,000 or more employees run an average 170 different innovation projects within the three-year period 2012-2014 with up to several thousand projects in very large corporations. The number of innovation projects per large firm increased between 2010-2012 and 2012-2014. Medium-sized firms manage project portfolios of about 5 to 15 projects. Small innovation-active firms with less than 20 employees focus their innovative efforts on just 2 to 3 projects on average. Differences between manufacturing and services are less pronounced. In manufacturing, the average number of innovation projects per innovation-active firm was 7.2 (2010-12) and 7.7 (2012-14) while innovation-active service firms report 3.3 and 4.1 projects in average.

Table 4-2. Number of innovation projects per innovative firm 2010-12 and 2012-14, by size class

	2010-2012			2012-2014		
	Total	Manufac-turing	Services	Total	Manufac-turing	Services
5-9 employees	2.3	2.6	2.2	2.7	2.6	2.7
10-19 employees	2.6	2.9	2.4	2.7	3.0	2.5
20-49 employees	3.6	4.4	2.9	4.0	4.0	4.1
50-99 employees	4.9	5.6	3.9	5.3	6.4	4.2
100-249 employees	7.6	8.9	5.4	6.8	7.8	5.4
250-499 employees	16.4	19.2	12.3	14.6	17.3	11.1
500-999 employees	23.3	29.0	15.1	22.3	26.8	15.8
1,000+ employees	144.6	197.6	71.5	170.5	218.3	102.8
Total	5.0	7.2	3.3	5.6	7.7	4.1

Source: ZEW, Mannheim Innovation Panel.

The average expenditure per innovation project in the German enterprise sector was about €600k in 2012-2014 and went up by more than €100k compared to 2006-2008 (Figure 4-7). The average expenditure per innovation project was calculated by dividing total innovation expenditure for the three years by the total number of innovation projects pursued during these three years (including stopped and still ongoing projects). As the MIP does not collect project-specific expenditure data, no information can be provided on the distribution of project size. The average project size differs considerably by firm size and sector. Large firms with 1,000 or more employees spend about €1.5m on average per project while small firms with 5 to 9 employees conduct innovation projects with about €50k per project. Firms in R&D-intensive manufacturing have significantly larger innovation projects on average (about € 1.3m) than firms from the other three main sector groupings. The difference can partly be explained by the higher share of very large enterprises in this sector. However, small firms from R&D-intensive manufacturing also report higher average project size compared to firms from other sectors.

The high average project size in R&D-intensive manufacturing implies that the high amount of innovation expenditure in this sector is allocated on a comparatively smaller number of projects than in the other sectors. In fact, the number of innovation projects is rather equally distributed across the four main sectors. In 2012-2014, about 209,000 of the total 705,000 innovation projects were conducted by firms from R&D-intensive manufacturing. A slightly smaller number (199,000) was executed in other manufacturing. The knowledge-intensive sector had a total of 182,000 different innovation projects in that period. Other services fall behind in terms of the number of innovation projects, with 115,000 projects performed between 2012 and 2014.

Figure 4-7. Expenditure per innovation project 2010-2014, by main sector and size class

Source: ZEW, Mannheim Innovation Panel.

The information collected on the number of completed, stopped, ongoing and newly started projects within a three year period can be used to produce a rough estimate of the average duration of innovation projects when assuming that starting, completing and stopping projects is evenly distributed over the three year time period and that project duration does not change during this period. Under these assumptions, the relation of ongoing projects at the end of the period —ipo(t_n)— to the annual number of projects that have been completed or stopped during this 3-year period —ipcs(t_o,t_n)/3— will give the average project duration. In the same way, the relation of ipo(t_n) to the annual number of projects that have been newly started during this 3-year period —ipn(t_o,t_n)/3— should give the same duration figure (as long as the assumptions hold). Since in fact the assumptions are not entirely realistic, there is some deviation in the results for both calculations. Hence, we use the averages of both figures to arrive at a somewhat realistic estimate of the average length of innovation projects.[5] F

or the 2012-2014 period the average duration of an innovation project in the German enterprise sector was 19 months (Figure 4-8). This figure was significantly higher for the 2010-2012 period (26 months) while in the pre-crisis period (2006-2008), the average project duration was only 16 months. A main reason for this fluctuation is the higher share of newly started projects in the 2006-2008 and 2012-2014 periods which push down average project length. It seems that in the periods affected by the economic crisis (2008-2010, 2010-2012), firms fo-

5 In the 2010 survey wave, a separate question on the average length of innovation projects was added to the questionnaire, offering six response categories. The results largely confirm the present calculation.

cused on longer projects and refrained from performing short-term projects. In addition, ongoing projects may have been lengthened, either because of a lack of funding or because firms waited for a better business climate to introduce innovations.

Figure 4-8. Estimated average length of innovation projects 2010-2014, by main sector and size class

Source: ZEW, Mannheim Innovation Panel.

Firm size differences in the duration of innovation projects are small. At the level of main sector groupings one can also find only little differences in the time it takes until an innovation project is completed or stopped. Differences are more pronounced at the level of individual industries.

Between 2012 and 2014, 16 per cent of all innovation projects that ended during that period were stopped before completion (Figure 4-9). This share is lower than in the two previous periods (2010-2012: 17 percent; 2008-2010: 19 percent) but higher than in 2006-2008 (14 percent). The share of stopped projects is highest in very large firms (20 per cent) but does not vary systematically among other size classes. The lower share of stopped projects in 2012-2014 as compared to the previous period is mainly driven by the service sectors while there is little change in the share in manufacturing sectors. This development mirrors the stronger increase in the share of stopped projects in service sectors during the economic crisis, suggesting that services are more vulnerable to adverse impacts of the economic crisis on innovation. Stopping projects before completion need not necessarily indicate a failure of innovation efforts, however, but can also indicate an efficient project management by refraining from projects that do not deliver and focussing resources on more promising ones (see Klingebiel and Rammer, 2014).

Figure 4-9. Share of stopped innovation projects 2010-2014, by main sector and size class

Source: ZEW, Mannheim Innovation Panel.

5 Financing of Innovation and Public Funding for Innovation

This section investigates the sources of financing of innovation and potential financial constraints for innovation. In principle, firms can use two types of finance. On the one hand, they can finance innovation projects using internal sources which mainly originate from retained profits or new equity. On the other hand, external finance, which includes bank loans, debt obligations or supplier credits among others, might serve as another source of financing. If capital markets were perfect, the sources of financing would not matter and investment decisions would be indifferent to the capital structure. That is, in markets characterized by no transaction costs due to the absence of asymmetric information, taxes or e.g. bankruptcy costs, firms could finance all planned innovation projects either with internal or external financing sources. As a result, they would be indifferent between both sources of finance (Modigliani and Miller, 1958). Imperfect markets, however, change this pattern and lead to a situation in which financing and the source of financing matters and in which firms might face financing constraints (Arrow, 1962; Nelson, 1959). That is, external investors do not provide sufficient external financing necessary to carry out planned investments in imperfect capital markets.

These financial constraints are particularly severe for investments in innovation projects for at least two reasons. First, innovation projects are often highly complex, specific and associated with a high degree of technical and demand uncertainty. These characteristics make it difficult for potential external lenders to judge the expected value of the project ex ante. Innovating firms usually have a better On top, firms might be reluctant to reveal project information in order to prevent unintended knowledge leakage (Stiglitz und Weiss, 1981; Anton und Yao, 2002). This leads to information asymmetries between external lenders and firms.[6] As a result, lenders will demand a risk premium on their required rate of return making external finance more costly than internal finance and under certain circumstances even prohibitively high (Akerlof, 1970). But even after a credit contract has been signed, information asymmetries exist between firms and lenders which might lead managers to invest in more risky innovation projects (Jensen and Meckling, 1976).[7]

The second main obstacle for firms to get external finance is related to the intangible nature of the innovation investment. When firms invest in physical capital like new machines, these new machines often simultaneously serve as security for the loan since they can be liquidated in case of project failure of bankruptcy (Williamson, 1988; Alderson and Betker, 1996). In contrast, a large proportion of R&D investment is used for financing R&D personnel. These outlays are usually sunk and cannot be redeployed in case of failure. Hence, innovation projects themselves do not provide any or only little collateral value raising the risk premium ex-

6 The problem of information asymmetries before conclusion of a contract is called *adverse selection*.
7 The problem of information asymmetries before conclusion of a contract is called *moral hazard*.

ternal lenders require for financing innovation or preventing firms from receiving external finance for innovation at all (Alderson and Betker, 1996; Akerlof, 1970).

Both higher external cost of capital and credit rationing make internal sources of finance (cash flow, new equity) and public finance more crucial for financing innovation. However, internal funds are also limited. In addition, firm‘s cash flow usually fluctuates with the business cycle whereas long-term innovation projects often needs stable financing conditions over several years. Likewise, access to equity capital and public funding is limited and differences in access exist for different kind of firms.

Results of the 2011 German innovation survey have corroborated that the great financial crisis strongly impacted firms’ innovation behavior. In particular, firms assessed the lack of internal and external finance as well as higher innovation costs and demand uncertainty as an increasing obstacle to innovation during the financial crisis (Aschhoff et al., 2013). An immediate resulting question is whether and to what extent firms‘ financing behaviour of innovation has changed due in the aftermath of the financial crisis.

The 2014 survey of the MIP therefore included several questions on the sources of financing and the extent of potential constraints related to internal and external finance. In the period 2013-2016, only the 2014 survey contained information on the financing of innovation. But the questions are comparable to the financing questions surveyed in 2007 thus allowing a comparison before and after the financial crisis. Results of the 2007 survey have been reported in Aschhoff et al. (2013). Except for subsection 5.3 this section uses the same structure of presentation in order to facilitate comparison.

5.1 Sources of Financing Innovation and Investment

The first set of question addresses the sources of financing for investment in general and for innovation in particular. General investment refers to financing replacement and expansion investment without innovation character. In the survey, firms could choose between ten different sources and of course they could indicate multiple financing sources. The ten financing sources can be grouped into 5 broader categories:

- *Internal financing* (cash flow);
- *Equity financing* either by issuing new equity/admission of new shareholders or by participation of other firms including VC funding;
- *Debt financing* through (i) issuing new bonds and debt obligations, (ii) overdraft facilities and credit lines, (iii) targeted bank loans and (iv) other forms such as leasing, factoring or supplier credits;
- *Hybrid financing* which represents a mixture of equity financing and debt financing such as shareholder loans or mezzanine capital (e.g. dormant equity) and
- *Public financing* consisting of public subsidies on the one hand and public loans or supportive loans (e.g. from KfW or federal states banks) on the other hand.

In order to reduce the response burden, firms have only been asked to indicate whether they have used any of the ten sources for financing innovation and investment but not to report the share of each financing source in total financing. Hence, when interpreting the following results one should keep in mind that there might be sources which are often used but only to a small extent and which are therefore overrepresented by the numbers. It is the other way round for sources which are less frequently used but given they are used they make an important contribution to the overall financing.

The results of Figure 5-1 show that by far internal financing has been the major source of financing innovation and investment in the period 2011-2013. 83% of firms with innovation activities have fall back on cash flow to finance innovation. This proportion is a little smaller for general investment. About three out of four firms with general investments have financed these using internal sources (76%).

Figure 5-1. Sources of funding for innovation and investment projects 2011-2013

Source: ZEW, Mannheim Innovation Panel.

In contrast, the role of equity financing is rather negligible, at least when we simply look at the proportion of firms that have make use of it. Only 3% of innovative firms have issued new equity or admitted new shareholders in order to finance innovation projects. This proportion is only slightly larger for general investments (4%). Only about 0.6% of innovative firms were able to attract venture capital for financing innovation. But as already mentioned, for those firms that get this type of funding, VC funds may represent an important share of total financing – something we cannot identify with the survey question.

In contrast to internal and equity financing where differences are rather small between innovation and investment, larger differences stick out for external financing. Around one third of

the firms have financed their general investments using long-term targeted bank loans (36%) or short-term oriented overdraft facilities (30%). 19% of the firms have fallen back on other types of external financing like supplier credits, factoring or leasing in order to finance general investments which themselves could serve as collaterals in external financing contracts. Merely issuing bonds and debt obligations are hardly used by firms for financing investments (0.3%). Overall, external financing is the second most important source of financing investments.

This is in contrast to the financing of innovation where external finance is used much less frequently and where public funding represents the second most important source of financing. About one out of five firms (21%) received public subsidies for innovation. Given the arguments represented in the last section, firms have to pay an additional risk premium when using external finance for innovation activities. This makes external financing a less attractive choice. Most intriguing is the fact that firms use short-term overdraft facilities, which are relatively costly, more often to finance long-term innovation activities (16%) than long-term targeted bank loans (14%). Other types of external financing like supplier credits, factoring or leasing do only play a minor role in financing innovation (6%). The fact that firms use external finance less frequently and if at all rely more heavily on short-term overdraft facilities is likely to be a signal of financial constraints due to short supply of capital financing. But it could also partly reflect firm's desire to be independent of any capital investor.

Interestingly, firms use hybrid financing more often to carry out innovation and investment than pure equity finance. 10% of innovative firms have used shareholder loans or mezzanine capital to finance innovation projects. This share is even slightly higher for general investment (13%).

When comparing these figures with results from the 2007 survey (see Aschhoff et al., 2013), we find the financial crisis to have had an important impact on firms' financing structure of innovation. The proportion of firms that use internal financing in the period 2011-2013 has remained unchanged compared to the period 2004-2006. However, for all other types of external, equity or hybrid financing we observe a strong decline. For instance, the proportion of firms using overdraft facilities has fallen from 29% to 16%. The drop is similarly high for targeted bank loans (-10 percentage points), shareholder loans (-6 percentage points) and the proportion of firms using equity financing has halved.

Public financing is the only source that has increased importance during the financial crisis and in its aftermath. As a reaction to the financial crisis the federal and state governments have decided to extent R&D support. As a result, the proportion of firms that could fall back on public subsidies to finance innovation has more than doubled from 8% to 21%. Public finance was ranked fifth among the financing sources before the financial crisis but it has become the second most important source of financing after the financial crisis. In addition to public subsidies, public loans have also slightly increased (from 7% to 8%).

Given the fact that the use of cash flow has remained stable but all other types of financing except for public funding has decreased, we can also conclude that the proportion of firms

that use only one source of financing – mainly cash flow – has increased and that having multiple financing sources has become less frequent.

Figure 5-2 shows the sources of financing for innovation by main sectors. Overall, we find a very similar financing pattern for R&D-intensive manufacturing, knowledge-intensive services and other services in terms of ranking of financial sources though the level partly differs across industries. In all three main sectors, cash flow is the most important financing source followed by public subsidies. 36% of R&D-intensive manufacturing firms used public subsidies to carry out innovation projects whereas only 20% and 18% of firms in knowledge-intensive and other services could fall back on public subsidies. Though this share was similarly high in other manufacturing (19%), public subsidies only come fourth. In other manufacturing short-term (21%) and long-term bank financing (20%) are much important than in the other three industries. In contrast, only 10% of R&D-intensive manufacturing firms use target bank loans for innovation (rank 5). This reflects the fact that innovation expenditure in R&D-intensive manufacturing contains a much higher proportion of R&D than in other manufacturing. In other manufacturing the largest component of innovation expenditure consists of expenses for acquiring machines and other equipment. Since these components can be better used as collaterals, it is easier for firms in other manufacturing to use credits for financing innovation. A similar pattern, though at an overall lower level, can be found for knowledge-intensive services and other services. Like in other manufacturing, expenses for acquiring machines and software are by far the most important component of innovation expenditure in other services.

Compared to other industries, equity financing is relatively more important in knowledge-intensive services. About 4% of the firms have used equity financing to carry out innovation projects. Equity financing is thus the sixth most important source of finance whereas it is placed eight in the other three main sectors.

Table 5-1 depicts the financing structure of innovation by size class. The use of cash flow to carry out innovation increases with firm size. While 81% of small innovative firms with 5-9 employees use internal financing, it is more than 95% among the large firms with 500 and more employees. Small and in particular young firms more often lack internal finance to carry out innovation so that they are more dependent on other sources of finance.

In contrast, no clear size pattern arises for public subsidies. The proportion of firms that get public subsidies for financing innovation varies between 16% among firms with 250-499 employees and 26% among firms with 50-99 employees and large firms with more than 1000 employees. Surprisingly little differences stick out with respect to external financing among small and medium sized companies up to 500 employees. Compared to larger firms they even use external financing more often than larger firms. Of course this is correlated with the fact that larger firms usually have more cash at their disposal to finance innovation and thus have a lower demand for more costly external finance.

Figure 5-2. Sources of funding for innovation projects 2011-2013, by main sector

Source: ZEW, Mannheim Innovation Panel.

Table 5-1. Sources of financing of innovation in Germany 2011-2013, by size class

Number of employees	Cashflow	Public subsidy	Overdraft facility	Target loan	Share-holder loan	Public loan	Supplier credit	New equity	Other comp. (VC)	Bonds
5-9	81	18	18	14	12	6	4	3	0.5	0.3
10-19	83	23	15	15	11	8	6	2	0.6	0.0
20-49	84	23	14	13	7	9	7	2	0.6	0.2
50-99	82	26	14	16	5	9	6	5	0.6	0.0
100-249	89	24	17	13	7	10	9	2	0.2	0.3
250-499	91	16	18	11	10	10	12	3	0.4	0.6
500-999	95	19	9	10	7	9	7	3	1.4	0.2
1,000+	95	26	10	13	8	7	7	3	3.3	1.7

Source: ZEW, Mannheim Innovation Panel.

With respect to other sources of finance for innovation, we find that shareholder loans play a more important role among small firms between 5-19 employees than for medium-sized and large enterprises. In contrast, supplier credits and leasing are more important for medium-sized firms. Among medium-sized firms with 100-499 employees, this type of finance is

equally important as targeted bank loans. Both new equity as well as bonds are instruments that are mainly used by large firms to finance innovation.

5.2 Extent of Financial Constraints for Innovation

The lack of finance can hamper innovation activities in several ways. On the one hand, firms might be forced to prolong existing innovation projects resulting in a delay of the introduction of new products and processes. On the other hand, firms might decide to abandon innovation projects or not even start planned projects. In both cases firms sacrifice innovation due to lack of finance. The second set of questions in the 2014 survey asked firms whether they have refrained from innovating due to the lack of finance and if so to characterize the innovation projects that were not implemented. The questions related to the impact of lack of finance were newly introduced in the 2014 survey. Thus, they cannot be compared with previous waves.

Due to the lack of finance, 13% of all firms have refrained from implementing at least one (additional) innovation project in the period 2011-2013 (see Figure 5-3).[8] This does not imply that the share of innovators would have increased by 13 percentage points. Among these firms are those that were still were able to implement at least one other innovation project. Indeed, the share of firms that have given up innovation projects due to insufficient financing is higher among innovative firms than among non-innovative firms. 18.5% of innovative firms have sacrificed additional innovation projects compared to 8% of non-innovative firms which have abstained from innovating.

A previous study using MIP data has shown that financial constraints do not depend on the availability of internal funds per se but that they are driven by innovative capabilities through increasing resource requirements. That is especially those firms with high innovative capabilities are financially constrained (Hottenrott and Peters, 2012). Innovative capabilities describe a firm's ability to generate and pursue new innovation project ideas. Hence, it is not surprising that firms in R&D-intensive manufacturing most frequently refrain from implementing (additional) innovation projects (25%), followed by firms from other manufacturing (14%). In knowledge-intensive services, every tenth firm has sacrificed (additional) innovation due to lack of finance.

With respect to firm size, a u-shaped pattern sticks out. That is, we find an equally strong impact of lack of finance for small firms with 5-19 employees and large firms with more than 1000 employees. In both groups, roughly every sixth firm has not implemented innovation projects due to financial constraints. In particular, the group of small innovative companies sacrifices additional innovation projects. About 22% of innovative firms with 5-19 employees have given up additional innovation projects due to lack of finance.

8 This does not imply that the share of innovators would have increased by 13 percentage points. Among these firms are innovative firms that have given up additional innovation projects.

Figure 5-3. Not implemented innovation projects due to lack of finance 2011-2013, by main sector and size class

Source: ZEW, Mannheim Innovation Panel.

When firms are forced to give up (additional) innovation projects due to the lack of finance, they mainly sacrifice product innovations that are associated with entering new market segments or thematic areas. These innovation projects are usually associated with extraordinarily high risks as firms might also lack relevant know-how about the demand, market and/or technology when they act outside their usual product market. They furthermore often lack a good competitive position. On the other hand, by opening up new market (segments) these innovations could offer a great potential for firm's future profitability. Nearly half of all financially constrained firms (49%) report that they have refrained from implementing (additional) innovation that mark entry into new market segments or thematic areas, for an additional 25% of financially constrained firms this partly applies (see Figure 5-4).

Pursuing the strategy to enter new markets is often associated with addressing new customers need. Hence, it is not surprising that high market and customer proximity is placed second in this ranking of innovation characteristics. Although, of course firms can also introduce new products on their usual product market that are particularly tailored towards customer's needs. 44% of firms have given up innovation projects that were aimed at better serving customer's needs. For an additional 37% of firms this partly applies. Taken together, market and customer proximity is even more important than entering new markets (75%).

40% of the firms indicated that the innovation projects they have refrained from due to financial constraints were characterized by a high degree of technological novelty. A higher degree of technological novelty is in general associated with higher innovation costs. Less

frequently financially constrained firms have given up innovation projects that are characterized by high uncertainty about feasibility or market acceptance (32%).

Figure 5-4. Characteristics of innovation projects not implemented due to lack of finance 2011-2013

Source: ZEW, Mannheim Innovation Panel.

As Figure 5-5 shows, there exist sector-specific differences in the type of innovation projects firms sacrifice due to the lack of finance. Whereas firms from R&D-intensive manufacturing (50%), other manufacturing (58%) and other services (49%) most frequently refrain from implementing innovation projects that are associated with entering new market segments or thematic areas, knowledge-intensive service most often give up innovation projects aimed at better serving customer's needs (44%). Taking also those firms into account for which the attribute partly applies, this pattern just reverses. To conclude, in all sectors firms innovations that are aimed at entering new markets or better addressing customers' needs are most affected by financial constraints. Other manufacturing is an exemption in a sense that renunciation of innovations with a high degree of novelty is in second place. In all four sectors firms least frequently abstain from implementing innovation that are characterized by a high degree of uncertainty about feasibility and market acceptance.

Financial constraints hamper market entry activities in particular among smaller firms with up to 99 employees. Roughly 50% of financially constrained firms in this group have given up innovation projects aimed at entering new markets or new thematic areas. In contrast, only 42% of the large constrained firms decided to give up innovations into new markets or thematic areas. The smallest proportion of firms, however, is found among medium-sized firms. Only 38% of financially constrained firms with 100-249 employees decide not to further pursue high-risk innovations into new markets or thematic areas. Furthermore, small and medium-sized firms more frequently give up innovation projects that are associated with a high degree of technological novelty. Summing up those firms for which this attribute fully or partly applies, the renunciation of innovations with a high degree of novelty becomes the most likely outcome for firms with 50-249 employees (80%). In contrast, larger firms with 250 and

more employees are most likely to refrain from innovation better addressing customers' needs.

Figure 5-5. Characteristics of innovation projects not implemented due to lack of finance 2011-2013, by main sector

Source: ZEW, Mannheim Innovation Panel.

5.3 Effect of Additional Internal Finance on Innovation

It is often argued that the lack of finance constrains firms in carrying out innovation projects. If they had more financial means they would invest more in innovation. However, as mentioned before, the lack of finance is not a constraint per se. It only becomes a financial constraint for innovation when firms have innovative ideas to develop and pursue (Hottenrott and Peters, 2012). Hall (2008) developed an ideal test for identifying financially constrained firms. It is based on the idea to give the firm additional cash exogenously and observe how it spends it (investments in innovation, investments in physical capital, dividend payments, re-

tained earnings or serving debts). If the firm chooses to spend it on innovation, it must have had some unexploited investment opportunities that were not profitable using more costly external finance. Only those firms that would use additional cash for financing innovation are in fact financially constrained (Hall, 2008; Hottenrott und Peters, 2012). The 2014 survey mimics this test as a quasi-experimental setting. It asked firms how they would spend additional windfall cash of about 10% of last year's turnover. Firms could choose one or multiple of the five options.

23% of the firms would use additional cash completely or partly for (additional) innovation activities. That is, about every fourth firm has been financially constrained at the time the survey was conducted (spring 2014). Based on this indicator, financial constraints are even more important compared to the previous subsection in which we used the proportion of firms that have not implemented innovation in 2011-2013 due to the lack of actual finance. Compared to 2007 when we observed a corresponding share of 27%, financial constraints have become a little less important after the financial crisis. Conversely, these numbers show that many firms are not short of financial means for innovations and the introduction of new products or processes does not fail because of lack of finance.

Figure 5-6. Use of additional cash (10% of last year's revenue), 2014

Source: ZEW, Mannheim Innovation Panel.

Most firms would spend the additional cash at least partly for investments in physical capital (46%). This proportion, however, has fallen significantly compared to 2007 (minus 11 percentage points). At the same time, we observe that more firms are unsure about how to spend the additional cash. This proportion of firms has increased from 8 to 17%. One likely explanation are the low dynamics in terms of demand growth rates observed on many markets coupled with a high uncertainty about future demand development. Under these circumstances even windfall cash is not incentive enough to stimulate additional innovation activities since there are other more attractive uses of cash.

For other uses of cash we only find little differences before (2007) and after the financial crisis (2014). 46% of firms would use additional cash to increase retain earnings (+2 percentage points), 37% of firms would pay back debts and 21% would pay out the money to shareholders (minus 1 percentage points each).

Figure 5-7 and Table 5-2 show the use of additional cash by size classes. Overall, the use of additional cash is pretty similar across size classes and we see only little size-specific differences. Surprisingly, though, we find smaller firms with 5-49 employees to be less financially constrained than medium-sized or large firms. Among smaller firms, the proportion of financially constrained firms varies between 17% for firms with 5-9 employees[9] and to 26% for firms with 20-49 employees. This proportion rises to 29% to 34% among medium-sized firms and 35% to 44% among large firms. For small firms, this ideal test identifies roughly the same proportion of firms that are financially constrained as the one in section 5.2. For medium-sized and larger firms, however, this indicator identifies a much larger innovation potential due to financial constraints than the indicator that is based on how many firms have not implemented innovation due to lack of finance. Interestingly, Figure 5-7 also shows that larger firms would use additional cash more often for paying dividends whereas small firms below 20 employees would use the additional money primarily to build up reserves.

Figure 5-7. Use of additional cash (10% of last year's revenue) 2014, by size class

Note: In % of all firms.

Source: ZEW, Mannheim Innovation Panel.

9 This share is roughly the same as the share of firms that have not implemented innovation due to lack of actual finance (see section 5.2).

Table 5-2. Use of additional cash (10% of last year's revenue) 2014, by size class

Number of employees	General investment	Innovation	Retain earnings	Dividend payment	Pay back debts	Indecisive
5-9	40	17	45	21	35	18
10-19	47	23	49	21	41	16
20-49	50	26	41	20	37	17
50-99	57	34	47	21	31	15
100-249	52	29	47	24	32	17
250-499	48	32	51	27	38	18
500-999	46	35	47	35	31	20
1,000+	54	44	45	34	34	19

Note: In % of all firms.

Source: ZEW, Mannheim Innovation Panel.

In contrast to size, we observe striking differences how firms in the four main sectors would spend additional cash (Figure 5-8). Almost every second firm in R&D-intensive manufacturing is financially constrained and would spend additional cash at least partly for financing (additional) innovation. The unused innovation potential is thus largest in R&D-intensive manufacturing and has even slightly increased compared to 2007 (48% compared to 45%). This holds for all four industries in this sector to a similar extent, with a share varying between 49% in electronics, 48% in chemicals, 47% in machinery and 46% in vehicles. In other manufacturing and knowledge-intensive services 23% and 22% of the firms would spend additional cash for investing in innovation.

Figure 5-8. Use of additional internal finance (10% of last year's revenue) 2014, by main sector

Source: ZEW, Mannheim Innovation Panel.

Within knowledge-intensive services computer and telecommunication stick out: 43% of firms are financially constrained and have unexploited innovation potential. This share is

comparable to R&D-intensive manufacturing firms. Among other manufacturing, financial constraints are highest among firms in the plastics and rubber industry (35%) as well as in textiles (28%). In contrast, only one out of eight firms in utilities/mining/petroleum production, water/sewerage/waste management or transport/postal activities are financially constrained in innovation activities.

Differences across sectors can also be observed for other usages although they are less distinctive than for innovation. For instance, 62% and 57% of firms from R&D-intensive and other manufacturing would spend additional cash for investments in physical capital. This proportion is significantly smaller for other and knowledge-intensive with 40% and 37%, respectively. In contrast, service firms would mainly use additional for building up reserves. Compared to manufacturing they would also use the money more often for paying shareholders. After investments in physical capital, paying back debts is the second most important use of additional cash in other manufacturing.

Figure 5-9. Implementation of additional innovation activities in case of additional cash among non-innovative firms 2014, by main sector and size class

Source: ZEW, Mannheim Innovation Panel.

From a policy point of view it is particularly interesting to know about the unexploited innovation potential among currently non-innovative firms. Figure 5-9 depicts the proportion of non-innovative firms that would spend additional windfall cash at least partly for financing innovation, separately by sector and size class. In total, one out of ten firms is financially constrained and would spend additional cash for innovation. On the other hand, this implies that nine out of ten firms do currently see no need to act on innovation. This might either be because they lack firm-specific innovative capabilities and are thus not able to identify profita-

ble innovation projects or because they technological opportunities. Another explanation might be that there is no or only low demand for new products and processes (which might be a result of prior innovations).

5.4 Use of Additional External Finance

Finally, firms were asked whether they would also implement additional innovation and investments in physical capital if they were provided with a loan of the same amount (10% of last year's turnover) with a comparably low interest rate. Implementing innovation activities not only with additional windfall cash but also with more costly external finance is likely to identify those firms which have a particularly high innovation potential as the expected benefits from innovating must be higher to cover the higher costs of external financing. The higher costs of external financing should be understood in a broader sense. In addition to the interest rates that firms have to cover, firms "pay" for external finance by a higher risk of knowledge leakage of innovative ideas and by less independence in decision making.

Figure 5-10. Use of additional low-interest loans instead of additional cash for financing additional investment and innovation 2014, by main sector and size class

Source: ZEW, Mannheim Innovation Panel.

Whereas 23% of firms would spend additional cash for investing in innovation, only 8% of firms would stick to this decision when they are provided with a low-interest loan. Among these 8% of firms, 2% of firms would spend the loan completely for innovation and 6%

would spend it for innovation and investment in physical capital simultaneously (see Figure 5-10). This pattern is consistently observed for all sectors and size classes with only minor differences. Firms in R&D-intensive manufacturing are the only exception. 16% of the firms and thus nearly twice as many firms as in the overall sample would make use of a low-interest loan offer to finance innovation.

Finally, Figure 5-11 illustrates the proportion of firms that would use a low-interest loan for innovation in relation to those firms that would use additional cash for innovation. Only about one out of four firms (27%) that use additional cash for financing innovation would also pursue the innovation project with external finance.[10] This discrepancy reflects the unobserved desire to be independent of external investors and to avoid knowledge leakage. The 2007 survey revealed that high interest rates and lower independence are almost equally important for refraining from innovating using external finance (see Aschhoff et al., 2013). In particular, family firms have a strong preference against losing control rights to external investors (Peters and Westerheide, 2011).

Figure 5-11. Proportion of firms with loan-financed innovation activities among all firms with cash-financed additional innovation activities, by main sector and size class

Source: ZEW, Mannheim Innovation Panel.

10 Note that a few firms indicated loan-financed but not cash-financed additional innovation projects

In contrast to Figure 5-10, we observe strong differences across size classes in Figure 5-11 when we restrict our comparison to the group of firms that would use additional cash for innovation. The willingness to use external finance for financing innovation is highest among small firms with 5-9 employees (31%) and 10-19 employees (29%) and is decreasing with increasing firm size (with firms with 100-249 employees being an exception). Among large firms with 1000 and more employees only 10% of firms would use additional external finance for innovation. This is in line with results in section 5.1 showing that large firms have used short- and long-term external finance less frequently for financing actual innovation projects.

5.5 Public Funding for Innovation

As already seen in subsection 5.1 public subsidies have become an increasingly important source of financing for innovation. In the ranking of sources used, public subsidies are currently placed second after internal finance in the period 2011-2013. This section reports in more detail results about the public funding structure. Information about public financial support for innovation by funding body is usually biannually asked in the MIP. For the period under consideration, we compare results from the 2013 and 2015 surveys which relate to public funding in the period 2010-2012 and 2012-2014, respectively.

Figure 5-12 shows that the proportion of firms that has received public funding (public grants, public subsidized loans, equity and guarantees) in the period 2012-2014 has slightly decreased from 18 to 17%. This slight decline has been observed for all different public funding bodies so that the overall funding structure has remained remarkably constant over both periods. The most important funding body is the federal government. 11% of all innovative firms received funding from at least one federal ministry (including authorized agencies) in 2012-2014. This share has declined by 2 percentage point between 2010-2012 and 2012-2014.

Within the federal government, the Federal Ministry of Economics and Technology (BMWi) is the most frequent funding body. 7% of all innovative firms in Germany received funding from one of the BMWI's funding programmes of which the Central Innovation Programme for SMEs (ZIM) is the single most important one. The Federal Ministry of Education and Research (BMBF) which runs a number of thematic R&D programmes ('*direkte Projektförderung*') is the second main funding body at the federal level. 5% of all innovative firms benefitted from financial support through one of the BMBF's funding programmes. The share of firms that received public financial support from the state government remained constant at about 5%. Another 4% of the firms successfully applied for European funding, among them 2% received funding within the EU Framework Programme for Research and Technology Development.

Figure 5-12. Public financial support to innovative firms by public funding body, 2010-2014

Source: ZEW, Mannheim Innovation Panel.

Figure 5-13. EU, federal and state financial support to innovative firms, 2004-2014

Source: ZEW, Mannheim Innovation Panel.

Figure 5-13 illustrates the long-run development of public funding between 2004 and 2014. The overall share of firms that received public financial support for innovation substantially increased in this period from 12% in 2004-2006 to 17% in 2012-2014. The increase in the overall share of subsidized firms took place in the first half the period between 2004 and 2010. It was mainly driven by a sharp increase in federal funding and to a lesser extent by

state funding. In contrast, the share of firms receiving public funding from the EU remained constant in the first half of the period. In the second half of the period after the financial crisis we observe a slight decrease in the overall share of funded firms. A fall in the share of state-funded firms is the major driver and it was reinforced by a fall in federal funding in the last three year 2012-2014. In contrast, EU funding has slightly gained importance since 2010.

Figure 5-14. Public financial support to innovative firms 2010-2014 by public funding body and main sector

Source: ZEW, Mannheim Innovation Panel.

Figure 5-15. Public financial support to innovative firms 2010-2014 by public funding body and size class

Source: ZEW, Mannheim Innovation Panel.

Figure 5-14 shows the share of funded firms by funding body and by main sector. Not surprisingly, the share of publicly funded firms is highest in R&D-intensive manufacturing, followed by knowledge-intensive services. Most striking is the strong decline of 7 percentage points in the proportion of publicly funded firms between 2010-2012 (42%) and 2012-2014 (35%) in R&D-intensive manufacturing. At the same time, we observe a shift towards knowledge-intensive services. The share of knowledge-intensive firms that have received public funding has risen from 17% to 20%. A similar shift towards services is observed between other manufacturing and other services. Despite differences in the level of funded firms, we find a similar funding pattern across sectors. In all sectors, the federal government

is the major actor for providing firms with public funding. BMWi funding is the single most important funding source for all sectors except for knowledge-intensive services which obtain most funding through BMBF subsidy programmes. In all sectors state funding comes second, followed by EU funding. Only other services exhibit a higher share of EU-funded firms than state-funded firms.

The proportion of firms receiving public funding significantly increases with firm size for all funding bodies as can be gathered from Figure 5-15. Among firms with 5-9 employees only 12% of innovative firms received public support to finance innovation. In contrast, 45% of large firms with more than 1,000 employees used public subsidies to finance innovation. Among firms with 10-499 employees the share of funded firms varies between 17% and 23%. When comparing these numbers one should keep in mind that the public funding usually covers a larger share of total innovation expenditure in small firms compared to medium and large firms. Hence, looking only at the share of funded firms we probably underestimate the contribution of public funding in total innovation expenditure for small firms.

6 Innovation Networks

Knowledge is a key factor for generating innovations, which ensure firms' competiveness. The need for knowledge and the resulting innovations has increased in the face of more complex innovation processes, the recent business cycle turbulences, shorter innovation cycles, and increased international competition. Furthermore, the necessity for knowledge increases in the degree of novelty. Since valuable knowledge increasingly arises outside of firms, they do not have to rely solely on knowledge and capabilities within the firm. Instead, firms also use external knowledge sources (Tidd et al., 2000; von Hippel, 1988). By interacting with third parties, on the one hand, firms can better estimate the demand and align their innovation activities to the needs and requirements of the market. On the other hand, a technology push can be fostered by complementing own capabilities and knowledge with external partners. Connecting external knowledge sources with in-house activities is crucial for firms to fully exploit their R&D and innovation capabilities (Laursen and Salter, 2006). In the literature, the opening up of the innovation process is also known as open innovation (Chesbrough, 2003b).

In this chapter, we provide an overview of three aspects regarding firms' external links: (1) the *information sources* firms use for their innovation projects, (2) the involvement of firms in *innovation cooperation* as a specific and important type of interaction, and (3) the extent to which firms' *innovations* are finally the *result of collaboration* with external partners. Innovation depends on the access to information. However, internal information is often not sufficient. For this reason, firms use knowledge from both internal and external sources. In order to assess the extent to which firms seek knowledge from specific sources, we use a corresponding question from the MIP questionnaire of 2013. Firms were asked to indicate the use and the importance of 14 different information sources for generating innovative ideas or for improving innovation projects.

External information can be acquired through a broad variety of different channels, including joint research projects, consulting and contract research, licensing contracts, personnel exchange, and informal interaction between scientists of different firms or institutions (D'Este and Patel, 2007; Schartinger et al., 2002). In case external knowledge is not accessible, transferable or requires adjustments, a formal way to exchange knowledge, thus to complement internal knowledge, is by cooperation in innovation projects. Two other important input-related motives are cost- and risk-sharing (Hagedoorn, 1993; Cassiman and Veugelers, 2002). In a cooperative project, two or more parties jointly work on a specific topic with a defined goal. Usually the partners agree beforehand about the inputs and tasks of each partner and predetermine the ownership of the results. Cooperative agreements in innovation are a common and important type of interaction (Hagedoorn, 2002).

Several studies provide evidence for the positive effect of (specific) cooperation on firms' innovation output (Aschhoff and Schmidt, 2008; Belderbos et al., 2004a; Tether, 2002). Furthermore, in all highly developed countries, public support policies explicitly encourage cooperation in R&D and innovation projects between different actors, in particular between firms and science. The questionnaires of 2013 and 2015 include the same question about a

firm's involvement in R&D and innovation cooperation. After indicating whether or not a firm cooperates at all, firms were asked about the type of partner such as suppliers or universities and about the location of the partner. Moreover, the firms had to specify the most valuable type of partner for the firms' innovation activities. As a consequence, firms' innovations are not necessarily developed by the firms themselves but may be developed in collaboration with third parties. In the last section of this chapter, we review to what extent firms' product and process innovations, respectively, were finally developed in collaboration with third parties. Please note that collaboration is not restricted to formal cooperation but also includes more loosely defined types of interactions. A corresponding question is included in the questionnaires 2013 and 2015 as well.

6.1 Use of Information Sources for Innovation

There are many different sources of information for innovation. In the 2013 questionnaire, the firms were asked about the following 14 sources, which can be separated into four main groups: (1) internal sources: within enterprise or enterprise group, (2) market sources: customers/clients of the business sector, customers/clients of the public sector, suppliers, competitors, consultancies/consulting engineers, (3) institutional sources: universities/universities of applied sciences, public research institutes, private research institutes/R&D service providers, and (4) other sources: conferences/trade fairs/exhibitions, scientific journals/trade/technical publications, associations/chambers, patent specifications and standardisation committees/documents. The firms were asked to indicate the importance the respective source had on (potential) innovation activities of the period 2010-20102. That is, the firms were asked to report whether or not the respective source had a low, medium or high importance for the generation of ideas for new innovation projects or for the general conduct of innovation projects. Please note that the question was only addressed to firms that stated to have been innovation-active between 2010 and 2012.

According to Figure 6-1, innovating firms most frequently used information available within their own enterprise or enterprise group for their innovation projects (85 percent). Market sources were also widely used. More than three out of four innovating firms uses customers and clients of the business sector as information sources. 74 percent of the innovating firms relied on information from competitors and 73 percent on information from conference attendance as well as from scientific journals. Only slightly fewer firms used their suppliers as information source (70 percent). This is followed by associations (58 percent), customers and clients of the public sector (49 percent) and consultancies (43 percent). Institutional sources were less frequently used. 43 percent of the firms retrieved their information from universities, while 26 percent and 28 percent of the firms used public and private research institutes as information source, respectively. Standards (32 percent) and patent specifications (24 percent) were also used by less than one out of three innovating firms as an information source.

Although innovating firms used a large variety of information sources the contribution of specific sources to innovation projects was rather limited. There were two sources seeming to have been most effective. 49 percent of the innovating firms declared their own enterprise or

enterprise group as a highly important provider for information. Business sector customers and clients played a highly important role as information source for one out of three innovating firms. These two sources were also most frequently used. All other sources seem to have been far less important as an information source for innovation, thus their use tend to be less efficient. Only three information sources, competitors (13 percent), conferences (15 percent) and suppliers (15 percent) were highly important for 10 to 15 percent of the innovating firms, even though at least 70 percent of these firms actually retrieved information from these sources. Less than 7 percent of the innovating firms appreciated consultancies (6 percent), universities (6 percent), standards (4 percent), public research institutes (3 percent), private research institutes (2 percent) and patent specifications (1 percent) as highly important information source. Hence, it rather seems that knowledge of the science sector is far from applicability and not ready for usage in the firms' innovation projects.

Figure 6-1. Importance of information sources for innovation activities, 2010-2012

Source: ZEW, Mannheim Innovation Panel.

Overall, the ranking of highly important information sources remains rather robust to different sector groups and size classes (Figure 6-2). All subgroups ranked their own enterprise and enterprise group, respectively, as most important source. Due to the larger need for information, firms of the R&D-intensive manufacturing sector used a broader range of information sources than firms of the other manufacturing sector. Exceptions include scientific journals, suppliers, consultancies and associations. A similar strict pattern appears for firms of the knowledge-intensive services sector in comparison to firms of the other services sector. Exceptions are customers and clients of the business and public sector as well as conferences

and suppliers. These sources have more frequently been stated as highly important by firms of the other services sector than by firms of the knowledge-intensive sector.

Figure 6-2. Highly important information sources for innovation activities, 2010-2012, by main sector group and size class

Source: ZEW, Mannheim Innovation Panel.

The larger the innovating firm the more often it stated that the own enterprise and enterprise group, respectively, was a highly important information source. While about two-thirds of firms having at least 250 employees stated that the own enterprise and enterprise group, respectively, was a highly important source, this share amounts to 46 percent for firms having less than 50 employees. This basic relationship also holds for customers and clients of the business sector and for universities. That is, the larger the firm the more often were the business sector customers and clients and universities a highly important information source.

6.2 Innovation Cooperation

In comparison to gathering information from different sources, cooperation implies a formalised and more target-oriented exchange of knowledge. Furthermore, external knowledge is being adjusted to the firms' needs. In the questionnaire, innovation cooperation is defined as an active participation with other firms or institutions on innovation activities. Thereby, both

partners do not need to commercially benefit from the collaboration. Mere contracting out of work with no active cooperation is excluded. Only firms with innovation activities answered this question.

During 2010 and 2012, 18 percent of the innovating firms cooperated with at least one partner on any of their innovation projects (Figure 6-3). In particular, firms of the R&D-intensive manufacturing sector seem to have had a strong demand for external knowledge and were more likely to cooperate with other firms or institutions. The share of cooperating firms of the R&D-intensive manufacturing sector (36 percent) is substantially larger than the corresponding share of the firms of the knowledge-intensive sector (22 percent) and of the other manufacturing sector (19 percent). The likelihood to cooperate was lowest for firms of the other services sector (6 percent). With respect to size, the larger the firm the more likely it was involved in cooperation. While almost 80 percent of the firms having at least 1,000 employees cooperated, only 15 percent of firms with less than 50 employees are engaged in innovation cooperation.

Figure 6-3. Involvement in innovation cooperation, 2010-2014, by main sector group and size class

Source: ZEW, Mannheim Innovation Panel.

Overall, the share of innovating firms that were engaged in innovation cooperation remains robust over the observed periods 2010 to 2012 and 2012 to 2014. A notable development is that the innovating firms of the more recent period were less likely to be involved in innovation cooperation, i.e. 17 percent in 2012-2014 as compared to 18 percent in 2010-2012. This also holds for each regarded sector group and size class.

Firms were also asked to state the type of cooperation partner. The question considered nine possible cooperation partners: enterprises within own enterprise group, business sector clients, public sector clients, suppliers, competitors and other enterprises of the sector, consulting firms and consulting engineers, universities, public research institutes and private research institutes. Firms may cooperate with more than one type of partners. Figure 6-4 indicates that universities were the most frequently used cooperation partner. 57 percent of the firms that were involved in innovation cooperation between 2010 and 2012 chose universities as partners. This implies a strong link between universities and firms. Suppliers (41 percent) and business sector clients (38 percent) were chosen less frequently as innovation partner. However, more than one out of three cooperating firms chose either type. The remaining types of partners were rather equally likely to be chosen as cooperation partner. About 25 percent of the firms involved in innovation cooperation chose public and private research institutes, consultancies, competitors and enterprises of the own enterprise group as cooperation partner. The lowest likelihood of becoming a cooperation partner had public sector clients. Only 18 percent of the cooperating firms chose clients of the public sector as partner.

Figure 6-4. Type of cooperation partner, 2010-2014

Source: ZEW, Mannheim Innovation Panel.

The share of innovating firms having been engaged in innovation cooperation remains largely robust to the observed periods again. The main difference is that the firms were more likely to choose universities and private as well as public research institutes as a cooperation partner between 2012 and 2014 compared to the period of 2010 to 2012. Furthermore, coopetition, i.e. cooperation with competitors (Brandenburger and Nalebuff, 1996), considerably decreased from 23 percent in the period of 2010 to 2012 to 15 percent in the period of 2012 to 2014.

The order of the most important cooperation partner largely coincides with the order of the frequency of the respective type of cooperation partner (Figure 6-5). It's not just that universi-

ties were the most frequently chosen cooperation partner they were also declared to be the most important partner. Furthermore, the development of the firm shares is similar as well in that universities were also more frequently declared as the most important cooperation partner in 2012-2014 than in 2010-2012. Almost one out of three cooperating firms assigned universities as the most important partner during 2012-2014, while the corresponding share of the period 2010 to 2012 amounts to 28 percent. Business sector clients (17 percent) and suppliers (14 percent) follow as the most important cooperation partner in 2010 to 2012. This order turns when considering the period 2012 to 2014 where suppliers were slightly more important (16 percent) than business sector clients (15 percent).

Figure 6-5. Most important type of cooperation partner, 2010-2014

Source: ZEW, Mannheim Innovation Panel.

This is in contrast to the order of the most frequently chosen cooperation partner (Figure 6-4), where the 2012-2014 shares of business sector clients and suppliers did not exceed the respective values of 2010-2012. A similar divergent development between the shares of the frequently chosen partner and the most important partner appeared in the enterprises of the own enterprise group and in public sector clients as cooperation partners. The importance of the former type of partner increased by one percentage point between 2010-2012 (11 percent) and 2012-2014 (12 percent). The importance of the latter type of partner also increased by one percentage point between 2010-2012 (2 percent) and 2012-2014 (3 percent). However, a reverse development between the shares of the frequently chosen partner and the most important partner has taken place in public research institutes as cooperation partner. The respective share of the most important cooperation partner decreased by two percentage points from 8 percent in 2010-2012 to 6 percent in 2012-2014.

With respect to universities, these findings seem to contradict the results regarding highly important information sources at first glance. On the one hand, universities were far less frequently used as information source and were considered less often as highly important than

the own enterprise group and other market participants, as for instance, business sector customers, competitors and suppliers. On the other hand, universities were more often chosen as cooperation partner than other types of partners and were declared more often as most important partner. This pattern supports the view that knowledge from the science sector is usually not ready to use and easy to apply. It needs to be further developed and adjusted in order to satisfy firms' needs. Once this is done, the knowledge is very valuable for firms' innovation activities (Aschhoff and Schmidt, 2008; Belderbos et al., 2004a; Siegel et al., 2004).

6.3 Product and Process Innovation Based on Collaboration

In order to determine to what extent collaboration finally contributes to a firm's innovation output, innovating firms were asked to indicate whether or not the product and process innovations they introduced in the previous three year period had been developed in collaboration with other enterprises and institutions, respectively. Collaboration is not restricted to formal cooperation but also captures other types of interactions, e.g. the use of customer inputs for the development of new products, close interaction with technology providers to adjust firms' innovation processes and informal exchange of knowledge with academic scientists to solve a specific problem. In the questionnaires of 2013 and 2015, the following four response items were given: own enterprise by itself, own enterprise together with third parties, own enterprise by adapting products developed by others and other enterprises or institutions. Multiple answers were possible.

Figure 6-6. Development of product and process innovation, 2010-2014

Source: ZEW, Mannheim Innovation Panel.

Figure 6-6 presents an overview on the collaboration type innovating firms used to develop their product and process innovations, respectively, implemented between 2010-2012 and 2012-2014. Most frequently, the enterprise that implemented the respective type of innovation developed it on its own without a collaborator. Between 2010 and 2014 more than 50 percent of the product and process innovators, respectively, declared that their innovations were developed by their own enterprise. While that share slightly increased from 55 percent in 2010-2012 to 60 percent in 2012-2014 for product innovations, it slightly decreased from 54 percent to 52 percent over the same two periods. However, about 40 percent of the product and process innovators, respectively, stated that they used an external collaboration partner to develop the respective innovation. The corresponding shares of both, product and process innovators, increased by three and two percentage points, respectively, between 2010-2012 and 2012-2014. The remaining two types of collaboration were used not nearly as frequently as the first two types. However, it is notable that the implemented product and process innovations between 2012 and 2014 were more frequently developed by other enterprises or institutions than in the period of 2010-2012 (16 percent and 13 percent, respectively compared to 17 percent and 13 percent, respectively).

As the innovators tend either to develop the product and process innovations within their own enterprise or with external partners, Figure 6-7 and Figure 6-8 differentiate the main sector group and size class of those innovators that did not use any collaboration partner and those that did use external partners, respectively. According to Figure 6-7, R&D-intensive product innovators did most frequently not rely on collaboration for the development of their product innovations. 72 percent of those innovators developed their product innovations within their own enterprise between 2010 and 2012. The respective share of product innovators among the other manufacturing firms (53 percent) and knowledge-intensive service firms (57 percent) is lower than the share of the R&D-intensive manufacturing product innovators. However, still more than every second product innovator of both sectors develop their product innovations on their own. The corresponding share only amounts to 41 percent for product innovators of the other services sector. With respect to firm size, the larger the product innovators the larger the likelihood that they did not collaborate in terms of product innovation development. While the respective share amounts to 52 percent for firms having less than 50 employees, the share gradually increased to 70 percent for firms having at least 1,000 employees. These very basic relationships also hold for the period of 2012-2014 as well with even larger magnitudes of each subgroup's shares.

Similar relationships appear for the group of process innovators as well. A notable difference is that process innovators of the other manufacturing sector were most unlikely to collaborate between 2010 and 2012 compared to innovators of other sectors. Only 47 percent of these process innovators did not collaborate, while the share amounts to 58 percent for the knowledge-intensive process innovators and 49 percent for the process innovators of the other services sector. Overall, it appears for the period of 2010-2012 that process innovators of the service sector relied more frequently on collaboration than product innovators of the service sector. This relationship, however, does not hold for process and product innovators of the manufacturing sector and it also ceases to hold for the period of 2012-2014. Another differ-

ence is that process innovators having 50 to 249 employees were most unlikely to collaborate compared to process innovators of other size classes. The share of 52 percent is even lower than the 54 percent of the process innovators having less than 50 employees. In contrast to the case of product innovators, the magnitudes of the subgroups' firm shares are generally lower in 2012-2014 than in 2010-2012. The only exceptions are the process innovator share of the other manufacturing sector (47 percent in 2010-2012 and 50 percent in 2012-2014) and the share of the firms having between 50 and 249 employees (52 percent in 2010-2012 and 53 percent in 2012-2014).

Figure 6-7. Development of product and process innovation by the enterprises alone, 2010-2014, by sector group and size class

Source: ZEW, Mannheim Innovation Panel.

According to Figure 6-8 and in comparison with Figure 6-7, those types of product innovators that frequently relied on external collaboration also frequently developed their product innovations without collaboration. For instance, R&D-intensive product innovators and innovators of the other manufacturing sector were most likely to develop their new products in collaboration with others. In addition, larger product innovators were more likely as well. These basic relationships again hold for the periods 2010-2012 and 2012-2014. Overall, this similarity implies that – since answering this question allows for multiple answers – among the product innovators the development of some new products were more likely to be developed by the enterprise alone, while the development of some new products required external collaboration.

In contrast to the case of no collaboration among the process innovators (right panel of Figure 6-7), the process innovators that used external collaboration are not overly different in terms of sector affiliation. Between 2010 and 2014 about 40 percent of the manufacturing-oriented and services-oriented process innovators relied on external collaboration for the development of their new processes. Furthermore, larger process innovators were also more likely to use external collaboration for the development of the innovations than smaller firms, which is a very similar relationship to the process innovators that did not rely on external collaboration (right panel of Figure 6-7).

Figure 6-8. Development of product and process innovation by the enterprises with external collaboration, 2010-2014, by sector group and size class

Source: ZEW, Mannheim Innovation Panel.

7 Barriers to Innovation

Firms conducting innovation projects tend to be more productive (Griffith et al., 2006; Peters, 2008) and tend to have higher economic success (Czarnitzki and Kraft, 2010). Potential productivity gains due to innovation can arise from cost reductions, quality improvements, and larger mark-ups for product novelties. However, in attempting to execute innovation projects firms typically have to face and to overcome certain barriers, respectively. These barriers, for instance, can lead to a reduction or delay of innovation activities, which would weaken the firms' competitiveness. The question is which types of factors would potentially hamper firms' innovation activities and preventing them from becoming more productive and successful? Answering this question could be very useful for policymakers to encourage innovation by reducing those barriers. Typical barriers for firms to conduct their innovation projects smoothly are a *too high economic risk* and *too high innovation costs*. Since innovation projects are typically planned to run long-term, they are subject to a certain economic risk. It is not just that there are uncertainties about the technological feasibility but also about the expected resource effort and demand (for new products) prior to the project start. In addition, the existing economic risks are even enhanced in case of rival firms imitate the original innovators' innovations.

Under these circumstances, the innovating firms cannot fully appropriate all the profits accruing from their innovation projects. This hampers the innovators' incentive to eventually innovate. A related type of innovation barrier is too high innovation costs. This considers that firms typically have to invest a significant amount of financial resources to develop and implement their innovations the success of which is uncertain. This implies that for the firms it may be more promising to allocate those financial resources to the preservation or broadening of the already existing product portfolio and process technology, respectively, than to use it to finance an innovation project. Hence, in case the opportunity costs of postponing innovation projects are not high enough, the firm may shift some resources to the existing technologies and products, respectively. Except for these two primary project-specific innovation barriers, there can be further barriers that are inherent to the firm (Hadjimanolis, 2003). For instance, these include the lack of internal funding, organisational problems, internal resistance and the lack of technological and of market information.

Furthermore, firms' innovation activities can also be prevented and hampered by external factors, respectively. These include shortages on the labour, capital and technology markets. In particular, *external financing* of innovation projects typically requires a higher risk premium than the financing of investment in tangible assets. This surcharge is due to the uncertainty of success inherent to innovation projects, existing information asymmetries between innovators and financiers and the lack of sufficient collateral in case of project failure (Hall, 2002; Hall and Lerner, 2010). For these reasons, external financing is rarely provided for innovation projects and – if so – it is only available at prohibitively high costs. Other factors impeding firms' innovation activities include the *lack of qualified personnel* and the *lack of access to IPRs*. In addition, potential supply deficits on factor input markets and demand deficits on the firms' product markets can also be barriers for innovation activities. Low demand levels for

new products, e.g. due to *lack of demand or due to a potential market dominance by other firms*, does rather not result in high innovation profits, thus could lead to less innovation. External innovation barriers also encompass *legislation, long bureaucratic procedures* and *standards and norms*.

The effects of the identified innovation barriers can be very diverse. For instance, they can lead to the situation where firms do *not start particular innovation projects or do not start innovation activities* at all. Potential effects further include the *termination* and the *delay/prolongation* of on-going innovation projects.

As part of the 2007, 2011 and 2015 MIP surveys, firms were asked to indicate the effects of a number of innovation barriers. Please note that all, i.e. innovating and non-innovating firms, were asked. In these three questionnaires, it was asked whether or not the specific innovation barrier has caused a termination of on-going innovation projects, a delay/prolongation of on-going innovation projects, whether or not innovation projects were not started in the first place or if the barrier was irrelevant. In the 2007 MIP questionnaire, 13 different innovation barriers were asked, while the 2011 and 2015 questionnaires additionally asked for the effects of two more barriers: (i) standards and norms and (ii) the lack of access to IPRs. Furthermore, the 2015 MIP questionnaire for the first time additionally asked whether the specific innovation barrier's importance increased or not since 2012.

7.1 Prevalence of Innovation Barriers

Figure 7-1 presents an overview on the types of firms that had to face at least one innovation barrier during 2004-2006, 2008-2010 or 2012-2014. While only 37 percent of all firms during 2004-2006 reported that their innovation behaviour was affected by innovation barriers, this share strongly increased to 55 percent for the periods 2008-2010 and 2012-2014. This big difference seems to be rooted in the non-innovating firms. In 2004-2006, only 13 percent of the non-innovators were affected by innovation barriers, while the corresponding shares were more than twice as large in 2008-2010 (33 percent) and 2012-2014 (39 percent). The difference among the innovating firms is less substantial. In 2004-2006, 60 percent reported to have been affected by barriers, while in 2008-2010 and 2012-2014 the shares amount to 72 percent and 73 percent, respectively. A potential explanation for the upsurge of innovation barriers for non-innovating firms over the periods may be that more and more non-innovating firms developed serious ambitions to innovate.

Figure 7-2 shows potential sector differences of the firm groups that were affected by innovation barriers. Across all observed periods and in comparison to other sectors, R&D-intensive manufacturing firms had the highest probability of being affected by innovation barriers. At least 58 percent of all R&D-intensive manufacturing firms in all periods were affected by at least one barrier, while the corresponding share was only surpassed of other manufacturing firms in 2008-2010 and 2012-2014. Innovation barriers were most important to innovating firms of the R&D-intensive manufacturing sector for each period. 66 percent of these firms were affected by innovation barriers in 2004-2006, while this share increased to 75 per-

cent (73 percent) in 2008-2010 (2012-2014). The barriers also impaired the innovation activities of the innovating firms of all other sectors very frequently. For instance, at least two out of three innovating firms across all sectors were affected by innovation barriers in 2008-2010 and 2012-2014. The corresponding shares amount to at least 56 percent for innovating firms of the period 2004-2006. A similar pattern appeared among the non-innovating firms. That is, R&D-intensive manufacturing non-innovating firms – in comparison to non-innovating firms of other sectors – were in each period the most frequently affected ones: (i) 2004-2006 (21 percent), (ii) 2008-2010 (40 percent) and (iii) 2012-2014 (53 percent). Overall, the results reveal that manufacturing firms (innovating and non-innovating) typically have to face barriers to their actual and potential innovation activities. Barriers seem to be a bit less relevant to firms of the service sector.

Figure 7-1. Barriers to innovation, 2004-2014, by firm group

Source: ZEW, Mannheim Innovation Panel.

While Figure 7-2 differentiates by main sector groups, Figure 7-3 presents the relationship between each firm group's frequencies of being affected by innovation barriers differentiated by the firms' size classes measured as number of employees. Since the share of firms conducting innovation activities increases by firm size and innovating firms are more likely to face innovation barriers than non-innovating firms, it is not surprising that the share of firms being affected by barriers also increases by firm size. In the period 2004-2006, for instance, the share of innovating firms the innovation activities of which were impaired by barriers is lowest for firms with 5-49 employees (59 percent), while it is highest for firms having 1,000 or more employees (86 percent). Even though this size pattern largely prevails in the two other periods as well, the corresponding shares are much higher in the other periods. For instance, the difference between the share of innovating firms that faced innovation barriers in 2012-2014 and the corresponding share of 2004-2006 amounts to 12 percentage points for firms having 5-49 and 250-999 employees. The respective differences amount to 16 percentage points (50-249 employees) and 8 percentage points (at least 1,000 employees). Hence, particularly SMEs' probability to face innovation barriers increased over the years. Even more intriguing is the development among the non-innovating firms. By comparing the fre-

quencies of the non-innovating firms to the frequencies depicted in Figure 7-1, it is not surprising that the probability of facing innovation barriers increased over the years and size classes.

Figure 7-2. Barriers to innovation, by sector group, 2004-2014

Source: ZEW, Mannheim Innovation Panel.

Large non-innovating firms (at least 1,000 employees) experienced a substantial upsurge in the likelihood of facing and overcoming barriers to their potential innovation activities, respectively. For instance, the share of non-innovating medium-sized firms that were affected by barriers more than quadrupled from 8 percent (2004-2006) to 36 percent (2012-2014). The corresponding share for non-innovating firms having at least 1,000 employees even more than quintupled from 5 percent in 2004-2006 to 27 percent in 2012-2014. This implies that particularly medium-sized and very large non-innovating enterprises strongly increased their ambitions to conduct innovation activities.

Figure 7-3. Barriers to innovation, by size class, 2004-2014

Source: ZEW, Mannheim Innovation Panel.

Figure 7-4 gives an overview on the frequencies of the different types of innovation barriers innovating firms had to face in 2004-2006, 2008-2010 and in 2012-2014. The primary reasons impairing innovating firms' innovation activities were too high costs and a too high economic risk. This holds for each observed period. In 2008-2010, for instance, 43 percent of the innovating firms had to face too high costs, while this share was only slightly lower for a too high economic risk (40 percent). Other barriers innovating firms had to frequently face include the lack of qualified personnel, the lack of internal funding, organisational problems, the lack of demand for innovation, legislation and the lack of external funding. While 17 percent of the innovating firms reported that they had a lack of qualified personnel in 2004-2006, this share increased to 33 percent in 2012-2014. A similar increase can be found for the lack of internal funding (21 percent in 2004-2006; 30 percent in 2012-2014) and for the lack of demand for innovation (16 percent in 2004-2006; 24 percent in 2012-2014). However, the frequency of organisational problems largely remained the same between 21 percent in 2008-2010 and 26 percent in 2012-2014. Furthermore, the appearance of legislation problems and the lack of external funding as innovation barriers was equally likely (22 percent) in 2012-2014, while both factors were less likely to disrupt the firms innovation activities in 2004-2006 (15 percent re-

garding the legislation and 16 percent regarding the lack of external funding). The remaining types of innovation barriers, i.e. long bureaucratic procedures, market dominance by other firms, internal resistance, standards and norms, the lack of market information, the lack of technological information and the lack of access to IPRs were not overly likely to appear over the years. The corresponding shares did not exceed 20 percent, which means that typically not even every fifth innovating firm had to face one of these barriers between 2004 and 2014.

Figure 7-4. Frequencies of different types of innovation barriers in innovating firms, 2004-2014

Source: ZEW, Mannheim Innovation Panel.

Figure 7-5 presents the shares of the different types of innovation barriers non-innovating firms had to face in 2004-2006, 2008-2010 and in 2012-2014. In principle, the ranking and the development over time of the respective barriers' frequency is comparable to the case of innovating firms (Figure 7-4). That is, a too high economic risk and too high costs were the most frequently reported barriers among the non-innovating firms as well. In 2012-2014, their shares amounted to 21 and 20 percent, respectively. The lack of demand for innovation (17 percent), the lack of internal funding (16 percent) and the lack of qualified personnel, the lack of external funding, market dominance by other firms and legislation (13 percent each) were the following important innovation barriers in 2012-2014. A very similar pattern prevails for

the two other periods as well. This means, seven out of the eight most frequently occurring innovation barriers among non-innovating firms could also be found among the first eight barriers of the innovating firms. The only difference is that the market dominance by other firms seems to have been less important in innovating firms than in non-innovating firms, while the reverse holds for organisational problems.

Figure 7-5. Innovation barriers in non-innovating firms, 2004-2014

Source: ZEW, Mannheim Innovation Panel.

7.2 Effects of Innovation Barriers

Innovation barriers can have different effects. On the one hand, they may induce firms to not pursue any innovation activities at all. In this case, potential innovation projects would not be started in the first place. On the other hand, in case a firm is already conducting innovation projects, certain barriers could lead to the termination of on-going projects, to the delay and prolongation of on-going project, respectively, and may also lead to the situation that some innovation projects may not be started in the first place.

With regards to non-innovating firms, innovation barriers can only induce the firms to not start any innovation activities at all. For this reason, Figure 7-1's depicted frequency shares for non-innovating firms mean that any potential innovation activities were not started in the first place. Hence, for instance, for 39 percent of the non-innovating firms in 2012-2014 innovation barriers had the effect of preventing non-innovating firms from the conduct of any innovation activities. Vice versa, 61 percent of the non-innovating firms did not conduct innovation activities because they had no ambition to invest in the development and implementation, respectively, of new products and processes.

With regards to the group of innovating firms, Figure 7-6 presents three possible effects innovation barriers can have on innovating firms' innovation activities. The most frequently reported effect of the barriers was that certain innovation projects were not started in the first place. The respective shares amount to 40 percent in 2004-2006, 54 percent in 2008-2010 and 45 percent in 2012-2104. The second most frequently reported effect was that on-going projects were delayed and prolonged, respectively. This effect's share ranges from 27 percent (2008-2010) to 44 percent (2012-2014). The termination of on-going innovation projects was the most unlikely effect occurring due to innovation barriers. About one out of four (2008-2010 and 2012-2014) to one out of five (2004-2006) innovating firms reported this effect.

Figure 7-6. Effects of innovation barriers in innovating firms, 2004-2014

Source: ZEW, Mannheim Innovation Panel.

According to Figure 7-7, there were large differences in the effects of the various types of innovation barriers. Five of the seven most frequently reported barriers primarily induced the firms to not start certain innovation projects in the first place. In particular, almost every fourth innovating firm did not start certain innovation projects in the first place due to a too high economic risk (22 percent) and too high costs (24 percent). Even 17 percent among the innovating firms stated that the lack of internal funding was the primary reason for not having commenced some innovation projects. With respect to the two reasons that did not primarily prevent projects to be started, i.e. organisational problems (15 percent) and the lack of qualified personnel (17 percent), they primarily led to the delay and prolongation of on-going projects, respectively.

Figure 7-7. Effects of different types of innovation barriers, 2012-2014

Source: ZEW, Mannheim Innovation Panel.

Internal resistance, the lack of technological knowledge relevant to innovation, legislation, long bureaucratic procedures, standards and norms and the lack of access to IPRs had about the same likelihood of delaying/prolonging and of not starting innovation projects in the first place. With respect to project termination, there is only little variation among the different types of innovation barriers. Less than 7 percent of the firms reported that as the primary effect. Only one barrier even surpassed the 5 percent value. That is, for 6 percent of the innovating firms the lack of demand for innovation resulted in the termination of on-going innovation projects. Hence, the different types of innovation barriers hardly induce firms to terminate on-going innovation projects. They are either not started in the first place or delayed and prolonged, respectively.

7.3 Increasing in Importance of Innovation Barriers

In addition to the effects of innovation barriers, the 2015 MIP survey also asked about whether the specific barrier had become more important or not. In general, innovating firms reported more frequently that the importance of barriers increased than non-innovating firms (Figure 7-8). This is not surprising given that innovation barriers are considerably more widespread among the innovating firms. However, both types of firms coincided on the assessment about the types of barriers the importance of which increased most. In both innovating and non-innovating firms, a too high economic risk and too high costs gained in importance most frequently. Almost every fifth firm reported that these barriers' importance increased, while in the group of non-innovating firms about every tenth firm reported an increase of that importance.

Figure 7-8. Increasing importance of different innovation barriers, 2012-2014

Source: ZEW, Mannheim Innovation Panel.

Following too high economic risk and too high costs, innovating and non-innovating firms assigned the lack of qualified personnel as the third most frequently increased importance of an innovation barrier. 17 percent and 9 percent of the innovating and non-innovating firms, respectively, reported that the situation on the labour market concerning finding qualified personnel to conduct innovation activities deteriorated. With respect to the increase in importance of innovation barriers, legislation ranks fourth followed by the lack of internal funding and long bureaucratic procedures. Furthermore, 11 percent of the innovating firms stated that it became more difficult to get innovation activities externally funded.

8 Protection of Innovation, Licensing, Standards and Certificates

8.1 Introduction

The economic value a firm prescribes to an innovation does not only depend on the technological advancement itself (which in turn determines consumers' willingness to buy) but on the ability to appropriate the rents from their initial R&D investment. If it is easy for competitors to copy the innovation without having to internalise the associated R&D costs, then many innovations may be rendered unprofitable, hampering technological development. Different types of strategies or mechanisms can be employed by the firm in order to appropriate the rents. Firms can try to commercialise their innovation quickly and gain lead time advantages, which provides a short-term monopolistic position by being the first, and potentially long-term market power through reputation. Another form of informal protection is secrecy, though not very effective if the innovation is easy to imitate or reverse engineer. A formal way of protecting innovations is through the use of intellectual property rights (IPRs). Patents, trademarks, copyright, as well as design- and utility-patents grant the inventor a monopolistic position that is enforced by law.

Innovation appropriation however, does not necessarily have to stem from the firm implementing the innovation itself internally. Especially the use of IPRs allows the firm to generate revenue from their innovations by licensing out their intellectual property to third parties. The economic value of an innovation also depends on its ability to push through and get accepted on the market. In this respect, standard setting patents can provide major benefits to the patent owner by making competitors dependant on his patents and thereby practically securing royalty payments. It should be noted though, that it is not particularly easy to achieve the status of a standard essential patent for an innovation. A further aspect in relation to this is certification, which serves as a means of reducing consumer uncertainty by ensuring that the product or service meets a certified quality standard.

In the CIS 2015 survey, German firms were asked to answer questions (with 'yes' or 'no' as possible answers) on whether they make use of formal IP (patents, trademarks, design and copyright), if they licensing-in and -out, sell or purchase their IP, and whether they engage in standardisation and certification. The answers apply to the years from 2012-2014. As the survey also provides information on firm size, the industrial sectors in which they operate and whether they are located in East- or West-Germany, we are able to provide statistics according to these categories.

In order to present statistics on the extent to which German innovative firms also make use of informal IP (such as lead time advantages, secrecy and design complexity), and how important or effective firms consider them to be for their competitiveness we draw upon the CIS 2013 survey. Here, firms were asked to indicate how effective the five formal types and the

three informal types of IP were in securing competitiveness of the product and process innovations that the firm had introduced in the period 2010-2012.

8.2 The Use of Formal IP Protection Methods

Trademarks are the most frequently used form of formal protection followed by patents. Out of all German firms 7.4 percent made use of trademarks and 5.6 percent used patents during 2012 and 2014. In absolute figures, more than 20,000 different firms (with 5 or more employees in the sectors covered by the innovation survey) registered a trademark during 2012 and 2014, and almost 16,000 firms applied for a patent. The least used form of protection was industrial designs (2.0 percent, i.e. about 5,500 firms). As expected, innovative firms are more likely to make use of IP protection and this holds for all five different types (Figure 8-1). Interestingly however, innovative firms use trademarks (11.1 percent) and copyright (4.3 percent) only around six times more often than non-innovative firms (1.8 percent and 0.7 percent, respectively). The use of industrial designs, patents and utility patents on the other hand is much more concentrated, where it is primarily innovative firms that make use of them. This suggests that trademarks and copyright are forms of protection that are less specific to innovative firms, as they must generate some economic value for non-innovative firms comparatively frequently.

Figure 8-1. Use of IPRs by firms in Germany, 2012-2014

Note: innovative firms including firms with product or process innovation activities as well as firms with marketing or organisational innovations

Source: ZEW, Mannheim Innovation Panel.

The industry or sector in which the company operates also changes the extent to which IP protection is used. Figure 8-2 shows that formal IP protection is particularly important for research intensive industries. Naturally, this sector operates at higher degrees of innovation and therefore has a higher need for protection. The utilisation of IP is the lowest in the sector of other services, where nearly all forms of protection are insignificant in magnitude, with the exception of trademarks, which 4 percent of firms active in other services utilize.

Interestingly, each form of protection is utilised to a different extent across each of the four industries. Even though trademarks were the most frequently used IPR overall (Figure 8-1), patents clearly take first place in research intensive industries. Where 27 percent of firms in this sector used patents, only 19 percent used trademarks, followed by 17 percent making use of utility patents (Figure 8-2). Industrial designs and copyrights were of less relative importance in this sector, yet in knowledge intensive industries copyright was the second most used IP, after trademarks.

Figure 8-2. Use of IPRs by firms in Germany, by main sector, size class and region

Source: ZEW, Mannheim Innovation Panel.

Large firms also utilise formal IP protection more intensively. The IP ranking order of firms with 1,000 or more employees reflects that of the research intensive industries. For these firms, as much as 38 percent of firms used patents as a means of protection for the innovations they introduced within the years 2012-2014, 36 percent had trademarks, 24 percent utility patents, 19 percent copyrights and 15 percent industrial designs. For firms with less than 50 employees these values are all below 10 percent. Whether a firm is situated in East or West

Germany does not make a substantial difference. West-German firms only indicated a slightly higher use of IP, but this may be explained by the slightly higher rate of innovation present in the west.

8.3 Importance of IPRs and Informal Protection Mechanisms in Securing Competitiveness of Innovations

The 2013 MIP survey included a question on the effectiveness of IPRs for securing or increasing the competitiveness of innovations. This question was borrowed from the first CIS conducted in 1993. The question also contained three items on informal mechanisms to protect innovation, lead time advantage, complex design and secrecy. Firms were asked to indicate the effectiveness of each of the five IPRs and each of the three informal mechanisms for protecting their innovations introduced during 2010 and 2012 on a three-stage Likert scale (low, medium, high effectiveness), with the option to tick "not used". The question was only shown to firms with either product or process innovation. While the share of firms indicating that a certain method or mechanism has been effective should equal the firms having used the respective method or mechanism during 2010 and 2012, the results show substantially higher shares of innovating firms using a certain IPR compared to the results of the 2015 survey reported in the previous section. For patents, the 2013 results indicate a share of 41 percent of innovating firms using that method, compared to 12 percent for product and process innovating firms in the 2015 survey. In absolute terms, the 2013 results suggest that more than 45,000 innovating firms in Germany have used patents during 2010 and 2012 to protect their innovations. This figure is clearly above the number of different firms from Germany that have applied for a patent at any patent office during this period. For other IPRs, the differences are of a similar magnitude. The best explanation of these differences is that firms applied a broader interpretation of the 2013 question and indicated their general judgement of the effectiveness of the various protection methods and mechanisms, rather than the actual use of these methods and mechanisms for their 2010-2012 innovations.

Having this in mind, 41 percent of all innovating firms considered lead time advantages to be highly effective in securing and increasing competitiveness for the firms' product- and process innovations (Figure 8-3). Innovations that are complex by nature or purposefully designed in a complex way ranked second in its effectiveness; 26 percent ranked it as highly effective and 30 percent considered it to a be a medium effective means of securing competitiveness. Out of all the innovating firms, 32 percent used industrial designs (6+12+14), yet out of these, only 18.8 percent considered them to be highly effective ((8÷32)×100), which means than more than 80 percent considered them to be of low or medium effectiveness. Values of similar magnitude are recorded for utility patents.

Figure 8-3. Importance of protection mechanisms in securing or increasing competitiveness of innovations introduced by German firms in 2010-2012

Source: ZEW, Mannheim Innovation Panel.

Figure 8-4. Percentage of innovating firms that rated different protection mechanisms as highly effective in securing or increasing competitiveness of their innovations introduced in 2010-2012, by main sector

Source: ZEW, Mannheim Innovation Panel.

When considering a selection of informal and formal protection mechanisms, it becomes apparent that particularly research intensive industries rate the three strategic (informal) mechanisms as highly effective in securing competitiveness (Figure 8-4). For instance, 32

percent of research intensive industries rated that keeping an innovation secret was highly effective, whereas only around 19-20 percent of firms in the other sectors shared this view. This pattern is even more pronounced for complex designs. The formal protection - trademarks - recorded less diverse results, indicating that round about the same share of firms from other industries (18 percent) and other services (18 percent) rated this form of protection as highly effective as research intensive industries (17 percent). The knowledge intensive service sector did not find patents (10 percent) nor trademarks (14 percent) particularly effective, but they do seem to be able to secure competition through lead time advantages (44 percent).

Differences in firm size also reveal some interesting trends, as can be seen in Figure 8-5. While lead time advantages were clearly considered highly effective by firms of all sizes (ranging from 34-57 percent), the flatter increase apparent for secrecy was rated rather similar across all firm sizes (23-26 percent) with exception to the smallest (17 percent) and largest firms (34 percent). In contrast to the generally increasing trend, complex designs were highly effective for securing competitiveness of medium sized firms with 10-99 employees. For firms with up to 249 employees, patents take one of the lowest ranks in terms of effectiveness. Interestingly however, the share of innovative firms that rate patents as being highly effective substantially increases from 21 percent for firms with 100-249 employees to 37-40 percent for larger firms. This indicates that large firms are better able to harness the benefits of patent protection.

Figure 8-5. Share of firms that rated different protection mechanisms as highly effective in securing or increasing competitiveness of innovations introduced in 2010-2012, by size class

Source: ZEW, Mannheim Innovation Panel.

8.4 Licensing, Sale and Purchase of Intellectual Property

Because formal types of intellectual property facilitate market transactions of intangible know-how, they are particularly useful for firms to source knowledge (purchase/license-in IP) or appropriate the rents of their R&D investment by selling/licensing-out their IP. The latter is particularly beneficial when the internal use or commercialisation of the innovation is not worthwhile or when internal development of such knowledge is too costly.

Survey results show that it was more common for firms to source knowledge on the market in the years 2012-2014 by purchasing and/or licencing-in IP; 1.5 percent of all firms (for both sourcing instruments) compared to 0.8 percent and 1.3 percent that sold and/or licensed-out their know-how respectively (Figure 8-6). Similar to the use of IP discussed in section 8.2, the licensing, sale and purchase of IP is noticeably more common among innovative firms for all four types of market transactions.

Figure 8-6. Licensing, sale and purchase of IP 2012-2014.

Source: ZEW, Mannheim Innovation Panel.

When distinguishing between the various industrial sectors and firm size, notable differences become apparent. Among the firms with 100 or more employees, licensing-in and -out is always preferred over the purchase or sale of IP, though this preference becomes much more pronounced as firm size increases (Figure 8-7). For firms with 1,000 or more employees for example, these values lie at 17.3 percent and 16.3 percent, compared to 11.4 percent and 8.4 percent for the purchase and sale of IP respectively. The share of firms selling their own IP ranged from 0.4 percent to 8.4 percent and was thereby the least common form of transaction in the market for technologies across all firm sizes, except firms with 50-99 employees, where licensing out IP was the lowest (1.7 percent). Purchasing IP is clearly preferred over the sale of IP, and this hold across all firm sizes and industries. Yet, this preference is much more pronounce for research intensive industries, where 4.4 percent purchase IP and 0.9 percent sell it. The knowledge intensive service sector on the other hand only demonstrated a minor difference, where 1.8 percent purchased IP and 1.7 percent sold it. The differences between East- and West-Germany are minor for the sale, purchase and licensing-out of technol-

ogy. A stark difference becomes apparent however, for the externally sourcing know-how through licensing, where West-Germany is nearly double as likely to license-in (1.7 percent) than East-Germany (0.9 percent).

Figure 8-7. Licensing, sale and purchase of IP 2012-2014, by main sector, size class and region

Source: ZEW, Mannheim Innovation Panel.

8.5 Engagement in Standardisation, Certification and the Use of Certificates

Standardisation and certification is an approach firms can take to achieve market acceptance of their own innovations, or to signal compliance and/or a certain level of quality standard to customers for products/processes that they are producing/employing with means of licensing-in know-how. Nearly one-fifth (19.9 percent) of all firms certified their own processes, management systems or working and environmental standards (see Figure 8-8). For innovative

firms, it was more than one in four (27.2 percent). Certification of own products/services to technical norms ranked in second place, carried out by 13.3 percent of all firms. Active participation in formal standardisation committees was also quite popular among innovative firms (9.7 percent), much in contrast to the low percentage of firms that participate in informal standardisation committees (2.3 percent).

Figure 8-8. Engagement in standardisation and certification 2012-2014

Source: ZEW, Mannheim Innovation Panel.

Figure 8-9 shows that certifying one's own products and process is particularly useful for certain types of firms, depending on the type of industrial sector and size of the firm. 46 percent of innovative firms certified their own processes, management systems and working or environmental practices. For very large firms with 1,000 or more employees the share even reached 66 percent. Certifying one's own products was typically the second most engaged in activity. Furthermore, research intensive firms applied technical certificates to their own products to a similar extent as they certified their own products (35 percent and 34 percent respectively), despite engagement in the former typically being significantly lower for all other types of firms, whether in terms of size or industrial sector. However, even for research intensive industries the share of firms actively participating in informal standardisation consortia remained low (4 percent). This phenomenon was however, practiced to a greater extent by large firms, where 15 percent of companies with 1,000 or more employees were engaged in this.

Figure 8-9. Engagement in standardisation and certification 2012-2014, by main sector, size class and region

Source: ZEW, Mannheim Innovation Panel.

9 Marketing and Organisational Innovation

9.1 Introduction

Schumpeter (1934, 1943) already had a broad understanding of innovation. While he differentiated between the constituent acts of innovation and implementation, he did so by not only referring to technological innovations in the sense of improved products or processes, but he realised at an early stage that, for example, opening new markets or establishing new customer or supplier relations would also constitute important aspects of innovative activity.

His broad interpretation has laid the foundations for our modern measurement conceptualization of innovation, which since the 3rd revision of the OSLO-Manual (OECD and Eurostat, 2005) has defined innovation not only in terms of product and process innovation, but also in terms of marketing and organisational innovations.

Since this data has become available in the Community Innovation Surveys in 2005, 2007, 2009, and 2011, 2013 and 2015 a couple of analyses have examined the relationship between product and process innovation (often called technological innovations) and marketing and organisational innovations (also called non-technological innovations). The question of the complementarity of technological and non-technological innovations has become particularly important. Here Rammer et.al. (2009) were able to demonstrate that under certain conditions organisational innovations can substitute technological innovation, particularly in small firms. At the same time, Schubert (2010) shows that marketing innovations causally tend to increase the success of product innovations, the latter highlighting the importance of non-technological innovations for the regular innovation process.

In any case, in many instances technological innovations are strongly intertwined with non-technological adjustments. For example, the introduction of a new process might often call for the adjustment of work organisation (Evangelista and Vezzani, 2010). Likewise it is reasonably obvious that new products will be accompanied by changes in marketing strategy.

Although the term organisational innovation is not often used, the open innovation paradigm (Chesbrough, 2003a) with its implications for producer-supplier and producer-user interactions (von Hippel, 1998) is closely related. Implying a reorganisation of a firm's environmental connections, this strand of the literature highlights the increasing importance of conducting innovations in open networks. For instance Chung and Kim (2003) have demonstrated the positive affects both on innovative performance and cash-flow rates.

These selected results demonstrate the significance of a broad understanding of innovation that goes beyond purely technological considerations. In the following we present a descriptive account of the interplay of technological and non-technological innovations as could be observed in firms in Germany.

9.2 Prevalence of Marketing Innovation

In the years 2012 and 2014, just over 30 percent of all firms in Germany introduced at least one marketing innovation. In 2012 and 2014 new advertising techniques and new distribution channels appeared to be the most common types of marketing innovation, followed by new design and new pricing. When looking at the changes by type of marketing between 2012 and 2014 (Figure 9-1) we see that new advertising techniques became more frequent and new design had become less widespread, while for new pricing and new advertising techniques, there were no major changes.

Figure 9-1. Type of marketing innovation in firms in Germany, 2010-2014

Source: ZEW, Mannheim Innovation Panel.

In the years 2012 and 2014, marketing innovations were more found in large firms than in small firms. 28 percent in 2012 and 29 percent in 2014 of the firms with below 19 employees introduced marketing innovations. This share rose to 51 percent in 2012 and 2014 for firms which had fewer than 500 employees. Among large firms, 61 percent of the firms in 2012 and 2014 were marketing innovators (Figure 9-2). This pattern is equivalent to that which one also observes in case of product and process innovations. This can be explained by the fact that large firms producing a wide range and many different types of products have more possibilities to implement a new marketing measure for at least one of the products.

As Figure 9-2 highlights, in the years 2012 and 2014, the R&D-intensive industries had the largest marketing innovator shares. They area followed by the knowledge-intensive services, the other industry sectors, and finally the other services. This order also is identical with the order that one observes where product and process innovations are concerned. In the year 2012, the share of firms, that introduced Marketing innovations, was slightly higher in West-

ern Germany (32 percent) than in Eastern Germany (30 percent). In 2014, this share increased to 34 percent for Western Germany and diminished to 27 percent for Eastern Germany.

Figure 9-2. Firms with marketing innovations in firms in Germany, 2010-2014, by main sector, size class and region

Source: ZEW, Mannheim Innovation Panel.

9.3 Prevalence of Organisational Innovation

In the years 2012 and 2014, 31 percent of all firms indicated that they introduced at least one organisational innovation (Figure 9-3). The most frequently adopted type of organizational innovation was a new work organisation (66 percent in 2014 and 67 percent in 2012 in all organisational innovators; 21 percent in 2014 and 20 percent in 2012 in all firms), followed by new business processes and new external relations.

The prevalence of organisational innovation by size classes and main sectors shows a similar pattern to marketing innovation. Large firms implement organisational innovation more frequently than small firms (Figure 9-4). The R&D-intensive industries have the largest organisational innovator shares (42 percent in 2012 and 48 percent in 2014). They are followed by the knowledge-intensive services, other industries, and finally the other services. In the year 2012, the share of firms, that introduced organisational innovations, was slightly higher in Western Germany (31 percent) than in Eastern Germany (30 percent). In 2014, this share increased to 32 percent for Western Germany and diminished to 28 percent for Eastern Germany.

Figure 9-3. Type of organisational innovation in firms Germany, 2010-2014

Source: ZEW, Mannheim Innovation Panel.

Figure 9-4. Organisational innovation in firms Germany, 2010-2014, by main sector, size class and region

Source: ZEW, Mannheim Innovation Panel.

9.4 Link between Marketing, Organisational, Product and Process Innovations

So far we have mainly discussed the prevalence of non-technological innovations in isolation and their dependence on sector and size differences. We will report on the link between marketing, organisational, product and process innovations. In the years 2012 and 2014, the share of firms that implanted either marketing or organisational innovation was about 45 percent of all enterprises (Figure 9-5). 14 percent of the firms introduced only marketing without organisational innovations, 13 percent just organisational innovations without significant variations in marketing and 18 percent both marketing and organisational innovations in 2012. These shares remained nearly constant in 2014 (Figure 9-5). The share of firms, that introduced both marketing and organisational innovations, tended to increase with increasing size of the firms in 2012 and 2014. This result shows that the probability that large firm introduced both marketing and organisational innovations, is greater than that of small firms. Underlying this are the facts that large firms are more complex and produce more diverse products, which would significantly increase the general demand for more marketing and organisational innovations.

Figure 9-5. Combination of marketing and organisational innovations in Germany, 2010-2014, by main sector, size class and region

Source: ZEW, Mannheim Innovation Panel.

The share of firms that introduced only marketing innovation did not vary systematically with firm size in 2012 and 2014. By contrast, the share of firms that only introduced organisational innovations is a little higher in large than in small firms. In 2012, the R&D-intensive industries held the highest percentage of all firms which only introduced marketing innovations. They were followed by other industries and other services and finally the knowledge-intensive services. However, when we consider the year 2014, this ranking changed: other industries were now followed by R&D-intensive industries, knowledge-intensive services and other services. In the year 2012 the share of firms, that introduced only organisational innovation, was the highest in R&D-intensive industries, followed by knowledge-intensive services, the other services and other industries, considering the year 2014: The R&D-intensive industries were followed by knowledge-intensive services, other industries and other services.

Figure 9-6. Combination of marketing/organisational innovation and product/process innovations in firms in Germany, 2010-2014, by main sector, size class and region

Source: ZEW, Mannheim Innovation Panel.

In the year 2012 and 2014, the share of firms, that introduced at least one product, process, marketing or organisational innovation, was about 56 percent (Figure 9-6). In the year 2012, 26 percent of the firms introduced both technological and non-technological innovations, 19 percent introduced only marketing or organisational innovations and 12 percent introduced only product or process innovations. Two years on, little has changed (Figure 9-6). In the years 2012 and 2014, the overall rate of innovators (both technological and non-technological

innovations) increased with increasing size of the firms. This result cannot be clearly observed for only marketing or organisational innovation and only product or process innovation. The overall rate of innovators is the highest in R&D-intensive industries, followed by the knowledge-intensive services, the other industries and the other services.

Between 2012 and 2014, the share of firms which introduced all four types of innovation decreased slightly from 7 percent to 6 percent. This share was highest in the R&D-intensive industries (15 percent in 2012 and 16 percent in 2014) and second highest in the knowledge-intensive services (Figure 9-7). In the years 2012 and 2014, the share of firms which introduced all four types of innovations increased significantly with the firm's size. For example, in the year 2012, 6 percent (5 percent in 2014) of small firms (between 10 and 19 employees) introduced all types of innovation, while this share increased to 28 percent (33 percent in 2014) for large firms (between 500 and 999 employees).

Figure 9-7. Firms with all four types of innovation, by main sector, size class and region

Source: ZEW, Mannheim Innovation Panel.

10 Public Procurement and Innovation

10.1 Introduction

Public procurement in Germany has a volume of around €360bn, or 13 percent of GDP, per year (Sack et al., 2016). There are around 30,000 government institutions, at the federal and state-level, that are responsible for procuring products and services in Germany. In recent years, there have been discussions about using public procurement as a policy tool to promote innovations activities by firms and to increase demand for innovative products, services, and technical solutions. In 2007, six Federal Ministries have agreed to use public procurement of innovations more strategically. This target is also set by the current high-tech strategy of the German federal government. Moreover, in 2013 a new competence centre for innovative public procurement, sponsored by the Federal Ministry of Economics and Technology, was opened, which advises other government institutions on the topic. However, data on the volume of innovative public procurement contracts was not available until recently.

In the harmonized CIS 2012 questionnaire a question about procurement contracts awarded by public institutions such as public administrations, schools, hospitals or utility companies was included for the first time. The question asks in particular whether firms were awarded public procurement contracts, by public entities in Germany or by foreign institutions, in the three years prior to the survey year. There is also an option to answer that no procurement contracts were awarded.

For those firms that won a public procurement contract in the previous three years, a follow-on question asks whether any innovation-related activities were conducted in the course of executing the contract. Furthermore, the item distinguishes between innovation activities that were specified explicitly in the contractual arrangements and those innovation activities that were conducted although they were not specified in the contract. A third category is reserved for the case when no innovation-related activities were associated with the procurement. All innovation activities concerned with in the questionnaire are related to product, process, marketing, or organisational innovations by firms.

10.2 Award of Public Procurement Contracts

Between 2010 and 2012, 16 percent of firms in Germany were awarded public procurement contracts by public institutions (Figure 10-1). This share is only slightly higher in knowledge-intensive services (18 percent) and R&D-intensive manufacturing than in other manufacturing (15 percent) and services (14 percent). Also there is no clear pattern in terms of firm size. With 19 percent for firms with 50 to 99 employees, the share is only marginally smaller than for large firms with more than 1,000 employees (22 percent). In East Germany, more firms got awarded a public procurement contract (20 percent) than in West Germany (15 percent).

Figure 10-1. Share of firms in Germany with public procurement contracts from public institutions, 2010 to 2012

Source: ZEW – Mannheim Innovation Panel.

Figure 10-2. Firms in Germany with public procurement contracts 2010 to 201by2 awarding institution and by main sector, size class and region

Source: ZEW – Mannheim Innovation Panel.

The share of firms with procurement contracts from public institutions is equal to 18 percent for innovative firms, and therefore higher by five percentage points than for non-innovative firms (13 percent) (Figure 10-2). The group of innovative firms is comprised by firms that introduced product or process innovations and firms that attempted to innovate but abandoned

their projects before completion. A large majority of procurement contracts to firms have been awarded by German institutions. Less than 2 percent of firms won a procurement contract form a public entity from abroad.

10.3 Relationship between Procurement Contracts and Innovation

Among the innovative companies that got awarded a public procurement contract between 2010 and 2012, 18 percent indicated that they conducted innovation-related activities, with respect to product, process, marketing, or organisational innovations, in the course of executing the contract (Figure 10-3). In particular, firms in the knowledge-intensive service industry reported that innovation activities were related to the procurement. The share of procurement contracts with innovation components amounts to 36 percent in this group.

For 18 percent of all firms with procurement contracts innovation-related activities were specifically part of the contractual arrangements. Furthermore, there is another group of firms that conducted innovation-related activities although they were not explicitly required in the procurement contract. 11 percent of innovative firms with procurement contracts did these kind of "voluntary" innovation activities. This share is the highest for firms in R&D-intensive manufacturing (15 percent) and lowest for firms in other services (6 percent).

Figure 10-3. Innovative firms in Germany that conducted innovation activities in the contest of public procurement contracts (2010 to 2012), by main sector and region

Source: ZEW – Mannheim Innovation Panel.

11 Environmental and Energy-related Innovations

11.1 Introduction

Environmental innovations comprise product, process, marketing and organizational innovations that lead to a marked reduction in environmental stress. Positive environmental effects can be both an explicit goal and a side effect of the innovation and can occur at any point along the value chain, either within or outside the innovating firm.

In principle there are market forces that lead firms to invest in environmental innovations. First, firms can use eco-innovations to signal environmental awareness to consumers who are willing to pay a premium for more environmentally friendly produced products. Second, and most importantly, firms may use eco-innovations to safeguard themselves against rising resource prices, including energy prices. Being less dependent on scarce resources may lower firm's production cost in the long-run, and strengthen their competitive position.

In addition, the transition towards more eco-friendly technologies is often pushed by policymakers, in an attempt to accelerate the transition process. Switching to eco-friendly technologies is then not self-imposed by firms but a response to environmental regulations, either to comply with existing standards, or in anticipation of future regulatory changes.

With rising awareness of climate change and its connection to the conventional and still prevalent generation of energy from fossil fuels, environmental innovations are increasingly associated with energy related innovations. In Germany, the energy transition was further accelerated by the aftermath of the reactor accident in Fukushima in 2011, which led to a series of policies to foster the transition to safe and clean back-stop technologies.

To assess the diffusion and impact of environmental innovations in the German economy, the 2009 innovation survey contained for the first time a detailed block of questions related to the issue, which covered three broad aspects:

- Introduction of process-related to environmental innovations
- Introduction of product-related to environmental innovations
- Drivers of environmental innovations

The block of questions was based on the harmonised questionnaire for the 2008 CIS (see Horbach et al., 2012) and was included again in the CIS 2014 and hence in the 2015 wave of the MIP, though in a slightly adjusted way. For both process-related and product-related, one additional item was included (replacing fossil energy resources by renewable ones, increase of product life through longer-lasting, more durable products). For process-related environmental innovations, two items have been merged into one (water pollution and soil pollution). The Likert-scale used to assess the contribution of environmental innovations to reducing environmental impacts was changed from a 4-point (high, medium, low, no) to a 3-point (significant, insignificant, no). The list of potential drivers was extended by one item (increase cost

of energy) and one item was split into two (existing environmental regulation and existing environmental taxes, charges or fees). A question on the use of environmental management systems was excluded in the MIP 2015 survey for lack of space.

The 2014 wave of the MIP contained two questions on energy-related innovations. These questions were placed at the end of the block on product and process innovation, respectively, and allowed to identify

- introduction of new processes that increase energy efficiency within the innovating firm;
- introduction of new products that lower energy consumption in usage compared to other comparable products;
- introduction of new processes that make increased use of renewable energies;
- introduction of new processes that increase security of energy supply.

11.2 Firms with Environmental Innovations

Between 2012 and 2014, 51 percent of firms in Germany have introduced environmental innovations (see Figure 11-1). The majority of firms introduced process-related environmental innovations (47 percent), 29 percent of firms have introduced product-related environmental innovations. Only 4 percent of firms have introduced only product-related and 22 percent only process-related environmental innovations. 25 percent of all firms have introduced both process and product-related environmental innovations. The share of firms that have introduced environmental innovations is markedly higher among innovating firms (firms that are actively pursuing product or process-related innovation activities). Within this group, 63 percent of firms have introduced product or process-related environmental innovations, while only 41 percent of non-innovating firms have done so. The proportions of process and product-related environmental innovations are similar in both groups.

Figure 11-1. Environmental innovations in firms in Germany 2012- 2014

"Innovating firms: firms with product and process innovation activity
Source: ZEW – Mannheim Innovation Panel.

It is well known that the share of innovating firms increases with firm size, and especially so in research intensive industries, where the share of innovating firms is high. These results translate to environmental innovations. Nonetheless, there are some characteristic differences. First, the share of firms with environment related innovation increases with firm size, but the differences are less pronounced compared to product – and process-related innovating firms. 80 percent of firms with 1,000 or more employees have introduced environmental innovations, while almost 46 percent of small firms with 5 to 9 employees have done so after all. Second, the sector differences are less pronounced, despite the fact that the share of environmental related innovating firms is highest in the research intensive industry with 68 percent. The distance compared to other industries is small, where 62 percent have introduced environmental innovations. Third, it stands out that environmental innovations play the least important role in knowledge intensive industries, where only 38 percent of firms have introduced them. This is in stark contrast to the share of innovating, which is especially high in knowledge intensive industries, usually higher compared to other industries and services, and sometimes even comparable in size to research intensive industries.

Figure 11-2. Environmental innovations in firms in Germany 2012-2014, by main sector, size class and region

Source: ZEW – Mannheim Innovation Panel.

Figure 11-3 shows different types of environmental innovations and their contribution to environmental protection. For processes, the reduction of energy consumption is by far the most common type of environmental innovation. 35 percent of firms have introduced innovations of this type in the years 2012-2014. 11 percent of firms consider this type of innovation an important contributor to environmental protection, while 26 percent of firms estimate the contribution to be low. For products, the reduction of energy consumption is equally the most common type of environmental innovation. 24 percent of firms have introduced innovations of this type in the years 2012-2014. 7 percent of firms consider this type of innovation an important contributor to environmental protection, while 17 percent of firms estimate the contribution to be low.

Figure 11-3. Types of environmental innovations in firms in Germany 2012-2014 by contribution to environmental protection

Source: ZEW – Mannheim Innovation Panel.

11.3 Share of Product-related Environmental Innovations

An important measure for the success of newly introduced product-related environmental innovations is their contribution to sales. The higher their sales contribution, the stronger is the diffusion of environmentally friendly products and therefore the more positive their contribution to environmental protection. In 2014 around €455bn of sales in Germany were in product-related environmental innovations. This accounts for about 9 percent of all sales in the German economy that were part of the innovation survey's reference base. To put this into perspective, in the same year the total sales related to product innovations was around 660bn €. That being said, not all product-related environmental innovations are product innovations according to the definition of the innovation survey. An example for a product-related

environmental innovation that is not a product innovation is the use of a more easily recyclable packaging material. This is a product adjustment that leads to a marked impact on environmental protection, but does not constitute a market novelty. Figure 11-4 sheds light on the firms that contribute to the sales of product-related environmental innovations. Almost 80 percent of these sales can be allotted to product innovators. Another 20 percent came from firms that have not introduced product innovations in 2012-2014.

The sales contribution of product-related environmental innovations to total sales was 12 percent for all firms that have introduced environmental innovations. For firms with product-related environmental innovations the share was 19 percent. Focusing on the group of product innovators, 11 percent of their sales were in product-related environmental innovations. This means that environmental innovations account for more than half of the sales in product innovations for the group of product innovators. This result underlines the importance of environmentally oriented innovations for the general innovation activity of the German economy. When only looking at those firms that have introduced at least one product-related environmental innovation, we see that 19 percent of the sales are generated by environmental innovations.

Figure 11-4. Share of sales of product-related environmental innovations in firms in Germany 2014

Source: ZEW – Mannheim Innovation Panel.

The success of environmental innovations varies by sector and firm size (see Figure 11-5). While in research intensive industries 19 percent of sectoral sales are allotted to product-related environmental innovations, it is only 4 percent in other services and 5 percent in knowledge intensive services. The picture changes when looking at only those firms that have introduced product-related environmental innovations. 19 percent of their sales are allotted to product-related environmental innovations, which is almost as high as in research intensive industries (25 percent).

Figure 11-5. Share of sales of product-related environmental innovations in firms in Germany 2014 by main sector, size class and region

Source: ZEW – Mannheim Innovation Panel.

Small firms show a low sales contribution of product-related environmental innovations (between 5 and 7 percent) compared to large firms (9 to 12 percent). One reason for the size differences is that smaller firms have introduced such innovations to a lesser extent. Looking only at the sales of product-related environmental innovations of those firms that have introduced such product innovations, medium firms have the highest share of more than 20 percent. This implies that those firms have oriented their product portfolio towards environmentally friendly products.

11.4 Drivers of Environmental Innovations

Firms have different motives to introduce environmental innovations. The literature emphasizes regulations, either existing or expected, as key drivers to engage in environmental innovations (Khanna et al., 2009). In addition, several other drivers exist such as cost and reputational considerations, as well as public support schemes and industry specific commitments.

Figure 11-6. Importance of motives for introduction of environmental innovations in firms in Germany 2012-2014

Source: ZEW – Mannheim Innovation Panel.

Figure 11-6 shows the importance of different drivers of environmental innovations in Germany in 2012-2014. Clearly, increasing energy and resources cost is the main driver of environmental innovations, both in terms of quantity and quality. More than 60 percent of firms consider increasing cost to be a driver of environmental innovation, and 45 percent regard its importance as high or medium. Only 16 percent of firms see increasing cost for energy as being of low importance, and for 39 percent increasing energy cost did not influence their decision at all. The second most important driver is compliance with existing regulation. 44 percent of firms have mentioned this as a motive for introducing environmental innovations, and 17 percent consider it a highly important driver. Reputation improvement and commitments within the industry were drivers for 43 percent of firms, and considered important by 9 and 11 percent respectively. Expected future changes in regulation are a motive for 39 percent of the firms. Other motives were of smaller importance both in quantitative and qualitative terms. Public financial support schemes are mentioned by only a quarter of all firms as a driver, and just 5 percent regard it as highly important driver.

11.5 Product Innovations with Higher Energy Efficiency

In the years 2011 to 2013 around 6 percent of all firms in Germany covered by the innovation survey have introduced at least one product innovations with higher energy efficiency (see Figure 11-7), which accounts for approx. 16.500 firms. Focusing on the group of product innovators, about every fifth firm (21 percent) has introduced such an innovation.

Figure 11-7. Diffusion of product innovations with lower energy consumption by usage of products in firms in Germany 2011-2013 by main sector, size class and region

Source: ZEW – Mannheim Innovation Panel.

The highest innovation activity in energy efficient products is in the research intensive industries, where 18 percent of all firms have introduced a more energy efficient product, and 32 percent of all product innovators have done so. From all other sectors, i.e. other industry, knowledge intensive services and other services, such firms constituted only a small share (between 3 and 6 percent). Focusing on firm size we see a clear relation between firm size and share of firms that have introduced product innovations with higher energy efficiency. This result even holds when we look at only the product innovators. Around one third of all firms with 1,000 or more employees have introduced a product innovation with higher energy efficiency, using product innovators as basis, 43 percent in this size class have introduced such product innovations.

Figure 11-8. Share of sales of product innovations with lower energy consumption by usage of products in Germany 2013 by main sector, size class and region

Source: ZEW – Mannheim Innovation Panel.

Looking at sales of product innovations with higher energy efficiency of German firms, these account for almost €160bn in 2013, which is about 3.1 percent of all sales in the German economy covered by the innovation survey. More than three quarters of these sales are generated in research intensive industries. In this sector, 11.6 percent of total sales were generated by product innovations with higher energy efficiency. In all other sectors, the share is markedly lower (0.3 to 1.5 percent). Again we see that the share of sales allotted to such product innovations increases with firm size. Based on just the sales generated by product innovations, those with higher energy efficiency accounted for around a quarter of all sales. This share is around twice as large for companies with 500 and more employees (26 percent) compared to small and medium sized enterprises with less than 250 employees.

11.6 Process Innovations Related to Energy Efficiency, Renewable Energies and Energy Supply Security

Around 20,000 firms, or 7 percent of all firms in the reference base, have introduced a clean energy transition related process innovation during 2011 and 2013. Here a process innovation is clean energy transition related if either it improves the security of energy supply or increases the use of renewable energy sources. Based on all process innovators, around one third of firms have introduced such process innovations. Looking at sector and size aspects, the picture is similar to energy efficient product innovations: high share of firms in research intensive industries compared to all others, and share increases with firm size.

The low overall share of firms that have made energy transition related process innovations can be explained by the fact that only those process innovations were considered that have resulted in markedly improved processes, i.e. those that have markedly improved the firm's productivity. This implies that activities such as energy efficient refurbishment, organizational actions to safe energy etc. are not accounted for. Likewise smaller measures to improve process technologies such as purchasing more energy efficient vehicles may not be counted as process innovations.

Figure 11-9. Diffusion of process innovations related to energy transition in firms in Germany 2011-2013 by main sector, size class and region

Source: ZEW – Mannheim Innovation Panel.

Figure 11-10 shows the diffusion of different types of energy transition related process innovations by sector, size class and region. It stands out that processes that increase energy efficiency constitute by far the most dominant type. In total, 5 percent of firms have introduced such innovations between 2011 and 2013. For the other two types of process innovations - increased used of renewables and increased security of energy supply - it was 2 percent of firms. Concerning sector and size aspects, the picture is similar to the overall introduction of clean energy transition related process innovations.

Figure 11-10. Diffusion of different types of process innovations related to energy transition in firms in Germany 2011-2013 by main sector, size class and region

Source: ZEW – Mannheim Innovation Panel.

12 Digitalisation

12.1 Introduction

Digitalisation refers to a general trend of technical change that affects firms in all industries and poses tremendous opportunities for innovation. A major aspect of digitalisation is thereby concerned with digital networks in supply chains and production processes as a whole. This phenomenon—known in Germany under the headline of "industry 4.0" —is not only relevant for manufacturing firms, but also for service firms which operate along value-adding chains in trading and logistics, design and construction, or software development and consulting. A second aspect of digitalisation relates to communication where new developments range from platform-based communication channels to social media applications. Also internet-based distribution of products and services and e-commerce fall in this realm. These developments allow for a reorganisation of labour, for example, through teleworking. A third aspect of digitalisation is the increased importance of data analysis in business processes. With the help of digital networks and new tools for collecting data, the amount of data points available to firms have increased dramatically, which allows for entire new ways of learning from data. These developments are known under the headline of "big data". A closely related point is cloud computing, i.e. the usage of interconnected machines and storage infrastructures.

Apart from specific technical developments, digitalisation offers possibilities for a reorganization of entire markets and business activities. In terms of product design the tailoring of products to specific customer needs, by analysing customer and usage data, offers a particularly interesting opportunity to firms. In the field of mobility, health care, education and public services, digitalisation offers the potential for systematic innovation through intelligent linkages between products and services and the use of real-time data. Digital platforms transform markets by bringing together suppliers and customers in whole new ways. These platforms not only increase the transparency of markets and decrease search costs, but can also overcome geographical boundaries.

In the innovation survey of 2016 items on the diffusion of digital technologies within participating companies were included. For this purpose, four broad areas of applications were defined. A challenge lied in defining applications in a sufficiently general way such that they apply to firms from very different industries. In the area of production and service provision the following sub-categories of applications were specified: digital networks in production processes, linkage of production and logistics, linkage with customers and linkage with suppliers. In the area of internal organization and communication sub-categories are: teleworking, software-based communication, and intranet-based platforms. The third area of distribution and external communication is comprised by e-commerce and social media. Eventually, the fourth area of applications refers to information processing technologies such as cloud computing and the analysis of big data.

12.2 Diffusion of Digital Technologies

Among all four broad technology areas digital networks in production and service provision show the highest penetration rate in 2016. 85 percent of all firms exhibit at least a low grade of adoption in one of the four sub-categories (Figure 12-1). In 30 percent of firms there is a high degree of adoption in at least one of the sub-categories. 62 percent of firms employ digital technologies in their internal organization and communication but only 13 percent of these firms indicate a high adoption rate. In the area of distribution and external communication (e-commerce, social media) 53 percent of firms rely on digital technologies; whereas the share amounts to 42 percent in the area of information processing (cloud computing and big data). The share of firms exhibiting a high degree of adoption, however, is low in both areas (7 percent and 5 percent).

Figure 12-1. Diffusion of digital technologies in firms in Germany 2016 by field of application

Note: “High” indicates that at least one sub-category out of the broad technology area was indicated as high, “intermediate” if at least one sub-category was indicated as intermediate but none as high, and so forth.

Source: ZEW – Mannheim Innovation Panel.

The share of firms with a high degree of adoption is the highest in knowledge-intensive services in all four technology areas (Figure 12-2). 51 percent of knowledge-intensive service firms rely on technologies from at least one of the four broad technology areas for their service provision. In R&D-intensive manufacturing this share amounts to 25 percent, in other manufacturing to 19 percent. Differences in terms of the use of information processing technologies are particularly stark between knowledge-intensive services and other sectors. 13 percent of knowledge intensive service firms show a high degree of adoption of cloud computing and big data applications, whereas this is the case for only 2 percent of manufacturing firms.

Figure 12-2. High degree of adoption of digital technologies in firms in Germany 2016, by area of application, and by main sector, size class and region

Note: A high degree of adoption indicates that at least one sub-category out of the broad technology area was indicated as high.

Source: ZEW – Mannheim Innovation Panel.

In the field of production and service provision, 5 percent of firms show a high degree of adoption in all four sub-categories. These firms appear to be part of the group of technology leaders when it comes to "Industry 4.0". Broken down according to industry affiliation the highest share of penetration of digital technologies can be found in the IT and telecommunication sector (around 16 percent), followed by the technical and R&D-service industry (more than 8 percent). The manufacturing sector with the highest share of adoption is the consumer goods industry "furniture/toys/medical devices/repair" with around 7 percent. In the sector of R&D-intensive manufacturing as a whole is with 2 percent much lower.

Figure 12-3. Diffusion of digital technologies in firms in Germany 2016 by industry

Source: ZEW – Mannheim Innovation Panel.

It turns out that knowledge-intensive service firms are much more receptive to the adoption of digital technologies. This is partly explained by the fact that products offered by these firms are in many cases already digital; definitely in the IT and telecommunication sector but also in, for example, advertising, technical and R&D services or consulting. In all these sectors the adoption rate of digital technologies is above 40 percent. For comparison, electronics is the manufacturing sector with the highest adoption rate of 31 percent.

The adoption of digital technologies and applications is positively correlated with firm size. This is due to economies of scale and scope that are more likely to be achieved by larger firms. Moreover, necessary resources such as sufficient IT know-how, e.g. in form of a separate IT division, are more likely to exist in larger firms. Looking at individual technologies, digital networks and linkages with customers are the most widely adopted ones. 76 percent of firms in Germany exhibit at least a low degree of adoption in this segment (Figure 12-4). 17 percent indicate a high degree of adoption. Digital networks and linkages with suppliers show a lower penetration rate (71 percent and 12 percent with a high degree). 70 percent of firms also use digital networks in their production processes and for service provision (including 21 percent with a high degree).

Outside of the area of production and service provision the use of software-based communication (e.g. Skype or other messenger services) shows the highest degree of adoption. Almost every second firm in Germany use these kinds of applications, 7 percent to a high degree. E-commerce technologies prevail in 43 percent of firms, but are adopted to a high degree in only 5 percent of firms. Social media is used by 43 percent of firms. These results coincide with surveys conducted by the German Statistical Office on the use of information and communication technologies (“ICT Survey”, 2016). There the share of firms—including small firms

with less than five employees from a broader range of sectors—that use social media amounts to 36 percent. Around 40 percent of firms use cloud computing technologies. Big data exhibits the lowest adoption rate with 28 percent, and only 2 percent of firms assign a high degree of importance to these applications.

Figure 12-4. Diffusion of digital technologies in German firms in 2016 according to individual technologies

Source: ZEW – Mannheim Innovation Panel.

12.3 Expected Change in the Usage of Digital Technologies

A majority of German firms expects that the use of digital technologies will remain constant in the next three to five years (Figure 12-5). The share of firms that expect an increasing importance ranges from 17 percent (teleworking) to 49 percent (interlinking with customers). Only occasionally firms expect digital technologies to become less important in the next years. In general there is a correlation between expectations of increased importance and current use of individual technologies. This means that the pattern of usage currently observed in the economy is most likely to prevail also in the coming years.

The same pattern is visible across sectors and size classes. In knowledge-intensive services more firms expect an increasing usage of digital technologies in the next three to five years than in the other three sectors. Only e-commerce, digital networks with suppliers and between production and logistics pose an exception. For these technologies an increasing importance is indicated by more firms in R&D-intensive manufacturing than in knowledge-intensive services.

Figure 12-5. Expected change in usage of digital technologies in German firms in the next three to five years

Source: ZEW – Mannheim Innovation Panel.

Figure 12-6. Expected change in usage of digital technologies in German firms in the next three to five years, by main sector, size class and region

Source: ZEW – Mannheim Innovation Panel.

Large companies expect too a much larger degree an increasing usage of digital technologies than small companies (Figure 12-6). This holds for all specified technological subcategories and in particular for big data applications. Around two thirds of large firms plan to increase their activities in this area in the next years. For small firms this only holds true for 15 percent. The smallest differences in expected importance between small and large firms can be found for social media usage. Around 50 percent of large firms and 25 percent of small firms intend to expand their activities in this field.

12.4 Difficulties in Using Digital Technologies

Data protection and security poses the greatest difficulties for German firms in 2016 in using digital technologies. 26 percent of firms indicate that data security poses a major obstacle to them, 23 percent mention data protection as a major problem (Figure 12-7). By contrast, uncertainty about future technological developments and the emergence of technical standards are indicated much less frequently, by 8 percent and 9 percent of firms respectively. These results likewise point to the conclusion that the technological evolution of digital technologies is already in an advanced stadium and creates only little uncertainty for firms.

Figure 12-7. Difficulties in using digital technologies in German firms in 2016

Source: ZEW – Mannheim Innovation Panel.

The state of the general technical infrastructure, such as the availability of sufficient transmission rates and speed, is another obstacle for firms in using digital technologies in their business practices. 19 percent of firms report major difficulties and 73 percent indicate having at least minor difficulties in this field. The adaption of existing IT systems is a major obstacle for 14 percent of firms and establishing adequate interfaces for data exchange with externals is difficult for 13 percent of firms. The financing of digital technology adoption, by contrast, is less of an issue. 10 percent of firms mention major, 19 percent intermediate, and 26 percent

minor difficulties with financing. In this regard it is noteworthy that a majority of digital technologies are not very costly to purchase. A current ZEW study shows that around half of German firms invest less than €10,000 per year in digitalisation and only 12 percent of SMEs (firms with an annual turnover of less than €500mn) invest more than €40,000 per year (Saam et al., 2016).

Of major importance for firms are low IT skills in their existing personnel. 72 percent of firms indicate this as a problem in using digital technologies, for 12 percent it is even a major difficulty. A related obstacle is the shortage of IT skilled personnel on the labour market, although this is less frequently mentioned by firms. The reason is most likely that many firms would not consider hiring additional employees in order to realise their IT projects.

Figure 12-8. Selected difficulties in using digital technologies with major importance to German firms in 2016, according to industry size class, and region

Source: ZEW – Mannheim Innovation Panel.

Data security and protection and problems with the general digital infrastructure are reported most often in knowledge-intensive services (Figure 12-8). With respect to low IT skills by employees there are only negligible differences between industries. Only in the knowledge-intensive services they are mentioned less frequently as difficulties by firms. This result is predominantly driven by the IT and telecommunication, and the technical and R&D-service industries. In these industries digital technologies are in many cases at the core of the business

model. Therefore the existing personnel often already possesses sufficient IT skills. There are no differences concerning a shortage of IT skilled personnel on the labour market across size classes. Only very small firms report this difficulty less frequently, which can be explained by a lower demand for high-skilled new employees in these firms. By contrast, the state of the general infrastructure is an obstacle predominantly for small firms with ten to 99 employees.

Low IT skills of the existing personnel are a more often mentioned in small and large firms as major difficulties (15 percent) than in very small firms (10 percent). Larger differences can be found across industries. Especially in industries within non-R&D-intensive manufacturing, such as "glass/ceramics/concrete" or "food/beverages/tobacco", low IT skills of employees pose a major difficulty (Figure 12-9). In these industries digital technologies have so far only played a minor role in production and design. Thus, the existing stock of employees is not sufficiently trained in the use of IT applications.

Figure 12-9. Major importance of the difficulties "shortage of IT skilled personnel" and "low IT skills of existing personnel" in German firms in 2016, according to industry

Source: ZEW – Mannheim Innovation Panel.

Data security is a major difficulty in using digital technologies in particular in the chemical and pharmaceutical industry, machinery, and in financial services (Figure 12-10). In R&D-intensive manufacturing industries this is most likely the case because digital networks, which are accessible from outside, pose the threat that sensitive information, e.g. related to technical processes or planned R&D projects, might leak to unauthorized outsiders. For financial service firms the security of sensitive customer data is of first-order importance. The state of the general digital infrastructure is an obstacle for firms in some manufacturing industries (machinery, automotive, glass/ceramics/concrete, and metals) and in wholesaling and transporta-

tion. In the IT and telecommunication industry and financial services there is only a small share of firms that suffer from an insufficient state of the general infrastructure. These industries always relied on digital technologies all along, therefore necessary infrastructure investments have been occurred already in the past.

Figure 12-10. Major importance of the difficulties "general technical infrastructure" and "data security" in German firms in 2016, according to industry

Source: ZEW – Mannheim Innovation Panel.

13 Firm Strategies and Organisational Characteristics

Managing firms successfully requires them to create internal capabilities and align these with their external environments (Zajac et al., 2000) by implementing appropriate strategies. The firm's competitive advantage depends heavily on its managers' abilities to anticipate correctly how major strategic actions will affect this alignment in the short and particularly in the long run. Innovation activities are one of the core strategic choices managers have. But there are many other decisions and influential factors. On the most general level, firms need to define their own strategic goals. These goals may differ considerably between sectors and market environments. For example, a new IT platform-based firm will try to expand the market as well as its market share as quickly as possible in order to realize network externalities. Profitability targets may be less important in the short run. The music streaming service Spotify with its now 75 million customers still incurs considerable losses. Firms operating in stable markets with homogenous goods may be much more reliant on their ability to produce cost efficiently.

Based on their goals, firms adopt strategies which help them to achieve their objectives. Strategies operationalise the goals by delineating specific actions. For example, if the goal is to reduce costs, firms can aim at reducing internal production costs or external costs (e.g. by renegotiating contracts with suppliers). Adopting certain strategies may not be an option for all firms to the same degree. Firms may be hindered from adopting a specific strategy, e.g. by a weak position in the market or by regulations. A small company, for example, may not be able to renegotiate more favourable contracts with its suppliers due to its limited market power.

The ownership structure of a firm can also have a considerable effect on how decisions are made. It is well established, for example, that family-owned businesses show markedly different behaviour regarding strategic choices. Family-owned businesses are often more committed to long-term strategies but less willing to change established practices. Another influential factor concerns the internal capability base. Firms with weak capability bases with regard to certain activities may be hindered from implementing all the available strategies. For instance, low technological capabilities may impede a firm's ability to enter foreign markets while pursuing the goal of increasing turnover. One solution may be to acquire the missing capabilities by buying existing firms on the market. Thus, actions like mergers and acquisitions, founding new companies, or even the closure of no longer profitable parts are all potential strategies to align the firm's capabilities to external requirements. These topics will be covered in this chapter, as all of the variables can have considerable influence on a firm's innovation activities.

13.1 Goals and Strategies

Increasing turnover was the dominant firm goal for the year 2012. 54 percent of all firms stated that high turnover was a very important goal for them. This was followed by increasing the profit rate, which 51 percent indicated to be a very important goal. 47 percent argued that

reducing costs was very important. However, only 27 percent of all companies stated that increasing their market share was very important to them.

Figure 13-1 Firm goals of firms in Germany (2012)

Source: ZEW – Mannheim Innovation Panel.

Figure 13-2. Goal "increasing turnover" by sector, size class, and region (2012)

Source: ZEW – Mannheim Innovation Panel.

The importance of these goals may differ considerably by sector and size class. As Figure 13-2 shows, the importance of increasing turnover appears to be highest in R&D-intensive manufacturing, where 93 percent stated that this was important or very important. It was lowest in other services, where 86 percent believed that the goal was important or very important. There also seems to be a positive correlation with size. Among the smallest firms (5-9 em-

ployees), 85 percent indicated that increasing turnover is an important or very important goal. This share was 93 percent in the group of firms with 1,000 or more employees. There is no difference between Western and Eastern Germany. 87 percent of the firms in both regions indicated that increasing turnover was important or very important to them.

A greater difference between sectors clearly emerges with respect to the strategy of reducing internal costs. When comparing sectors, firms from other manufacturing placed the greatest emphasis on this strategy; 92 percent considered the reduction of internal costs an important or very important strategy. At 91 percent, this share was almost identical in R&D-intensive manufacturing. It was 4 percentage points lower in other services (87 percent). However, in knowledge-intensive services, only 68 percent of firms indicated that reducing internal costs was at least an important strategy. This much lower share shows that cost reductions are not a primary strategy of firms in this sector. This may have to do with the differences in the markets triggered by product specificities. Knowledge-intensive services are often, though not exclusively, related to consultancy activities, implying that the services are highly customer-specific and therefore customers have a lower price sensitivity here. The quality of the service is often more important.

Figure 13-3. Goal "reducing internal costs" by sector, size class, and region (2012)

Source: ZEW – Mannheim Innovation Panel.

When looking at the overall firm strategies from a broader perspective, we see that most firms consider increases in the quality of existing products to be most important. 52 percent stated that increased quality was a very important goal. This was followed by the reduction of

internal costs, which 40 percent of all firms considered to be very important. 34 percent had a strong focus on reducing external costs, while 27 percent replied that the introduction of new products was very important. Still almost a quarter (24 percent) stated that greater flexibility of the internal organisation was very important. All the other strategies were only named by much fewer firms. 17 percent considered marketing improvements to be very important. Entering new markets in Europe was very important for only 12 percent and entering new markets outside Europe was very important for only 7 percent.

Figure 13-4. Strategies of firms in Germany to meet their firm goals (2012)

Source: ZEW – Mannheim Innovation Panel.

Figure 13-5. Obstacles to achieving the firm's goals (2012)

Source: ZEW – Mannheim Innovation Panel.

Regarding the obstacles to achieving the firm's goals (Figure 13-5), by far the highest share of firms considered strong price competition to be very important (54 percent) or important (27 percent). Strong competition in terms of product quality or marketing was ranked second; 22 percent thought that this obstacle was very important and another 37 percent that it was important. The lack of qualified personnel was also considered an important hindrance. In total, 46 percent of all firms considered this to be very important or important to their company. The obstacles with the least relevance for all firms were the high costs of entering new markets (11 percent very important), lack of appropriate funding sources (10 percent very important) and innovation by competitors (6 percent).

13.2 Ownership Structure: Family-owned Businesses

Family-owned businesses are a special characteristic of the German SMEs, where many firms are owned by only one family often spanning multiple generations. In total, 67 percent of all firms in Germany were owned by a family in 2014 (Figure 13-6). Because larger companies tend to be transformed into equity-based companies, it can be expected that the share of family-owned businesses declines with firm size. In fact, this is what can be observed. Overall, 71 percent of firms in the smallest size class (5-9 employees) were family-owned, while this share was only 59 percent for firms with 100-249 employees. Nonetheless, 37 percent of all firms with 1,000 or more employees were still owned by a family. These figures underline the fact that family-owned businesses constitute a very important part of the German economy. This result is not particularly surprising for smaller firms organised as partnerships (*Personengesellschaft*), because smaller firms usually start with one owner, which makes them by definition a family-owned business.

Figure 13-6. Family-owned businesses in Germany 2014, by main sector, size class and region

Source: ZEW – Mannheim Innovation Panel.

The majority of family-owned businesses has been founded by the family members that are currently owning the business (first generation family businesses). 27 percent of all family-owned businesses in Germany are run by the second generation and 16 percent by the third generation. Old family-owned businesses that are owned by the family in the fifth generation or more are very rare (3 percent).

Most family-owned businesses are solely managed by family members (77 percent). In 19 percent of family-owned businesses, both family members and external managers form the top management. Only 4 percent of family-owned businesses are run entirely by external managers.

More interesting is the question of how persistent family ownership is over generations. Firms were asked to indicate whether plans existed to hand over the company to the next generation. Not surprisingly the share increases here with the size of the firm. While 40 percent of all family-owned businesses with 5-9 employees indicated that the firm should be continued by the next generation, the corresponding share was 51 percent in the group of family-owned firms with more than 1,000 employees.

Figure 13-7. Family-owned businesses to be handed over to the next generation (2014), by size class and region

Source: ZEW – Mannheim Innovation Panel.

13.3 Company Events

In 2012, a total of 4.1 percent of all firms indicated that a merger or an acquisition had taken place. This was somewhat higher in 2014 with 5.1 percent. 3.5 percent all firms reported that parts had been sold or closed down in 2012, while the respective share was 5.5 percent in 2014. The share of firms outsourcing activities to other companies remained relatively stable over time. 4.2 percent stated they had outsourced activities in 2012, while the respective share

was 4.3 percent in 2014. Founding new subsidiaries increased as well (5.5 percent in 2014). If all the eventualities are considered together, in 2012, 12.3 percent reported that at least one of the four actions had occurred. This share increased by 1.8 percentage point to 14.1 percent in 2014. Overall, the results show that such company actions are relatively rare and are not part of the day-to-day business in most companies.

Figure 13-8. Frequency of mergers & acquisitions, founding of subsidiaries, selling/closure of company parts and outsourcing of firm activities in firms in Germany, 2010-2014

Source: ZEW – Mannheim Innovation Panel.

Figure 13-9. Mergers & acquisitions and foundations by sector, size class and region (2014)

Source: ZEW – Mannheim Innovation Panel.

Despite their overall rarity, Figure 13-9 and Figure 13-10 show that the overall frequency depends strongly on size and to some degree on the firm's sector. While only 3 percent of firms with 5-9 employees reported a merger or acquisition, the corresponding figure of 31 percent represents almost a third for firms with 1,000 or more employees. The foundation of new companies was even less frequent among the smallest firms, where only 1 percent reported such an event. This share was 27 percent for firms with 1,000 or more. A clear sectoral pattern emerges with regard to mergers, acquisitions and foundations of new companies. In general, the frequency of such actions is the highest in R&D-intensive manufacturing and the lowest in other services. Other manufacturing and knowledge-intensive services lie in-between.

Comparable patterns emerge when looking at selling or shutting down firm activities. 4 percent of all firms in the smallest size group report such events, but 30 percent of the firms with 1,000 or more employees. The same holds for outsourcing of company activities, where the shares are 3 percent and 16 percent, respectively. The sectoral effect seems less pronounced however. The shares hover between 4 percent and 6 percent both with respect to closing/selling parts of firms and outsourcing of firm activities with little variation between sectors.

Figure 13-10. Mergers and acquisitions and foundations by sector, size class and region (2014)

Source: ZEW – Mannheim Innovation Panel.

14 Competitive Environment

The competitive environment refers to how producing firms interact with their competitors, customers, and suppliers. The competitive environment is strongly shaped by the type of goods and services exchanged on the market. Because the competitive environment has direct effects on a firm's market power, it also shapes its incentives for innovation as well as its direction. It is still being debated how the competitive environment affects innovation. Some authors have argued that fully competitive markets will maximize the incentives for innovation, because monopolists will only replace their existing position which would limit their incentives to innovate (Arrow, 1962). Others have argued that monopolists have stronger internal financing positions, greater command over distribution channels, and are more able to reap the profits from innovation. Monopolists would therefore have greater incentives to innovate (Schumpeter, 1943). Some have argued in favour of an inverted u-shape where innovation incentives are maximized for intermediate degrees of competition (Arrow et al., 2005; Schubert, 2010).

The relationship between innovation and competition becomes even more complicated because it is bi-directional in the sense that innovation can also affect the competitive environment. For example, if a firm introduces a ground breaking new product, it can escape competition and increase its market power. Most authors assume that the bi-directional relationship between innovation and the degree of competition depends on how firms interact strategically. Furthermore, competition needs to be understood in a broader sense, not simply as the degree of rivalry between firms. In other words, the competitive environment determines the rules of the game. The competitive environment in this respect depends on technological dynamism, among other things, which comprises the speed of technological change and uncertainty about its direction (Bourgeois and Eisenhardt, 1988). It also depends on how international competitors threaten regional and national markets by their entry. And it depends on the degree of product differentiation. All these factors affect not only the degree of rivalry between competing firms, but also the customers' willingness to pay, and the incentives to innovate both in terms of intensity and direction. The competitive environment therefore determines how much firms spend on innovation and whether they seek to reduce costs or introduce new and improved products. It also determines whether firms seek to develop incremental or more radical innovations.

14.1 Market Share and Number of Competitors

A key variable describing a firm's competitive environment is its market share. If a firm is able to capture a large share of the market, it is usually exposed to less competition, opening up the possibility to generate above-normal profits by exerting market power. It should, however, be noted that the relevant market can vary strongly in terms of size and geographic spread between firms. For example, a bakery may apply a rather local definition of the relevant market because the majority of its customers live nearby. It may have a relatively high share of its relevant market, which is a relatively small one. A globally active car manufactur-

er, in contrast, may hold a relatively small share of a very large market. In our analyses, the average market share in 2014 amounted to 9 percent when weighted by the firms' turnovers.[11] These figures differ considerably by sector and company size. In R&D-intensive manufacturing, the average market share was 15 percent followed by other manufacturing with 11 percent. Services ranked lower with 8 percent in other services and 7 percent in knowledge-intensive services. The reason for the higher market shares of manufacturing firms may also have to do with higher capital intensity, which implies the necessity for upfront investments before entering the market. Higher upfront investments will also reduce the number of competitors. When looking at the differentiation by firm size, we see the expected pattern that the market share increases with size. Firms with 5-9 employees have an average market share of 8 percent, while firms with 1,000 or more employees have an overall market share of 19 percent. Although the market shares increase with firm size, the increase is moderate, showing that larger firms operate on markets with a much larger volume. With regard to regional differentiation, the results for Eastern and Western Germany are identical at 9 percent.

Figure 14-1. Market share by sector, size, and region (2014), by main sector, size class and region

Source: ZEW – Mannheim Innovation Panel.

11 The weighting by number of companies is presented as a point of reference. It will however not be described because the pure numbers do not account for different firm sizes.

Apart from market shares, the number of competitors also influences the strategic interaction between firms and thus the extent of rivalry between them. No main competitors indicate that the firm holds a monopoly and thus has relatively large market power. The results in Figure 14-2, however, indicate that this situation was relatively rare in 2012. Only 5 percent of all firms indicated that they did not have any competitors. Although this share does not differ dramatically between sectors, size classes, and regions, it is interesting to see that the smallest firms with 5-9 employees were most likely to be monopolists. This result is probably due to the fact that many small firms operate on localised small markets. While, again, regional differences do not seem to be pertinent, we do see the expected pattern that the number of competitors seems to be negatively related to firm size regarding the other categories. More than 50 main competitors, which can be considered close to fully competitive markets, are reported by 28 percent of the smallest firms, while only 12 percent of the firms with 1,000 or more employees report this number. The sector pattern is also interesting. Only 9 percent of the firms in R&D-intensive manufacturing stated that their main competitors numbered more than 50. This share was more than a third (34 percent) in knowledge-intensive services. Likewise, R&D-intensive manufacturing was also characterized by a high share of firms with only a few main competitors. Almost half the firms reported having 1-5 main competitors.

Figure 14-2. Number of main competitors (2012), by main sector, size class and region

Source: ZEW – Mannheim Innovation Panel.

14.2 Main Geographical Markets

At the same time R&D-intensive manufacturing was much more focused on supra-regional markets in 2012. From Figure 14-3, we see that only 11 percent of firms produced mainly for

local markets. The supra-regional share was higher by a factor of five with 51 percent. Other services were the sector-group focused most strongly on local markets with 59 percent. The main market was outside Germany for only a minority of firms. In total, 3 percent of firms reported they served mainly European markets, while 4 percent reported that their main markets were located outside Europe. These figures correspond roughly to the shares reported by firms in other manufacturing, other services, and knowledge-intensive services. In R&D-intensive manufacturing, the international firms were still a minority. Nonetheless, the shares were higher.

Figure 14-3. Location of main market, 2012 and 2014, by main sector, size class and region

Source: ZEW – Mannheim Innovation Panel.

12 percent of the firms in R&D-intensive manufacturing claimed they supplied mainly European markets, while another 16 percent stated that their main markets were located outside Europe. With regard to the effect of firm size, we see that the share of firms focused on local markets decreases dramatically with size. Among the firms with 5-9 employees, 57 percent served mainly local markets, while the share was 19 percent in the group of 1,000 or more employees. The regional differences were again small, although Eastern German firms are slightly more likely to operate regionally (55 percent) than Western German firms (50 percent). When comparing the results from 2012 with 2014, the overall patterns with respect to size, sector, and region remain relatively stable. The only difference is that the regional focus seems to have declined slightly on average (48 percent in 2014 compared to 51 percent in 2012), while the importance of the German national market increased slightly (44 percent in 2014 compared to 42 percent in 2012).

14.3 Competitive Environment of the Main Market

The specific competitive parameters are often of direct relevance for innovation activities, because they determine not only the abstract degree of rivalry but also the types of competitive activity firms can successfully pursue. Figure 14-4 illustrate that high product substitutability was the main issue for the majority of all firms. In 2012, 59 percent (62 percent in 2014) stated substitutability was the main competitive factor. Markets characterised by substitutable goods imply a high degree of competition, considerably reducing the firms' possibilities to set higher prices. Typically, the market structure is close to full competition with relatively homogeneous products. Such a market structure guarantees high static efficiency because welfare-reducing deadweight losses are minimized. However, firms are continuously under threat of falling prey to their competitors because there are only low potentials for gaining a competitive advantage by offering unique products. In fact, many firms indicated that the threat of new competitors entering the market was also very high. In 2012, 54 percent regarded the threat of market entry as very relevant or relevant. In 2014, this share was roughly the same with 53 percent.

On the contrary, only a small share of firms indicated that their competitive environment was characterised by forces typically associated with high levels of innovation. In 2014, 22 percent agreed or agreed completely with the statement that goods were quickly outdated, while about 30 percent agreed or agreed strongly with the statement that the direction of technological change was difficult to predict. Markets characterised by rapid technological change and uncertainty about its direction require firms to show great innovativeness and high capabilities to remain competitive. However, they also allow firms to develop unique goods/services which can give them a lasting competitive edge beyond the ability to produce homogeneous goods/services at low prices. In that respect, the results show that, although Germany's economy is one of most competitive, the majority of firms still operate under conditions characterised by high substitutability, high threat of competitors' market entry, and price competition.

Figure 14-4. Characteristics of the competitive environment 2012 and 2014

Source: ZEW – Mannheim Innovation Panel.

As expected, the relative importance of the competitive forces differs strongly by sector and company size (Figure 14-5). Figure 14-4 showed that firms in R&D-intensive manufacturing were more likely to operate on foreign markets. As a consequence, we find that these firms rate the threat of foreign competition much higher. 58 percent of these firms agreed or agreed completely with the statement that there is a high threat of foreign competition. This share was 39 percent in other manufacturing and 33 percent in other services. This share was the lowest by far in knowledge-intensive services, where only 12 percent emphasized the importance of foreign competition. The threat of competitors' market entry, in contrast, was ranked the lowest by firms in R&D-intensive manufacturing (42 percent), had intermediate values in knowledge-intensive services (45 percent) and was the highest in other services, where 63 percent highlighted the threat of market entry. The share of firms indicating that the direction of technological change was hard to predict was highest in R&D-intensive manufacturing (35 percent) and lowest in other services (28 percent). However, the relatively small difference here indicates that the sector classification does not have a strong effect on how firms rate the uncertainty about technological developments. The same seems to be true for

firm size as well, where no clear pattern emerges. The share of firms ranking the uncertainty of technological developments as important hovers around 30 percent across all size classes. A clearer pattern is observable for the threat of market entry. Among the smallest firms, 57 percent consider this to be important, while the respective share is 45 percent among firms with 1,000 or more employees. As expected, the share of firms considering foreign competition to be important increases with size. 29 percent of the firms with 5-9 employees rate foreign competition as important, while this share is 44 percent among the largest firms.

Figure 14-5. Characteristics of the competitive environment (2014), by main sector, size class and region

Source: ZEW – Mannheim Innovation Panel.

Figure 14-6 shows the change in selling price between 2010 and 2012. On average, the firms indicated that prices they could charge increased by 2 percent. Interestingly, the breakdown by sector shows that other services experienced the highest increase (3.3 percent), while prices remained almost unchanged in the knowledge-intensive services (+0.2 percent). In R&D-intensive services, the selling price increased by 1.7 percent on average and by 2.6 percent in other manufacturing. The pattern with respect to company size fluctuates. The highest increase in selling price was reported by firms with 10-19 employees (4.6 percent), while larger firms experienced lower increases. The increase was 1.5 percent for firms with 1,000 or more employees, and 2.4 percent for firms with 500-999 employees. Furthermore, price in-

creases appear to differ by region. Eastern German firms reported price increases of 0.9 percent, while Western German firms reported an average increase of 2.1 percent.

Figure 14-6. Change in selling prices (2010-2012), by main sector, size class and region

Source: ZEW – Mannheim Innovation Panel.

15 Innovation and Investment

In recent years, the concept of intangible assets has received increasing attention as a more comprehensive approach to capture firms' investment in innovative assets than the innovation expenditure approach following the Oslo Manual. Investment in intangible assets includes informational capital (software and databases), knowledge capital (R&D, non-technological knowledge), human capital, organisational capital, and reputational capital (see Brynjolfsson et al., 2002; Corrado et al., 2005, 2006; OECD, 1998). Most of these intangible assets are closely related to innovation, and most innovation activities result in the creation of intangible assets (see Awano et al., 2010).

The aim of this chapter is twofold. First, it provides a quantitative estimate on the volume of intangible as well as tangible investment in the German business enterprise sector. For this purpose expenditure data collected in the MIP is combined with investment data from the national accounts statistics. Secondly, the chapter analyses the share of innovation-related expenditure in total tangible and intangible investment.

The chapter builds upon a first exercise on this topic conducted for the reference years 2006 to 2010 (see Aschhoff et al., 2013). In order to ease comparison, this chapter follows the same structure and contains the same types of tables and figures as the report on the 2006 to 2010 results.

15.1 Innovation and the Concept of Intangibles

Capital spending of firms is traditionally separated in two classes: capital spending for tangible assets and capital spending for intangibles. While tangible (or fixed) asset is a well-established concept that refers to a firm's investment in equipment and building, the notion of intangibles is rather blurred. From a theoretical perspective, all activities that generate assets other than fixed assets are intangible investment. These activities are often related to the creation of knowledge or intellectual capital. In recent years, a classification of intangibles proposed by Corrado et al. (2005) has become generally accepted. Corrado et al. (2005, 2006) distinguish three main groups of intangibles:

- Computerised information, particularly software and databases;
- Innovative property, particularly knowledge produced by R&D and other creative or inventive activities;
- Economic competencies, particularly brand equity/reputation and firm-specific human and organisational resources.

It is evident that innovation activities (as defined in the Oslo Manual) are closely related to the concept of intangibles. Basically all innovation expenditure for other items than fixed assets will qualify as capital spending for intangibles. However, expenditure for intangibles also includes activities that would not qualify as innovation activities. This is true for advertising,

market research and reputation building expenditure on non-innovative products, for training and other types of human capital development not related to innovation, for software and database development not linked to innovation, and for most activities in the context of organisational development since such activities are not regarded as process innovation in the Oslo Manual (but rather as organisational innovation, see Chapter 7).

Table 15-1 summarises the coverage of spending for intangibles in innovation expenditure as defined by the Oslo Manual. By definition, all expenditure for R&D is both intangible and innovation expenditure. The same is true for expenditure for other creative work as such work such lead to an innovative property according to Corrado et al. (2005). Expenditure for intellectual property rights such as patents, brand names or industrial designs may also be linked to non-innovative activities though it is very likely that the largest fraction of such expenditure is used for product or process innovation as defined by the Oslo Manual.

Measuring intangibles is complicated by the fact that the different types of spending are treated differently in business accounting. Some spending such as purchase and in-house development of software or intellectual property rights (including brand names) qualify as capital expenditure in accounting policies and can be capitalised as intangible assets in the balance sheet. Some part of R&D expenditure may also be capitalised if certain requirements are met (which applies to certain technological development). Other spending for intangibles are current costs and do not enter a firm's balance sheet. This includes expenditure for advertising, market research, reputation building, training and organisational development as well as research, design, engineering and other creative work.

Table 15-1. Coverage of intangibles in innovation expenditure

	Innovation expenditure		
Expenditure for intangible assets	*R&D*	*Capex*	*other*
Expenditure for software and databases		(x)	(x)
Expenditure for R&D	x	x	
Expenditure for other creative work other than R&D			x
Expenditure for intellectual property rights		(x)	
Expenditure for brand equity and reputation building			(x)
Expenditure for training			(x)
Expenditure for organisational development/business process improvement			0

x: (almost) completely covered; (x): only partially covered; 0: mostly uncovered

15.2 Measuring Intangible Investment and the Innovation Share in Total Investment

Data on tangible investment by industry in the German enterprise sector is readily available from business and national account statistics. National account statistics also include data on intangible investment in software. Data on R&D expenditure —including a breakdown by in-house and external as well as by current and capital expenditure— is provided by R&D statistics (see Kladroba and Stenke, 2013; Eckl et al., 2015). Data on firms' expenditure for training are collected as part of the EU's Community Vocational Training Survey (CVTS) every

fifth year (the most recent data are for 2010). For all other expenditure on intangibles, including brand equity and creative work other than R&D, no industry data is available from existing statistics.

In order to estimate the total amount of tangible and intangible investment and the share of innovation in these totals for individual industries of the German business enterprise sector, we combine three data sources: the MIP, national accounts statistics (NAS), and R&D statistics. Total investment is broken down by seven expenditure categories:

1. Capital expenditure for machinery, equipment and buildings (‘capex for tangibles’)
2. Capital expenditure for software
3. Expenditure for advertising, market research, marketing innovation and other types of product promotion (‘promotion/branding expenditure’)
4. Expenditure for continuing and further education of employees and other activities in human capital development (‘training expenditure’)
5. R&D expenditure (in-house plus external)
6. Current innovation expenditure for creative work other than R&D such as design, engineering and conceptual and preparatory work (‘other innovation expenditure’)
7. Expenditure for intellectual property rights (IPRs) in the context of innovation activities and capital expenditure for copyrights for audiovisual media and pool test in mining (‘Expenditure for IPRs’)

Note that categories 1 to 4 refer to expenditure for both innovative and non-innovative purposes and include expenditure by non-innovative firms. MIP data is used to measure the expenditure categories 1, 3, 4, 5 and 6. Note that data on capex for tangibles (1) and R&D expenditure (5) are taken from the MIP despite their availability in existing statistics in order to guarantee consistency of industry data with other investment items since industry assignment of large corporations differs between official investment statistics, R&D statistics and the approach used in the MIP. Total figures for both expenditure items derived from the MIP are highly consistent with totals from official statistics.

NAS data is used for measuring capex for software (category 2). The MIP collects data on expenditure for software including current expenditure since the reference year 2011. This data is not used, however, since it is not possible to identify the share of current expenditure for software that is included in R&D expenditure.

Expenditure for IPRs consist of two components. Expenditure for IPRs in the context of innovation activities is taken from the MIP. NAS provide capital expenditure on IPRs for two sub-categories, copyrights for audiovisual media and pool test in mining. Any other expenditure on IPRs outside of innovation activities is missing in this analysis.

When summing up R&D expenditure and capex for tangibles and software, double counting of capital expenditure for R&D will occur since R&D expenditure data include both current

spending and capital expenditure on tangibles and software. To avoid such double counting, data on capital expenditure for R&D from the R&D survey are taken to deduct capital expenditure from total R&D expenditure. Note that development costs that are capitalised as intangible assets remain part of R&D expenditure and are not included in capital expenditure categories.

In order to determine the share of innovation-related expenditures in total tangible and intangible investment, capex on tangibles and software, promotion/branding expenditure and training expenditure need to be split up in an innovation and a non-innovation fraction.[12] For capex on tangible assets and software, the MIP directly collects the amount of this expenditure made in the context of innovation activities which allows for the calculation of the respective innovation share. Unfortunately, no separation can be made between tangibles and software since the MIP —following the CIS questionnaire— surveys only the total of the two types of capital expenditure as an innovation expenditure category. With respect to capital expenditure on IPRs, no innovation share can be calculated since no total (innovative plus non-innovative) expenditure data are available.

The straightforward way to determine the innovation share of promotion/branding and training expenditure would be to collect this information in the MIP. While this has been done in some earlier survey waves, in more recent waves the corresponding questions have been skipped in order to reduce response burden for firms. Currently, only the total of innovation-related current expenditure for advertising, market research, reputation building, training, design, engineering and other conceptual and preparatory activities for developing and introducing product or process innovation is collected (i.e. category 5 in the list above). This total is separated into the three components promotion/branding, training and others at the firm level by using three types of information: (a) whether a firm has conducted any of the three activities in the context of innovation (if this is not the case, the expenditure for the respective component can be set to zero), (b) the firm's total expenditure for advertising, market research, marketing innovation etc. and for training; and (c) the significance of innovation results in the firm's total output. The latter is used to calculate two indexes of innovativeness which are used to weight total expenditure for promotion/branding and for training to derive an estimate of innovation-related expenditure for each of the two categories. For promotion/branding expenditure, the innovativeness index sums up the share of sales generated by market novelties, product-range novelties and product imitations (i.e. new products that are only new to the firm; see Chapter 4 on details), but weights sales share of the two novelties with 1.25 to represent higher efforts for advertising, market research and other activities of reputation building for new products with a higher degree of novelty. The index ranges from zero (for firms without new products) to 1. For training expenditure, the innovativeness index also takes process innovation success into account (measured by the share of cost savings

12 Note that R&D expenditure is by definition a part of innovation expenditure.

through process innovation and sales growth due to quality improvements) as such innovations often require additional training efforts.

Table 15-2 presents the main categories of total tangible and intangible investment used in this analysis, the data source for each category and to what extent a breakdown by innovation is possible. The first reference year for which full information on all investment categories is available in the MIP is 2006 since it was the 2007 survey that included a question on promotion/branding expenditure for the first time.

Table 15-2. Categories of tangible and intangible investment and data sources

	Data source	Innovation breakdown
1a. Capex on tangibles	MIP	yes (based on survey question)
1b. Capex on software	MIP, NAS	
2. Promotion/branding expenditure	MIP	yes (based on estimation)
3. Training expenditure	MIP	yes (based on estimation)
4. R&D expenditure[2)]	MIP, RDS	100% innovation
5. Other innovation expenditure	MIP	100% innovation
6. Capex on IPRs[1)]	MIP, NAS	not possible

1) Only for innovation, except for copyright for audiovisual media and pool test in mining.
2) Including extramural R&D, excluding capital expenditure for tangibles and software.
NAS: national account statistics; RDS: R&D survey.

Compared to other empirical work on intangibles (see Corrado et al., 2005; Goodridge et al., 2012), the following expenditure categories are not covered in the present analysis:

- Non-capitalised costs for software development, costs for databases and other computerised knowledge not for innovation.
- Costs for creative work other than R&D that is not used for product or process innovation (e.g. design for packaging or presentation of products, which is part of marketing innovation).
- Expenditure on IPRs not for innovation other than copyrights for audiovisual media.
- Expenditure on organisational development and business process improvement.

It is not possible to assess the extent of undercoverage of total intangible investment due to these missing categories except for expenditure on organisational development and business process improvement. For this category, data on firms' expenditure for organisational innovation is available for the reference year 2012. As organisational innovation is closely related to organisational development and business process improvement, the amount of expenditure for this type of innovation provides some hint on the likely volume of intangible investment into organisational capital. The results are presented at the end of the next section.

With respect to non-capitalised costs for software, data from the MIP can be used to assess the magnitude of these costs. Since the 2013 survey (starting with the reference year 2011) the MIP collects information on software expenditure including both capex and current in-house and extramural expenditure. In 2014, total software expenditure according to the MIP data

was €25.8bn, compared to €16.4bn of software capex in NAS. It is not known, however, how much of current software expenditure is included in R&D expenditure.

15.3 Tangible and Intangible Investment by Industry

This section presents the main findings on the level and composition of tangible and intangible investment in the German business enterprise sector for the reference year 2014. It provides a breakdown by industry and discusses the share of innovation-related investment in total investment. Developments over time are presented in the following section.

In 2014, German enterprises (within the sectors covered by the MIP and with 5 or more employees) spent €310.3bn on tangible and intangible investment. Investment in tangible assets (machinery, equipment, buildings) was €138.5bn (Table 15-3). The figure is slightly lower than capex on tangibles as reported in national account statistics for those industries that are covered by the MIP (€149.3bn). The difference mainly reflects that the MIP does not cover enterprises with less than 5 employees. In addition, industry assignment of large enterprises with main activities in different industries deviates in the MIP from national account statistics. While the latter assigns the entire enterprise to one industry, the MIP splits up some of the very large enterprises by industries. The share of tangible assets in total investment was 44.6% of total investment and is certainly overrated since some parts of intangible investment is missing in total investment.

Table 15-3. Tangible and intangible investment 2014, by main sector

billion €	R&D-intensive manufacturing	Other manufacturing	Knowledge-intensive services	Other services	**All sectors**
1a. Capex on tangibles	36.5	46.1	19.8	36.1	**138.5**
1b. Capex on software	4.4	2.6	6.1	3.3	**16.4**
2. Promotion/branding expenditure	21.3	12.5	11.6	6.1	**51.4**
3. Training expenditure	2.3	1.4	2.6	1.6	**8.0**
4. R&D expenditure[1)]	58.8	6.9	9.5	0.8	**75.9**
5. Other innovation expenditure	5.5	3.0	3.4	1.8	**13.7**
6. Capex on IPRs[2)]	0.8	0.5	5.1	0.1	**6.4**
Total investment	**129.5**	**73.0**	**58.0**	**49.8**	**310.3**

1) Including extramural R&D, excluding capex for tangibles and software; 2) only for innovation, except for copyright for audiovisual media and pool test in mining.

Source: ZEW calculation based on data sources given in Table 15-2.

Total intangible investment (excluding missing categories of intangibles) was €171.8bn. The largest part of intangible investment is R&D. In 2014, €75.9bn (which is 44% of total intangible investment) was spent on in-house or external R&D (excluding capital expenditure for tangible assets or software). The figure is higher than the figure reported by official R&D statistics for the industries covered by the MIP (€68.4bn excl. capex). The difference mainly reflects a broader definition of R&D in the MIP which may include software development

costs as well as costs for design engineering that do not qualify as R&D expenditure according to the Frascati Manual definition which is used in R&D statistics.

Expenditure for promotion and branding amounted to €51.4bn in 2014, which is 30% of total intangible investment. Capital expenditure for software was €16.6bn in 2008 which is 10% of total intangible investment. Other current innovation expenditure was €13.6bn in 2014 (8% of total intangible investment), and expenditure on IPRs was €6.4bn (4%). Expenditure for training in 2014 was €8.0bn (5% of total intangible investment). Training expenditure per employee was €512. This figure is slightly lower than training expenditure per employee according to the CVTS, which was €592 in 2010. Though a fall in training expenditure may not be excluded it is more likely that the figures obtained from the MIP somewhat underrate the wage costs of employees while they are undergoing training. R&D-intensive manufacturing industries spent €129.5bn on tangible and intangible investment in 2014 which is 41.7% of total investment of the sectors covered by the MIP. Other manufacturing industries invested a total of €73.0bn (23.5%). Knowledge-intensive services spent €58.0bn (18.7%) and other services €49.8bn (16.0%) on tangible and intangible assets.

The significance of the main investment categories varies substantially by main sector (Figure 15-1). In R&D-intensive manufacturing, R&D expenditure is the most important category 45.4% of total investment), followed by capital expenditure on tangible assets (28.2%) and promotion/branding (16.4%). In all other three sectors, expenditure on tangible assets is the most important category. In other manufacturing and other services, 63.1 and 72.5%, respectively, of total investment falls in this category. In knowledge-intensive services, it is only 34.1%. This sector shows the highest share for software investment and IPRs investment (the latter is strongly driven by the film and broadcasting industry). Knowledge-intensive services also report the highest share for other current innovation expenditure. Training expenditure is of little significance in all four sectors, though service sectors show a higher share (3.3 to 4.5%) than manufacturing sectors (1.8 to 2.0%).

Figure 15-1. Composition of total investment 2014, by main sector

R&D expenditure includes extramural R&D and excludes capex for tangibles and software; capex on IPRs only for innovation, except for copyright for audiovisual media and pool test in mining.

Source: ZEW calculation based on data sources given in Table 15-2.

The share of total investment in total sales is 6.0% for the German enterprise sector (Figure 15-2). The highest share is reported for R&D-intensive manufacturing (11.9%) while knowledge-intensive services spent 4.9% of their total sales on tangible or intangible assets. This low ratio is driven by financial intermediation and is mainly caused by high sales figures of this particular sector. As sales mainly comprise gross interest income and gross premium written, sales figures are not directly comparable to those of other service sectors. When excluding financial intermediation from knowledge-intensive services, it turns out that the share of expenditure on tangible or intangible assets exceeds that of R&D-intensive manufacturing, reaching 12.1%. This higher ratio mainly results from the higher capital expenditure on software and higher expenditure on IPR as well as the higher share of other innovation expenditure in sales. Capital expenditure on tangible assets in relation to sales is also higher in knowledge-intensive services than in R&D-intensive manufacturing. Knowledge-intensive service investment in this category is mainly driven by capital expenditure on IT and telecommunication infrastructure. As R&D-intensive manufacturing unites all those manufacturing industries that have a high share of R&D expenditure in sales, it is evident that this sector reports the highest investment to sales ratio for this category. Other manufacturing stands out for a relatively high share of tangible capital investment, though spending 3.0% of sales on this investment category is still lower than for R&D-intensive manufacturing and for knowledge-intensive services (when excluding financial intermediation). Investment in all other categories in other manufacturing is relatively lower than for the German business enterprise sector as a whole, resulting in a share of total investment in sales of 4.8%. Other services spend only 3.6% of their total sales on tangible or intangible investment, with a clear focus on tangible investment, though their share of 2.6 in sales is lower than for any other sector.

Figure 15-2. Total investment by category as a percentage of total sales 2014, by main sector

R&D expenditure includes extramural R&D and excludes capex for tangibles and software; capex on IPRs only for innovation, except for copyright for audiovisual media and pool test in mining.

Source: ZEW calculation based on data sources given in Table 15-2.

45% of total investment in tangible assets and intangibles takes place as part of innovation activities (see Table 15-4). While all R&D and other current innovation expenditure qualify

for innovation, the innovation share is rather low for training expenditure (37%), capital expenditure on tangible assets and software (24%), and promotion/branding expenditure (19%). The low innovation share of expenditure for building up brand equity and reputation results from two facts. First, many firms do not have any product innovation which means that all their expenditure on advertising and market research is for non-innovative products. Secondly, firms that have introduced new products generate, on average, the largest part of their sales with non-innovative products. As investment in brand equity and reputation is not only needed when introducing a product to the market for the first time but also in later stages of the product life cycle, most of the product innovators expenditure on advertising and market research aims at their older products.

Table 15-4. Share of innovation-related expenditure in total tangible and intangible investment 2014, by main sector

Innovation-related expenditure in total expenditure (percent)	R&D-intensive manufacturing	Other manufacturing	Knowledge-intensive services	Other services	**All sectors**
1. Capex on tangibles/software	47	20	16	13	**24**
2. Promotion/branding expenditure	34	7	12	4	**19**
3. Training expenditure	62	28	29	20	**37**
Total investment[1)]	**71**	**29**	**32**	**17**	**45**

1) Including R&D and other current innovation expenditure as well as capital expenditure on IPRs (the innovation share of all these components is, by definition, 100%) and capital expenditure on audiovisual copyrights/pool test not for innovation (0% innovation share).

Source: ZEW calculation based on data sources given in Table 15-2.

In R&D-intensive manufacturing, more than two thirds of total investment is for innovation. This high share is strongly driven by high R&D expenditure of this sector which represents a major part of their total investment. But also capital expenditure for tangible assets and software as well as training expenditure are often related to innovation activities. In knowledge-intensive services, 32% total investment is spent for innovation while other manufacturing devotes 29% of all investment to innovation, and other services just 17%. In all three sectors, 13 to 20% of capital expenditure for tangible assets and software is used for product or process innovation, which is a substantially lower share than in R&D-intensive manufacturing (47%).

A ranking of industries by the ratio of their total investment in sales produces a significantly different result than a ranking solely based on innovation expenditure. Figure 15-3 shows the respective ranking by splitting up total investment three categories: innovation expenditure, non-innovation intangible investment and non-innovation tangible investment. The industry with the highest share of total investment in sales is computer services (incl. programming activities) and telecommunications (16.0%). This sector invests quite strongly in all three categories. Innovation expenditure represents 6.6% of sales (which is rank 4 across the 21 industries considered), intangibles outside of innovation 4.9% (rank 2) and tangibles outside of innovation 4.5% (rank 3). Other industries with a high share of total investment in sales include the electronics and electrical industry (13.5%), the chemical and pharmaceutical industry

(13.3%), manufacturing of motor vehicles and other transport equipment (12.8%) and the media services (12.0%). The latter industry shows particularly high investment in non-innovation intangibles (8.1%) but medium investment in the two other categories.

Figure 15-3. Total investment as a percentage of total sales 2014, by industry

Source: ZEW calculation based on data sources given in Table 15-2.

There are some industries with very low innovation expenditure in sales that show a high share of total investment in sales owing to high tangible investment outside of innovation. This is particularly true for water supply and waste management (incl. recycling activities). This industry spent 8.1% of their sales in 2014 on tangible assets that are not related to any innovation activity. Consequently, only 10% of their total investment goes to innovation. Other industries with a very low share of innovation expenditure in total investment include wholesale trade (9%) and media services (16%). Industries with a high share of non-innovation tangible investment include transportation, storage and logistics (6.3%), computer services and telecommunications, and manufacture of glass, ceramics and concrete products (3.0%). A high share of intangible investment not related to innovation is reported for manufacturing of textiles, clothing and leather (3.3%), manufacturing of chemicals and pharmaceuticals (3.0%), legal/business consulting and advertising (2.5%), and manufacturing of food, beverages and tobacco (2.3%). The three manufacturing industries show a high share of consumer goods (in case of chemicals: detergents and cosmetics)) which require high spending for promotion and branding also for non-innovative products. The high share for le-

gal/business consulting and advertising is related to high software expenditure outside of innovation.

Expenditure for Organisational Innovation

The 2013 MIP survey included a question on the firms' expenditure for organisational innovation. As these expenditure are closely related to investment in organisation capital (organisational development activities, business process improvement) they provide a hint on the size of investment into this category of intangible assets which is missing in the data presented above. The attempt to collect expenditure data for organisational innovation was restricted by the fact that the majority of firms with organisational innovation (56%) were not able to provide an estimate of the spending made for this type of innovation. While missing values have been imputed, the results are subject to a high level of imprecision. The estimated total amount of expenditure for organisational innovation by firms in Germany in 2012 was €12.7bn which is 0.14% of the firms' total sales. The share of expenditure for organisation innovation in total sales is higher in R&D-intensive manufacturing and knowledge-intensive services (0.17% each) and lower in other manufacturing (0.09%) and other services (0.10%).

If one would add the expenditure for organisational innovation to total investment, the volume of total investment would increase by 4.2% in 2012. Intangible investment would increase by 7.7%. The significance of expenditure for organisational innovation is higher in knowledge-intensive services (6.9% increase in total investment) and other services (5.4% increase) and less significant in the manufacturing sectors (2.8% rise in total investment in R&D-intensive manufacturing, 3.5% rise in other manufacturing). Expenditure for organisational innovation is a quantitatively important category of intangible investment in other services. Total intangible investment would have been 22.4% higher in 2012 if expenditure for organisational innovation would be added. In knowledge-intensive services, intangible investment would rise by 10.3% and in other manufacturing by 9.3%. In R&D-intensive manufacturing, intangible investment would increase by 4.0% in case expenditure for organisational innovation would be added.

Figure 15-4. Expenditure for organisational innovation as a share of total (tangible) investment 2012, by main sector

Source: ZEW, Mannheim Innovation Panel..

15.4 Total Investment 2006 to 2014

MIP data allows estimating the volume of total investment in the German enterprise sector for the years 2006 to 2014. Total investment in the German business enterprise sector was €269.0bn in 2006 and rose to €310.3bn in 2014 (Figure 15-5). In 2008, total investment was at €304.6bn and fell by 10.9% to €271.5bn in 2009, reflecting the sharp economic crisis in that year. 2010 saw an increase by 7.2% to €291.0bn. In the years 2011 to 2013, total investment stayed rather stable while 2014 saw a rise by 4.4%. Comparing total investment by main category in 2014 with the pre-crisis year 2008 reveals that both capital expenditure for tangible assets and capital expenditure for software is 8% lower in 2014. Expenditure for IPRs fell by 16%. R&D expenditure increased considerably by 32%. Significant increases are also reported for training expenditure (13%) and other innovation expenditure (9%) while expenditure for promotion and branding remained almost stable (+1%). The decline in capex for software is somewhat astonishing as the current trend of digitalisation may require increasing investment in new software. It seems that most of this additional software spending is not capitalised but current expenditure. One part of this current software expenditure is included in R&D expenditure, another part is not captured by the present measure of total investment.

Figure 15-5. Total investment 2006 to 2014, by main spending category

Innovation expenditure and capex on IPRs are estimates except for 2008 and 2012. R&D expenditure includes extramural R&D and excludes capex for tangibles and software; capex on IPRs only for innovation, except for copyright for audiovisual media and pool test in mining.

Source: ZEW calculation based on data sources given in Table 15-2.

R&D expenditure increased steadily from 2006 to 2014 except for 2009 (Figure 15-6). In 2009 expenditure in all other components of total investment fell too, except for capitalised

software. Training expenditure also shows a strong and rather steady increase over the past nine years. Expenditure on promotion and branding grew strongly in 2007 and 2008, followed by a sharp decline in 2009. In 2014, expenditure reached again the 2008 level. Capital expenditure on tangible assets shows a similar trend. The decline in expenditure in 2009 was even sharper (-17%). Investment in fixed assets increased significantly in 2010 again (+9%) but did not grow further in the following years. Expenditure on IPRs strongly fell in 2011 owing to lower expenditure on IPRs for innovation activities. Other innovation expenditure declined in 2009 but substantially increase in 2010 and 2011 and remained rather stable since then.

Figure 15-6. Development of total investment 2006-2014, by main spending category

Note that other innovation expenditure and capex on IPRs are estimates except for 2008 and 2012. R&D expenditure includes extramural R&D and excludes capex for tangibles and software; capex on IPRs only for innovation, except for copyright for audiovisual media and pool test in mining.

Source: ZEW calculation based on data sources given in Table 15-2.

The share of innovation expenditure in total investment did not change significantly from 2006 to 2010 but substantially increased from 2010 (41.7%) until 2013 (48.9%) and fell in 2014 to 46.7% (Figure 15-7). The share of capital expenditure in total investment (which includes capex for tangible assets, software and IPRs) peaked in 2008 (57.9%) and went down to 52.0% in 2014.

Figure 15-7. Share of innovation expenditure and of capital expenditure in total investment 2006-2014

Note that other innovation expenditure and capex on IPRs are estimates except for 2008 and 2012. R&D expenditure includes extramural R&D and excludes capex for tangibles and software; capex on IPRs only for innovation, except for copyright for audiovisual media and pool test in mining.

Source: ZEW calculation based on data sources given in Table 15-2.

When looking at the trends in total investment by spending category between 2006 and 2014, some significant changes across main sectors become evident (Table 15-5). In R&D-intensive manufacturing, total investment increased at an annual rate of 3.4% which was mainly driven by R&D expenditure (+5.7). All other components showed an increase below the average growth rate. Expenditure on IPRs and other innovation expenditure even declined. In other manufacturing, the increase in total investment of 1.4% per year resulted from an expansion of promotion/branding expenditure (+4.1%) and other innovation expenditure (+3.1%) while R&D expenditure grew at about the average rate of this sector.

Table 15-5. Change in total investment by spending category 2006 to 2014, by main sector

Average annual rate of change (percent)	R&D-intensive manufacturing	Other manufacturing	Knowledge -intensive services	Other services	**All sectors**
1a. Capex on tangibles	2.3	1.0	3.0	2.1	**1.1**
1b. Capex on software	1.3	-2.6	-2.6	6.3	**5.5**
2. Promotion/branding expenditure	2.2	4.1	0.4	-0.5	**1.8**
3. Training expenditure	2.5	1.4	2.4	4.6	**2.7**
4. R&D expenditure[1)]	5.7	1.5	3.6	2.9	**5.0**
5. Other innovation expenditure	-1.3	3.1	3.2	-0.2	**0.7**
6. Expenditure on IPRs[2)]	-5.0	-4.9	0.0	-15.6	**-1.8**
Total investment	**3.4**	**1.4**	**1.7**	**1.8**	**2.3**

1) Including extramural R&D and excluding capex for tangibles and software; 2) only for innovation, except for copyright for audiovisual media.

Source: ZEW calculation based on data sources given in Table 15-2.

Knowledge-intensive services increased their total investment at an annual rate of 1.7%. Particularly high rates of growth are reported for capital expenditure on tangibles (+3.0%), R&D expenditure (+3.6%) and other innovation expenditure (+3.2%). Capital expenditure on software declined. In other services, the increase in total investment of 1.8% per year between 2006 and 2014 is driven by a rapid expansion of capital expenditure on software (+6.3%) and substantial growth in expenditure for training (+4.6%) and R&D (+2.9%). Promotion and branding expenditure, other innovation expenditure and expenditure on IPRs decreased.

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17 Appendix: Questionnaires

17.1 2013

Community Innovation Survey 2013

Fraunhofer ISI

infas

ZEW
Zentrum für Europäische Wirtschaftsforschung GmbH

Aim of the survey

Regulation (EC) 995/2012 of the European Commission of 26 October 2012 commits member states to report biannually indicators on innovation activities of enterprises. For this purpose, a harmonized survey across Europe – the **Community Innovation Survey** – is conducted coordinated by the Statistical Office of the European Commission (Eurostat). The aim of this year's survey is to collect information on innovation activities in the years 2010 to 2012 and planned innovation activities in 2013 and 2014. The information gathered serves as an important basis for economic policy decisions on regional, national and European levels in order to improve the business environment.

Who is conducting the survey?

In Germany, the Federal Ministry of Education and Research (BMBF) has commissioned the Centre for European Economic Research (ZEW) together with the Fraunhofer-Institute for System and Innovation Research (ISI) and the Institute for Applied Social Sciences (infas) to conduct the Community Innovation Survey 2013.

What happens to the data you provide?

The three institutions conducting the survey bear full legal responsibility for data protection. All data provided by enterprises will be treated strictly confidentially, based on the provisions of data privacy law. This means: All collected data will be processed anonymously, i.e. without names and addresses, and only pooled data will be analyzed. It will not be possible to identify the data from individual enterprises from the published results. In other words: data protection is fully guaranteed.

Further information on the German Innovation Survey you can find on www.zew.de/innovation.

How to answer the questionnaire

Please tick the correct answer in the corresponding box: ☒

Please enter the numbers or text requested in the large boxes: 87

If a number is equal to zero, please enter "0".

Please skip a question only if instructed to do so, e.g. ➔ *Please continue with **Section 3***

In case of any queries about this survey, please contact:

- Julian von der Burg · infas · phone 0800 7 384 500 · E-mail j.vonderburg@infas.de
- Dr. Christian Rammer · ZEW · phone 0621 1235 221 · E-mail rammer@zew.de
- Prof. Dr. Torben Schubert · ISI · phone 0721 6809 357 · E-mail schubert@isi.fraunhofer.de

Please return completed questionnaires in the **enclosed envelope** to:
infas
P.O. Box 24 01 01
D-53154 Bonn

1 General Information on Your Enterprise

1.1 Is your enterprise part of an enterprise group (corporate group or a consortium of several enterprises)**?**

Yes, a national enterprise group ..... ☐1 ➔ The headquarters is located: ... in the old Federal Lands (states) ..... ☐1
Yes, a multinational enterprise group ..... ☐2 ➔ ... in the new Federal Lands (incl. Berlin) ..... ☐2
No ..... ☐3 ... abroad ..... ☐3
→ Country: ☐

1.2 Please state the entity that your following statements in the questionnaire will refer to.

The enterprise ..... ☐1 The entire enterprise group (corporate group) ..... ☐2

➔ ***When answering the following questions, refer only to the entity given in 1.2 and only to activities in Germany!***

1.3 What was your enterprise's average number of employees from 2010 to 2012?

	2010	*2011*	*2012*
Employees (annual averages; incl. apprentices and interns, excl. contract workers)			
→ ***This includes***: part-time employees			

1.4 What was the percentage of your enterprise's employees in the years 2011 and 2012 who are holding a university degree?

	2011	*2012*
Share of employees holding a university degree (incl. universities of applied sciences and "Berufsakademien")	ca. ☐ %	ca. ☐ %
No employees with university degree	☐1	☐1

1.5 What was your enterprise's total turnover (incl. exports) **and export value in 2010 to 2012?**

***Exports**: Turnover with clients located outside of Germany.*
*In case of a **bank**: Turnover = gross interest and commission earnings; in case of an **insurance enterprise**: Turnover = gross premiums written.*

	2010	2011	2012
Turnover (excl. VAT)	.000 EUR	.000 EUR	.000 EUR
→ ***This includes**: Exports*	.000 EUR	.000 EUR	.000 EUR
	☐	☐	☐

1.6 Please state your enterprise's top-selling line of products / services in 2012 and its share in turnover. In case your enterprise only has one line of product / service, please state this one.

Share in turnover ☐ %

1.7 Please estimate your enterprise's market share for your top-selling line of products / services in 2010 to 2012.

***Market share**: Your enterprise's turnover as a percentage of total turnover within the applicable sales market (total turnover = your enterprise's plus your competitor's turnover)*

	2010	2012
Your enterprise's market share within the top-selling line of products / services	ca. ☐ %	below 0,1% ☐ 1
	ca. ☐ %	below 0,1% ☐ 1

1.8 Did any of the following significant changes occur to your enterprise (as defined in question 1.2) **during 2010 to 2012?**

	Yes	No
Merge with or take over another enterprise	☐ 1	☐ 2
Sell or close parts of your enterprise	☐ 1	☐ 2
Outsource some of the tasks or functions of your enterprise	☐ 1	☐ 2
Establish new subsidiaries in Germany	☐ 1	☐ 2
Establish new subsidiaries in other European countries	☐ 1	☐ 2
Establish new subsidiaries in outside Europe	☐ 1	☐ 2

As a result of these changes, did the turnover of your enterprise (as defined in question 1.2) from 2010 to 2012

	Yes	No
... increase by 10% or more?	☐ 1	☐ 2
... decrease by 10% or more?	☐ 1	☐ 2

2 Market Environment

2.1 In which geographic markets did your enterprise sell goods or services in 2010 to 2012?

(Multiple responses possible)

A. Local / regional within Germany (within a radius of ca. 50 km) ☐ 1
B. National (other regions of Germany) ☐ 1
C. Other European Union (EU), EFTA, or EU candidate countries ☐ 1
D. All other countries ☐ 1

Which of these geographic areas was your largest market in terms of turnover in 2012? *(Give corresponding letter)* ☐

2.2 How did the average sale prices of your products / services (with respect to your top-selling line of products / services according to question 1.6) **change between 2010 and 2012?** Please refer to sale prices before tax.

Sale prices have been reduced between 2010 and 2012 ☐ 1 ➔ average amount of price reduction - %
Sale prices remained constant between 2010 and 2012 ☐ 1
Sale prices have been increased between 2010 and 2012 ☐ 1 ➔ average amount of price increase + %

2.3 Please indicate to what extent the following characteristics describe the competitive situation of your enterprise.

Please mark one X for each line!

	applies fully	applies somewhat	applies very little	applies not at all
Products / services become outdated quickly	☐ 1	☐ 2	☐ 3	☐ 4
The technological development is difficult to predict	☐ 1	☐ 2	☐ 3	☐ 4
Products / services from competitors are easily substitued for those of your enterprise	☐ 1	☐ 2	☐ 3	☐ 4
Major threat to market position because of entry of new competitors	☐ 1	☐ 2	☐ 3	☐ 4
Competitor's actions are difficult to predict	☐ 1	☐ 2	☐ 3	☐ 4
Demand development is difficult to predict	☐ 1	☐ 2	☐ 3	☐ 4
Strong competition from abroad	☐ 1	☐ 2	☐ 3	☐ 4

2.4 How many main competitors does your enterprise face on your main market (according to question 1.6)**?**

None ☐ 1 ➔ *Please continue with **Section 3***
1-5 ☐ 2
6-10 ☐ 3
11-15 ☐ 4
16-50 ☐ 5
More than 50 ☐ 6

Your main competitors are ...
mostly larger ☐ 1
mostly smaller ☐ 2
mostly of equal size ☐ 3
both smaller and larger ☐ 4

How did the number of your main competitors change over the past three years?
increased ☐ 1
remained constant ☐ 2
decreased ☐ 3

3 Product Innovation

Product innovation describes a product (incl. services) whose components or basic characteristics (technical features, components, integrated software, applications, user friendliness, availability) are either **new or significantly improved**.

The innovation must be new to your enterprise, but it does not need to be new to your sector or market. **The sole significant factor is your enterprise's evaluation of it**. It does not matter if the innovation was developed by your enterprise alone or in collaboration with other enterprises. Purely aesthetic modifications of products (e.g. colouring, styling) are not regarded as product innovations. Selling alone of innovations that have been developed and produced entirely by other enterprises, also does not count as product innovation in this sense.

➔ *For examples of product innovations, see the foldout section*

3.1 During the years 2010 to 2012, did your enterprise introduce new or significantly improved products / services?

Yes ..... ☐ 1 ➔ No ..... ☐ 2 ➔ *Please continue with* ***Section 4***

Do these product innovations relate to ... *(Multiple responses possible)*
- goods (= physical products, incl. software)? ..... ☐ 1
- services? ..... ☐ 1

Who developed these product innovations? *(Multiple responses possible)*
- Your enterprise by itself ..... ☐ 1
- Your enterprise together with other enterprises or institutions ..... ☐ 1
- Your enterprise by adapting or modifying goods or services originally developed by other enterprises or institutions ..... ☐ 1
- Other enterprises or institutions ..... ☐ 1

3.2 How does your turnover (incl. exports) break down among the following types of products in 2012?

Newly introduced or significantly improved products / services during 2010 to 2012 ..... ca. ☐ %

Unchanged or slightly changed products / services since 2010 (incl. products / services developed and produced entirely by other enterprises) ..... ca. ☐ %

Total turnover in 2012: **1 0 0** %

3.3 Were any of the product innovations introduced during 2010 to 2012 new to the market, i.e. your enterprise was the first one to market these products / services?

Yes ..... ☐ 1 ➔ What was the share in total sales of these market novelties in 2012? ..... ca. ☐ %

No ..... ☐ 2

Were any of these market novelties ... *(Multiple responses possible)*
- ... new to the local / German market? ..... ☐ 1
- ... new to the European market? ..... ☐ 1
- ... new to the world market? ..... ☐ 1 ➔ Share in total sales of these world market novelties in 2012 ca. ☐ %

3.4 Were any of the product innovations introduced during the three years 2010 to 2012 new to your enterprise's product range, i.e. there was no previous version of this product in your enterprise's product line?

Yes ..... ☐ 1 ➔ What was the share in total sales of these innovations in 2012? ..... ca. ☐ %

No ..... ☐ 2

4 Process Innovation

A **process innovation** is the implementation of a new or significantly improved manufacturing / production process, distribution method, or support activity for goods or services. It should have a noticeable impact on the level of productivity, the quality of your product / service or the cost of production / distribution. Newly introduced procedures that enabled the introduction of product innovations, also count as process innovations.

The innovation must be **new to your enterprise**, but your enterprise does **not need** to be the **first to introduce** it. The significant factor is your enterprise's evaluation of it. It does not matter if the innovation was developed by your enterprise alone or in collaboration with other enterprises. **Purely organizational changes** such as the introduction of **new management practices** are **not** process innovations.

➔ *For examples of process innovations, see the foldout section*

4.1 During the years 2010 to 2012, did your enterprise introduce new or significantly improved products / services (incl. distribution methods and processes to deliver services)**?**

Yes ..... ☐ 1 ➔ No ..... ☐ 2 ➔ *Please continue with* ***Section 5***

Do these process innovations relate to ... *(Multiple responses possible)*
- methods of manufacturing or producing goods or services ..... ☐ 1
- logistics, delivery or distribution methods for your inputs, goods or services ..... ☐ 1
- supporting activities for your processes (e.g. maintenance systems, operations) ..... ☐ 1

Who developed these process innovations? *(Multiple responses possible)*
- Your enterprise by itself ..... ☐ 1
- Your enterprise together with other enterprises or institutions ..... ☐ 1
- Your enterprise by adapting or modifying goods or services originally developed by other enterprises or institutions ..... ☐ 1
- Other enterprises or institutions ..... ☐ 1

4.2 Were any of your process innovations introduced between 2010 and 2012 new to your market, i.e. no other enterprise in your market has applied these process innovations yet (that is your enterprise is the first innovator)**?**

Yes ..... ☐ 1 No ..... ☐ 2 Don't know ..... ☐ 3

4.3 Did the process innovations introduced by your enterprise during 2010 to 2012 reduce the average costs (per unit / operation)**?**

Yes ..... ☐1 ➔ What was the reduction in average unit costs due to these
No ..... ☐2 process innovations in 2012 ..... ca. ☐ %

4.4 Did the process innovations introduced by your enterprise during 2010 to 2012 lead to improvements in quality?

Yes ..... ☐1 ➔ What was the increase in turnover due to these
No ..... ☐2 quality improvements in 2012 ..... ca. ☐ %

5 Ongoing, Discontinued / Abandoned and Planned Innovation Activities

5.1 Did your enterprise have any on-going activities in 2010 to 2012 to develop or introduce product or process innovations that were discontinued or were still in progress at the end of 2012?

Also include ongoing and abandoned R&D activities, including contract R&D for third parties.

(Multiple responses possible)	*product innovations*	*process innovations*	*not assignable*
Yes, innovation activities still in progress at the end of 2012	☐1	☐1	☐1
Yes, discontinued / abandoned innovation activities in 2010 to 2012	☐1	☐1	☐1
No	☐1	☐1	

4.2 Does your enterprise intend to conduct activities in 2013 or 2014 leading to product or process innovations? Also include ongoing and abandoned R&D activities, including contract R&D for third parties.

(Multiple responses possible)	*2013*	*2014*
Yes, product innovation activities planned	☐1	☐1
Yes, process innovation activities planned	☐1	☐1
Yes, innovation / R&D activities planned, assignment to product or process innovations not possible	☐1	☐1
Not yet determined	☐1	☐1
No, no innovation / R&D activities planned	☐1	☐1

➔ If you answered No to questions 3.1, 4.1, 5.1 and 5.2 continue with Section 12 on page 6

6 Innovation Activities and Innovation Expenditures

6.1 During the three years 2010 to 2012, did your enterprise engage in the following innovation activities?

	Yes	*No*
A. In-house research and experimental development (**internal R&D**)	☐1	☐2
Systematic creative work for the expansion of available knowledge and utilization of the knowledge gained in that way on Development of new applications, e.g. newer or noticeably improved products or processes (including software development)		
↳ If yes: Was R&D conducted **continuously** or **occasionally** ..... continuously	☐1	
occasionally	☐2	
B. Awarding of R&D contracts to third parties (**external R&D**)	☐1	☐2
Same activities as above, but carried out by other enterprises (incl. enterprises of your group) or research organisations		
C. Acquisition of **machinery, equipment, software** and **buildings**	☐1	☐2
Machinery, equipment, software and buildings procured to be used for product or process innovation		
D. Acquisition of other existing **external knowledge**	☐1	☐2
Acquisition of patents, non-patented inventions, licenses, trademarks, copyrighted work associated with innovation activities		
E. **Training** for innovative activities	☐1	☐2
In-house or contracted out training for your personnel specifically for product or process innovation		
F. **Market introduction** of innovations	☐1	☐2
In-house or contracted out activities for the market introduction of innovations, incl. market research and launch advertising		
G. **Design** for innovations	☐1	☐2
In-house or contracted out activities to design or alter the shape or appearance of innovations		
H. **Other preparatory and implementation activities** for innovations	☐1	☐2
Other in-house or contracted out activities to develop implement product and process innovation such as feasibility studies, testing, tooling up, industrial engineering, conceptual work		

6.2 Please estimate the total amount of expenditures for all innovation activities (sum of items A to H, as per question 6.1) **in 2012, as well as all the amount of capital expenditures for innovation.**

Note: ***Innovation expenditures*** *include all expenditures for personnel and consumables, including services provided by third parties, as well as capital expenditure. Total innovation expenditures include all types of* ***R&D expenditures****.*
Capital expenditures *(capex) for innovation include the purchase of fixed investment and intangibles used to realise innovation projects.*

Total innovation expenditures in 2012 ..... ca. ☐ .000 EUR → ***This includes:*** Capex for innovation projects ..... ca. ☐ .000 EUR

No expenditure for innovation in 2012 ..... ☐1 No capex for innovation in 2012 ..... ☐1

6.3 Please estimate the amount of your enterprise's expenditure in 2012 for innovation activities A. to D. (as stated in question 6.1)**. Please fill in "0" if no expenditure has been made in the respective field of activity in 2012.**

A. In-house R&D (incl. capex specifically for R&D) ..... ca. [.000] EUR

B. External R&D (R&D contracted out to third parties) ..... ca. [.000] EUR

C. Acquisition of machinery / software for innovation (less R&D capex) ..... ca. [.000] EUR

D. Acquisition of other external knowledge ..... ca. [.000] EUR

6.4 What are the anticipated changes in total innovation expenditures (as stated in question 6.2) **for your enterprise in 2013 and 2014?**

Total innovation expenditure in 2013 and 2014 will **compared with the previous year** ...	*increase*	*stay the same (+/- 1 %)*	*decrease*	*don't know*
2013	☐ 1	☐ 2	☐ 3	☐ 4
2014	☐ 1	☐ 2	☐ 3	☐ 4

6.5 Please estimate the expected total innovation expenditures in 2013 and 2014.

	2013	*2014*
Estimated total innovation expenditure (incl. capex for innovation projects)	ca. [.000] EUR	ca. [.000] EUR
No innovation expenditures	☐ 1	☐ 1

7 Innovation Projects

7.1 What was the total number of innovation projects (incl. R&D projects**) executed in your enterprise during 2010 to 2012?**

Total number of innovation projects executed in the years 2010 to 2012 (finished or still ongoing projects)	'10-'12 successfuly finished projects	*thereof:* '10-'12 discon-tinued / abandoned projects	ongoing projects at the end of 2012	*thereof:* '10-'12 newly started projects
ca. [ ]	[ ]	[ ]	[ ]	[ ]

8 Public Financial Support to R&D and Innovation

Public financial support to innovation **includes the financial promotion of R&D or innovation projects by public authorities** by grants, subsidised loans, equity or loan guarantees. The payment for contracted R&D or innovation activities by public authorities is not considered as public financial support. Please also take into consideration public support through authorized agencies such as 'Projektträger' or public banks.

8.1 Did your enterprise receive public financial support for innovation projects during 2010 to 2012?

Yes, from ...
- States (German state government departments) ..... ☐ 1
- Federal Ministry of Economics and Technology (BMWi) ..... ☐ 1
- Federal Ministry of Education and Research (BMBF) ..... ☐ 1
- Other German Federal Ministries ..... ☐ 1
- 7. EU Community RTD Framework Programme ..... ☐ 1
- other EU programmes / institutions ..... ☐ 1
- others: [ ] ... ☐ 1

No ..... ☐ 1

How many of your R&D / innovation projects executed during 2010-2012 (as stated in question 7.1) received public financial support (# of projects) ..... [ ]

9 Co-operation for Innovation Activities

Innovation co-operation is active participation with other enterprises or institutions on innovation activities. Both partners do not need to commercially benefit. **Exclude pure contracting out** of work with no active co-operation.

9.1 Did your enterprise co-operate on any of your innovation activities during 2010 to 2012?

Yes ..... ☐ 1 No ..... ☐ 2 → *Please continue with* ***Section 10***

9.2 Please indicate the type of innovation co-operation partner by location.

(Tick all that apply)	*Germany regional*	*Germany national*	*Europe (excl. DE)*	*USA*	*China, India*	*other countries*
A. Other enterprises within your enterprise group	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1
B. Clients or customers from the private sector	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1
C. Clients or customers from the public sector*	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1
D. Suppliers of equipment, materials, software, etc.	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1
E. Competitors or other enterprises in your sector	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1
F. Consultants and commercial labs	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1
G. Universities or other higher education institutions	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1
H. Government / public research institutes	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1
I. Private research institutes	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1

* Local, regional and national administrations / agencies and government owned organisations, incl. schools, hospitals, service providers etc.

9.3 Which type of co-operation partner did you find the most valuable for your enterprise's innovation activities during 2010 and 2012?

(Please give corresponding letter according to the categories in question 9.2)

Co-operation partner with the most important contribution: ..... ☐ No assessment possible ..... ☐1

10 Sources of Information for Innovation

10.1 How important were each of the following information sources to your enterprise's innovation activities during 2010 to 2012, both for generating ideas for new projects and for completing existing projects?

Please mark one X for each line! Tick ‚not used' if no information was obtained from a source.	***Importance** of information source* High	Medium	Low	Not used
Sources within your enterprise or enterprise group	☐1	☐2	☐3	☐4
Clients / customers from the private sector / private households	☐1	☐2	☐3	☐4
Clients / customers from the public sector*	☐1	☐2	☐3	☐4
Suppliers of equipment, materials, software, etc.	☐1	☐2	☐3	☐4
Competitors or other enterprises in your sector	☐1	☐2	☐3	☐4
Consultants and commercial labs	☐1	☐2	☐3	☐4
Universities or other higher education institutions	☐1	☐2	☐3	☐4
Government / public research institutes	☐1	☐2	☐3	☐4
Private research institutes	☐1	☐2	☐3	☐4
Conferences, trade fairs, exhibitions	☐1	☐2	☐3	☐4
Scientific journals, trade / technical publications	☐1	☐2	☐3	☐4
Professional and industry associations	☐1	☐2	☐3	☐4
Patent files	☐1	☐2	☐3	☐4
Standards / Standardisation boards and documents	☐1	☐2	☐3	☐4

* Local, regional and national administrations / agencies and government owned organisations, incl. schools, hospitals, service providers etc.

11 Effectiveness of Protection Measures for Innovation

11.1 How effective were the following protection methods for maintaining or increasing the competitiveness of product and process innovations introduced during 2010 to 2012?

Please mark one X for each line!	*Degree of **Effectiveness*** High	Medium	Low	Not used
Patents	☐1	☐2	☐3	☐4
Utility Patents	☐1	☐2	☐3	☐4
Design registration	☐1	☐2	☐3	☐4
Trade marks	☐1	☐2	☐3	☐4
Copyright	☐1	☐2	☐3	☐4
Lead time advantage over competitors	☐1	☐2	☐3	☐4
Complex design of goods / services	☐1	☐2	☐3	☐4
Secrecy (incl. include non-disclosure agreements)	☐1	☐2	☐3	☐4

12 Marketing and Organisational Innovations

12.1 Did your enterprise introduce the following marketing innovations during 2010 to 2012?

A **marketing innovation** is the implementation of a new marketing concept or strategy that differs significantly from your enterprise's existing marketing methods and which has not been used before. It requires significant changes in product design or packaging, product placement, product promotion or pricing. Exclude seasonal, regular and other routine changes in marketing methods.

	Yes	*No*
Significant changes to the aesthetic design or packaging of a good or service *(exclude changes that alter the product's functional or user characteristics - these are product innovations)*	☐1	☐2
New media or techniques for product promotion, introduction of brands *(e.g. the first time use of a new advertising media, a new brand image, introduction of loyalty cards, etc.)*	☐1	☐2
New methods for product placement or sales channels (incl. new ways to present products and services) *(e.g. first time use of franchising or distribution licenses, direct selling, exclusive retailing, new concepts for product presentation, etc.)*	☐1	☐2
New methods of pricing goods and services *(e.g. first time use of variable pricing by demand, discount systems, etc.)*	☐1	☐2

➔ *Please continue with **Question 12.3** in case you replied **No** to all four items.*

12.2 Please estimate the amount of your enterprise's expenditures in 2012 for the development and introduction of marketing innovations? Please include both in-house labour costs and costs for contracted out services.

Expenditures for marketing innovations in 2012 ..... ca. [.000] EUR ☐1 ..... no estimate to be given

12.3 Did your enterprise introduce the following organisational innovations during 2010 to 2012?

An **organisational innovation** is a **new organisational method** in your enterprise's business practices (including knowledge management), workplace organisation or external relations that **has not been previously used** by your enterprise. It must be the result of strategic decisions taken by management. Exclude mergers or acquisitions, even if for the first time.

	Yes	*No*
New business practices for organising procedures *(e.g. supply chain management, business re-engineering, knowledge management, lean production, quality management, etc.)*	☐1	☐2
New methods of organising work responsibilities and decision making *(e.g. team work, decentralization, integration or de-integration of departments, job rotation, etc.)*	☐1	☐2
New methods of organising external relations with other firms or public institutions *(e.g. first use of alliances, partnerships, outsourcing or sub-contracting, etc.)*	☐1	☐2

➔ *Please continue with **Section 13** in case you replied **No** to all three items.*

12.4 Please estimate the amount of your enterprise's expenditures in 2012 for the development and introduction of organisational innovations? Please include both in-house labour costs and costs for contracted out services.

Expenditures for organisational innovations in 2012 ..... ca. .000 EUR ☐1 ..... no estimate to be given

13 Public Sector Procurement and Innovation

13.1 Did your enterprise receive any public procurement contracts to provide goods or services during 2010 to 2012?

Yes, from public sector institutions* from Germany ☐1
Yes, from public sector institutions* from abroad ☐1
No ☐1 ➔ *Please continue with **Section 14***

* Local, regional and national administrations / agencies and government owned organisations, incl. schools, hospitals, service providers etc.

13.2 Did your enterprise undertake any innovation activities as part of a public procurement contract? Please consider activities for product, process, organisational and marketing innovations.

Yes, innovation activities were required as part of the contract ☐1
Yes, but innovation activities were not explicitly required by the contract ☐1
No ☐1

14 Strategies and Obstacles for Reaching Your Enterprise's Goals

14.1 How important were each of the following goals for your enterprise during 2010 to 2012?

Please mark one X for each line!

	*Degree of **Importance***			*Not*
	High	*Medium*	*Low*	*relevant*
Increase turnover	☐1	☐2	☐3	☐4
Increase market share	☐1	☐2	☐3	☐4
Decrease costs	☐1	☐2	☐3	☐4
Increase profit margin	☐1	☐2	☐3	☐4

14.2 How important were each of the following strategies for reaching your enterprise's goals during 2010 to 2012?

Please mark one X for each line!

	*Degree of **Importance***			*Not*
	High	*Medium*	*Low*	*relevant*
Developing new markets within Europe	☐1	☐2	☐3	☐4
Developing new markets outside Europe	☐1	☐2	☐3	☐4
Reducing in-house costs of operation	☐1	☐2	☐3	☐4
Reducing costs of purchased materials, components or services	☐1	☐2	☐3	☐4
Increasing the quality of existing goods and services	☐1	☐2	☐3	☐4
Introducing new or significantly improved goods or services	☐1	☐2	☐3	☐4
Intensifying or improving the marketing of goods or services	☐1	☐2	☐3	☐4
Increasing flexibility / responsiveness of your organisation	☐1	☐2	☐3	☐4
Building alliances with other enterprises or institutions	☐1	☐2	☐3	☐4

14.3 How important were the following factors as obstacles to meeting your enterprise's goals during 2010 to 2012?

Please mark one X for each line!

	*Degree of **Importance***			*Not*
	High	*Medium*	*Low*	*relevant*
Strong price competition	☐1	☐2	☐3	☐4
Strong competition on product quality, reputation or brand	☐1	☐2	☐3	☐4
Lack of demand	☐1	☐2	☐3	☐4
Innovations by competitors	☐1	☐2	☐3	☐4
Dominant market share held by competitors	☐1	☐2	☐3	☐4
Lack of qualified personnel	☐1	☐2	☐3	☐4
Lack of adequate finance	☐1	☐2	☐3	☐4
High cost of access to new markets	☐1	☐2	☐3	☐4
High cost of meeting government regulations or legal requirements	☐1	☐2	☐3	☐4

15 Basic Financial Information

15.1 What were your enterprise's payroll costs (including benefits and social security contributions) **and expenditures for material, energy and services contracted out in 2011 and 2012?**

	2011	2012
Payroll costs (incl. employee benefits and social security contributions)	ca. .000 EUR	ca. .000 EUR
Expenditures for materials, intermediate inputs, energy, incl. services contracted out	ca. .000 EUR	ca. .000 EUR

15.2 What were your enterprise's expenditures for professional development training in 2011 and 2012?

Professional development training expenditures *include all in-house and contracted out expenditures for training and further education of employees, including payroll costs of employees for working time used to attend training. Please* ***exclude*** *expenditures for* ***vocational education****.*

	2011	2012
Expenditures for professional development training (in-house + contracted out)	ca. .000 EUR	ca. .000 EUR
No expenditures for professional development	☐ 1	☐ 1

15.3 What were your enterprise's total marketing expenditures in 2011 and 2012?

Marketing expenditures *include all in-house and contracted out expenditures for advertising and branding (incl. commercial marketing), reputation building, conceptual design of marketing strategies, market and costumer research, and the installation of new distribution channels.* ***Pure selling costs*** *are* ***not*** *considered as marketing expenditures.*

	2011	2012
Total marketing expenditures (in-house + contracted out)	ca. .000 EUR	ca. .000 EUR
No marketing expenditures	☐ 1	☐ 1

15.4 What were your enterprise's total software expenditures in 2011 and 2012?

Software expenditures *include expenditure for the acquisition of software and for in-house development of software (incl. costs of embedded software), regardless whether expenditures have been capitalised.*

	2011	2012
Total software expenditures (in-house + contracted out)	ca. .000 EUR	ca. .000 EUR
No software expenditures	☐ 1	☐ 1

15.5 What was your enterprise's gross investment in fixed assets (i.e. gross addition of fixed assets, including assets created internally and buildings) **and what was the amount of tangible fixed assets in 2011 and 2012?**

	2011	2012
Gross investment in fixed assets	ca. .000 EUR	ca. .000 EUR
No investment in fixed assets	☐ 1	☐ 1
Total amount of tangible fixed assets at the beginning of the year	ca. .000 EUR	ca. .000 EUR

15.6 What was your enterprise's operating margin (i.e. profit before taxes on income as a percentage of turnover) **in 2011 and 2012?**

	Below ***-5 %***	***-5 %*** *to* ***-2 %***	***-2 %*** *to* ***0 %***	***0 %*** *to* ***2 %***	***2 %*** *to* ***4 %***	***4 %*** *to* ***7 %***	***7 %*** *to* ***10 %***	***10 %*** *to* ***15 %***	***15 %*** *and more*	*No estimate possible*
2011	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10
2012	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10

Thank you very much for your valuable assistance!

To allow further enquiries, please complete your contact information below.

Name of responder	Enterprise address or stamp
Position within enterprise	
Telephone	
Fax	
E-mail	

17.2 2014

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German Innovation Survey 2014

Fraunhofer ISI

infas

ZEW
Zentrum für Europäische Wirtschaftsforschung GmbH

Aim of the survey
The German Innovation Survey commissioned by the German Federal Ministry of Education and Research (BMBF) is intended to collect information on innovation activities in the economy during the years 2005 to 2007. The information gathered serves as a key basis for economic policy decisions, in order to improve conditions for the business environment.

Who is conducting the survey?
The German Innovation Survey is conducted jointly by the Centre for European Economic Research (ZEW) together with the Fraunhofer-Institute System and Innovation Research (ISI) and the Institute for Applied Social Sciences (infas).

What happens to the data you provide?
The three institutions conducting the survey bear full legal responsibility for data protection. All your data will be handled strictly confidentially and only anonymously, i.e. without name and address, and only pooled data from enterprises will be analysed. It will not be possible to identify the data from individual enterprises from the published results. In other words: **data protection is fully guaranteed**.
Further information on German innovation surveys can be found at: www.zew.de/innovation

How to answer the questionnaire
Please tick the correct answer in the corresponding box: ☒

Please enter the numbers or text requested in the large boxes: 85

If a number is equal to zero, please enter "0". Please skip a question only if instructed to do so, e.g.: ➔ *Please continue with Question 8!!*

In case of any queries about this survey, please contact:
- Julian von der Burg · infas · Tel 0800 7 384 500 · E-Mail j.vonderburg@infas.de
- Dr. Christian Rammer · ZEW · Tel 0621 1235 221 · E-Mail rammer@zew.de
- Prof. Dr. Torben Schubert · ISI · Tel 0721 6809 357 · E-Mail schubert@isi.fraunhofer.de

Please return completed questionnaires in **the attached envelope** to:
infas
Postfach 24 01 01
53154 Bonn

1 General information on your enterprise

1.1 Is your enterprise part of an enterprise group (corporate group or a consortium of several enterprises)?

Yes, a national enterprise group ..... ☐ 1 ➔ The head office is located
... in the old German *Länder* [states] ..... ☐ 1
... in the new German *Länder* (incl. Berlin) ..... ☐ 2
... abroad ..... ☐ 3
Yes, a multinational enterprise group ..... ☐ 2 ➚
No ..... ☐ 3

1.2 Please state the entity that your following statements in the questionnaire will refer to.

The enterprise ..... ☐ 1
The entire enterprise group (corporate group) ..... ☐ 2

➔ ***When answering the following questions, refer only to the entity given in 1.2 and located in Germany!***

1.3 What was your enterprise's average number of employees (incl. apprentices and interns, but without temporary workers) **in 2013?**

Total number of employees ..... [ ]
Therein: part-time employees ..... [ ]

1.4 Please indicate the percentage of your enterprise's employees in 2013 holding a university degree.

Percentage of employees holding a university degree
(incl. universities of applied sciences and of cooperative education) ..... ca. [ ] %
No employees holding a university degree ..... ☐ 1

1.5 What was your enterprise's total turnover (incl. exports) and export value in 2013?

Turnover (without VAT) ..... [.000] EUR
Therein: exports ..... [.000] EUR

*If a **bank**: turnover = gross interest and commission earnings; if an **insurance enterprise**: turnover = income from premiums.*

1.6 Please state your enterprise's top-selling line of products/services in 2013 and its share of sales.

[ ]
Share of sales 2013
ca. [ ] %

2 Produkt Innovation / Service Innovation

Product innovation describes a product (incl. services) whose components or basic characteristics (technical features, integrated software, applications, user friendliness, availability) are either new or significantly improved.
The innovation must be **new to your enterprise**, but it does **not need** to be **new to your sector or market**. The sole significant factor is your enterprise's evaluation of it. It does not matter if the innovation was developed by your enterprise alone or in collaboration with other enterprises. **Purely aesthetic modifications** of products (e.g. colouring, styling) are **not** regarded as product innovations. **Selling alone of innovations** that have been developed and produced entirely by other enterprises, also does **not** count as product innovation in this sense.

➔ *For examples of product innovations, see the fold-out section at the left.*

2.1 During the years 2011 to 2013, did your enterprise introduce new or significantly improved products/services?

Yes ..... ☐ 1 No ..... ☐ 2 ➔ *Please continue with **part 3**.*

2.2 Please briefly describe your enterprise's most important product innovation of the years 2011 to 2013?

2.3 How does your enterprise's turnover (incl. exports) **in 2013 break down among the following types of products?**

Newly introduced or significantly improved products/services during 2011 to 2013 ..... ca. ☐ %

Unchanged or slightly changed products/services since 2011
(Also include products/services developed and produced entirely by other enterprises) ..... ca. ☐ %

Turnover in 2013: **100** %

2.4 Were any of the product innovations introduced during the three years 2011 to 2013 new to the market, i.e. your enterprise was the first one to market these products/services?

Yes ..... ☐ 1 ➔ What was the share of these market innovations in total turnover in 2015? ..... ca. ☐ %
No ..... ☐ 2

2.5 Were any of the product innovations introduced during the three years 2011 to 2013 new to your enterprise, i.e. there was no previous version in your enterprise's product line?

Yes ..... ☐ 1 ➔ What was the share of these products in total turnover in 2015? ..... ca. ☐ %
No ..... ☐ 2

2.6 Did any of the product innovations introduced during the three years 2011 to 2013 new to your enterprise reduce energy consumption during the use of the products?

Yes ..... ☐ 1 ➔ What was the share of these products with reduced energy consumption in total turnover in 2013? ..... ca. ☐ %
No ..... ☐ 2

3 Process Innovation

A **process innovation** is the implementation of a new or significantly improved manufacturing/production process, distribution method, or support activity for goods or services. It should have a noticeable impact on the level of productivity, the quality of your product/service or the cost of production/distribution. Newly introduced procedures that enabled the introduction of product innovations, also count as process innovations.
The innovation must be **new to your enterprise**, but your enterprise does **not need** to be the **first to introduce** it. The significant factor is your enterprise's evaluation of it. It does not matter if the innovation was developed by your enterprise alone or in collaboration with other enterprises. **Purely organizational changes** such as the introduction of **new management practices** are **not** process innovations.

➔ *For examples of process innovations, see the fold-out section at the left.*

3.1 During the years 2011 to 2013, did your enterprise introduce new or significantly improved internal processes (incl. processes for service performance and product delivery)?

Yes ..... ☐ 1 No ..... ☐ 2 ➔ *Please continue with **part 4**.*

3.2 Please briefly describe your enterprise's most important process innovation of the years 2011 to 2013?

3.3 Did the process innovations introduced by your enterprise during 2011 to 2013 reduce the average cost (per unit / per operation)**?**

Yes ..... ☐ 1 ➔ What was the reduction in average unit cost due to process innovations in 2013?..... ca. ☐ %
No ..... ☐ 2

3.4 Did the process innovations introduced by your enterprise from 2011 to 2013 lead to a clear improvement in the quality of your products/services?

Yes ..... ☐ 1 ➔ What was the increase in turnover due to these quality improvements in 2013? ..... ca. ☐ %
No ..... ☐ 2

3.5 Did any of the process innovations introduced during the three years 2011 to 2013 significantly increase energy efficiency, increase the use of renewable energy sources or increase security of energy supply?
Multiple answers allowed!

Yes, increase in energy efficiency ..... ☐ 1 Yes, increased use of renewable energy sources ..... ☐ 1
Yes, increase in security of energy supply ..... ☐ 1 No ..... ☐ 1

4 Ongoing, Discontinued and Planned Innovation Activities

4.1 Did your enterprise have any on-going activities at the end of 2013 to develop or introduce product or process innovations or were any such activities discontinued during 2011 to 2013?

(Please include in-progress/discontinued R&D activities - including R&D commissioned by third parties! Multiple responses allowed.)	*Product Innovation*	*Process Innovation*	*Not assignable*
Yes, ongoing innovation activities at the end of 2013	☐ 1	☐ 1	☐ 1
Yes, discontinued innovation activities in 2011-2013	☐ 1	☐ 1	☐ 1
No innovation activities in progress or discontinued 2011-2013	☐ 1	☐ 1	☐ 1

4.2 Does your enterprise plan to conduct activities in 2014 or 2015 aiming at product or process innovations? Please include planned R&D activities, including R&D commissioned by third parties!

	Product Innovation	*Process Innovation*	*Not assignable*	*Not known yet*	*No*
2014	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1
2015	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1

➔ *If you answered No to all questions 2.1, 3.1, 4.1 and 4.2, please continue with part 7.*

5 Innovation Expenditures

Innovation expenditures include all expenditures including labour costs and capital expenditures relating to the following activities:
- In-house research and experimental development (internal R&D)
- Awarding of R&D contracts to third parties (external R&D)
- Acquisition of machinery, facilities and software to realize innovation projects
- Acquisition of external knowledge (e.g. patents, licenses, trademarks, industrial property rights) associated with innovation projects
- Product design, construction, design of services and other preparations for the production and distribution of innovations
- Continuing training expenditures related to innovation projects
- Market introduction of innovations (marketing campaigns directly linked to an innovation project, including market research)

5.1 Please estimate the total amount of expenditures for all innovation activities in 2013 (including labour cost, cost of material, cost of external services and capital costs), **as well as for all capital costs for innovation.**

Total innovation expenditures ..... ca. [.000] EUR

No innovation expenditures in 2013 ..... ☐ 1

Therein: Capital expenditures* for innovation projects ..... ca. [.000] EUR

No innovation expenditures in 2013 ..... ☐ 1

** in fixed and intangible assets, excl. capitalised development costs.*

5.2 What will be the expected total innovation expenditures (according to question 5.1) **in 2014 and 2015 for your enterprise?**

The total innovation expenditures will ... in the year ... **compared to the year before** ...	*Increase*	*Stay approx. the same (+/- 1 %)*	*Decrease*	*Not yet determined*
2014	☐ 1	☐ 2	☐ 3	☐ 4
2015	☐ 1	☐ 2	☐ 3	☐ 4

5.3 Please estimate the expected total innovation expenditures in 2014 and 2015.

	2014	*2015*
Total innovation expenditures (incl. capital expenditures for innovation projects) ..... ca.	[.000] EUR	..... ca. [.000] EUR

No expenditures for innovation projects planned ..... ☐ 1 ..... ☐ 1

6 Research and Experimental Development (R&D)

We define R&D as systematic creative work undertaken to increase the stock of knowledge and its use to devise innovative applications such as new and improved products and processes (incl. the development of software).

6.1 Did your enterprise conduct in-house R&D activities during 2011 to 2013?

Yes, continuously ..... ☐ 1
Yes, occasionally..... ☐ 2
No ..... ☐ 3 ➔ *Please continue with question 6.3!*

6.2 How many persons were concerned with R&D activities in your enterprise in the years 2011, 2012 and 2013?

	2011	*2012*	*2013*
R&D employees (annual average) ..... ca.	[ ]	[ ]	[ ]

6.3 Did your enterprise issue R&D contracts to third parties during 2011 to 2013 (i.e. extramural R&D)**?**

Yes, to domestic contractors ..... ☐ 1 Yes, to foreign contractors ..... ☐ 1 No ..... ☐ 1

➔ *If you answered No to questions 6.1 and 6.3, please continue with part 7!*

6.4 Please give the total expenditure for R&D (internal + R&D contracts to third parties) **in 2013.**
(Please note: R&D expenditures are part of the innovation expenditures, as stated in question 5.1!)

Total R&D expenditures* in 2013 (internal + external) ..... ca. [.000] EUR ☐ 1 ... No R&D expenditures in 2013

** including. expenditures for R&D activities and capitalised R&D expenditures, without amortizations on capitalized development costs.*

7 Financing

7.1 Which of the following sources of funding were employed by your enterprise to finance general investment (and innovation activities in the years 2011 to 2013?

General investment: Expenditure for replacement investment and capacity expanding investment without innovative components.
Innovation activities: Expenditure for product and process innovation activities according to question 5.1, incl. R&D expenditure.

In case your enterprise had no general investment or no innovation activities during 2011 and 2013, please tick „no such activities during 2011 and 2013“!
→ *Multiple answers allowed!*

	Used to finance ... General investment	Used to finance ... Innovation activities
No such activities during 2011 and 2013	☐ 1	☐ 1
Ongoing business operation (cash flow)	☐ 1	☐ 1
New equity, admission of new shareholders	☐ 1	☐ 1
Participation of other enterprises (incl. VC funds)	☐ 1	☐ 1
Shareholders' loans, dormant equities, participation certificates	☐ 1	☐ 1
Issue of bonds and debt obligations	☐ 1	☐ 1
Factoring, leasing, supplier credit	☐ 1	☐ 1
Overdraft facilities	☐ 1	☐ 1
Earmarked bank loans	☐ 1	☐ 1
Public loans /supportive loans (e.g. from KfW, federal state banks)	☐ 1	☐ 1
Public subsidies/grants	☐ 1	☐ 1

7.2 Did your enterprise refrain from conducting (certain) innovation activities because of a lack of financial sources?

Yes ☐ 1 ➔ To what extent did the following characteristics apply to these not realised innovation activities?

No ☐ 2

	Fully applies	*Partly applies*	*Does not apply*
High technological intent / degree of novelty	☐ 1	☐ 2	☐ 3
High uncertainty over feasibility / market acceptance	☐ 1	☐ 2	☐ 3
High marketability / closesness to client requests	☐ 1	☐ 2	☐ 3
Entering new market segments / thematic areas	☐ 1	☐ 2	☐ 3

7.3 Assuming your enterprise had at its disposal an unexpected additional profit or additional equity capital of 10% of last year's turnover. Which possibilities of resource-allocation would your enterprise choose most probably?

	Yes	*No*
Conducting (additional) general investment (as defined in question 7.1)	☐ 1	☐ 2
Conducting (additional) innovation activities (as defined in question 7.1)	☐ 1	☐ 2
Retention / accumulation of reserves	☐ 1	☐ 2
Payout of proprietors (incl. repayment of shareholders' loans)	☐ 1	☐ 2
Payment of liabilities (e.g. payment of bank credits, supplier credit)	☐ 1	☐ 2
No estimation possible	☐ 1	

7.4 Assuming, instead of the unexpected additional profit / additional equity capital mentioned above, your enterprise had access to a credit of the same amount and with a comparatively attractive interest rate. Would your enterprise in this case conduct general investments or innovation activities? *(→ Multiple response allowed!)*

Yes, for (additional) general investment ☐ 1
Yes, for (additional) innovation activities ☐ 1
No ☐ 1
No estimation possible ☐ 1

7.5 What was your enterprise's operating margin (profit before taxes on income as a percentage of turnover) **in 2011 and 2013?**

	Below -5 %	*-5 % to -2 %*	*-2 % to 0 %*	*0 % to 2 %*	*2 % to 4 %*	*4 % to 7 %*	*7 % to 10 %*	*10 % to 15 %*	*15 % and more*	*No estimate possible*
2011	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10
2013	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10

Thank you very much for your valuable assistance!

If you have any questions, or would like a copy of the survey findings ("Sector Report on Innovation"), please complete your contact information below:

Name of respondent	Enterprise address or stamp
Position in the enterprise	
Telephone	
E-Mail	

17.3 2015

Community Innovation Survey 2015

Fraunhofer ISI

infas

ZEW
Zentrum für Europäische Wirtschaftsforschung GmbH

Aim of the survey

Regulation (EC) 995/2012 of the European Commission of October 26, 2012 commits member states to report biannually indicators on innovation activities of enterprises. For this purpose, a harmonized survey across Europe – the **Community Innovation Survey** – is conducted coordinated by the Statistical Office of the European Commission (Eurostat). The aim of this year's survey is to collect information on innovation activities in the years 2012 to 2014 and planned innovation activities in 2015 and 2016. The information gathered serves as an important basis for economic policy decisions on regional, national and European levels in order to improve the business environment.

Who is conducting the survey?

In Germany, the Federal Ministry of Education and Research (BMBF) has commissioned the Centre for European Economic Research (ZEW) together with the Fraunhofer-Institute for System and Innovation Research (ISI) and the Institute for Applied Social Sciences (infas) to conduct the Community Innovation Survey 2015.

What happens to the data you provide?

The three institutions conducting the survey bear full legal responsibility for data protection. All data provided by enterprises will be treated strictly confidentially, based on the provisions of data privacy law. This means: All collected data will be processed anonymously, i.e. without names and addresses, and only pooled data will be analyzed. It will not be possible to identify the data from individual enterprises from the published results. In other words: data protection is fully guaranteed.

Further information on the German Innovation Survey you can find on www.zew.de/innovation.

How to answer the questionnaire

Please tick the correct answer in the corresponding box: ☒

Please enter the numbers or text requested in the large boxes: 82

If a number is equal to zero, please enter "0".

Please skip a question only if instructed to do so, e.g. ➔ *Please continue with **Section 3**.*

In case of any queries about this survey, please contact:

- Julian von der Burg · infas · phone 0800 7 384 500 · E-mail innovation@infas.de
- Dr. Christian Rammer · ZEW · phone 0621 1235 221 · E-mail rammer@zew.de
- Prof. Dr. Torben Schubert · ISI · phone 0721 6809 357 · E-mail schubert@isi.fraunhofer.de

Please return completed questionnaires in the **enclosed envelope** to:
infas
P.O. Box 24 01 01
D-53154 Bonn

1 General Information on Your Enterprise

1.1 Is your enterprise part of an enterprise group (corporate group or a consortium of several enterprises)**?**

Yes, a national enterprise group ..... ☐1 ➔ The headquarters is located: ... in the old Federal States ..... ☐1
Yes, a multinational enterprise group ..... ☐2 ↗ ... in the new Federal States (incl. Berlin) ..... ☐2
No ..... ☐3 ... abroad ..... ☐3
→ Country: [ ]

1.2 Please state the entity that your following statements in the questionnaire will refer to.

The enterprise ..... ☐1 The entire enterprise group (corporate group) ..... ☐2

➔ ***When answering the following questions, refer only to the entity given in 1.2 and only to activities in Germany!***

1.3 What was your enterprise's average number of employees from 2012 to 2014?

	2012	2013	2014
Employees (annual averages; incl. apprentices and interns, excl. contract workers)			
→ ***Therin***: part-time employees			

1.4 What was the percentage of your enterprise's employees in the years 2013 and 2014 who are holding a university degree?

	2013	2014
Share of employees holding a university degree (incl. universities of applied sciences and "Berufsakademien")	ca. [ ] %	ca. [ ] %
No employees with university degree	☐1	☐1

1.5 What was your enterprise's total turnover (incl. exports) **and export value in 2012 to 2014?**

***Exports**: Turnover with clients located outside of Germany.*
*In case of a **bank**: Turnover = gross interest and commission earnings; in case of an **insurance enterprise**: Turnover = gross premiums written.*

	2012	2013	2014
Turnover (excl. VAT)	.000 EUR	.000 EUR	.000 EUR
→ ***Therein**: Exports*	.000 EUR	.000 EUR	.000 EUR
	☐	☐	☐

1.6 Please state your enterprise's top-selling line of products / services in 2014 and its share in turnover. In case your enterprise only has one line of product / service, please state this one.

Share in turnover ☐ %

1.7 Please estimate your enterprise's market share for your top-selling line of products / services in 2012 to 2014.

***Market share**: Your enterprise's turnover as a percentage of total turnover within the applicable sales market (total turnover = your enterprise's plus your competitor's turnover)*

	2012	2014
Your enterprise's market share within the top-selling line of products / services	ca. ☐ %	below 0,1% ☐ 1
	ca. ☐ %	below 0,1% ☐ 1

1.8 Did any of the following significant changes occur to your enterprise (as defined in question 1.2) **during 2012 to 2014?**

	Yes	No
Merge with or take over another enterprise	☐ 1	☐ 2
Sell or close parts of your enterprise	☐ 1	☐ 2
Outsource some of the tasks or functions of your enterprise	☐ 1	☐ 2
Establish new subsidiaries	☐ 1	☐ 2

Did the turnover of your enterprise change between 2012 and 2014 by at least 10%

	Yes	No
... increase?	☐ 1	☐ 2
... decrease?	☐ 1	☐ 2

1.9 Is your enterprise controlled by a family - or part of an enterprise group controlled by a family?

In case of an enterprise controlled by a family, family members hold at least 50% of the company's shares.

Yes ☐ 1 ➔ For how many generations has the enterprise been family-owned? ☐ Generation(s)
No ☐ 2

Are family members part of the enterprise's management or does the management consist of external managers only?
☐ 1 family members only
☐ 2 both family members and external managers
☐ 3 external managers only

Is it planned to transfer the enterprise to the next family generation? ☐ 1 Yes ☐ 2 No

2 Market Environment

2.1 In which geographic markets did your enterprise sell goods or services in 2012 to 2014?

(Multiple responses possible)

A. Local / regional within Germany (within a radius of ca. 50 km) ☐ 1
B. National (other regions of Germany) ☐ 1
C. Other European Union (EU), EFTA, or EU candidate countries ☐ 1
D. All other countries ☐ 1

Which of these geographic areas was your largest market in terms of turnover in 2014? *(Give corresponding letter)* ☐

2.2 Please indicate to what extent the following characteristics describe the competitive situation of your enterprise.

Please mark one X in each line!

	applies fully	applies somewhat	applies very little	applies not at all
Products / services become outdated quickly	☐ 1	☐ 2	☐ 3	☐ 4
The technological development is difficult to predict	☐ 1	☐ 2	☐ 3	☐ 4
Products / services from competitors are easily substitued for those of your enterprise	☐ 1	☐ 2	☐ 3	☐ 4
Major threat to market position because of entry of new competitors	☐ 1	☐ 2	☐ 3	☐ 4
Competitor's actions are difficult to predict	☐ 1	☐ 2	☐ 3	☐ 4
Demand development is difficult to predict	☐ 1	☐ 2	☐ 3	☐ 4
Strong competition from abroad	☐ 1	☐ 2	☐ 3	☐ 4
Price increases lead to immediate loss of clients	☐ 1	☐ 2	☐ 3	☐ 4

2.3 How many main competitors does your enterprise face on your main market (according to question 1.6)**?**

None ☐ 1	6-10 ☐ 3	16-50 ☐ 5
1-5 ☐ 2	11-15 ☐ 4	more than 50 ☐ 6

3 Product Innovation

Product innovation describes a product (incl. services) whose components or basic characteristics (technical features, components, integrated software, applications, user friendliness, availability) are either **new or significantly improved**.

The innovation must be new to your enterprise, but it does not need to be new to your sector or market. **The sole significant factor is your enterprise's evaluation of it**. It does not matter if the innovation was developed by your enterprise alone or in collaboration with other enterprises. Purely aesthetic modifications of products (e.g. colouring, styling) are not regarded as product innovations. Selling alone of innovations that have been developed and produced entirely by other enterprises, also does not count as product innovation in this sense.

➔ *For examples of product innovations, see the foldout section.*

3.1 During the years 2012 to 2014, did your enterprise introduce new or significantly improved products / services?

Yes ..... ☐ 1 ➔ No ..... ☐ 2 ➔ *Please continue with **Section 4**.*

Do these product innovations relate to ... *(Tick all that apply)*
- goods (= physical products, incl. software)? ..... ☐ 1
- services? ..... ☐ 1

Who developed these product innovations? *(Tick all that apply)*
- Your enterprise by itself ..... ☐ 1
- Your enterprise together with other enterprises or institutions ..... ☐ 1
- Your enterprise by adapting or modifying goods or services originally developed by other enterprises or institutions ..... ☐ 1
- Other enterprises or institutions ..... ☐ 1

3.2 How does your turnover (incl. exports) break down among the following types of products in 2014?

Newly introduced or significantly improved products / services during 2012 to 2014 ..... ca. ☐ %

Unchanged or slightly changed products / services since 2012 (incl. products / services developed and produced entirely by other enterprises) ..... ca. ☐ %

Total turnover in 2014: **1 0 0** %

3.3 Were any of the product innovations introduced during 2012 to 2014 new to the market, i.e. your enterprise was the first one to market these products / services?

Yes ..... ☐ 1 ➔ What was the share in total sales of these market novelties in 2014? ..... ca. ☐ %

No ..... ☐ 2

Were any of these market novelties ... *(Tick all that apply)*
- ... new to the local / German market? ..... ☐ 1
- ... new to the European market? ..... ☐ 1
- ... new to the world market? ..... ☐ 1 ➔ Share in total sales of these world market novelties in 2014? ca. ☐ %

3.4 Were any of the product innovations introduced during the three years 2012 to 2014 new to your enterprise's product range, i.e. there was no previous version of this product in your enterprise's product line?

Yes ..... ☐ 1 ➔ What was the share in total sales of these innovations in 2014? ..... ca. ☐ %

No ..... ☐ 2

4 Process Innovation

A **process innovation** is the implementation of a new or significantly improved manufacturing / production process, distribution method, or support activity for goods or services. It should have a noticeable impact on the level of productivity, the quality of your product / service or the cost of production / distribution. Newly introduced procedures that enabled the introduction of product innovations, also count as process innovations.

The innovation must be **new to your enterprise**, but your enterprise does **not need** to be the **first to introduce** it. The significant factor is your enterprise's evaluation of it. It does not matter if the innovation was developed by your enterprise alone or in collaboration with other enterprises. **Purely organisational changes** such as the introduction of **new management practices** are **not** process innovations.

➔ *For examples of process innovations, see the foldout section.*

4.1 During the years 2012 to 2014, did your enterprise introduce new or significantly improved products / services (incl. distribution methods and processes to deliver services)**?**

Yes ..... ☐ 1 ➔ No ..... ☐ 2 ➔ *Please continue with **Section 5**.*

Do these process innovations relate to ... *(Tick all that apply)*
- methods of manufacturing or producing goods or services ..... ☐ 1
- logistics, delivery or distribution methods for your inputs, goods or services ..... ☐ 1
- supporting activities for your processes (e.g. maintenance systems, operations) ..... ☐ 1

Who developed these process innovations? *(Tick all that apply)*
- Your enterprise by itself ..... ☐ 1
- Your enterprise together with other enterprises or institutions ..... ☐ 1
- Your enterprise by adapting or modifying goods or services originally developed by other enterprises or institutions ..... ☐ 1
- Other enterprises or institutions ..... ☐ 1

4.2 Did the process innovations introduced by your enterprise during 2012 to 2014 reduce the average costs (per unit / operation)**?**

Yes ..... ☐ 1 ➔ What was the reduction in average unit costs due to these process innovations in 2014 ..... ca. ☐

No ..... ☐ 2

4.3 Did the process innovations introduced by your enterprise during 2012 to 2014 lead to improvements in quality?

Yes ..... ☐ 1 ➔ What was the increase in turnover due to these quality improvements in 2014 ..... ca. ☐
No ..... ☐ 2

5 Ongoing, Discontinued / Abandoned and Planned Innovation Activities

5.1 Did your enterprise have any on-going activities in 2012 to 2014 to develop or introduce product or process innovations that were discontinued or were still in progress at the end of 2012?

Also include ongoing and abandoned R&D activities, including contract R&D for third parties.

(Tick all that apply)	*product innovations*	*process innovations*	*not assignable*
Yes, innovation activities still in progress at the end of 2014	☐ 1	☐ 1	☐ 1
Yes, discontinued / abandoned innovation activities in 2012 to 2014	☐ 1	☐ 1	☐ 1
No	☐ 1	☐ 1	

5.2 Does your enterprise intend to conduct activities in 2015 or 2016 leading to product or process innovations? Also include ongoing and abandoned R&D activities, including contract R&D for third parties.

(Tick all that apply)	*2015*	*2016*
Yes, product innovation activities planned	☐ 1	☐ 1
Yes, process innovation activities planned	☐ 1	☐ 1
Yes, innovation / R&D activities planned, assignment to product or process innovations not possible	☐ 1	☐ 1
Not yet determined	☐ 1	☐ 1
No innovation / R&D activities planned	☐ 1	☐ 1

➔ *If you answered No to questions 3.1, 4.1, 5.1 and 5.2 please continue with Section 10 on page 6.*

6 Innovation Activities and Innovation Expenditures

Innovation expenditure includes expenditure on the following activities:
- R&D within the enterprise (in-house R&D)
- R&D conducted by third parties (external R&D)
- Acquisition of equipment, machinery or software for innovation purposes
- Acquisition of external knowledge for innovation activities (e.g., patents, licenses, trademarks)
- Product design, service philosophy, preparation of production / distribution for innovation activities
- Professional development for innovation activities (e.g., employee training or continued education)
- Marketing of innovations (marketing activities directly related to innovation projects, incl. market research)

6.1 Please estimate the total amount of expenditures for all innovation activities (including R&D activities) **in 2014, as well as all the amount of capital expenditures for innovation.**

*Note: **Innovation expenditures** include all expenditures for personnel and consumables, including services provided by third parties, as well as capital expenditure. Total innovation expenditures include all types of **R&D expenditures**.*
__Capital expenditures__ (capex) for innovation include the purchase of fixed investment and intangibles used to realise innovation projects.

Total innovation expenditures in 2014 ..... ca. ☐ .000 EUR → ***Therein:*** Capex for innovation ..... ca. ☐ .000 EUR

No expenditures for innovation in 2014 ..... ☐ 1 No capex for innovation in 2014 ..... ☐ 1

6.2 How did your enterprise's innovation expenditure in 2014 (as stated in question 6.1) **split up by product and process innovation?**

Innovation expenditures for product innovation ..... ca. ☐ %

Innovation expenditures for process innovation ..... ca. ☐ %

Assignement to product and process innovation not possible ..... ca. ☐ %

Innovation expenditures in 2014: **1 0 0** %

6.3 What are the anticipated changes in total innovation expenditures (as stated in question 6.1) **for your enterprise in 2015 and 2016?**

Total innovation expenditures in 2015 and 2016 will **compared with the previous year** ...	*increase*	*stay the same (+/- 1 %)*	*decrease*	*don't know*
2015	☐ 1	☐ 2	☐ 3	☐ 4
2016	☐ 1	☐ 2	☐ 3	☐ 4

	2015	*2016*
Estimated total innovation expenditures (incl. capex for innovation projects)	ca. ☐ .000 EUR	ca. ☐ .000 EUR

No innovation expenditures ..... ☐ 1 ..... ☐ 1

6.4 What was the number of innovation projects (incl. R&D projects**) executed in your enterprise during 2012 to 2014?**

Total number of innovation projects executed in the years 2012 to 2014 (finished or still ongoing projects)	'12-'14 successfully completed projects	*thereof:* '12-'14 discontinued / abandoned projects	ongoing projects at the end of 2014	*thereof:* '12-'14 newly started projects
ca. ☐	☐	☐	☐	☐

7 Research and Experimental Development (R&D)

R&D is defined as the systematic creative work to increase the stock of knowledge and its use to devise new products or services and new processes (incl. software development).

7.1 Did your enterprise conduct in-house R&D in the years 2012 to 2014?

Yes, continued ..... ☐ 1
Yes, occasionally ..... ☐ 2
No ..... ☐ 3

How many persons were involved in the R&D activities in the year 2014?

R&D employees in 2014 (annual average) ..... ca. ☐

7.2 Did your enterprise conclude R&D contracts with third parties during 2012 to 2014 (i.e. conduct external R&D)?

Yes, with a domestic partner ..... ☐ 1 Yes, with a foreign partner ..... ☐ 1 No ..... ☐ 1

7.3 Please estimate the amount of R&D expenditures (internal and external, incl. capital expenditures) **of your enterprise in 2014.**
(Note: R&D expenditure is part of total innovation expenditure according to question 6.1)

R&D expenditures in 2014 (internal + external, incl. capex) ..... ca. ☐ .000 EUR ☐ 1 ..... No R&D expenditures in 2014

8 Public Financial Support to R&D and Innovation

Public financial support to innovation **includes the financial promotion of R&D or innovation projects by public authorities** by grants, subsidised loans, equity or loan guarantees. The payment for contracted R&D or innovation activities by public authorities is not considered as public financial support. Please also take into consideration public support through authorized agencies such as 'Projektträger' or public banks.

8.1 Did your enterprise receive public financial support for innovation projects during 2012 to 2014?

Yes, from ...
- States (German state government departments) ..... ☐ 1
- Federal Ministry of Economics and Technology (BMWi) ..... ☐ 1
- Federal Ministry of Education and Research (BMBF) ..... ☐ 1
- Other German Federal Ministries ..... ☐ 1
- 7th EU Community RTD Framework Programme ..... ☐ 1
- other EU programmes / institutions ..... ☐ 1
- others: ☐ ... ☐ 1

No ..... ☐ 1

How many of your R&D / innovation projects executed during 2012-2014 (as stated in question 6.4) received public financial support (# of projects) ..... ☐

9 Co-operation for Innovation Activities

Innovation co-operation is active participation with other enterprises or institutions on innovation activities. Both partners do not need to commercially benefit. **Exclude pure contracting out** of work with no active co-operation.

9.1 Did your enterprise co-operate on any of your innovation activities during 2012 to 2014?

Yes ..... ☐ 1 No ..... ☐ 2 ➔ *Please continue with* ***Section 10.***

9.2 Please indicate the type of innovation co-operation partner by location.

(Tick all that apply)	*Germany regional*	*Germany national*	*Europe (excl. DE)*	*USA*	*China, India*	*other countries*
A. Other enterprises within your enterprise group	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1
B. Clients or customers from the private sector	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1
C. Clients or customers from the public sector*	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1
D. Suppliers of equipment, materials, software, etc.	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1
E. Competitors or other enterprises in your sector	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1
F. Consultants and commercial labs	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1
G. Universities or other higher education institutions	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1
H. Government / public research institutes	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1
I. Private research institutes	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1

* Local, regional and national administrations / agencies and government owned organisations, incl. schools, hospitals, service providers etc.

9.3 Which type of co-operation partner did you find the most valuable for your enterprise's innovation activities during 2012 and 2014?
(Please give corresponding letter according to the categories in question 9.2)

Co-operation partner with the most important contribution: ..... ☐ No assessment possible ..... ☐ 1

10 Obstacles to innovation activities

10.1 What effect did the following obstacles possibly have to your innovation activities during 2012 to 2014, and did the importance of these obstacles change since 2012?

(Tick all that apply)	*Innovation projects were not started*	*stopped / discontinued*	*delayed*		*Importance of obstacle did increase* Yes	No	*Not relevant*
High financial risk	☐1	☐1	☐1	➔	☐1	☐2	☐1
High innovation costs	☐1	☐1	☐1	➔	☐1	☐2	☐1
Lack of internal sources of financing	☐1	☐1	☐1	➔	☐1	☐2	☐1
Lack of external sources of financing	☐1	☐1	☐1	➔	☐1	☐2	☐1
Internal opposition against innovation projects	☐1	☐1	☐1	➔	☐1	☐2	☐1
Organisational problems within the enterprise	☐1	☐1	☐1	➔	☐1	☐2	☐1
Lack of skilled labour	☐1	☐1	☐1	➔	☐1	☐2	☐1
Lack of technological information	☐1	☐1	☐1	➔	☐1	☐2	☐1
Lack of appropriate market information	☐1	☐1	☐1	➔	☐1	☐2	☐1
Lack of demand for innovation	☐1	☐1	☐1	➔	☐1	☐2	☐1
Legal restrictions	☐1	☐1	☐1	➔	☐1	☐2	☐1
Long administrative procedures (red tape)	☐1	☐1	☐1	➔	☐1	☐2	☐1
Industry standards and norms	☐1	☐1	☐1	➔	☐1	☐2	☐1
Lack of excess to intellectual property rights (e.g. patents)	☐1	☐1	☐1	➔	☐1	☐2	☐1
Dominant market positions of incumbent firms	☐1	☐1	☐1	➔	☐1	☐2	☐1
Other obstacles:	☐1	☐1	☐1	➔	☐1	☐2	

11 Marketing and Organisational Innovations

11.1 Did your enterprise introduce the following marketing innovations during 2012 and 2014?

A **marketing innovation** is the implementation of a new marketing concept or strategy that differs significantly from your enterprise's existing marketing methods and which has not been used before. It requires significant changes in product design or packaging, product placement, product promotion or pricing. Exclude seasonal, regular and other routine changes in marketing methods.

	Yes	*No*
Significant changes to the aesthetic design or packaging of a good or service *(exclude changes that alter the product's functional or user characteristics - these are product innovations)*	☐1	☐2
New media or techniques for product promotion, introduction of brands *(e.g. the first time use of a new advertising media, a new brand image, introduction of loyalty cards, etc.)*	☐1	☐2
New methods for product placement or sales channels (incl. new ways to present products and services) *(e.g. first time use of franchising or distribution licenses, direct selling, exclusive retailing, new concepts for product presentation, etc.)*	☐1	☐2
New methods of pricing goods and services *(e.g. first time use of variable pricing by demand, discount systems, etc.)*	☐1	☐2

11.2 Did your enterprise introduce the following organisational innovations during 2012 and 2014?

An **organisational innovation** is a **new organisational method** in your enterprise's business practices (including knowledge management), workplace organisation or external relations that **has not been previously used** by your enterprise. It must be the result of strategic decisions taken by management. Exclude mergers or acquisitions, even if for the first time.

	Yes	*No*
New business practices for organising procedures *(e.g. supply chain management, business re-engineering, knowledge management, lean production, quality management, etc.)*	☐1	☐2
New methods of organising work responsibilities and decision making *(e.g. team work, decentralization, integration or de-integration of departments, job rotation, etc.)*	☐1	☐2
New methods of organising external relations with other firms or public institutions *(e.g. first use of alliances, partnerships, outsourcing or sub-contracting, etc.)*	☐1	☐2

12 Intellectual Property Rights, Standardisation, Certificates

12.1 Did your enterprise use the following intellectual property rights during 2012 and 2014? *(Tick all that apply)*

- Yes, patent application ☐1
- Yes, utility patent application ☐1
- Yes, registration of industrial designs ☐1
- Yes, registration of trade marks ☐1
- Yes, claim of copyright ☐1
- No intellectual property rights used ☐1

12.2 Did your enterprise license-out / sell own intellectual property rights or license-in / buy intellectual property rights of others during 2012 and 2014? *(Tick all that apply)*

- Licensing-out own IPRs ☐1
- Licensing-in IPRs of others ☐1
- Selling own IPRs ☐1
- Buying IPRs of others ☐1
- No such activity ☐1

12.3 Did your enterprise engage in the following activities related to standardisation, certification and the use of certificates during 2012 and 2014?

	Yes	No
Active participation in formal standardisation committees (e.g. DIN, DKE, CEN, ETSI, ISO, IEC, ITU)	☐ 1	☐ 3
Active participation in informal standardisation consortia (e.g. AUTOSAR, IEEE, IETF, W3C, ZHAGA)	☐ 1	☐ 3
Certification of own products or services to technical norms (e.g. DIN, ISO)	☐ 1	☐ 3
Certification of own processes, management systems, working / environmental standards (e.g. ISO 9000, 14000, 50001)	☐ 1	☐ 3
Application of technical certificates for own products (e.g. CE, GS)	☐ 1	☐ 3
Application of certificates in the area of environment, health, employee protection for own products	☐ 1	☐ 3

13 Environmental Innovations

An **environmental innovation** is a new or significantly improved product (good or service), process, organisational method or marketing method that creates environmental benefits compared to alternatives. The environmental benefits can be the primary objective of the innovation or the result of other innovation objectives. The environmental benefits of an innovation can occur **during the production** of a good or service, or during the after sales use of a good or service by the **end user**.

13.1 During 2012 to 2014,, did your enterprise introduce innovations that had any of the following environmental benefits, and if yes, was their contribution to environmental protection rather significant or insignificant?

Please mark an X in each line!	*Yes, significant*	*Yes, insignificant*	*No*
Reduced energy use per unit of output	☐ 1	☐ 2	☐ 3
Reduced material use / use of water per unit of output	☐ 1	☐ 2	☐ 3
Reduced CO_2 ‚footprint' (total CO_2 production)	☐ 1	☐ 2	☐ 3
Reduced air pollution (i.e. SO_x, NO_x)	☐ 1	☐ 2	☐ 3
Reduced water or soil pollution	☐ 1	☐ 2	☐ 3
Reduced noise pollution	☐ 1	☐ 2	☐ 3
Replaced fossil energy sources by renewable energy sources	☐ 1	☐ 2	☐ 3
Replaced materials by less hazardous substitutes	☐ 1	☐ 2	☐ 3
Recycled waste, water, or materials for own use or sale	☐ 1	☐ 2	☐ 3

13.2 During 2012 to 2014, did your enterprise introduce new products or services with the following environmental benefits through the use of these products/services, and if yes, what was their contribution to environmental protection?

Please mark an X in each line!	*Yes, significant*	*Yes, insignificant*	*No*
A. Reduced energy use	☐ 1	☐ 2	☐ 3
B. Reduced air, water, soil or noise pollution	☐ 1	☐ 2	☐ 3
C. Improved recycling of product after use	☐ 1	☐ 2	☐ 3
D. Extended product life through longer-lasting, more durable products	☐ 1	☐ 2	☐ 3

→ If you answered **„Yes"** in **A, B, C** or **D**: How high was the share of sales with new products or services that had a positive environmental impact on your enterprise's total sales in 2014? ca. ☐ %

13.3 During 2012 to 2014, how important were the following factors in driving your enterprise's decisions to introduce environmental innovations?

Please mark an X in each line!	*Degree of **importance*** High	Medium	Low	Not relevant
A. **Existing** environmental regulations	☐ 1	☐ 2	☐ 3	☐ 4
B. **Existing** environmental taxes, charges or fees	☐ 1	☐ 2	☐ 3	☐ 4
C. Environmental regulations or taxes **expected** in the future	☐ 1	☐ 2	☐ 3	☐ 4
D. Government grants, subsidies etc. for environmental innovations	☐ 1	☐ 2	☐ 3	☐ 4
E. Current or expected market demand for environmental innovations	☐ 1	☐ 2	☐ 3	☐ 4
F. Improving your enterprise's reputation	☐ 1	☐ 2	☐ 3	☐ 4
G. Voluntary actions or standards for environmental good practice within your sector	☐ 1	☐ 2	☐ 3	☐ 4
H. Increasing cost of energy, water or materials	☐ 1	☐ 2	☐ 3	☐ 4

→ If you answered at least **„Low importance"** in **A, B, C** or **D**: Please name the respective laws, regulations, environmental taxes of public support programmes:

14 Basic Financial Information

14.1 What were your enterprise's payroll costs and expenditures for material/ intermediate inputs and energy in 2013 and 2014?

	2013	*2014*
Payroll costs (incl. employee benefits and social security contributions)	ca. ☐ .000 EUR	ca. ☐ .000 EUR

Expenditures for materials, intermediate inputs, incl. services contracted out ..... ca. [.000] EUR ..... ca. [.000] EUR

Expenditures for energy ..... ca. [.000] EUR ..... ca. [.000] EUR

14.2 What were your enterprise's expenditures for professional development training in 2013 and 2014?

Professional development training expenditures *include all in-house and contracted out expenditures for training and further education of employees, including payroll costs of employees for working time used to attend training. Please* ***exclude*** *expenditures for* ***vocational education****.*

	2013	2014
Expenditures for professional development training (in-house + contracted out)	ca. [.000] EUR	ca. [.000] EUR
No expenditures for professional development	☐ 1	☐ 1

14.3 What were your enterprise's total marketing expenditures in 2013 and 2014?

Marketing expenditures *include all in-house and contracted out expenditures for advertising and branding (incl. commercial marketing), reputation building, conceptual design of marketing strategies, market and costumer research, and the installation of new distribution channels.* ***Pure selling costs*** *are* ***not*** *considered as marketing expenditures.*

	2013	2014
Total marketing expenditures (in-house + contracted out) ..	ca. [.000] EUR	ca. [.000] EUR
No marketing expenditures	☐ 1	☐ 1

14.4 What were your enterprise's total software expenditures in 2013 and 2014?

Software expenditures *include expenditure for the acquisition of software and for in-house development of software (incl. costs of embedded software), regardless whether expenditures have been capitalised.*

	2013	2014
Total software expenditures (in-house + contracted out)	ca. [.000] EUR	ca. [.000] EUR
No software expenditures	☐ 1	☐ 1

14.5 What was your enterprise's gross investment in fixed assets (i.e. gross addition of fixed assets, including assets created internally and buildings) **and what was the amount of tangible fixed assets in 2013 and 2014?**

	2013	2014
Gross investment in fixed assets	ca. [.000] EUR	ca. [.000] EUR
No investment in fixed assets	☐ 1	☐ 1
Total amount of tangible fixed assets at the beginning of the year	ca. [.000] EUR	ca. [.000] EUR

14.6 What was your enterprise's operating margin (i.e. profit before taxes on income as a percentage of turnover) **in 2013 and 2014?**

	Below -5 %	*-5 % to -2 %*	*-2 % to 0 %*	*0 % to 2 %*	*2 % to 4 %*	*4 % to 7 %*	*7 % to 10 %*	*10 % to 15 %*	*15 % and more*	*No estimate possible*
2013	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10
2014	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10

15 Information on Replying to the Questionnaire

In order to further improve the Community Innovation Survey we kindly ask you to provide the following information regarding the completion of this year's questionnaire.

15.1 How many persons did contribute to completing the questionnaire?

[ ] No. of persons

15.2 How much time did it need to complete the questionnaire?

[ ] Hours [ ] Minutes

15.3 Did you use your answers to questionnaires from earlier innovation surveys to complete this questionnaire?

Yes ..... ☐ 1 No ..... ☐ 2

15.4 Was all information needed to complete the questionnaire easy at hand, or did you have to research for some information?

All information was readily available ..... ☐1 (Some) Information hat to be researched ..... ☐2

15.5 For how many years have you been working in your enterprise?

☐ No. of years in the enterprise

thereof:

☐ No. of years in the current position

15.6 Do you have any comments on the questionnaire?

Thank you very much for your valuable assistance!

To allow further enquiries, please complete your contact information below.

Name of respondent	Enterprise address or stamp
Position within enterprise	
Telephone	
E-mail	

17.4 2016

German Innovation Survey 2016

Fraunhofer ISI

infas

ZEW
Zentrum für Europäische Wirtschaftsforschung GmbH

Aim of the survey
The German Innovation Survey commissioned by the German Federal Ministry of Education and Research (BMBF) is intended to collect information on innovation activities in the economy during the years 2005 to 2007. The information gathered serves as a key basis for economic policy decisions, in order to improve conditions for the business environment.

Who is conducting the survey?
The German Innovation Survey is conducted jointly by the Centre for European Economic Research (ZEW) together with the Fraunhofer-Institute System and Innovation Research (ISI) and the Institute for Applied Social Sciences (infas).

What happens to the data you provide?
The three institutions conducting the survey bear full legal responsibility for data protection. All your data will be handled strictly confidentially and only anonymously, i.e. without name and address, and only pooled data from enterprises will be analysed. It will not be possible to identify the data from individual enterprises from the published results. In other words: **data protection is fully guaranteed**.
Further information on German innovation surveys can be found at: www.zew.de/innovation

How to answer the questionnaire
Please tick the correct answer in the corresponding box: ☒

Please enter the numbers or text requested in the large boxes: 85

If a number is equal to zero, please enter "0". Please skip a question only if instructed to do so, e.g.: ➔ *Please continue with Question 8!!*

In case of any queries about this survey, please contact:	Please return completed questionnaires in **the attached envelope** to:
■ Julian von der Burg · infas · Tel 0800 7 384 500 · E-Mail innovation@infas.de ■ Dr. Christian Rammer · ZEW · Tel 0621 1235 221 · E-Mail rammer@zew.de ■ Prof. Dr. Torben Schubert · ISI · Tel 0721 6809 357 · E-Mail schubert@isi.fraunhofer.de	**infas** **Postfach 24 01 01** **53154 Bonn**

1 General information on your enterprise

1.1 Is your enterprise part of an enterprise group (corporate group or a consortium of several enterprises)?

Yes, a national enterprise group ..... ☐ 1 ➔ The head office is located ... in the old German *Länder* [states] ..... ☐ 1
Yes, a multinational enterprise group ..... ☐ 2 ➚ ... in the new German *Länder* (incl. Berlin) ..... ☐ 2
No ..... ☐ 3 ... abroad ..... ☐ 3

1.2 Please state the entity that your following statements in the questionnaire will refer to.

The enterprise ..... ☐ 1 The entire enterprise group (corporate group) ..... ☐ 2

➔ ***When answering the following questions, refer only to the entity given in 1.2 and located in Germany!***

1.3 What was your enterprise's average number of employees (incl. apprentices and interns, but without temporary workers) **in 2015?**

Total number of employees ..... ☐ ***Therein***: part-time employees ..... ☐

1.4 Please indicate the percentage of your enterprise's employees in 2015 holding a university degree.

Percentage of employees holding a university degree
(incl. universities of applied sciences and of cooperative education) ..... ca. ☐ %

No employees holding a university degree ..... ☐ 1

1.5 What was your enterprise's total turnover (incl. exports) and export value in 2015?

Turnover (without VAT) ..... ☐ .000 EUR ***Therein***: exports ..... ☐ .000 EUR

*If a **bank**: turnover = gross interest and commission earnings; if an **insurance enterprise**: turnover = income from premiums.*

1.6 Please state your enterprise's top-selling line of products/services in 2015 and its share of sales.

☐ *Share of sales 2015* ca. ☐ %

2 Produkt Innovation / Service Innovation

Product innovation describes a product (incl. services) whose components or basic characteristics (technical features, integrated software, applications, user friendliness, availability) are either new or significantly improved.

The innovation must be **new to your enterprise**, but it does **not need** to be **new to your sector or market**. The sole significant factor is your enterprise's evaluation of it. It does not matter if the innovation was developed by your enterprise alone or in collaboration with other enterprises. **Purely aesthetic modifications** of products (e.g. colouring, styling) are **not** regarded as product innovations. **Selling alone of innovations** that have been developed and produced entirely by other enterprises, also does **not** count as product innovation in this sense.

➔ *For examples of product innovations, see the fold-out section at the left.*

2.1 During the years 2013 to 2015, did your enterprise introduce new or significantly improved products/services?

Yes ..... ☐ 1 No ..... ☐ 2 ➔ *Please continue with **part 3**.*

2.2 Please briefly describe your enterprise's most important product innovation of the years 2013 to 2015?

2.3 How does your enterprise's turnover (incl. exports) **in 2015 break down among the following types of products?**

Newly introduced or significantly improved products/services during 2013 to 2015 ..... ca. ☐ %

Unchanged or slightly changed products/services since 2013
(Also include products/services developed and produced entirely by other enterprises) ..... ca. ☐ %

Turnover in 2015: **1 0 0** %

2.4 Were any of the product innovations introduced during the three years 2013 to 2015 new to the market, i.e. your enterprise was the first one to market these products/services?

Yes ..... ☐ 1 ➔ What was the share of these market innovations in total turnover in 2015? ..... ca. ☐ %
No ..... ☐ 2

2.5 Were any of the product innovations introduced during the three years 2013 to 2015 new to your enterprise, i.e. there was no previous version in your enterprise's product line?

Yes ..... ☐ 1 ➔ What was the share of these products in total turnover in 2015? ..... ca. ☐ %
No ..... ☐ 2

3 Process Innovation

A **process innovation** is the implementation of a new or significantly improved manufacturing/production process, distribution method, or support activity for goods or services. It should have a noticeable impact on the level of productivity, the quality of your product/service or the cost of production/distribution. Newly introduced procedures that enabled the introduction of product innovations, also count as process innovations.

The innovation must be **new to your enterprise**, but your enterprise does **not need** to be the **first to introduce** it. The significant factor is your enterprise's evaluation of it. It does not matter if the innovation was developed by your enterprise alone or in collaboration with other enterprises. **Purely organizational changes** such as the introduction of **new management practices** are **not** process innovations.

➔ *For examples of process innovations, see the fold-out section at the left.*

3.1 During the years 2013 to 2015, did your enterprise introduce new or significantly improved internal processes (incl. processes for service performance and product delivery)?

Yes ..... ☐ 1 No ..... ☐ 2 ➔ *Please continue with **part 4**.*

3.2 Please briefly describe your enterprise's most important process innovation of the years 2013 to 2015?

3.3 Did the process innovations introduced by your enterprise during 2013 to 2015 reduce the average cost (per unit / per operation)**?**

Yes ..... ☐ 1 ➔ What was the reduction in average unit cost due to process innovations in 2015?..... ca. ☐ %
No ..... ☐ 2

3.4 Did the process innovations introduced by your enterprise from 2013 to 2015 lead to a clear improvement in the quality of your products/services?

Yes ..... ☐ 1 ➔ What was the increase in turnover due to these quality improvements in 2015? ..... ca. ☐ %
No ..... ☐ 2

4 Ongoing, Discontinued and Planned Innovation Activities

4.1 Did your enterprise have any on-going activities at the end of 2015 to develop or introduce product or process innovations or were any such activities discontinued during 2013 to 2015?

(Please include in-progress/discontinued R&D activities - including R&D commissioned by third parties! Multiple responses allowed.)	*Product Innovation*	*Process Innovation*	*Not assignable*
Yes, ongoing innovation activities at the end of 2015	☐ 1	☐ 1	☐ 1
Yes, discontinued innovation activities in 2013-2015	☐ 1	☐ 1	☐ 1
No innovation activities in progress or discontinued 2013-2015	☐ 1	☐ 1	☐ 1

4.2 Does your enterprise plan to conduct activities in 2016 or 2017 aiming at product or process innovations? Please include planned R&D activities, including R&D commissioned by third parties!

	Product Innovation	*Process Innovation*	*Not assignable*	*Not known yet*	*No*
2016	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1
2017	☐ 1	☐ 1	☐ 1	☐ 1	☐ 1

➔ ***If you answered No to all questions 2.1, 3.1, 4.1 and 4.2, please continue with part 7.***

5 Innovation Expenditures

Innovation expenditures include all expenditures including labour costs and capital expenditures relating to the following activities:
- In-house research and experimental development (internal R&D)
- Awarding of R&D contracts to third parties (external R&D)
- Acquisition of machinery, facilities and software to realize innovation projects
- Acquisition of external knowledge (e.g. patents, licenses, trademarks, industrial property rights) associated with innovation projects
- Product design, construction, design of services and other preparations for the production and distribution of innovations
- Continuing training expenditures related to innovation projects
- Market introduction of innovations (marketing campaigns directly linked to an innovation project, including market research)

5.1 Please estimate the total amount of expenditures for all innovation activities in 2015 (including labour cost, cost of material, cost of external services and capital costs), **as well as for all capital costs for innovation.**

Total innovation expenditures ..... ca. [.000] EUR

No innovation expenditures in 2015 ..... ☐ 1

Therein: Capital expenditures* for innovation projects ..... ca. [.000] EUR

No innovation expenditures in 2015 ..... ☐ 1

** in fixed and intangible assets, excl. capitalised development costs.*

5.2 What will be the expected total innovation expenditures (according to question 5.1) **in 2016 and 2017 for your enterprise?**

The total innovation expenditures will ...	*Increase*	*Stay approx. the same (+/- 1 %)*	*Decrease*	*Not yet determined*
in the year ... **compared to the year before** ... 2016	☐ 1	☐ 2	☐ 3	☐ 4
2017	☐ 1	☐ 2	☐ 3	☐ 4

5.3 Please estimate the expected total innovation expenditures in 2016 and 2017.

	2016	*2017*
Total innovation expenditures (incl. capital expenditures for innovation projects) ..... ca.	[.000] EUR	..... ca. [.000] EUR
No expenditures for innovation projects planned	☐ 1	☐ 1

6 Research and Experimental Development (R&D)

We define R&D as systematic creative work undertaken to increase the stock of knowledge and its use to devise innovative applications such as new and improved products and processes (incl. the development of software).

6.1 Did your enterprise conduct in-house R&D activities during 2013 to 2015?

Yes, continuously ..... ☐ 1 ➔ How many persons were concerned with R&D activities in 2015 in your enterprise?

Yes, occasionally ..... ☐ 2 ➚

No ..... ☐ 3

R&D employees in 2015 (annual average) ..... ca. [ ]

6.2 Did your enterprise issue R&D contracts to third parties during 2013 to 2015 (i.e. extramural R&D)**?**

Yes, to domestic contractors ..... ☐ 1 Yes, to foreign contractors ..... ☐ 1 No ..... ☐ 1

6.3 Please give the total expenditure for R&D (internal + R&D contracts to third parties) **in 2015.**

(Please note: R&D expenditures are part of the innovation expenditures, as stated in question 5.1.)

Total R&D expenditures* in 2015 (internal + external) ..... ca. [.000] EUR ☐ 1 ... No R&D expenditures in 2015

** including. expenditures for R&D activities and capitalised R&D expenditures, without amortizations on capitalized development costs.*

7 Usage of Digitalisation

7.1 To what extent does your enterprise currently use the following applications of digitalisation in different business function areas, and will the usage of these application likely increase, decrease or stay the same in the next three to five years?

Please tick at least one box in each line!	*Current usage* High	Medium	Low	No	*In the next 3 to 5 years* Increase	Stay the same	Decrease
Production / service provision:							
- Digital interconnection within production / provision of services	☐1	☐2	☐3	☐4	☐1	☐2	☐3
- Digital interconnection between production / service provision and logistics	☐1	☐2	☐3	☐4	☐1	☐2	☐3
- Digital interconnection with customers	☐1	☐2	☐3	☐4	☐1	☐2	☐3
- Digital interconnection with suppliers	☐1	☐2	☐3	☐4	☐1	☐2	☐3
Internal organisation / communication:							
- Teleworking	☐1	☐2	☐3	☐4	☐1	☐2	☐3
- Software-based communication (Skype etc.)	☐1	☐2	☐3	☐4	☐1	☐2	☐3
- Intranet-based platforms (Wikis etc.)	☐1	☐2	☐3	☐4	☐1	☐2	☐3
Sales / external communication:							
- E-Commerce	☐1	☐2	☐3	☐4	☐1	☐2	☐3
- Social media (Facebook, Twitter etc.)	☐1	☐2	☐3	☐4	☐1	☐2	☐3
Information processing:							
- Cloud computing / cloud applications	☐1	☐2	☐3	☐4	☐1	☐2	☐3
- Big data analysis	☐1	☐2	☐3	☐4	☐1	☐2	☐3

7.2 In what areas does your enterprise currently experience the greatest difficulties when trying to use the opportunities of digitalisation?

Bitte machen Sie in jede Zeile ein Kreuz!	*Difficulties when using digitalisation* High	Medium	Low	No
Financing	☐1	☐2	☐3	☐4
Shortage of skilled IT personnel	☐1	☐2	☐3	☐4
Shortage of IT knowledge of own staff	☐1	☐2	☐3	☐4
Uncertainty about future development in sales markets	☐1	☐2	☐3	☐4
Uncertainty about future technological development in the area of digitalisation	☐1	☐2	☐3	☐4
Uncertainty about future technical standards	☐1	☐2	☐3	☐4
Technical infrastructure (data transfer rate etc.)	☐1	☐2	☐3	☐4
Adaptation or conversion of existing IT systems	☐1	☐2	☐3	☐4
Interfaces / data exchange with business and co-operation partners	☐1	☐2	☐3	☐4
Data protection	☐1	☐2	☐3	☐4
Data security	☐1	☐2	☐3	☐4

Thank you very much for your valuable assistance!

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ZEW

Zentrum für Europäische
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Das Zentrum für Europäische Wirtschaftsforschung GmbH (ZEW) ist ein Wirtschaftsforschungsinstitut mit Sitz in Mannheim, das 1990 auf Initiative der Landesregierung Baden-Württemberg, der Landeskreditbank Baden-Württemberg und der Universität Mannheim gegründet wurde und im April 1991 seine Arbeit aufnahm. Der Arbeit des ZEW liegen verschiedene Aufgabenstellungen zugrunde:

- interdisziplinäre Forschung in praxisrelevanten Bereichen,
- Informationsvermittlung,
- Wissenstransfer und Weiterbildung.

Im Rahmen der Projektforschung werden weltwirtschaftliche Entwicklungen und insbesondere die mit der europäischen Integration einhergehenden Veränderungsprozesse erfaßt und in ihren Wirkungen auf die deutsche Wirtschaft analysiert. Priorität besitzen Forschungsvorhaben, die für Wirtschaft und Wirtschaftspolitik praktische Relevanz aufweisen. Die Forschungsergebnisse werden sowohl im Wissenschaftsbereich vermitteltals auch über Publikationsreihen, moderne Medien und Weiterbildungsveranstaltungen an Unternehmen, Verbände und die Wirtschaftspolitik weitergegeben.
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Die Aufgabenstellung des ZEW in der Forschung und der praktischen Umsetzung der Ergebnisse setzt Interdisziplinariät voraus. Die Internationalisierung der Wirtschaft, vor allem aber der europäische Integrationsprozeß werfen zahlreiche Probleme auf, in denen betriebs- und volkswirtschaftliche Aspekte zusammentreffen. Im ZEW arbeiten daher Volkswirte und Betriebswirte von vornherein zusammen. Je nach Fragestellung werden auch Juristen, Sozial- und Politikwissenschaftler hinzugezogen.

Forschungsprojekte des ZEW sollen Probleme behandeln, die für Wirtschaft und Wirtschaftspolitik praktische Relevanz aufweisen. Deshalb erhalten Forschungsprojekte, die von der Praxis als besonders wichtig eingestuft werden und für die gleichzeitig Forschungsdefizite aufgezeigt werden können, eine hohe Priorität. Die Begutachtung von Projektanträgen erfolgt durch den wissenschaftlichen Beirat des ZEW. Forschungsprojekte des ZEW behandeln vorrangig Problemstellungen aus den folgenden Forschungsbereichen:

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- Internationale Finanzmärkte und Finanzmanagement,
- Umwelt- und Ressourcenökonomik, Umweltmanagement
- Unternehmensbesteuerung und Öffentliche Finanzwirtschaft

sowie den Forschungsgruppen

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- Marktdesign
- Wettbewerb und Regulierung.

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03-02	Jürgen Egeln, Sandra Gottschalk, Christian Rammer, Alfred Spielkamp	Spinoff-Gründungen aus der öffentlichen Forschung in Deutschland.
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12-05	Georg Licht, Oliver Pfirrmann, Robert Strohmeyer, Stephan Heinrich, Vartuhi Tonoyan, Thomas Eckert, Michael Woywode, Dirk Crass, Mark O. Sellenthin	Begleit- und Wirkungsforschung zur Hightech-Strategie: Ex-post-Evaluierung der Fördermaßnahmen BioChance und BioChancePlus im Rahmen der Systemevaluierung „KMU-innovativ“
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14-02	ZEW: Irene Bertschek, Thomas Niebel, Jörg Ohnemus, Fabienne Rasel, Marianne Saam, Patrick Schulte Pierre Audoin Consultants (PAC): Katrin Schleife, Andreas Stiehler, Tobias Ortwein Universität Mannheim: Armin Heinzl, Marko Nöhren	Produktivität IT-basierter Dienstleistungen. Wie kann man sie messen und steuern?
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16-02	Marianne Saam, Thomas Niebel	Vergleich der Ausgaben für Digitalisierungsprojekte im Mittelstand mit den gesamtwirtschaftlichen IKT-Investitionen.
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17-04	Vanessa Behrens (ZEW) Marius Berger (ZEW) Martin Hud (ZEW) Paul Hünermund (ZEW) Younes Iferd (ISI) Bettina Peters (ZEW) Christian Rammer (ZEW) Torben Schubert (ISI)	Innovation Activities of Firms in Germany – Results of the German CIS 2012 and 2014. Background Report on the Surveys of the Mannheim Innovation Panel Conducted in the Years 2013 to 2016.